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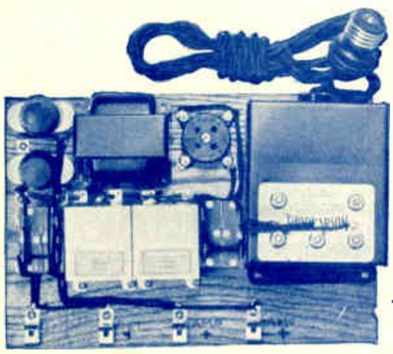

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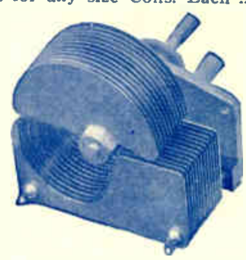

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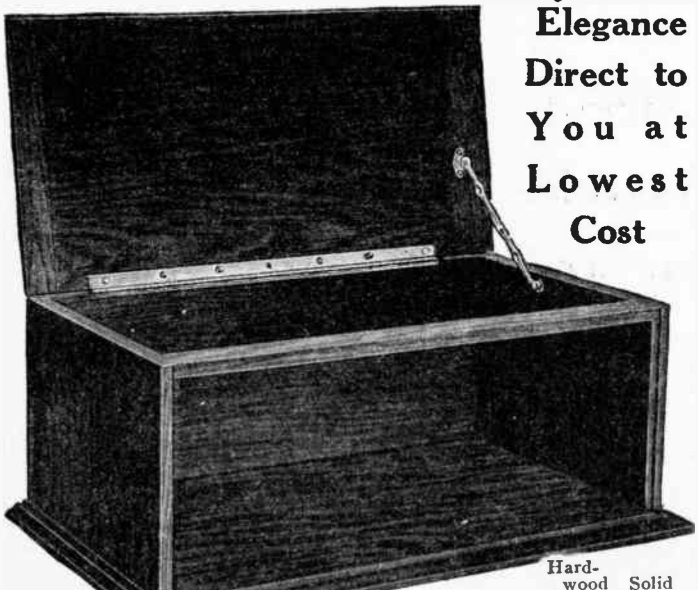

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Vol. No. 2

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World Radio History

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World Radio History

How to Build and Use The Best and Latest Circuits

Single-Tube Circuits

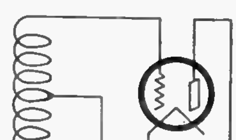
By L. W. HATRY

This is a review of regenerative circuits using but one tube—an excellent article for the beginner and the experimenter.

THE amateur has come to the conclusion that for this short-wave work he can seldom, it ever, surpass, the regenerative receiver, and some broadcast fans are of the same opinion. There are a number of circuits that one encounters when he prepares to build a set, all one-tube regenerative hook-ups—which serves rather to confuse him than to simplify his choice. So many and various are these receivers that one is at loss to what to do or how to do it, even if he has not delved into super-regeneration, or investigated any of the dynes or the plexes. It is with the hope of clarifying this muddle specifically in reference to the simple regenerative hook-ups that this article is written.

This article by Mr. Hatry is a general review of single-tube circuits. If the experimenter would stop to realize that the extra tubes in multi-tube receivers merely amplify, single-tube sets would come into the prominence which they really deserve. Whenever a new circuit involving some hitherto unexploited feature is published, invariably but one tube appears in the diagram.

So let more attention be paid to the "one-lungers" of radio, for if the principles underlying these circuits are mastered, the rest is comparatively simple.—Editor.



A

Fig. 1

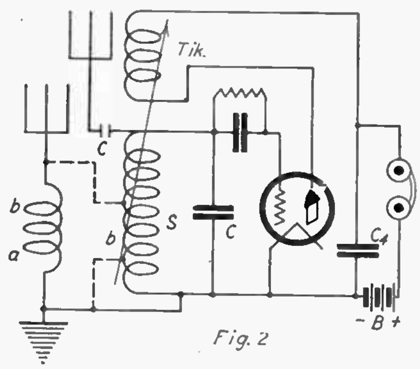
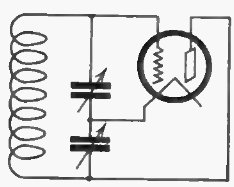


Fig. 2



B

Fig. 1

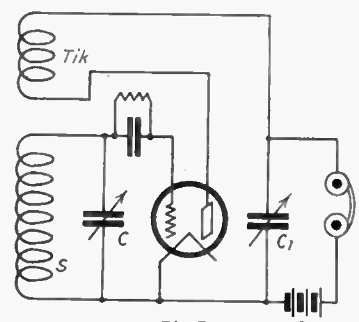


Fig. 3 B

Fig. 1. A and B show fundamental regenerative circuits. Fig. 2 is an old favorite, where regeneration is obtained with a tickler coil. In the diagram shown in Fig. 3 regeneration is again obtained with a tickler, but it is in fixed relation with the secondary. In Fig. 2, "C" connected to both ends of "S" should be a variable tuning condenser.

We must start off with this understood; in spite of the fact that all these circuits differ in some detail or another, they are based on the two fundamental circuits of Fig. 1, the inductively coupled A or the capacitatively coupled B; and in spite of the fact that all are apparently different, they will prove equally effective under the same conditions and similar construction. Thus, understand that it is not for superior results that any of these circuits may be considered, but for practical facts of constructional simplicity or operating ease. So the viewpoint in every case is entirely that of practicality; data to fit concludes the article.

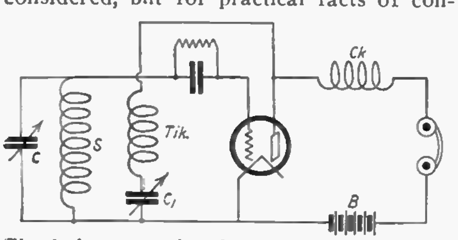


Fig. 4. A regenerative circuit with fixed coils that is smooth of operation and not critical.

We stick to these simple regenerative circuits and laud them because in them is both economy and satisfaction. Furthermore, there is little chance of the perpetration of a new "wonder" one-tube circuit without the discovery of a new principle or the invention of new "tools".

We take up the well-known tickler circuit in Fig. 2. Everyone seems to know it, for all seem to have used it at one time or another. Yet there remains the fact that although it can be said to be practically the first regenerative circuit, it has not been surpassed. In Fig. 2 the coil labeled "tickler" is variable in its relation to the coil labeled "secondary". Its sole electrical drawback lies in the fact that the tickler causes some change in the secondary wave-length when tuning. This can be overcome by the proper design of the tickler. When this last condition is fulfilled, the dial settings are reproducible and the set's log can be depended upon. However, the diagram is shown essentially to discuss the methods of coupling to the antenna circuit.

METHODS OF COUPLING

Three methods are shown for coupling to the antenna, one in which the antenna is coupled by means of a coil similar to the tickler and with a similar type of variable relation. This is an excellent method from a result viewpoint, but it is open to the same mechanical drawbacks as the rotable tickler. This is indicated schematically by "a," in Fig. 2. This sort of primary construction, contrary to usual practice, is still better when at least one tap is provided which allows a variation of the number of turns in the antenna circuit. This last generally makes the construction hopelessly difficult, but is mentioned because it is an improvement. This method of coupling the antenna circuit is the best of the three, but it is so difficult in construction that for the fellow who makes his own, one of the other methods is to be preferred. The second method is indicated by the dotted line of "b" in the same figure. It consists of fixed coupling between the secondary and primary, with the primary necessarily smaller on account of the closer coupling necessary in such an arrangement. Its greatest disadvantage lies in having the period of the antenna circuit affect the secondary circuit at that wave-length. This last can be overcome with either an antenna loading coil or a tapped primary, in which manner it becomes possible to shift the antenna period off the secondary tuning. On the amateur wave-bands very loose coupling is necessary, which is best provided by a single primary turn an inch to two inches from the secondary. The last method, "c" of Fig. 2, consits in using a very small fixed condenser to provide the necessary coupling. In two respects it is poorest method of the three. It generally results in less signal strength and has the same diadvantage of fixed coupling as "b". However, it must be admitted that it is easy to install and works satisfactorily. It is certainly worth a trial, for trial finds for us.

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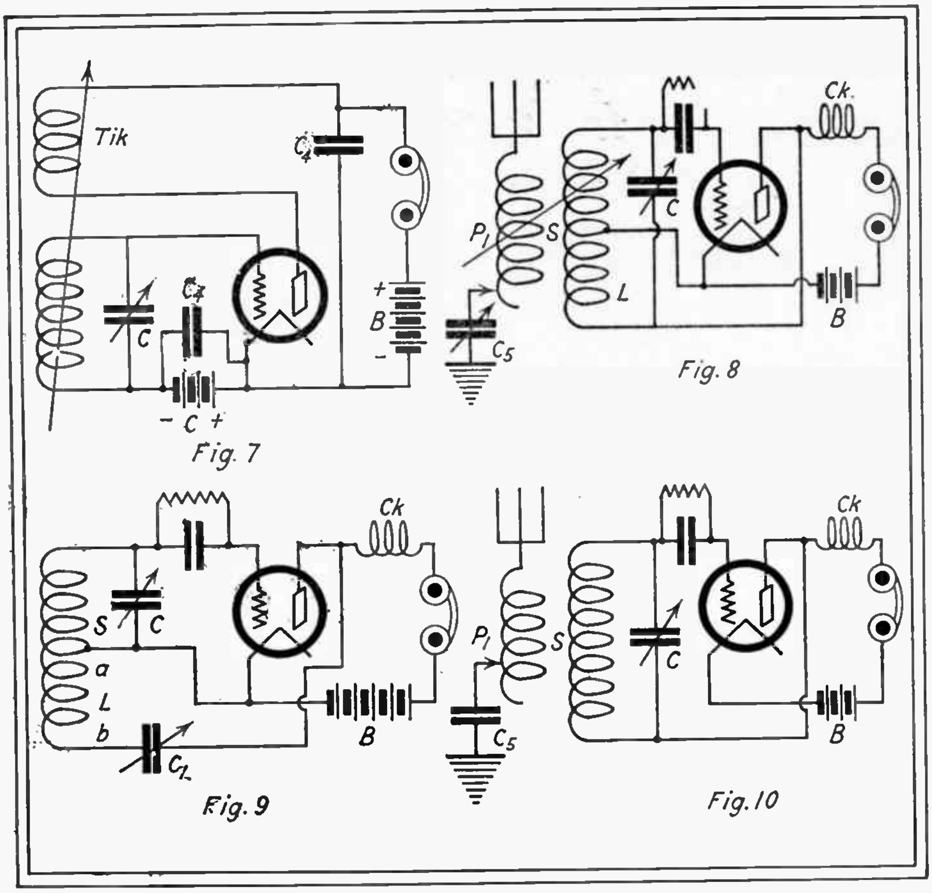

Fig. 7 shows the use of a 'C" battery instead of a grid condenser and leak. Figs. 8 and 9 are variations of the Hartley circuit with two different methods of controlling oscillations. Fig. 10 shows the ultra-audion circuit having a tuned primary circuit. In Fig. 8, insert .001 mfd. condenser in plate to coil L lead.

the things we like, as well as those we dislike.

In Fig. 3 is illustrated another method of controlling regeneration. This is excellent and deserves trial. It is a variation of the tickler circuit that provides greater mechanical simplicity. The tickler is coupled rather closely to the secondary and is fixed in that relation. Control of oscillation is effected by means of a variable bypass condenser across the high R.F. resistance of the head-set and "B" battery. This condenser, controlling as it does the R.F. resistance of the plate circuit, very satisfactorily controls the feed-back. This effectively eliminates the trouble encountered in the tickler construction. Then, too, there is no need of using a low-loss condenser for the variable by-pass, which fact is mentioned in the interests of economy. This method of controlling regeneration has its foibles, too. It requires careful choice of grid leak, "B" battery voltage and tickler size to avoid howling and attain smooth operation. This difficulty generally appears in the form of an audio frequency "fuzz" which makes itself known just where oscillation breaks off or starts. Yet, it is possible to adjust the circuit so that it will operate as smoothly and quietly as any other. Because it is possible to use fixed coils, the circuit offers a definite advantage. It permits of easy interchange of coils, so that different wave-length ranges may be covered.

A FAVORITE CIRCUIT

Fig. 4 depicts a circuit which the writer admits is his favorite. Therefore, if the description in this paragraph becomes too glowing, you are fairly warned to discount accordingly. It has the preference for two reasons: The coils necessary are fixed in relation to each other and the circuit is not critical and is smooth of operation. Like Fig. 3, it reduces the oscillation and tuning controls to two condensers, which certainly simplifies the construction. It requires the addition of a choke coil, but this is not critical and is therefore easy to make. By using as small a tickler as possible both in diameter and the necessary number of turns, the affecting of the tuning by the oscillation control can be reduced to negligible. (This is just as true of Fig. 3.) For short-wave telegraph reception it is usually possible to leave the series stopping condenser fixed, and to do all tuning with the secondary capacity, which gives a single-control circuit. This last is not true for the circuit when used for broadcast reception, although careful choice in tickler size will permit an accurate log.

The circuit in Fig. 5 is easily recognizable as the Reinartz. It is purposely shown in a somewhat unusual manner so that you may recognize in it the Weagent circuit of Fig. 4, on which it is based. The Reinartz possesses all of the qualities of Fig. 4, with the weakness of lower selectivity due to close primary coupling. It is also a very effective transmitter (blooper) because the plate and antenna circuits are conductively coupled. By paying but little attention to the conventional directions given for it and using a little time and care in the choice of the tickler size, it is possible to adjust the circuit so that the regeneration control does not affect the tuning. If the antenna coupling is loosened and the plate circuit connected direct to the filament, we no longer have the Reinartz, but Fig. 4.

Fig. 6 shows a modification of the Reinartz later offered by that persistent experimenter. It allows the use of a tapped coil without the losses due to dead-end and with a theoretical gain of grid voltage—the effective signal-producer—due to the use of a great amount of inductance for relatively short wave-lengths. A number of experimenters who have tried the arrangement feel that it delivers subnormal signal strength, which is the writer's opinion, also. Certainly it has failed of the popularity of the original circuit.

The use of the "C" battery in place of the grid condenser to make detection possible is illustrated in Fig. 7. This occasionally suffers rediscovery and the nascent enthusiasms of its discoverer; it fails of the popularity of the grid condenser because it complicates both care and operation. It certainly gives no increase in sensitivity, which could be the only justification for its use.

THE HARTLEY CIRCUIT

The Hartley circuit is shown in Fig. 8. A tuned antenna circuit provides the control of oscillation by the introduction of resistance through load. When the antenna circuit is in tune, provided proper coupling is used, the tube will not oscillate. This tuning of the antenna then becomes a satisfactory method of producing an effective two-control receiver, and having the antenna circuit tuned on the wave-lengths above 200 meters is an advantage that shows itself in greater volume and sensitivity. With proper choice of the number of turns of L, which is the plate coil or feed-back coil, although it is part of the secondary, it is possible to adjust operation so that the primary can be used with loose enough coupling to give good selectivity. If L is too large, the tube will oscillate with unnecessary vigor and the primary will have to be coupled excessively close to the secondary to control oscillation. Oscillation is a persistent condition with this hook-up, save when the antenna circuit is in tune, and even then it is present if insufficient coupling is used.

Fig. 9 is the same Hartley circuit with a variable stopping condenser to control oscillation and regeneration. This can be used with fixed antenna tuning of the usual sort. In fact it should be used with the fixed antenna coil, to avoid the complication of control which results when there are three knobs to turn on a regenerative receiver. Because the plate coil L is a portion of the total coil making up the secondary—there being, thereby, tight coupling between it and the grid circuit—the effect of the regeneration control C1 on tuning is very noticeable. This prevents the log of the set from being particularly accurate. Furthermore, the condenser C1 will show capacity effect to the body due to the locating of the potential from "a" to "b" on the condenser frame. However, such capacity effect is minimized by not grounding the "A" battery positive or negative, as is usual. Complete elimination of capacity effect at C1 can be accomplished only by shielding. The choke coil is not entirely necessary on a set using this circuit without audio amplification, but with the addition of andio amplification it cannot be satisfactorily omitted.

THE ULTRA-AUDION

The circuit shown in Fig. 10 possesses the same quality as that shown in Fig. 8. It is possible to use with it a tuned primary circuit and have at the same time a two-control receiver. This is again because the tube circuit used is a steady oscillator. The secondary circuit is the well-known ultra-audion. The main disadvantage in comparison with the circuit shown in Fig. 8 lies in the fact that the strength of oscillation is not controllable (remember that the turns in the plate coil of Fig. 8 allow such control) without complication of tuning. This means that the primary must be coupled, generally, too close to the secondary to allow good selectivity. Of course, in the reception of C.W, oscillation need not be stopped, so that the coupling need not be close enough to destroy the selectivity; but broadcast reception is dependent on the stoppage of oscillation and the regeneration obtained just before the begin-

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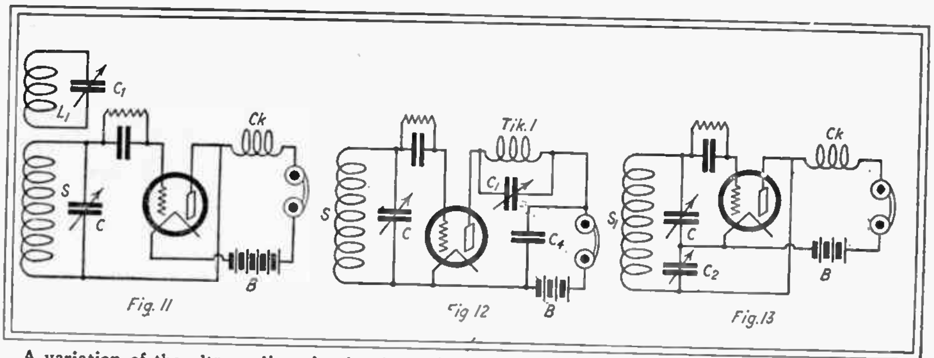


A variation of the ultra-audion circuit will be found in Fig. 11. In Fig. 12 is shown the tuned plate circuit, which is excellent because plug-in coils may be used. Both condensers in the circuit in Fig. 13 may be mounted on the same shaft, with satisfactory results.

ning of that stage, so the "selectivity" statment can only hold true in this latter use. Control of the oscillation strength is possible with the use of a variable grid condenser, but that means the addition of a control.

THE COCKADAY CIRCUIT

In Fig. 11 is shown a variation of the circuit in Fig. 10. The same ultra-audion circuit is used, but a closely coupled trap circuit L1-C1 is used to control oscillation. This makes Fig. 11 a duplicate of Fig. 10 in action, for the trap circuit acts as the antenna circuit does in Fig. 10. It will be recognized as the well-known Cockaday circuit. It is used with fixed or semi-fixed antenna tuning so that it will make up a two-control receiver. Cockaday recommends a single turn of direct antenna coupling coil and a nearby antenna loading coil mounted at right angles to S, the secondary. The antenna loading coil is an excellent addition to any fixed coupling coil arrangement, but the writer does not believe that a single-turn primary coupling coil is sufficient for the wave-lengths above 200 meters. The single turn is plenty for the shorter wave-lengths, however, and the loading coil is *not* needed. Because, as was mentioned in relation to Fig. 10, the ultra-audion is an excessively persistent oscillator, close coupling of the trap circuit—the so-called fourth circuit—is required; this makes its adjustments directly affect the secondary tuning. Yet, because this set is a strong oscillator, most settings are repeatable and the set's log will have fair dependability. This circuit, as well as the circuit in Fig. 10, could readily be used with plug-in coils to cover many wave-lengths.

The plate-tuned circuit arrives with Fig. 12. The same circuit is used with variometers in either the grid or plate circuits or both. With 201A tubes it is an effective circuit on any wave-length but with the smaller tubes trouble is often experienced in making it dependable on wave-lengths as high as 300 meters. This is because the

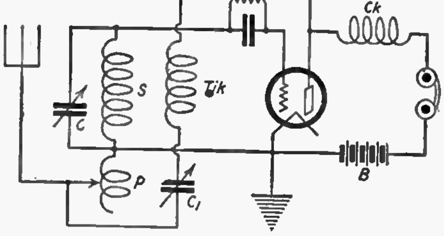


Fig. 5

The familiar Reinartz regenerative circuit, not quite as selective as that in Fig. 4.

capacity of the vacuum tube is depended upon to furnish the feed-back coupling necessary to oscillation and regeneration. The smaller tubes do not have the capacity to provide this for the higher wave-lengths although they will work well on the low ones. This failure to function presents itself in the form of spotty oscillation, or none at all. Fig. 12 has two advantages: the plate coil is independent of polarity unless it is inductively coupled to the secondary, which is not supposed to be the case. The second advantage is the fact that a plug-in coil system can be used to cover a great range of wave-lengths. The circuit has had, and still has, a large following on account of its sensitivity and selectivity, but it will do nothing that the others illustrated and described in the article will not. With this circuit, the plate tuning, the regeneration-oscillation control, directly affects the tuning of the secondary. This makes the log of the set only fairly dependable, and this is an unrectifiable defect.

Finally, in Fig. 13, we come back to one of the fundamental circuits with a completion of the phone circuits. The antenna circuit is coupled by one of the usual methods. The two variable condensers control the tuning and the oscillation. Because they control the tuning, the use of each separately is hardly satisfactory, so the best construction makes them a unit with both rotary plates controlled by a single knob. Then regeneration can be controlled at the by-pass condenser—it being made variable—or at a variable grid condenser; the variable by-pass is preferable. In general, the circuit is not very effective on wave-lengths below 600 meters, mainly because its control is not as smooth as that of the other circuits described. Furthermore, it is difficult to gain stability of control on the tube circuit, which could easily be made into a plug-in proposition.

CONSTANTS FOR COILS AND CONDENSERS

The man who likes to try things will want constants for the various coils and condensers used in the circuits, so they are given herewith. The short-wave constants are given for coils to cover only the 75-85 meter wave-band and vicinity, about 60 to 120 meters. The larger sizes of coils are for the broadcast band of wave-lengths, or approximately 200 to 600 meters.

In all cases of coil marked S, there are 16 turns between filament and grid shunted by a .00015 microfarad condenser, C. These 16 turns can be basket-weave or spider-web of double-cotton-covered wire or white annunciator wire, No. 18. Or they may be wound on hard rubber or skeleton frame tubing. They should be spaced, if straight wound, about one-sixteenth of an inch, but the spacing need not be uniform. Tickler, 8 turns of any size wire. The L end of a tapped coil should have 8 turns and be a continuation of the coil, of course. A rotating or fixed tickler, not part of S, should be mounted at the filament end of S, as should the primary also. Reinartz type of primaries, Fig. 6, consists of three turns extra on the secondary, tapped every turn to a three-point switch. The secondary in Fig. 6, is tapped from either end. C1, in every case a regeneration control, is a .00025 microfarad variable. Primaries, type "a," are three turns, well removed from the secondary; type "b" are single-turn, set closer, and the coupling capacity "c" is half-by half-inch plates about an eighth of an inch apart. Ck, the R.F. choke, is 150 turns of wire finer than 28 on tubing one inch in diameter. C4 should be a fixed condenser of .001. C2 and C in Fig. 13 can best be a double .00025 microfarad unit. Tuned antenna circuits are more troublesome than useful in the amateur game, so are not considered.

FOR BROADCAST RECEIVERS

Jumping to data for the broadcast band: S, as mentioned above, is in this case 45 turns of No. 22 D.S.C. on a 3½-inch diameter tubing. It is shunted by a .0005 microfarad variable. The tickler is 25 turns of smaller wire on a form half the diameter of the secondary. The L end of a tapped coil has 20 turns and is part of the coil, of course. The rotating or fixed types of ticklers should be mounted at the filament end of the secondary, as should the primary coil. Reinartz type of primaries consists of ten turns tapped every two turns. The secondary in Fig. 6 is tapped 10 turns from either end. C1 is always .0005 microfarad or .001, as either is satisfactory. Primaries, type "a," are 15 turns spaced one-half an inch from the secondary on the same tubing; type "b" are single-turn, wound in the center and two to four turns if necessary, while the coupling condenser system "c" is not always best. Ck consists of 250 turns of wire wound in a lump on a wood spool or something small; No. 30 wire or smaller is O.K. C4 is a fixed condenser of .002 capacity. C2 and C Fig. 13 are a double .0005 microfarad unit and S1 is 70 turns on the 3½-inch tubing. Primaries P1 are 70 turns of No. 22 D S.C. wire tapped every ten turns with a series antenna condenser C5, of .001 or .0005 mfd. capacity.

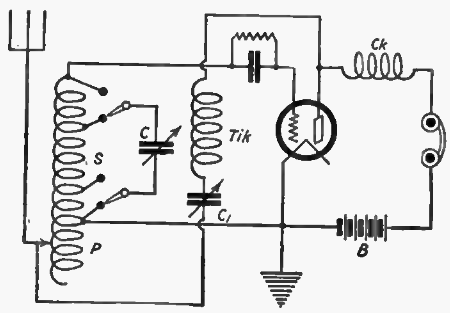


Fig. 6

A modified Reinartz circuit using a tapped coil to eliminate dead-end effects.

The grid condenser in every case will be .00025 fixed with a grid leak between 3 and 7 megohms if 201A tubes are used. The grid leak does not hold to these limits with other tubes.

And so, from the foregoing paragraphs we can all readily see that experimental work with single tube circuits offers much of great interest to everyone connected with radio. If the work is followed out regularly and strict attention is paid to details, some of the most surprising and interesting results can be obtained with only one tube. The proper constants are absolutely necessary, however, and unless these are found, the results will usually not be satisfactory. Experience will often teach us just what parts to use in certain places in different circuits and the details given in this article will aid in attaining this experience.

One thing more in connection with experimental work and that is that every time you do anything that is, in your opinion, new or novel, put it down on paper. Sketch out the hookup used and jot down all of the necessary details so that if you have to, you can perform the experiment again. Often valuable data is accumulated in this way.

World Radio History

The Four Types of Audio Amplification

By SYLVAN HARRIS

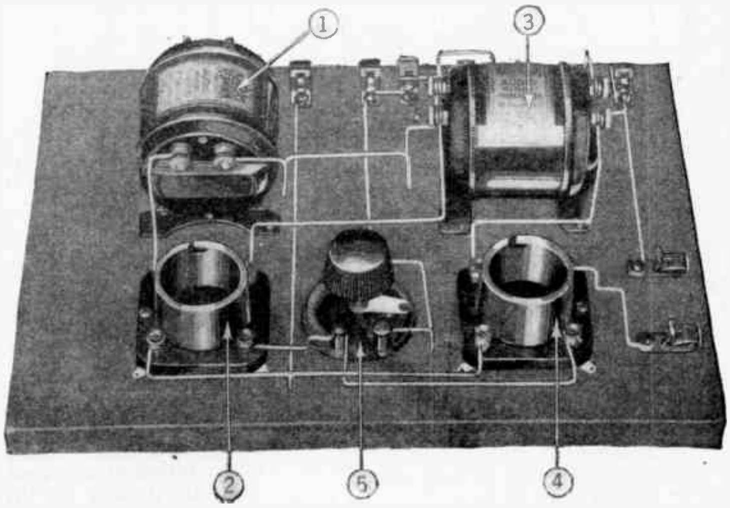
This article is a comprehensive discussion of audio amplifiers. Note that all types are described and their characteristics defined.

THERE are, in general, four types of amplifiers, any one of which can be made to operate satisfactorily in amplifying audio frequency currents. The choice of the type to use in a radio receiver depends upon many considerations, and it cannot fairly be said that one type is better than another. This will become apparent, as we proceed, and it will be seen that the different types of amplifiers are suited to different purposes. It is not well to confuse these purposes, any more than it would be well to confuse the purposes of the various types of automobiles. It would obviously not be well to put a truck adapted to heavy hauling into an automobile race, or to use a fly-weight runabout in a trans-continental tour.

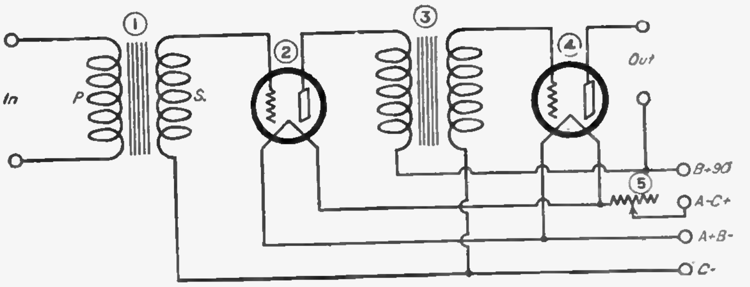
The four types of audio frequency amplifiers are.

1. Ordinary transformer coupled.
2. Impedance coupled.
3. Resistance coupled.
4. Push-pull.

Types 1 and 2 are very closely allied to each other; in fact, the impedance used in type 2 may be considered as ordinary transformers having two windings, in which the co-efficient of coupling, and the turns ratio are nearly unity. The impedance acts as an auto-transformer, the same winding acting as primary and part secondary at the same time.



The best-known type of amplifier. This amplifier uses ordinary transformers for coupling the stages.



Wiring diagram of the transformer coupled amplifier which is shown in the photo above. Fig. 1.

TRANSFORMER COUPLED AMPLIFICATION

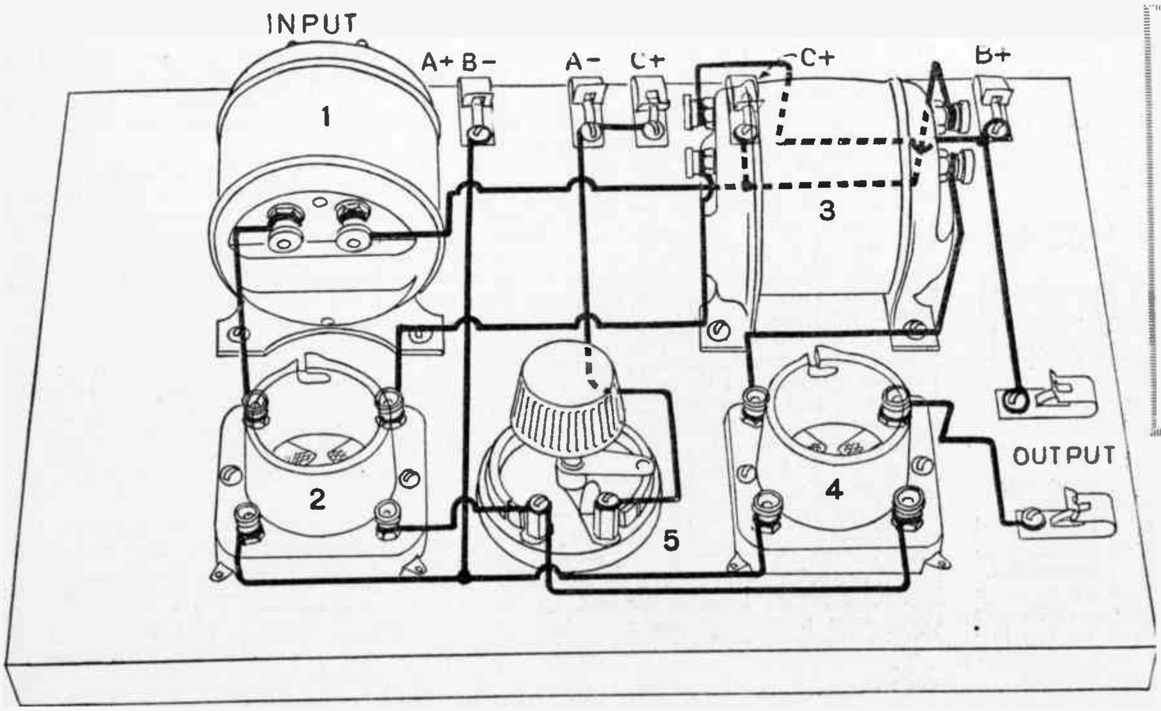
Fig. 1 illustrates the use of the ordinary transformer used in type 1. The output of one tube is connected to the primary winding of the transformer, and the secondary of the transformer is connected to the input of the next tube. This is the cascade arrangement. In this arrangement, the maximum amplification per stage (that is, considering the tube and transformer as a complete unit) is equal to the amplification constant of the tube multiplied by the turns ratio of the transformer. In the transformer, as is well known, the voltage of the secondary bears the same ratio to the input or primary voltage as the number of turns in the secondary bears to the turns in the primary. That is, in which v^1

$$\frac{v^1}{v^2} = \frac{n^1}{n^2}$$

and v^2 are the primary and secondary voltages, and n^1 and n^2 are the primary and secondary turns. The ratio n^1/n^2 is called the turns ratio of the transformer. This step-up of voltage occurs only under certain theoretical conditions, which are never attained in actual practice. However, it follows that the maximum voltage attainable in a stage comprising a tube and transformer is

$$K = \mu \frac{n^2}{n^1}$$

There has been a long-felt need for a general discussion of the various types of amplifiers, which, we feel, has been filled by Mr. Harris' article. The four well-known types are here described in detail, with full instructions on how to connect them up. There is also included in the arcticle an excellent discussion of the factors entering into the choice of the type of amplifier for the various uses found in radio reception. It is not often that the amateur endeavors to select the proper instrument for the purposes at hand; here is an opportunity for him to begin to think about it.



Transformer coupled amplifier. 1—First stage coupling transformer. 2—First stage tube socket. 3—Second stage coupling transformer. 4—Second stage tube socket. This phantom diagram shows plainly the component parts of the amplifier and their relation to each other.

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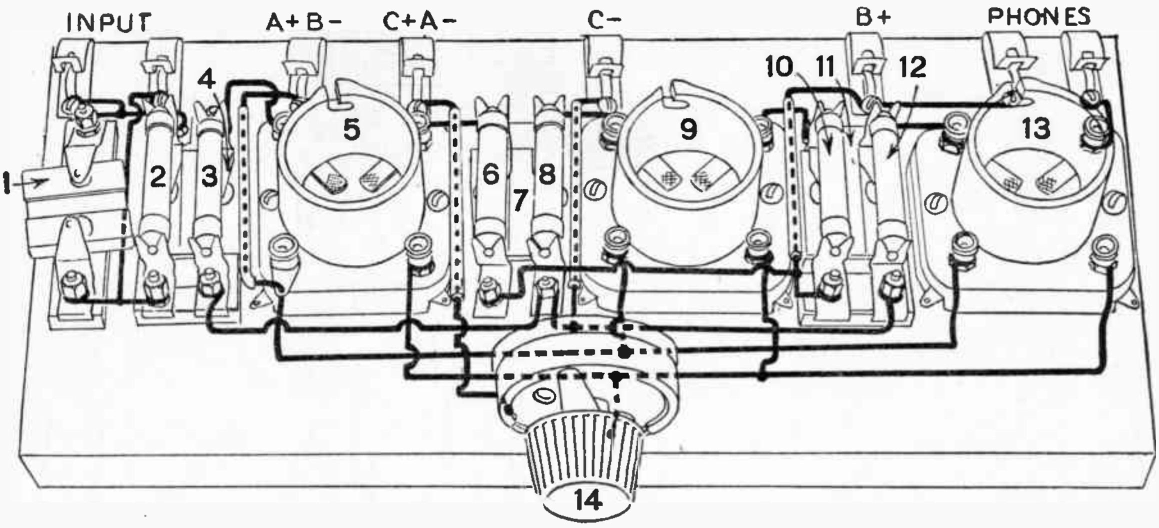


Resistance-coupled amplifier. 3, 8, 12—first, second and third stage grid resistances. 2, 6, 10—coupling resistances of each stage. 4, 7, 11—stopping condensers. 1—by-pass condenser.

in which K is the total voltage amplification and μ is the voltage amplification constant of the tube.

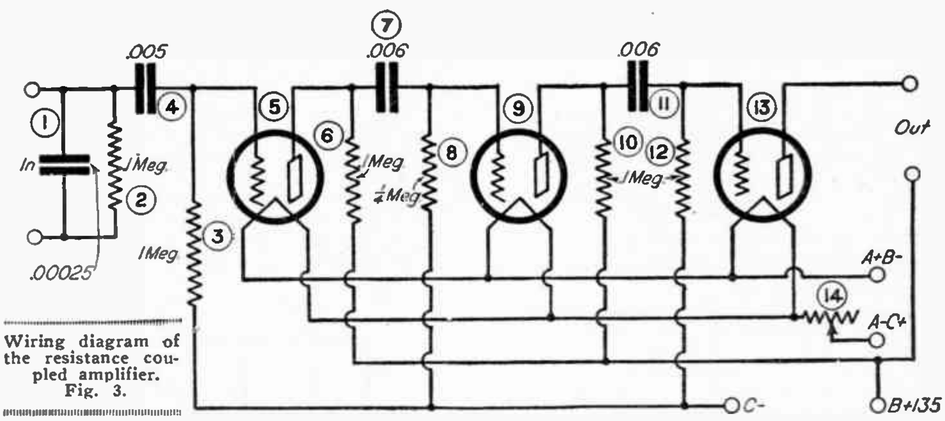
IMPEDANCE AND RESISTANCE COUPLING

The second type of amplifier is that which uses an ordinary impedance for the coupling unit between the tubes. This impedance, as explained before, acts as an auto-transformer, in which the number of turns in both primary and secondary is nearly the same. The turns ratio is close to unity, so that the maximum amplification obtainable when using this type of coupling with an amplifier tube is equal to the amplification constant of the tube. In other words, the ratio n^1/n^2 in the formula is nearly equal to one.

The third type of coupling given in the list above is the resistance coupling. It is, of course, evident that in this case there are no turns to consider, hence no turns ratio, and the maximum amplification obtainable in a stage comprising a tube and coupling resistance is equal to the amplification constant of the tube. The fundamental circuit connections for this type amplifier are shown in Fig. 3. It will be noted that in both Fig. 2 and Fig. 3 a condenser is connected to the grid of the second tube. This is a stopping condenser, to keep the high constant voltage of the "B" batteries from setting up a large grid current in the second tube.

PUSH-PULL AMPLIFICATION

This is a system devised by the Western Electric Company for the purpose of reducing the distortion which often results from the curvature of the tube characteristics when the tubes are carrying considerable current. The fundamental circuit connections are shown in Fig. 4. This diagram shows two amplifiers connected in cascade by means of coupling transformers. The two tubes on the right, in spite of the fact that two tubes are employed, represent only one stage of amplification. Little more voltage amplification can be obtained with the push-pull arrangement than with the ordinary transformer coupled amplifier, but it will be found that a much greater plate voltage, and hence greater plate current can be handled without distortion, than can be handled by the ordinary amplifier.



Wiring diagram of the resistance coupled amplifier. Fig. 3.

APPLICATIONS OF EACH TYPE

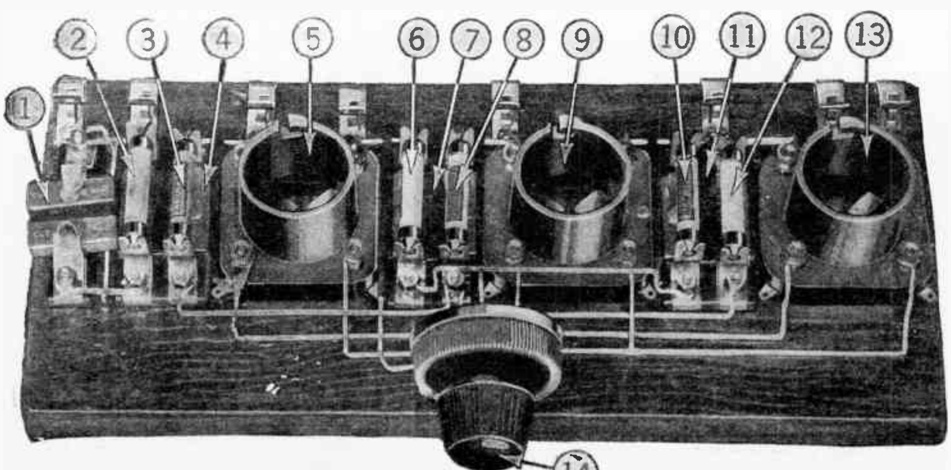
The next point to consider is the proper application of these various types of amplifiers. The most common arrangement is the ordinary cascade amplifier using ordinary transformers. Very satisfactory results are obtained with these amplifiers, but in the old days, before transformers had been developed to the point they have reached, distortion in the signals received developed quite often. This was generally due to the fact that the transformers would not produce the same amplification at all frequencies. For instance, if a violin were sounding the note C, which has a frequency of 256 per second, the amplification through the transformer would have a certain value. To reproduce all sounds faithfully, notes of all frequencies should produce the same amplification. Generally they did not, and it was found that the transformer curves were as round as an old cobble road.

To overcome these difficulties, before any considerable improvements in transformer design had been obtained, the other types of coupling were tried. In the resistance coupling unit, due to the flow of the plate current through it, a voltage drop occurs, which, of course, reduces the effective voltage on the plate of the tube. For instance, if the voltage of the "B" battery is 150 volts, the resistance is 100,000 ohms, and there is a plate current of 1 milliampere flowing, the effective voltage on the plate is

150 — (100,000+0.001) or 50 volts.

The figures may vary considerably from these, but the idea is always the same. It will be noted that the effective voltage on the plate is reduced considerably because of the voltage drop in the resistance, and to make up for this effect, it is necessary to use high values of "B" voltages.

The same ideas hold with regard to the impedance couplings, for impedances cannot be built to have large impedances, and at the same time keep the resistance low. If this could be, the effective plate voltage



This resistance coupled amplifier is shown in the bread-board layout.

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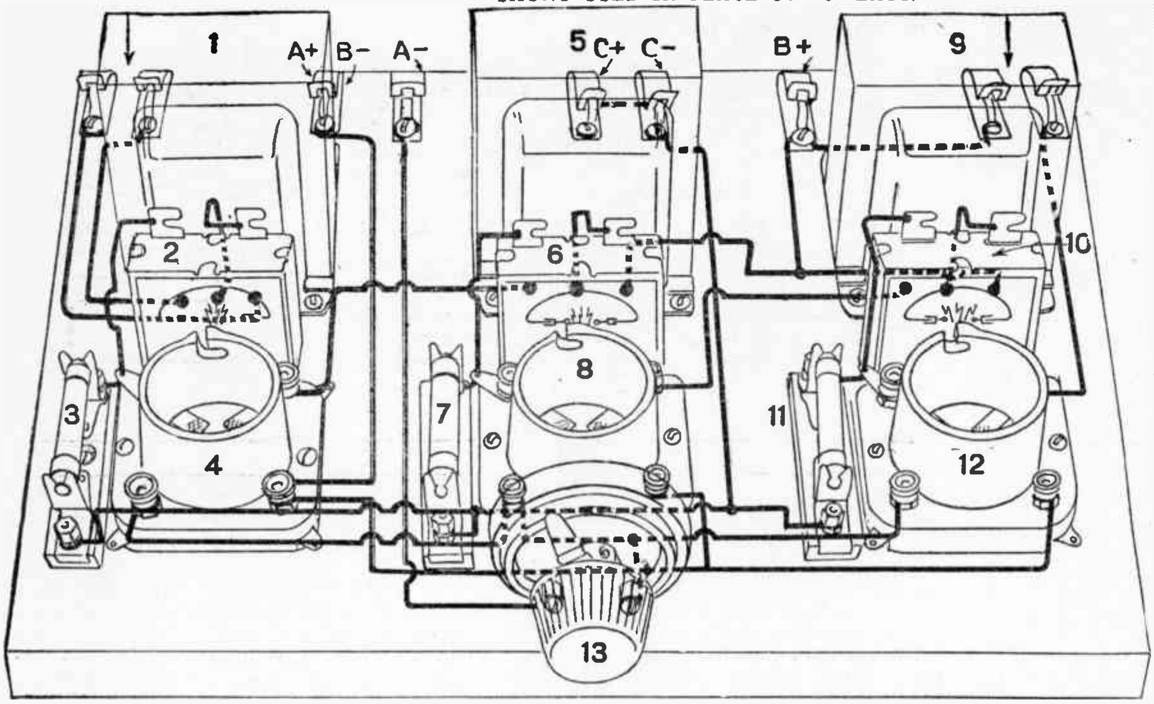
SHUNT USED IN PLACE OF "C" BATT.



The bread-board layouts on these pages have been made because they show exactly how the amplifier will look when built into a complete set. The only difference will be found in the position of the rheostat controlling the filament current, which is generally mounted on the panel. To tell the truth, it may as well be mounted in back of the panel, for it is seldom necessary to adjust it, provided, of course, that a filament switch is included in the circuit.

1, 5, 9—autoformers, or coupling impedances. 3, 7, 11—grid resistances. 2, 6, 10—stopping condensers. This type of amplifier is coming more and more into its own as the most perfect in point of truth to the transmitted program.

would be the same as the "B" voltage, for a constant current through an inductance produces no voltage drop excepting that due to its resistance.

The push-pull system can be used with the ordinary plate voltages but if it is desired to get out of the circuit all that is possible it is advisable to use much higher plate voltages. Voltages as high as 150 to 200 volts can be used successfully in push-pull stages.

A COMPARISON

Now, to discuss the four systems from the economic point of view, let us look at the following table:

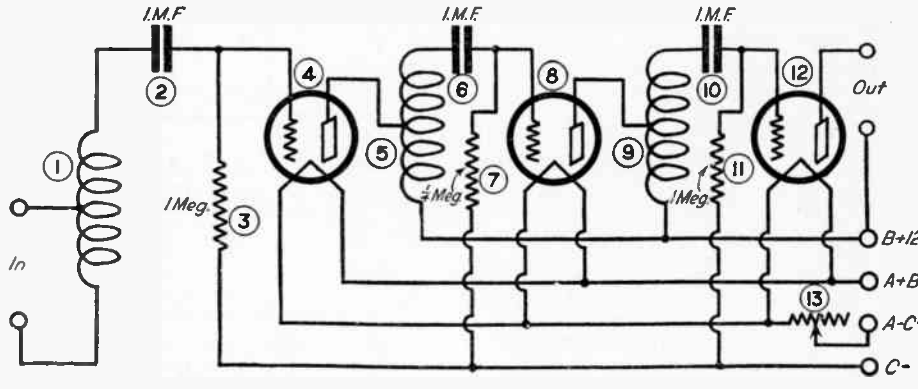
TRANSFORMER	IMPEDANCE
2 tubes	3 tubes
2 sockets	3 sockets
2 transformers	3 impedances
Ord. "B" battery	Large "B" battery
Ord. fil. current.	Increased fil. current
	3 stopping cond.
	3 grid leaks

RESISTANCE	PUSH-PULL
3 tubes	3 tubes
3 sockets	3 sockets
3 resistors	3 transformers
Large "B" battery	Large "B" battery
do.	do
3 stopping cond.	
3 grid resistors	

This table is for the purpose of outlining the parts required to build the various types of amplifiers, and from it can be obtained a fair idea of the relative cost of each type. It will be noted that in order to obtain the same amplification, or nearly the same, in the second and third types as is obtained from the first, it is necessary to use an extra stage, which means another tube and coupling unit. Furthermore, although the amplification in the push-pull system is little more than that obtained in the ordinary transformer system, it is necessary to use an extra tube to take advantage of the distortion-killing properties of the system. However, as has been said above, this makes it possible to use higher plate voltages without overloading the tubes.

The first three types of amplifiers eliminate the distortion which arises from the non-linear characteristics of the transformers. but allow the distortion due to curvature of the tube characteristics to remain. The last mentioned type, the push-pull, eliminates this also.

One of the main considerations in connection with amplifiers is the battery drain. In all of the types, excepting the ordinary transformer coupled amplifier, the filament consumption is increased 50 per cent. on

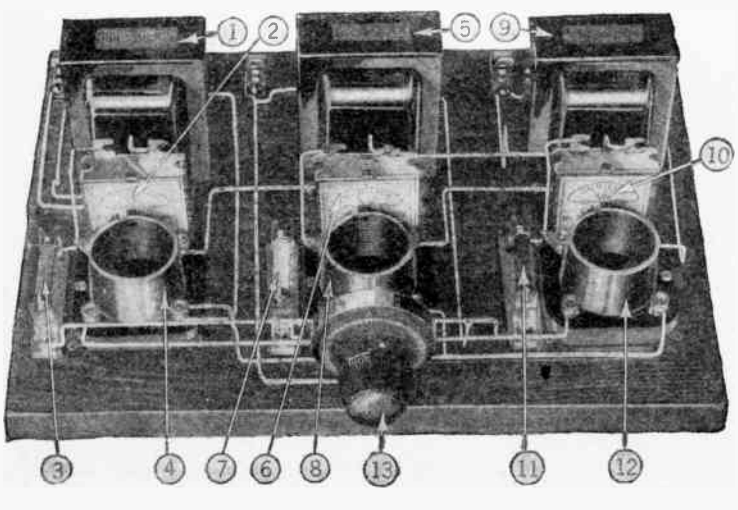


AUTOFORMER

account of the addition of the extra tube. Likewise, the "B" battery drain is increased, but in the resistance coupled type it is increased far out of proportion to the number of tubes.

So far we have said nothing about the "C" batteries. To claim good reproduction, it is almost always necessary to use biasing batteries in each stage. These add materially to the quality of reproduction, and at the same time contribute toward economy in reducing the plate current. This is especially true where high voltages are used, either on the grids or on the plates. In the resistance coupled amplifiers, the grid bias is obtained through the grid resistances shown in the diagrams.

Where great volume is desired without distortion, the push-pull system seems to meet the requirements best. The system corrects, at the same time, the distortion re-



Above: Fig. 2. Wiring diagram of the impedance coupled amplifier. To the left: photo of the impedance coupled amplifier shown in the two sketches above.

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sulting from the curvature of the tube characteristic and irregularity of the transformer characteristic. Full advantage of the push-pull system cannot be obtained, however, unless its load factor is kept high; use plate voltages not less than 135 volts, and have a good grid bias of about 4 to 6 volts negative.

The general construction of these four types of amplifiers is shown plainly in the various diagrams on these pages. The layout diagrams should be followed very carefully. These have been shown in "breadboard" fashion, but the assembly does not differ materially from the way in which it would really be assembled in a receiver, with the exception of the rheostats which are generally mounted on the panel. It may be well to point out here, however, that it is not generally necessary to adjust these rheostats very much, so for the sake of simplifying the appearance of the panel they may just as well be mounted behind it. Then, once adjusted, it will not be necessary to open the lid of the receiver and readjust them, unless the "A" battery runs pretty low. To tell the truth, it is just as convenient, in most cases, to do away with the rheostats entirely and use ballast resistances.

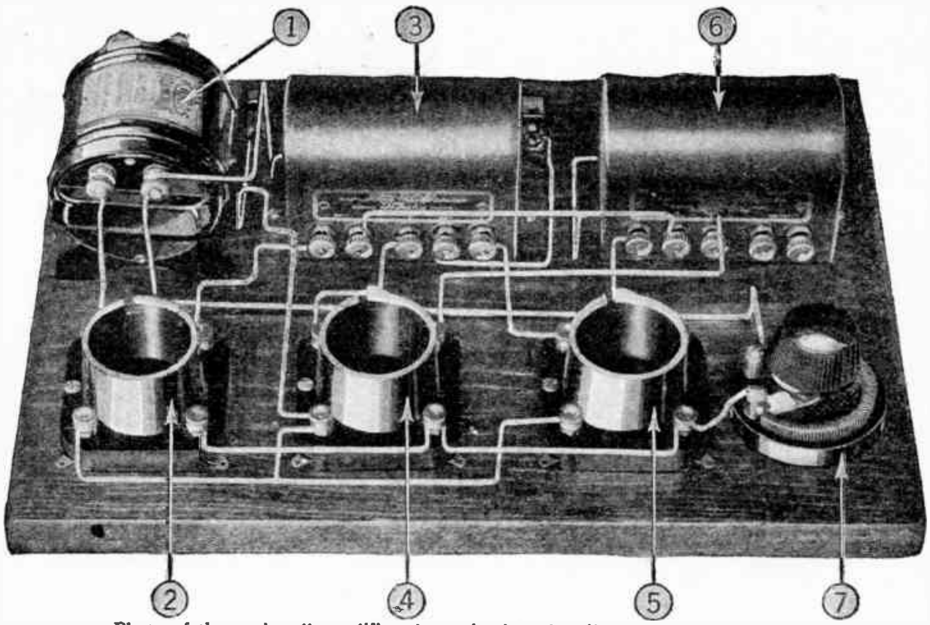
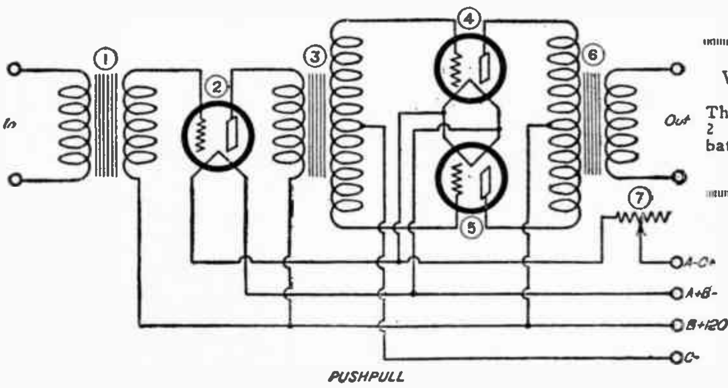


Photo of the push-pull amplifier shown in the other illustrations on this page.



Wiring diagram of the push-pull amplifier. The grid return of tube 2 should go to the—C battery instead of +B. Fig. 4.

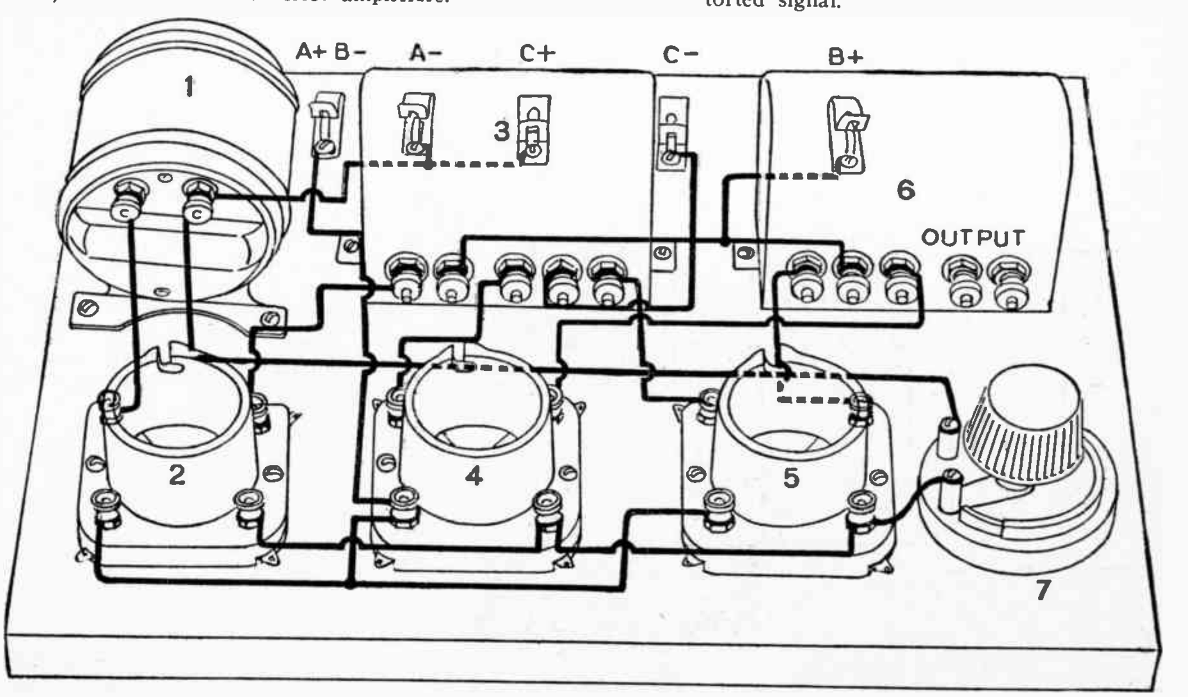
If an amplifier is assembled properly there should be no trouble experienced from audio frequency howling. This should be true whether the transformers are at right angles or not, for most transformers nowadays are carefully shielded in metal cases. It is well, however, to keep the radio frequency conductors well away from the audio end, as considerable trouble may be experienced from coupling the audio and the radio frequency stages. Of course, there is no radio frequency current in an audio frequency amplifier; we are referring to the high frequency amplifiers or the regenerative detector which may feed into the amplifiers.

It will be found that the push-pull system will give more volume, for a given amount of distortion, than any of the other types, but, as I have explained before, there is no economy in building a push-pull stage and then working it at a poor load-factor; that is, we should get all there is to get out of a stage of push-pull; use voltages up to 150 volts. They may, of course, be worked at the usual plate voltages, but the experimenter may be disappointed at the resulting volume when he considers that he is using another tube.

The push-pull system has much to recommend it, when properly designed and used, as can be seen from the fact that it is used in repeater stations on long distance telephone lines. It is not likely that large telephone companies would be content with inferior amplifiers.

The resistance coupled units have also much to recommend them, for they practically entirely remove all distortion, excepting, of course, distortion resulting from curvature of the tube characteristic. The difficulty with them is that if they are not handled properly, they are likely to become expensive, in the way of running down the "B" batteries.

There is one other point that should be brought out very carefully and never forgotten. That is, that if there is distortion in the signal currents entering the amplifier, no matter what type of amplifier it may be or how good, it is not possible to obtain good reproduction. The fault here does not lie in the amplifier, but in the associated apparatus. For instance, if a regenerative detector precedes the amplifier, and regeneration is pushed too near the critical point, distortion will result and this distortion will be passed through the amplifier into the horn. When the term distortionless is applied to an amplifier, it means that it will reproduce faithfully whatever is put into it. It follows, therefore, that if a distorted signal is sent into an amplifier, it would be impossible to get out of the amplifier anything but a distorted signal.



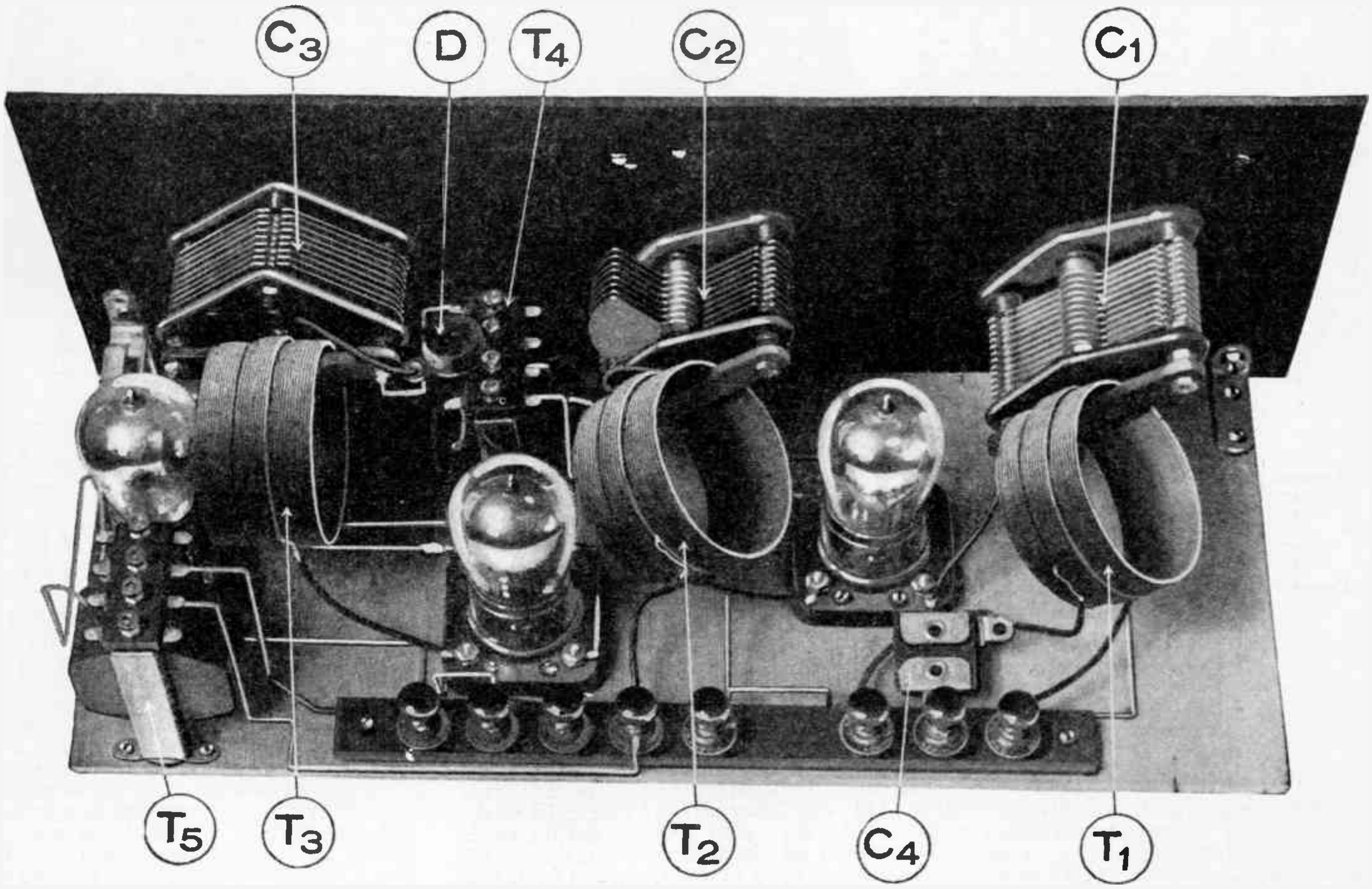
Push-pull amplifier. 1—first stage input transformer. 3, 6—input and output transformers of push-pull stage. 4, 5—tube sockets for push-pull stage.

World Radio History

The Tu-Ra-Flex Radio Receiver

(TUNED RADIO FREQUENCY REFLEX)

A tuned radio frequency reflexed receiver of exceptional merit is the Tu-ra-flex. Three tubes are made to do the work of four in a very efficient manner.



A rear view of a complete Turaflex Receiver. The components are: C1, C2, C3—variable condensers; C4—series antenna fixed condenser; T1—antenna coupler; T2, T3—radio frequency transformers; T4, T5—audio frequency transformers and D—crystal detector.

A GREAT advance in radio receiver design is incorporated in this new circuit, in which three tubes do the work of four. There are two stages of tuned radio frequency amplification, a crystal detector and two stages of audio frequency amplification. The losses due to a potentiometer or other devices to keep the tubes from oscillating are eliminated by using special low loss coils. There are added advantages, namely: This receiver will not re-radiate; it is as stable in operation as the best neutralized circuit; it is simple in operation, as stations once logged are always received on the same dial settings; and its selectivity is excellent.

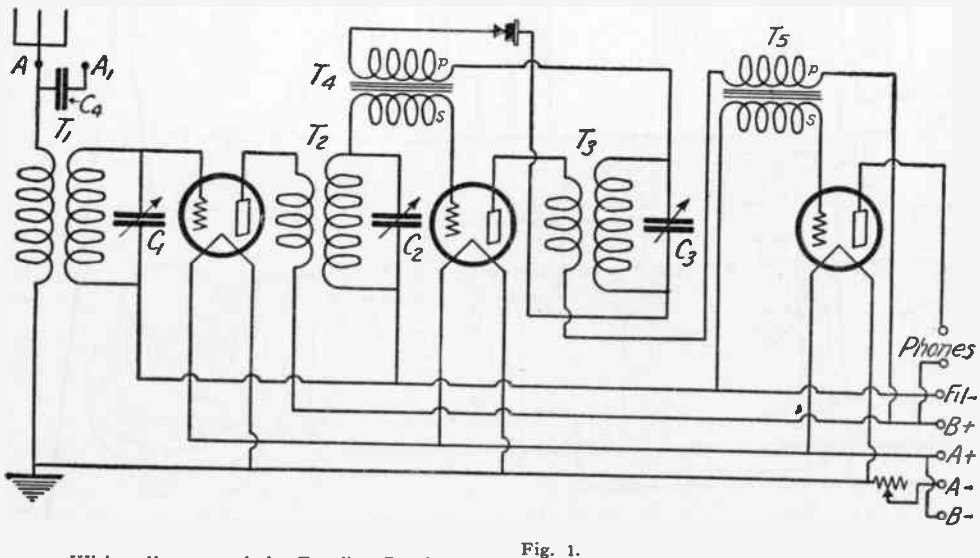


Fig. 1.
Wiring diagrams of the Turaflex Receiver. By the method employed the three tubes provide two stages of radio frequency amplification and two stages of audio frequency amplification.

The circuit diagram of this remarkable hook-up is shown in Fig.1. The action of the circuit is: The incoming signal is amplified at radio frequency in the first two tubes, is then rectified by the crystal detector; then reflexed through the second radio frequency tube at audio frequency, and then amplified through the third tube. The fixed coupler T_1, and the radio frequency transformers T_2 and T_3 are mounted on the rear of the variable condesers C_1, C_2, and C_3. As shown in the photograph D is a crystal detector and T_4 and T_5 are the audio frequency transformers. T_1 and T_2 are mounted at an angle of 45 degrees and T_3 is mounted vertically. C_1 is a 23-plate condenser and the other two condensers have 17 plates each. The tubes are controlled by one rheostat, which should be a heavy duty type to carry the current.

It will be noted that two antenna binding posts are indicated, the one marked A being used for a short antenna and A_1 for a long antenna, the latter having the .0025 mf. condenser C_4 in series.

The fixed coupler T_1, which is shunted by the 23-plate condenser, has a primary winding of 15 turns wound directly on the secondary of 50 turns. The radio frequency transformers have 14 turns wound over the 60 turns of the secondary and are shunted across the 17-plate condensers. No. 26 B. & S. gauge S. C. wire is used for winding the coils.

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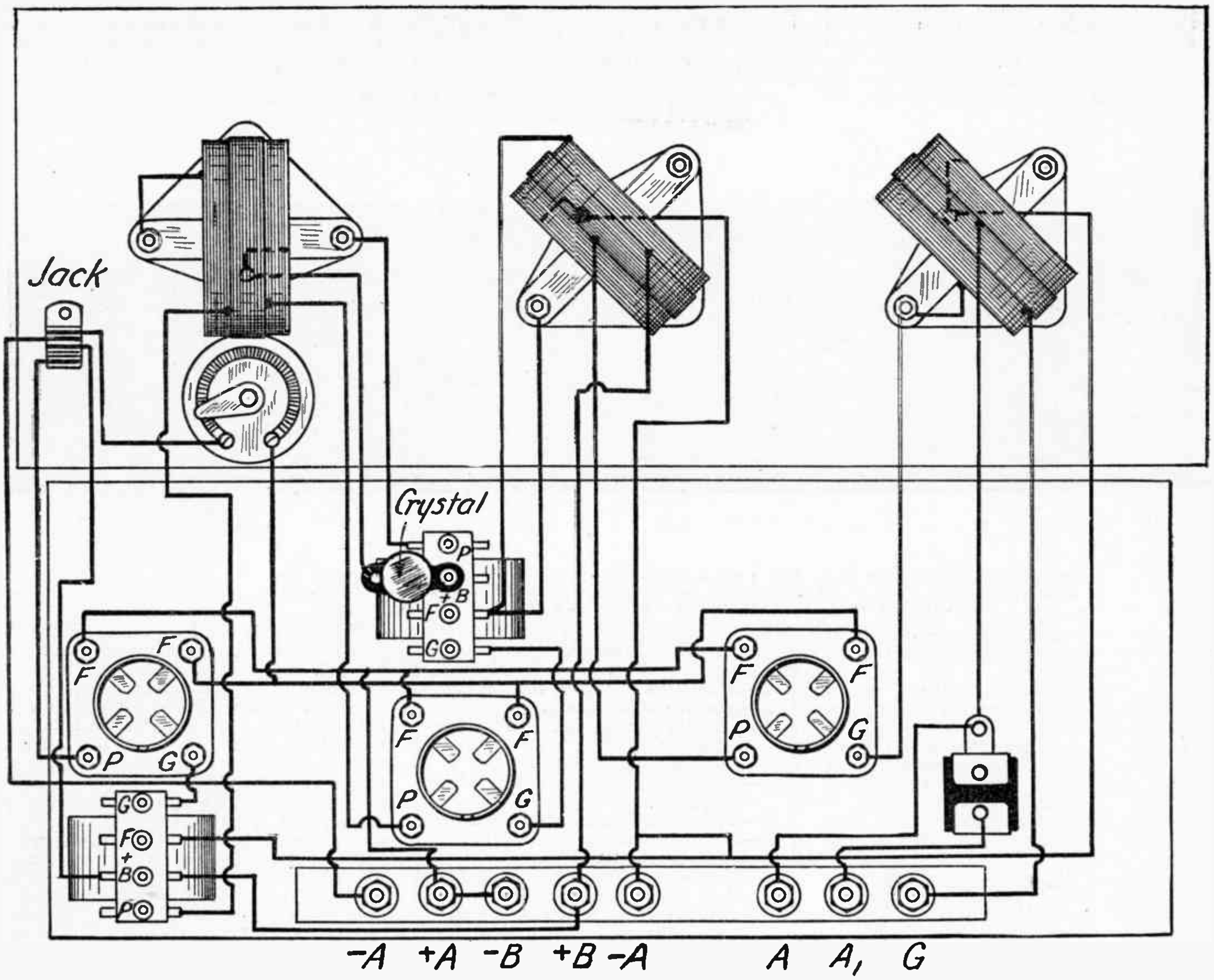

Picture layout and wiring of the Turaflex Receiver. The instruments are exactly as positioned on the panel and baseboard.

The coils may be wound on a bakelite tube 2¾ inches in diameter by putting on the secondary and then the primary over and in the center of it. If the constructor wishes to wind the coils without using a bakelite tube and make them self supporting, they may be built as follows: On a cardboard tube 2⅝ inches in diameter, wind on sufficient small string. Over the string place a strip of adhesive tape with the sticky side up, so that the wire will be held in position. In the center of the winding, place another strip of adhesive tape about ¾ of an inch wide with the sticky side out for the secondary. A drop of sealing wax or a strip of tape may be used to keep the leads in place, after the string is pulled out and the coil slipped off the winding tube.

PARTS REQUIRED FOR THE CONSTRUCTION OF A TURAFLEX RECEIVER

2—17 plate condensers.
1—23 plate condenser.
1—fixed coupler.
2—radio frequency transformers.
2—audio frequency transformers.
1—6 ohm rheostat.
3—tube sockets.
1—crystal detector.
3—dials.
1—jack.
1—.00025 mfd. fixed condenser
8—binding posts.
7" x 18" panel.

It is best to have the ends of the primary winding diametrically opposite to the ends of the secondary, as the leads to the condensers and tubes will be shorter.

In tuning, condensers 1 and 3 are moved simultaneously, the center condenser being moved a small amount at a time. After a station has been picked up, condenser 2 is readjusted to maximum volume. UV-201A or C-301A tubes give the best results, although UV-199 tubes may be used. As with all circuits, one tube may function better in one position than in another, so shifting the tubes around should be tried. This set will give excellent results on any type antenna. but best reception is usually obtained on an outside antenna about 100 feet in length.

A Cascade Regenerative Receiver

By THE STAFF OF RADIO NEWS

An unusually sensitive type of receiving set employing rather a unique system, cascade regeneration. Efficient design has eliminated the critical adjustment characteristics usually manifested in sets of this form.

A NEW idea in radio frequency amplification is applied to this Cascade Regenerative Receiver. In practical form it has been tried and has given excellent results. The two tubes used as radio frequency amplifiers and the regenerative detector give approximately the same results as four stages of radio frequency amplification. The set is no more difficult to tune or control than an ordinary receiver and at the same time is exceptionally stable.

The idea is comparatively simple. The plate current of the first tube is fed back through the tickler, giving regeneration in the antenna circuit. The output of this first tube is passed to a second tube which is used as a resistance coupled radio frequency

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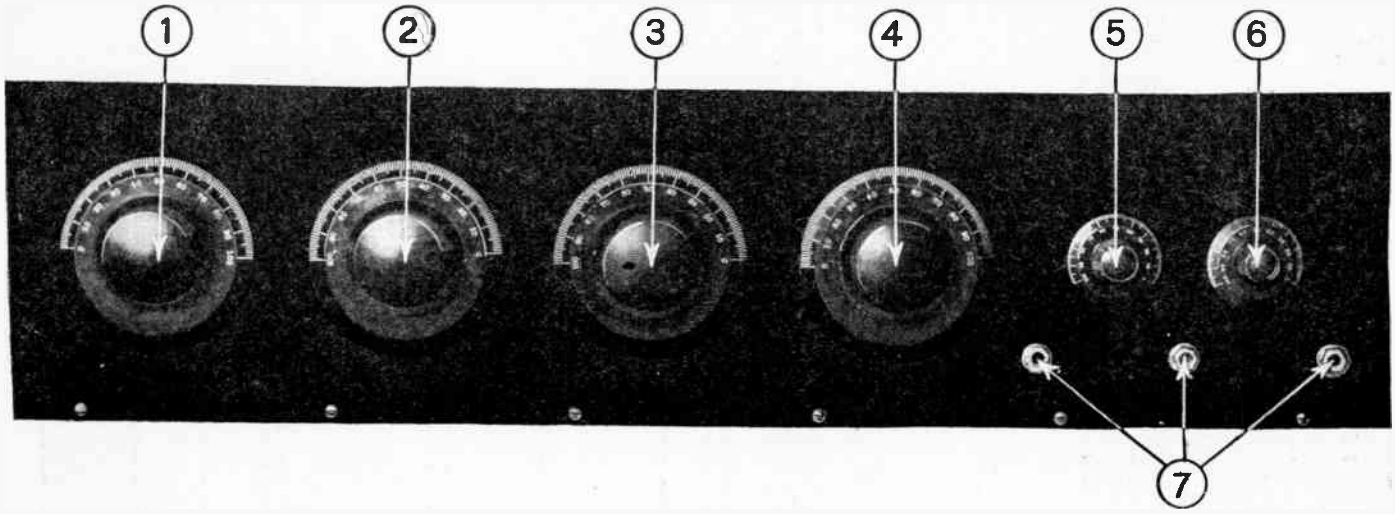
amplifier of the ordinary type and acts also as a blocking tube, keeping the first and second regenerative circuits entirely separated. The output of this second radio frequency amplifier is passed, in the regular manner to the detector, which also is regenerative.



Front view of the completed receiver. Nos. 1 and 4 are the radio frequency and detector regenerative controls respectively. Nos. 2 and 3 are the condensers, tuning R.F. and detector coupler secondaries. No. 5 is R.F. rheostat and No. 6 is the detector rheostat. No. 7 indicates the jacks.

In the present instance, two stages of audio frequency are added to the set in the regular manner.

In the next column is the list of apparatus necessary to construct the cascade regenerative receiver.

The secret of the set's success lies in the blocking tube used between the first and second regenerative circuits. Oscillations are controlled entirely by the two ticklers, there being no potentiometer which adds greatly to simplicity of control. Coupling between the aerial and first radio frequency circuit is made through an aperiodic primary system, the aerial coil consisting of seven turns wound directly over the grid coil of the coupler and not tuned.

The second radio frequency amplifier tube is connected to the first through resistance coupling. The output of this tube is passed to the detector by coupling through seven turns of wire wound directly over the grid coil of the second coupler. This second coupler is identical with the first.

Results will be obtained with either loop or outside antenna as a collective agency, although a good outdoor aerial is preferable.

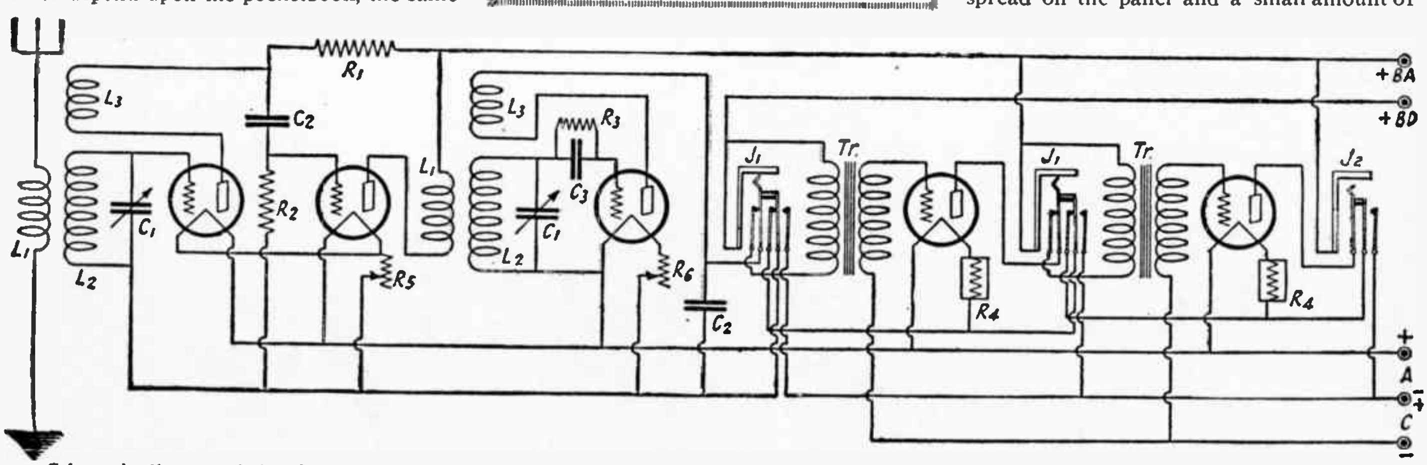
The quality of the apparatus will in most cases depend upon the pocketbook, the same as the results will depend upon the quality of the material used. The best parts are always cheaper in the end and they can be taken out of one set and used again and again in more efficient hook-ups. One learns to pick out the good parts after a little experience, but while he is acquiring the experience he had better buy from the dealer who guarantees merchandise.

1—7 x 28 inch panel.
1—7 x 27¼ inch wood baseboard.
2—.0005 mfd. variable condensers.
2—special variocouplers.
1—variable resistance 10,000—100,000 ohms.
2—2 megohm grid leaks.
1—.00025 mfd. fixed condenser with leak clips.
2—.0005 mfd. fixed condensers.
1—6 ohm rheostat.
1—20 ohm rheostat.
2—automatic filament adjustors for U.V. 201A type tubes.
2—medium ratio audio frequency transformers.
2—double circuit filament control jacks.
1—single circuit filament control jack.
4—four inch dials.
8—binding posts.
5—standard sockets.
Various wood screws for fastening apparatus to baseboard.
1—strip of insulating material 5 x 2 inches for binding posts.
1—strip of insulating material 2 x 2 inches for binding posts.

After all the parts have been secured, the first thing to be done is to mark and drill the panel. The parts used in the model set are all of standard size and manufacture which allows the reader to place his apparatus in the same position, if desired. There are two ways of marking the panel. One is to secure a piece of heavy paper and cut to the exact size of the panel, and then draw a line across the paper exactly in the center. The center holes for all instruments, with the exception of the jacks, will be made on this line. The measurements for the mounting screw holes can be made from the instruments themselves or the templates may be used. Another line is drawn 1½ inches from the right lower corner of the panel, on which the three jack holes will be drilled. After the centers of all the holes are marked the paper is pasted on the panel and and impression is made on the surface of the panel with a center punch and hammer. After drilling all of the holes with the proper size drill, a countersink should be used on all holes through which a machine screw is to pass to that the dials can be set close to the panel. The paper template can be removed before drilling is started and used over again if desired. The second method of working on the panel is to measure off the instruments on the panel and mark each hole with a center punch as it is measured.

FINISHED PANEL

In some cases it may be desired to have a grained finish on the panel. The requisites are some pumice powder, thin lubricating oil or linseed oil and some rags. The panel should be made fast to the workbench by fastening a thin brace to the table on all four sides of the panel. A little oil should be spread on the panel and a small amount of the powder sprinkled on. Care should be taken that the surface is rubbed either lengthwise or crosswise, but not both, as this will do anything but improve the looks



Schematic diagram of the circuit employed. The numbers designate the following parts: L1, L2, L3 are the primary, secondary and tickler of the couplers; R1, variable resistance; R2, R3, two-megohm grid leaks; R4, amperites; R5, six-ohm rheostat; R6, 20-ohm rheostat; C1, .0005 mfd. variable condensers; C2, .0005 mfd. fixed condensers; J1, double circuit filament control jacks; J2, single circuit filament control jack.

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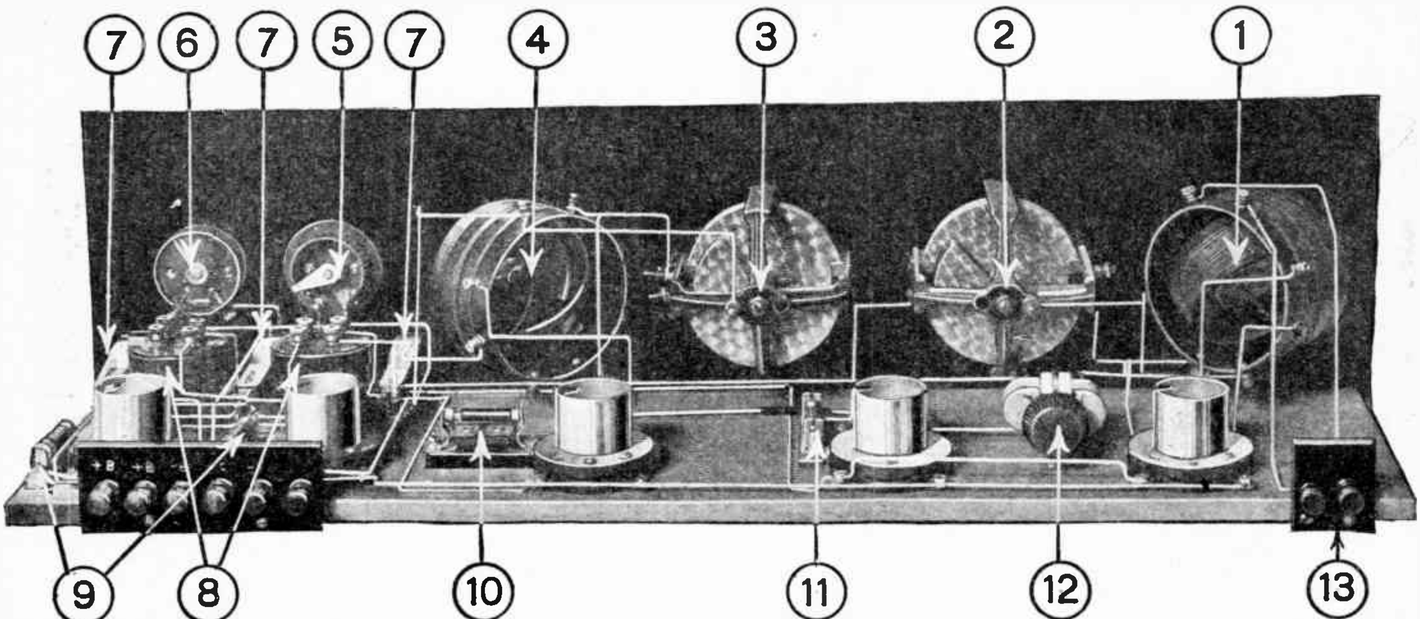
of the finished product. When the desired finish is procured, a little oil should be spread on the surface and rubbed with a clean cloth until it is perfectly dry. This necessary feed-back. Where it is possible, have wires cross at right angles. If two leads come very close together, a short length of cambric tubing should be used. rheostat is for use with the two radio frequency tubes while the 20 ohm rheostat passes the current for the detector tube.

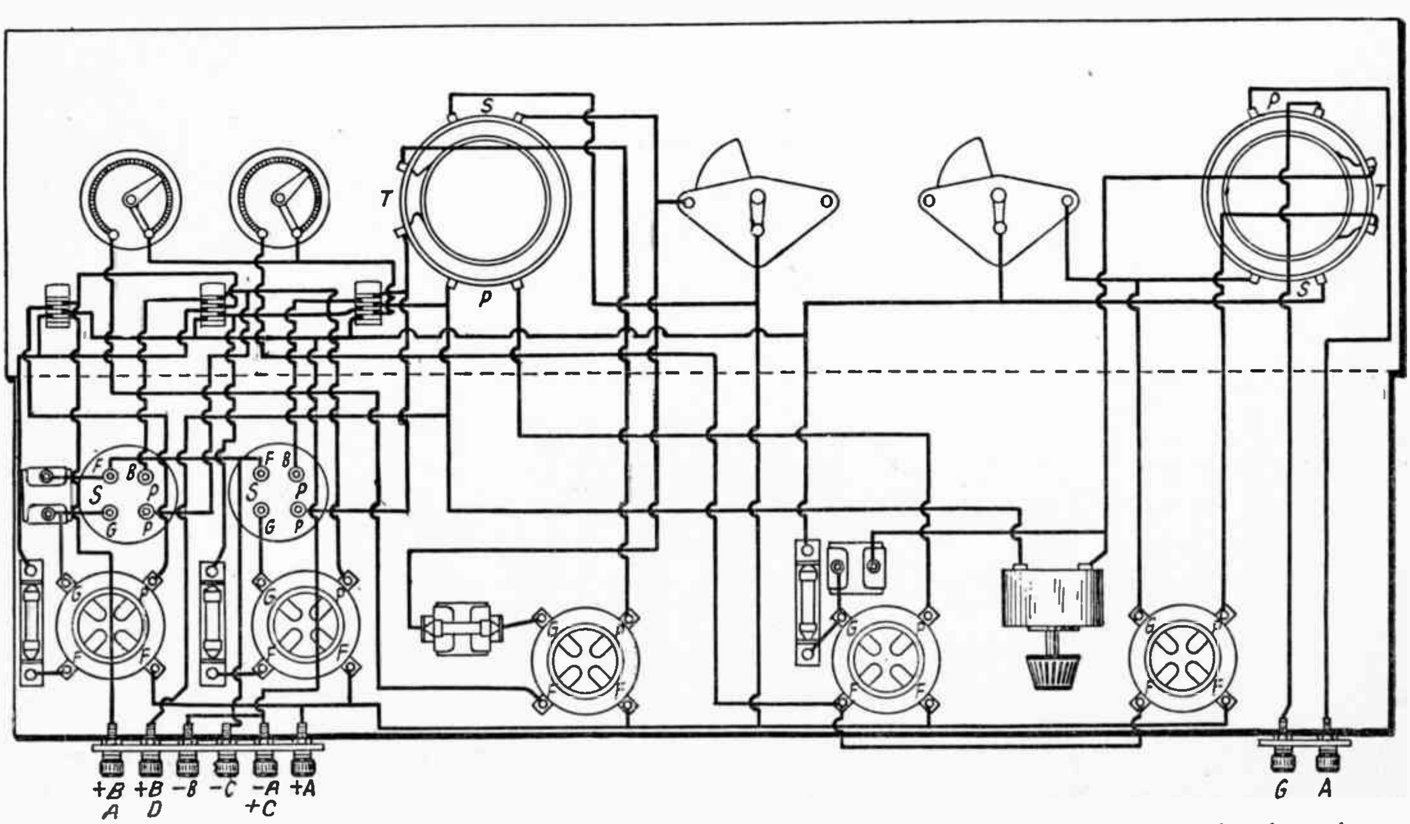
The couplers are both alike as to size and



Rear view of the receiver. The numbers designate the following parts: 1 and 4, variocouplers; 2 and 3, .0005 mfd. variable condensers; 5, six-ohm rheostat; 6, detector rheostat; 7, filament control jacks; 8, A. F. transformers; 9, amperites; 10, grid condenser and leak; 11, two-megohm grid leak; 12, variable resistance; 13, antenna and ground connections. Coils 4 and 1 absolutely must be in non-inductive relation.

can be done either before or after the panel is drilled, preferably before.

The baseboard should be about three-fourths inch shorter than the panel so that it will fit into the cabinet. It should be the first thing to be fastened. The condensers, variocouplers, rheostats and jacks should be fastened to the panel before the sockets, transformers and other apparatus are fastened to the baseboard. The sockets and other parts should be so placed that the leads are as short as possible. At the same time the plate and grid leads should be placed as far apart as possible to avoid unnecessary feed-back. All contacts which are not made with machine screws should be soldered. All excess flux should be scraped or washed off with alcohol to avoid corrosion. Filament control jacks are used throughout so as to have the least number of controls possible. The filaments of the audio frequency amplifying tubes are controlled by automatic resistances made for use with any particular type of tube. The kind used in this set allow one-fourth ampere to pass to a five-volt tube from a six-volt storage battery, thus only UV-201A tubes or others with a similar current rating can be used. The six ohm windings. They may be made with any 180 degree variocoupler form. It will usually be much more efficient to buy a form than to make one. Perhaps there are two couplers which are similar in size and shape around the workbench for which there is no further use. The old primary winding should be removed and in its place 40 turns of No. 24 D. S. C. wire should be wound. Directly on top of this winding a strip of cambric cloth should be wound, over which 7 turns of the same size wire is placed. A light coating of radio cement will hold these



Layout of the receiver showing the arrangement of the apparatus on the panel and the baseboard. With the instruments arranged as shown, short leads are obtained and the wiring is greatly simplified. Only by careful wiring, well soldered joints and short leads can maximum results be obtained.

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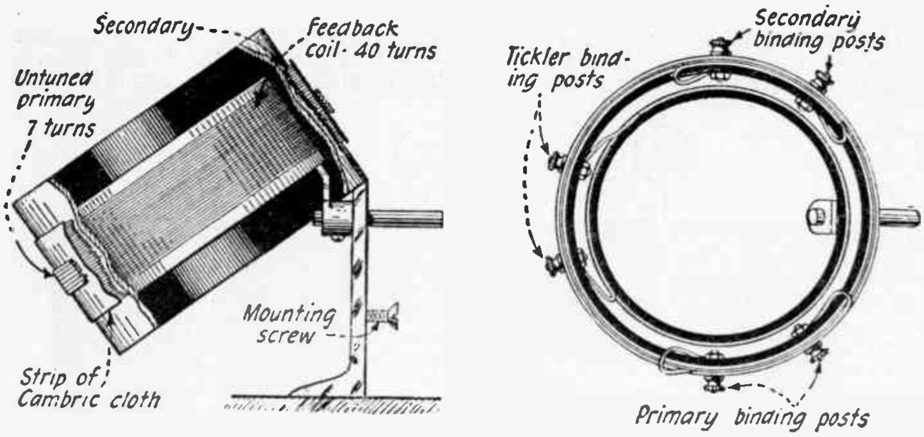
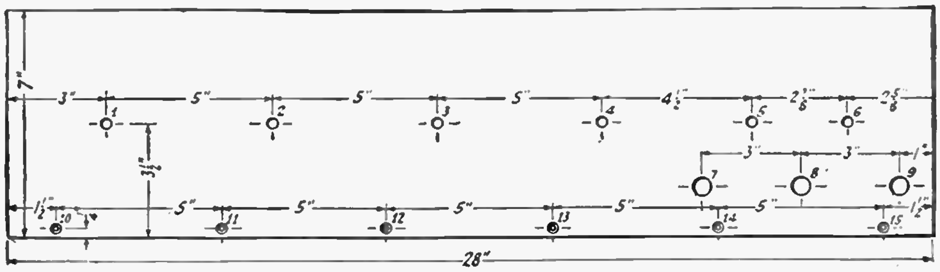


Constructional details of the variocouplers employed. The primary is wound directly over the secondary, separated from it by a layer of cambric cloth. It is best to purchase a variocoupler similar to the type shown and rewind it as specified.

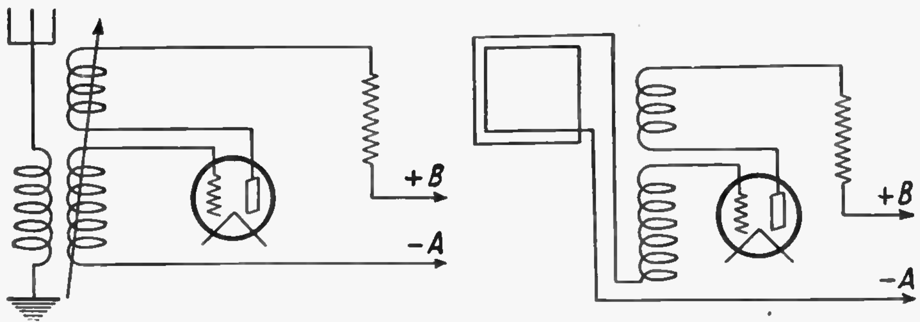
windings in place. Each loose end should be fastened to a binding post placed along the edge of the secondary tube. The wire on the tickler coil probably can be left as it is, but in case there is not enough for regeneration, about 40 turns of No. 24 S. S. C. wire should be used. All three coils should be wound in the same direction. If care is taken in securing two couplers of the same size and provided the respective winding on both couplers are alike, then the dial readings of both condensers should be alike if the condensers are of the same make and same size. The two ticklers should also have approximately the same readings.

After the wiring is complete the filament battery should be connected and a tube placed in each socket. When the phone plug is placed in the first jack, turn on the left rheostat. The two radio frequency tubes should light while the detector tube should light when its rheostat is turned on. When the phone plug is withdrawn from the first jack, these tubes should go out. When putting the plug in the middle jack the radio frequency tubes, the detector tube and the first audio frequency tube should light while the third jack should light all five tubes. As the filament wiring is quite complicated it is fairly easy to make a mistake wiring the jacks, so be careful. The aerial and ground wires as well as the "B" batteries should now be connected. When the phone plug is thrust into any jack, a click should be heard in the phones. Set the two variocoupler dials at about 40 degrees and move the two condenser dials slowly with approximately the same reading for each. A whistle should be heard as a carrier wave is picked up. If no whistle is heard, but a station is heard, try turning the ticklers and if the signal becomes louder as the coupling is decreased then the connections of the tickler which acts in this manner should be reversed. If a buzzing sound is heard there is probably some grid connection open or the variable resistance is open. If the former are perfect, try tightening up the latter.

If all of the directions given are carefully followed, no one should have the least bit of trouble in making this set work.



Panel layout of the Cascade regenerative receiver giving the correct position of all parts. Holes 1, 2, 3, 4, 5 and 6 are 1/4 inch; 7, 8, 9 are 1/2 inch and 10, 11, 12, 13, 14, 15 are 1/8 inch and countersunk.



The receiver may be used with an outside antenna and ground or, as shown at the right, a loop may be employed by connecting it in series with the secondary. Both arrangements work exceedingly well. The use of an outdoor aerial of fair dimensions will, of course, produce the best results.

A Three-Range Receiver

By the Laboratory Staff of Radio News

We take great pleasure in introducing to the radio public the three-range receiver herein described. It is very simple in construction and operation.

IT will most likely be desirable in the near future for the radio fan to extend the range of his receiver from 600 to 200 meters, as it is now, to 600 to 150 meters. Much of interest in amateur circles is to be heard below 200 meters.

One of the main difficulties which will arise is that of congestion. A little consideration of the frequency range will make this apparent. Six hundred meters is equivalent to 500 kilocycles, and 150 meters is equivalent to 1,500 kilocycles. The frequency range of the receiver, therefore, must be 1,000 kilocycles. At the present time broadcast stations are allocated on frequencies 10 kilocycles apart, so that in this total range there will be 100 channels in which the stations may operate. It will be next to impossible to tune with the circular plate condenser to the stations having the shorter wave-lengths. The crowding at the lower dial settings will be worse than ever.

Following is a list of the parts necessary for the construction of the three-range tuner described in the accompanying article:

1—Variocoupler—wound as shown.
1—.0002 fixed mica condenser.
1—.00025 fixed condenser and grid leak.
1—.001 by-pass condenser.
1—.0005 variable condenser.
1—.0005 fixed condenser.
3—Vacuum tube sockets and tubes (201A type).
2—Audio frequency transformers.
1—Single-circuit jack.
1—Double-circuit jack.
Brass, bakelite and switch-points for construction of multi-point switch, bus-bar binding posts, panel baseboard, screws, nuts, etc.

Even if a straight-line frequency condenser be used in the tuning circuit, and half the dial circumference divided into 100 divisions, there will be one channel for each division on the dial which is about as closely as one can tune with comfort.

However, it is apparent that we would not have the whole dial to tune over, for in the average variable condenser, a motion of from 5 to 10 divisions is required before the plates are in mesh and the condenser begins to act as a true straight-line frequency condenser. It is apparent, therefore, that we must not count on more than about 90 divisions on the dial for accurate tuning.

Even at that there should be no difficulty tuning over the whole range when a straight-line frequency condenser is used. At the present time, however, these are quite expensive and the straight-line wave-

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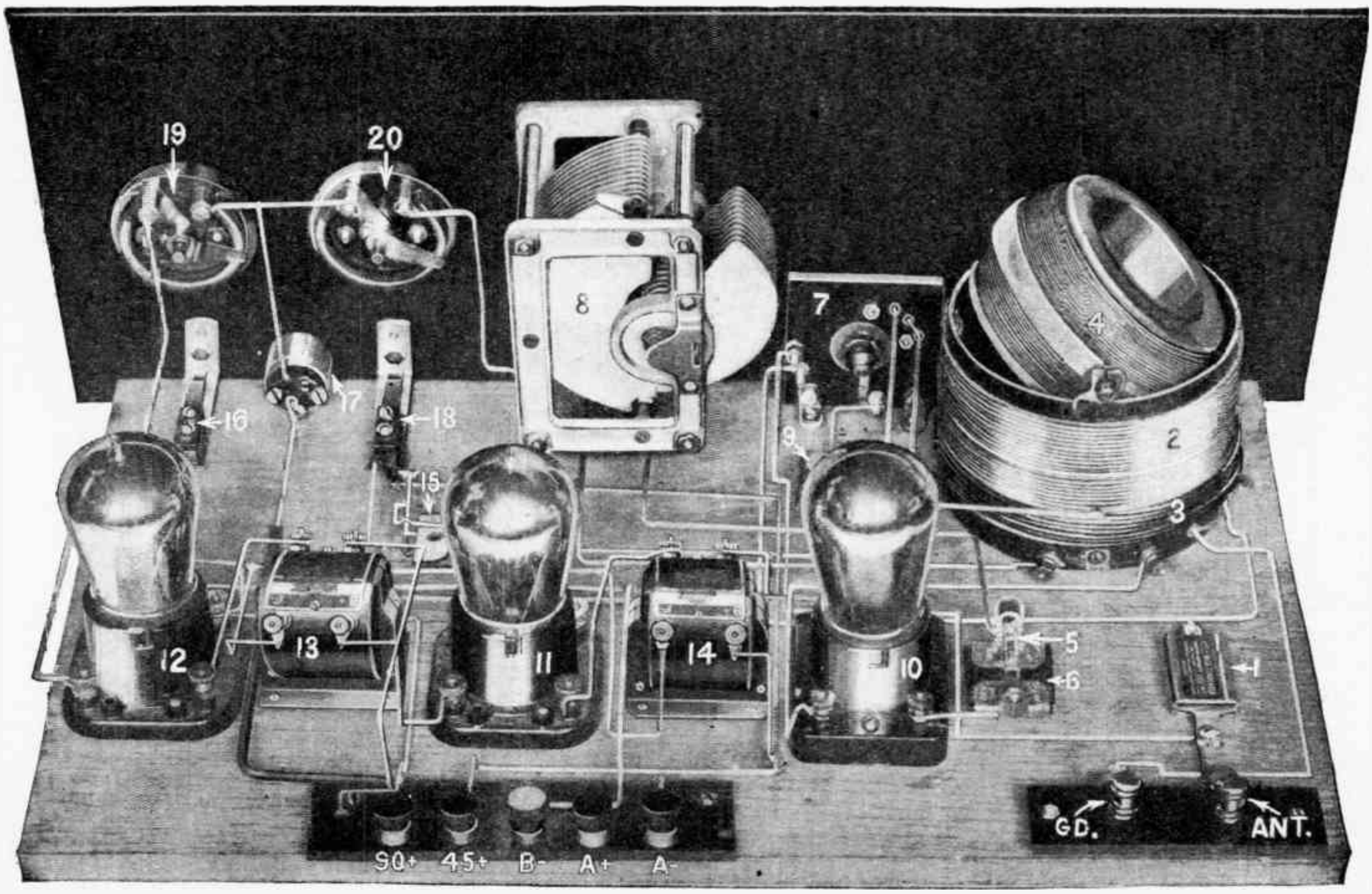
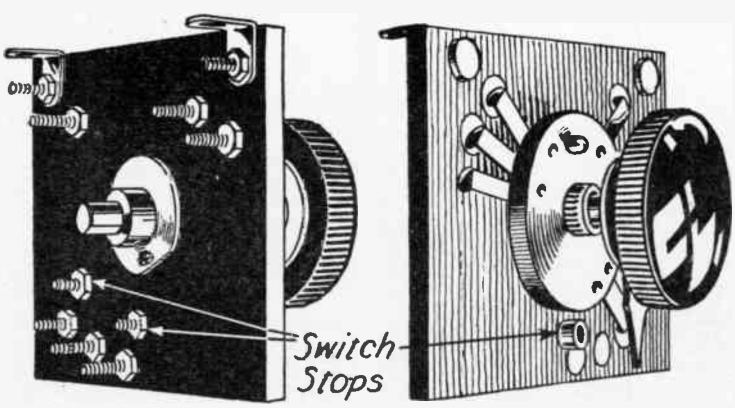


Rear view of the three-range receiver. The numbers on the instruments correspond to those given in the caption on the next page.

length type is just as bad as the circular condenser, so that for the present other methods of spreading out the stations must be found.

A "THREE-RANGE" SET

In the set to be described in this article the range is divided into three parts, making it a three-range tuner. By turning a point switch, described here, it is possible to cover three bands with high efficiency and a surprising degree of simplified tuning. The first point of the switch gives a range from 600 to 400 meters approximately; the second point gives a range from about 440 to 200 meters, and the third point gives an approximate range from 240 to 140 meters.



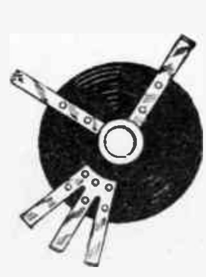


Fig. 2. The contacts for this switch can be easily and simply made.

These three drawings show all of the details of the switch construction. It should be designed for back-panel mounting for the sake of panel appearance.

Each of these three ranges is covered completely by the whole condenser dial, so that the 1,000 frequency channels are spread out over three dials, as it were, and there is not much likelihood of crowding with this arrangement.

The method used is shown very clearly in the wiring diagram. A special switch was constructed for the purpose, which anyone can make of scrap parts lying about the workshop or laboratory.

The coil used in the tuner was wound with ordinary bell wire. There were 30 turns of this wire on a 3¼-in tube. The tickler or rotor was of the ball type, which can be purchased anywhere, and had on it 15 turns of No. 18 D.C.C. wire. The secondary coil was tapped at the 20th turn as shown in the wiring diagram.

The variable condenser used had a capacity of 0.0005 microfarad.

On the first point of the switch a fixed condenser having a capacity slightly less than 0.0005 microfarad is connected in parallel with the variable condenser, so that we are tuning the coil with a condenser having a maximum capacity of 0.001 microfarad. When the variable condenser plates are entirely out of mesh, the capacity in the circuit is equal to that of the fixed condenser. The whole coil is used on the first switch-point.

On the second point of the switch the fixed condenser is thrown out of the circuit, so that the coil is tuned by the 0.0005 microfarad variable condenser alone.

On the third switch-point, the variable condenser is allowed to remain in the circuit, while the coil is cut down by the tap shown in the diagram. To get down to the shorter wave-lengths it is necessary to reduce the inductance in the circuit as has been done in this circuit.

It will not be necessary to go into the construction of the remainder of the circuit. This has been assembled in the usual manner, and consists of two stages of transformer-coupled audio frequency amplification.

The construction of the switch is shown very clearly in Fig. 2. It will be noted that there are three prongs of the switch not connected to the switch shaft, which make contact with two points connected to a fixed condenser in the antenna circuit.

This fixed condenser has a capacity of 0.0002 microfarad, and is used to reduce the natural wave-length of the antenna circuit. This was found to be necessary in calibrating the set, on the third point of the switch, for the shorter wave-length. The ordinary antenna, as generally used, did not seem to function as satisfactorily on the shorter wave-lengths without this series condenser. It is short-circuited on the first point of the switch and also on the second point. It is only when we come to the third point that it is necessary to break the short circuit.

The sequence of operations is shown in Fig. 3, giving the three circuits corresponding to the three positions of the switch.

The operation of the set is comparatively simple. For the first band of waves reaching from the top of the broadcast range to about 400 meters, it is only necessary to set the triple-point switch in the first position and rotate the variable condenser through 180 degrees in the usual manner.

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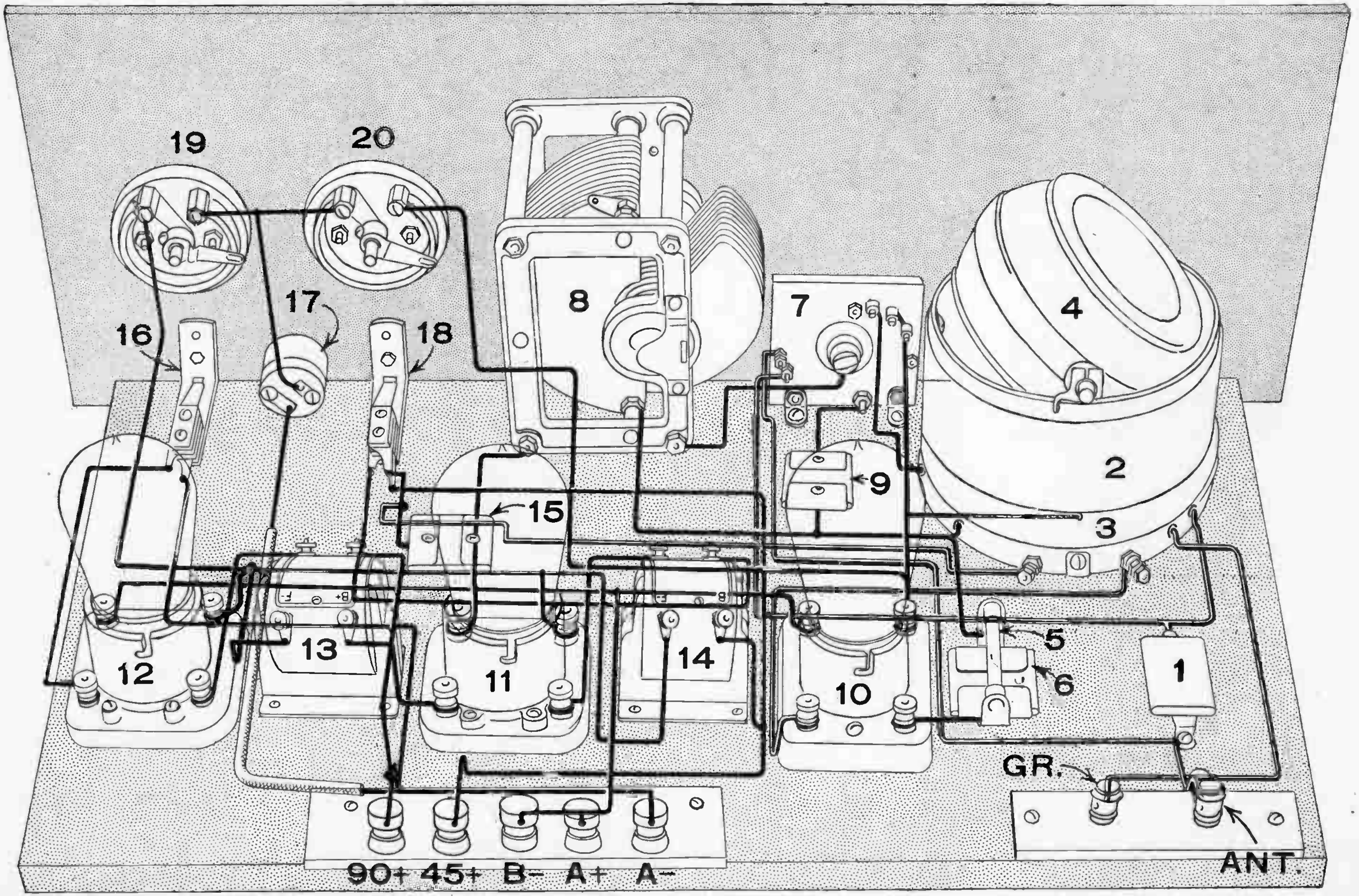


Arrangements of apparatus in 3-Range Circuit: 1, series condenser; 2, secondary coil; 3, primary coil; 4, tickler; 5, grid leak; 6, grid condenser; 7, special switch; 8, .0005 mfd. variable condenser; 9, .0005 mfd. condenser shunted across variable condenser by switch; 10; detector tube; 11 and 12, amplifier tubes; 13 and 14, audio frequency transformers; 15, by-pass condenser; 16, single-circuit jack; 17, filament switch; 18, double-circuit jack; 19, amplifier tube's rheostat; 20, detector tube rheostat.

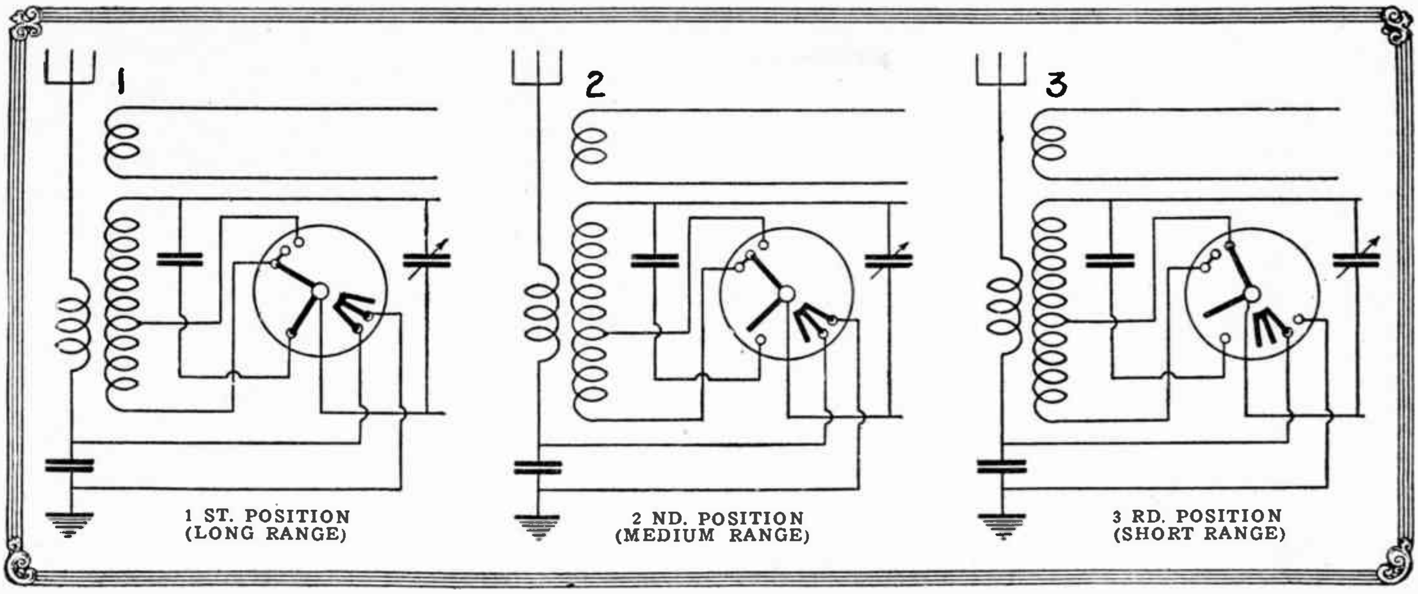


Fig. 3. All switch positions are shown above.

For 420 meters to 220 meters, the multipoint switch is moved to its second position and the dial of the variable condenser again revolved through the whole of its 180 degrees.

Then the real advantage of the set is made obvious. Instead of covering only the waves now in use as is the case with a large majority of the commercial sets on the market, a third setting of the switch reduces the range of the set to 150 meters, where again the rotation of the condenser dial gives the final tuning.

As it was constructed in the RADIO NEWS LABORATORIES, the action of the set was all that could be desired. In one evening more than twenty-five stations were pulled in without the slightest difficulty.

When the operator wishes to drop to the lower wave-length band in which the amateurs are located, it is easy with this set.

Appended is a list of the calls of an evening's haul, all on the loud speaker:

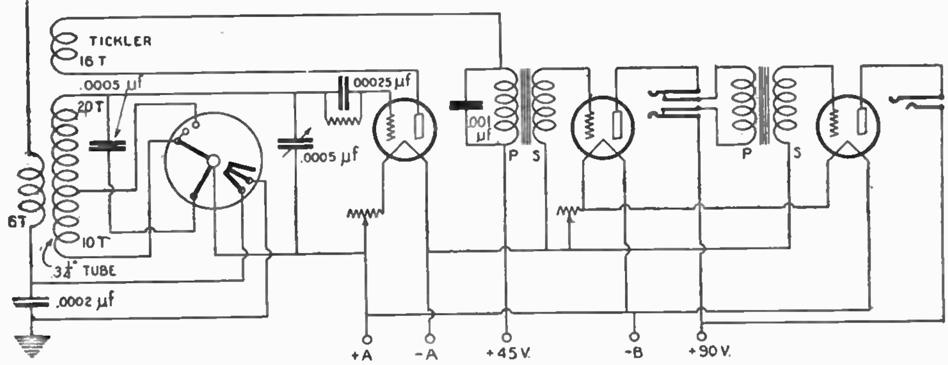
BROADCASTING

WEAF, WNYC, WJZ, New York; WOR, Newark, N. J.; WHN, WGBS, New York; WAHG, Richmond Hill, N. Y.; WMCA, WFBH, New York; WTAM, Cincinnati; WBAP, Fort Worth, Texas; WFBI, WSAI, Cincinnati; WTBE, WBZ, Springfield, Mass.; WLW, Cincinnati; KDKA, Pittsburgh, Pa.

AMATEUR

2CLG; 1ABA, Hyde Park, Mass.; 2HL; 2RK; 2KX; 9OA, Petersburg, Ind.; 9OK, St. Joseph, Mo.; 2AHR; 2AHN; 8AZY, Grampian, Pa.; 2EY; 2ABY; 3YZ; 2DBA.

This is the complete wiring diagram of the 3-range, 3-circuit tuner described in the article.



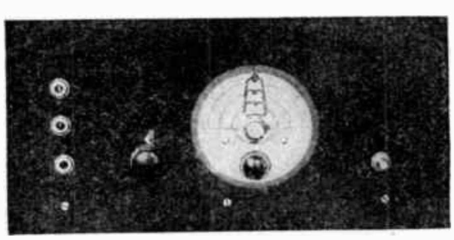
Unicontrol for Regenerative Sets

By SANDER STERN

Application of the unicontrol principle to the regenerative set is usually followed by failure. However, the system here detailed works with a good degree of success.

IN order that the enthusiast who builds this set may have as little difficulty as possible in its construction, adjustment and operation, a brief description of the action of a three-circuit tuner and the development of the single dial control will be presented.

In Fig. 1 is shown a three-circuit tuner diagram. The coil A, which is connected in series with the antenna and ground, transfers its energy to the coil B, which is the secondary shunted by a variable condenser. This condenser is used for tuning the secondary circuit. The rectification of the high frequency radio current is brought about through the asymmetrical flow of current in the plate-filament circuit. The grid of the tube impresses the modulated radio frequency signals upon the space current, which is direct current. This modulated direct current passes first through E, which by magnetic induction passes some of it back into B. Thus this process of feed-back produces a further amplification. However, this feed-back reaches a limit when too much energy is returned to B, for then B, D and E act as an oscillator.



Front view of single control receiver, showing vernier dial used for tuning.

That is, E and B become the existing field of the generator D with the phones as its load. However, when E is properly adjusted, the amplified signals heard in the phones are clear and undistorted.

When an attempt was made to combine the controls of E and B, it was found that the coupling control of E had a more or less vague relation with the condenser control of B, since B is tuned when E is not. Furthermore, the intensity of a signal produced by a nearby station caused a setting for the feed-back coupling different from that necessary for a distant station of the same wave-length.

After experimenting with several different types of regenerative circuits, it was found that the circuit shown in Fig. 5 overcame these objections. Here the feed-back coil is permanently coupled to Lg, so the feed-back will always be the same at the same wave-length, since the tuning condenser and the regeneration control condenser are geared together. Another factor that enters is the tendency of regenerative sets to oscillate at the lower wave-lengths.

CONSTRUCTION

The logical procedure for the construction of the single dial regenerative receiver is opposite to the usual procedure familiar to the radio constructor. Instead of mount-

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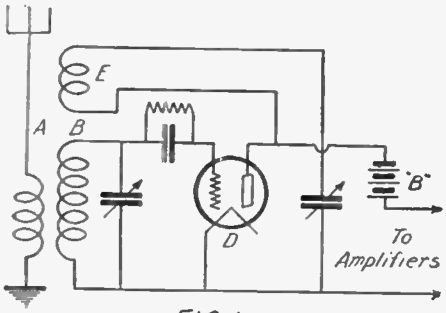

FIG. 1
The three-circuit tuner diagram, showing detector tube.

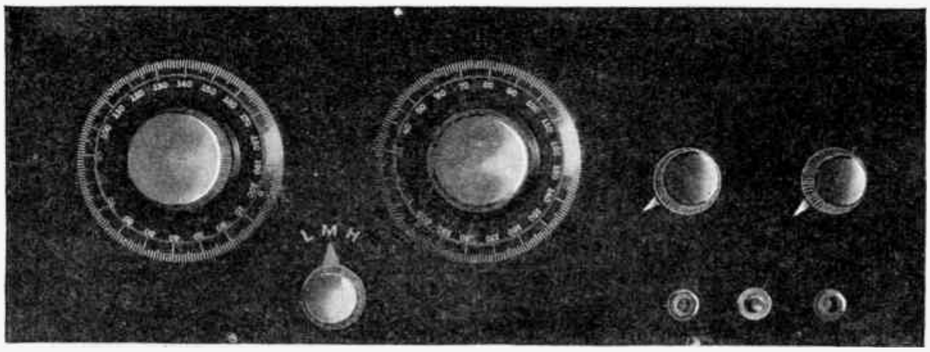

Photo shows three range tuner described on page 16, 17, 18 and 19.

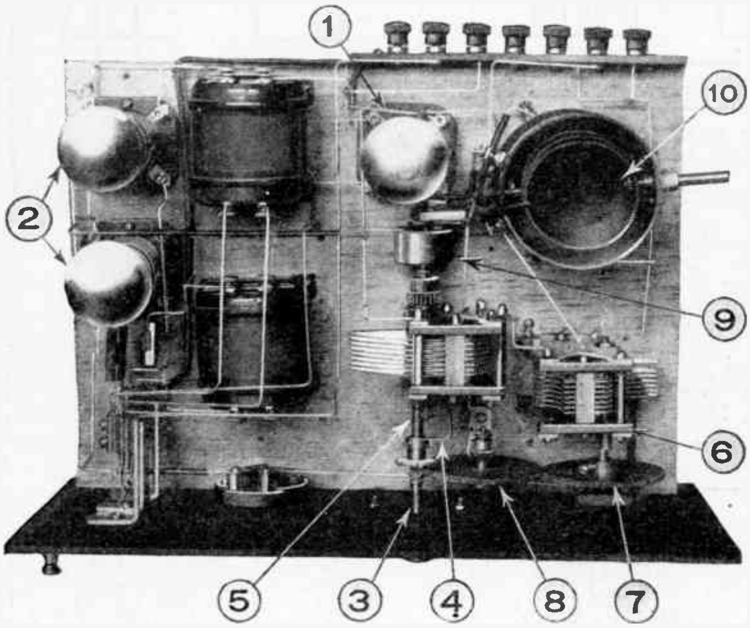

Fig. 4. Arrangement of apparatus on baseboard and panel. 1 is the detector tube; 2, the amplifiers; 3, the control shaft; 4, the condenser stop; 5, the condenser shaft; 6, the feed-back condenser; 7, the gear wheel; 8, the idler gear; 9, the variable grid leak; 10, the fixed tickler coil.

ing all possible parts on the front panel, the builder should mount them on the baseboard, in order to simplify the supporting parts and the gear train shown in Fig. 3.

Little need be said about the mounting and wiring of the audio part of this set, except to repeat the usual caution of making all grid and grid return leads as short as possible. Run the plate and "B" battery wires in such a fashion that no strain is applied to the soldered ends; otherwise, disagreeable cracking microphonic noises will be experienced. On the shaft of each condenser there is fastened a 100-division dial for determining the relation between the tuning and regeneration control condensers. With the set connected to the antenna and ground, the usual procedure is followed in tuning for stations; the wavelength condenser is brought to its proper setting or resonance, and the control condenser adjusted to a position just below the oscillating point. These positions of the wave-length and control dials are noted in order to determine the relation between the two for the proper gear ratio. For example, the tuning dial for a certain station is at 70 and the control at 40. This is noted and then another station is tuned in. This new station, we will say, appears at 60 on the wave-length dial and 39 on the control dial, showing that for a wave-length change of 10 divisions on the tuning dial, there is a one-division change on the control dial. Obviously a 10 to 1 gear ratio becomes necessary. This relation should be proved for a number of different stations. Should this relation change at the lower wave-lengths, for any of many obvious reasons, the variable grid leak is adjusted until the relation becomes the same throughout the scale.

With the condesers used this ratio was found to be 10 to 1. Therefore, three small fibre-toothed gears were obtained, two of 2½ inches diameter, and one of ¼ inch diameter. The idler gear, which is 2½ inches in diameter, is mounted at the proper height, so that its center is in line with the centers of the two condenser shafts. The tuning condenser is brought into its proper place and fastened to the base, so that its ¼-inch gear will be surely meshed with the idler. The same is done to the plate tuning condenser and its 2½-inch gear. The set is then tuned once more to some station and the control condenser adjusted to a point below the oscillatory condition, after which the gear on its shaft is permanently fastened. Tune in on the shortest wave that it is desired to receive and then loosen the set screw on the regeneration control condenser. Set the tickler coil at 5 degrees with the stator and move the condenser plates in until the set just starts to oscillate. Then tighten the set screw.

The panel is now added to the base. It will be found that the usual length of the tuning condenser shaft will be too short to project beyond the panel. Therefore a rod of similar size and proper length should be soldered or screwed on to it. Finally connect up the filament switch and filament rheostat and the set is finished.

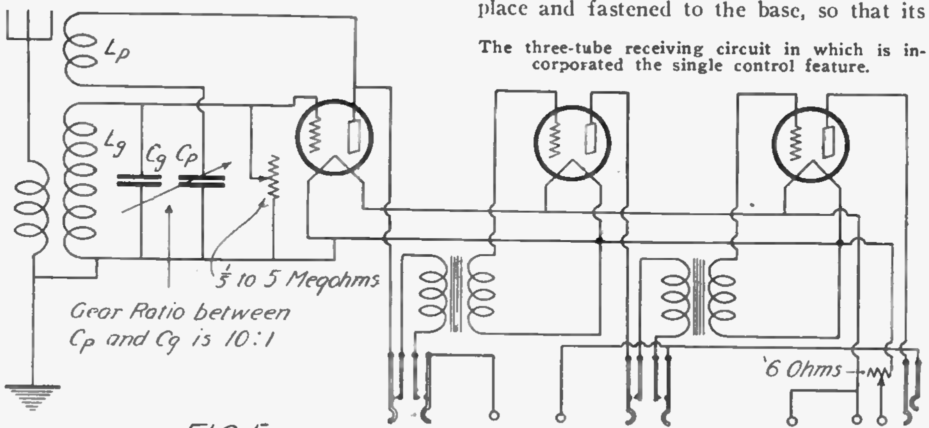

FIG. 5

The three-tube receiving circuit in which is incorporated the single control feature.

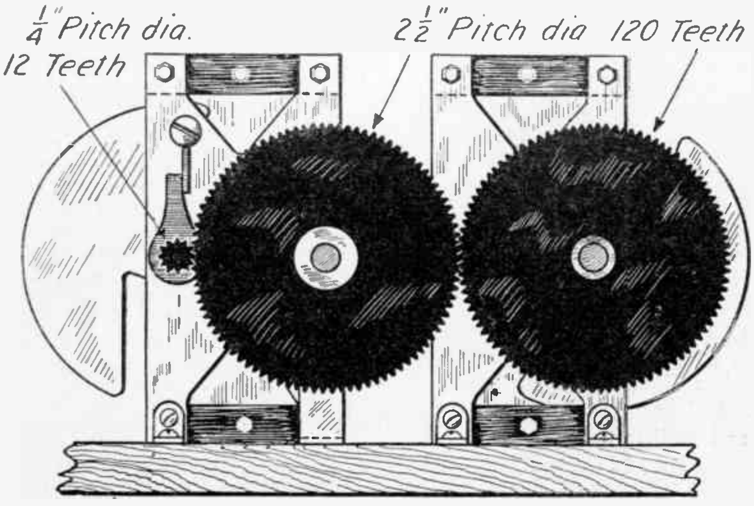

Fig. 3. The gear train that varies the two condensers. These condensers are first adjusted as shown in the text and the gears then tightened to the shafts.

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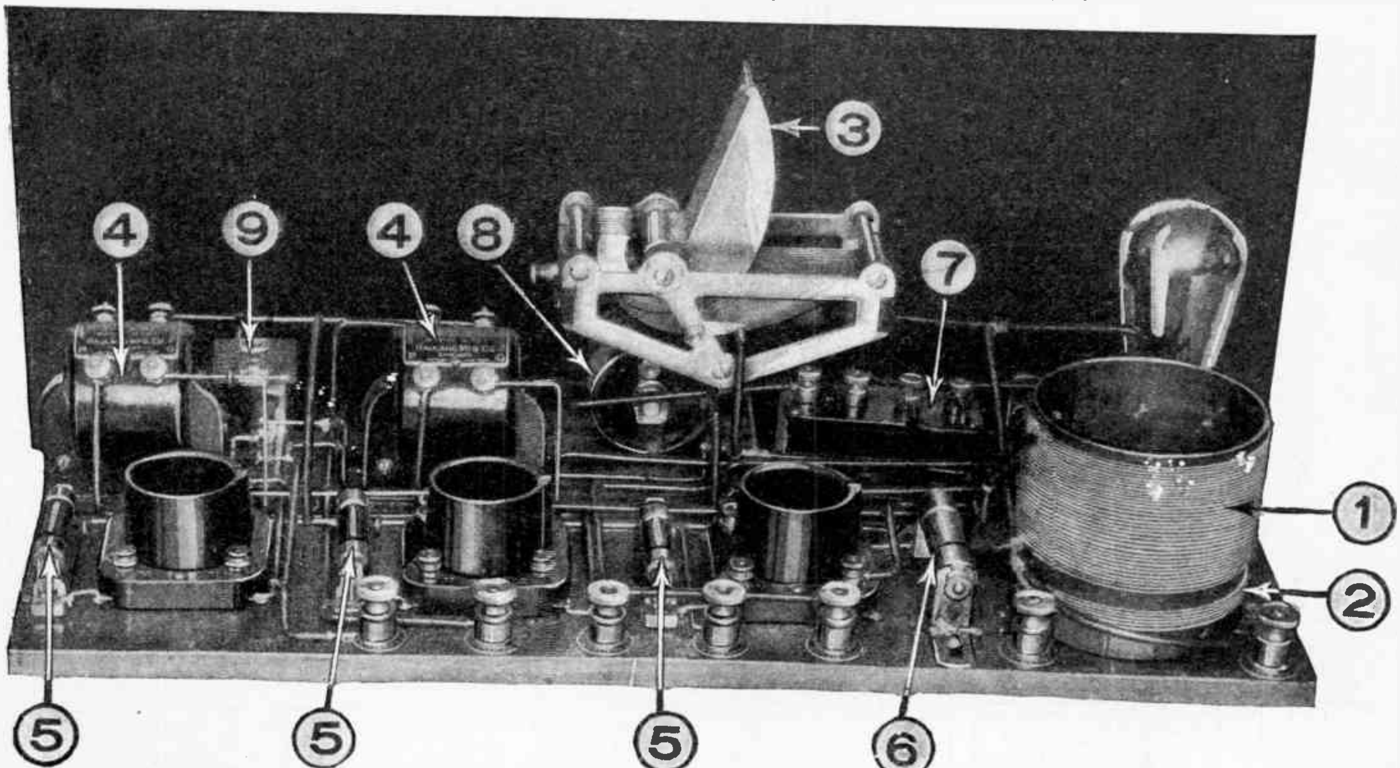
The Interflex-4 Circuit

By HUGO GERNSBACK

Member American Physical Society

The Author here describes a rather unusual set that bids fair to become popular. It has several original twists and brings out a principle that is but little known.



1 and 2 are secondary and aperiodic primary respectively. 3 is the sta ight-line frequency condenser. 4, audio transformers. 5, Amperites. 6, fixed carborundum crystal. 7, radio frequency transfor mer. 8, potentiometer. 9, fixed by-pass condenser.

SOME years ago, while experimenting with a crystal-vacuum tube combination, we fell upon a circuit shown in Fig. 1, in which a crystal detector is connected right into the grid circuit. The writer at the time thought that this was original, but later on found that the principle was known, having been previously described in some scientific papers.

The final circuit evolved is the one shown in Fig. 1. The coil L-1 is a 3-inch tube, wound with about 55 turns of No. 20 S. C.C. wire, while the condenser C should have a capacity of 0.0005 mf. The crystal A may be any good crystal, although the writer in his experiments has found that a fixed carborundum crystal is the best, because it is the most stable. Any good vacuum tube may be used.

This circuit is not a reflex, nor is there regeneration. The crystal in the grid circuit acts as a detector, while the first tube acts as an amplifier; the amplification depending upon the crystal is from 10 to 20. In other words, if you use a crystal detector alone, the addition of the tube will give an amplification of 10 to 20 times. The same is the case, in this particular circuit, if you use a tube alone, when the addition of the crystal will give you great amplification.

Stations Logged By the Author Within 2 Hours in New York City

Station		Dial Setting	Meters
WNYC	Local	13	526
WEAF	Local	21	491.5
WJZ	Local	31	454.3
WJY	Local	46	405.2
WGY	Schenectady, N.Y.	55	379.5
WHN	Local	63	361.2
WCBD	Zion, Ill.	67	344.6
WMCA	Local	74	340.7
WGBS	Local	89	315.6
KDKA	Pittsburgh, Pa.	91	309.1
WJAR	Providence, R. I.	94	305.9
WPG	Atlantic City, N.J.	98	299.8
WORD	Batavia, Ill	108	278
WCAU	Philadelphia,Pa.	115	278
WRW	Tarrytown, N. Y.	120	273
WBBR	Staten Island, N.Y.	121	273
WAAM	Newark, N. J.	132	263
WRNY	Local	135	258.5
WNJ	Newark, N.J.	139	233
WOKO	Local	157	233
WODA	Paterson, N. J.	164	202.6

The Interflex takes in the entire broadcast range.

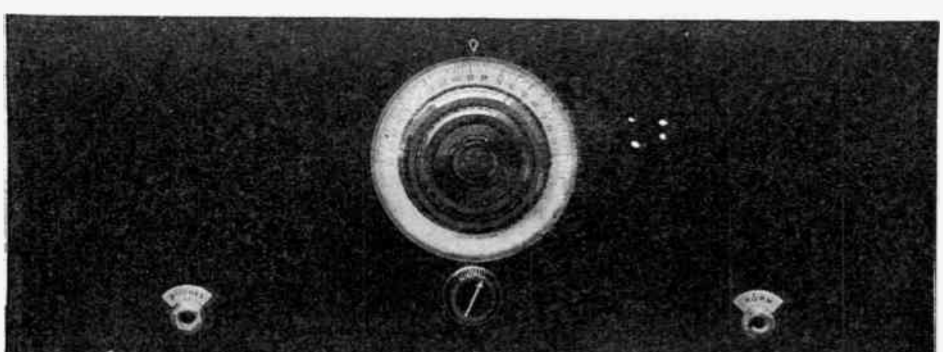
This circuit is remarkable in that there is no distortion, and the reception of the signals is about as clear as the writer has ever heard. The only drawback with this circuit is that it tunes broadly—that is, for local stations.

A surprising fact, which the writer believes has not been recorded heretofore, is that this circuit is really excellent for DX work. With a single-tube set of this kind the writer has listened repeatedly, in New York City, using a 60-foot aerial and ground, to stations in Philadelphia, Atlantic City, Pittsburgh, Springfield (Mass.) all of the Chicago stations and WOC, Davenport, which was the furthest station recorded on this circuit and is at a distance of 1,100 miles.

On DX the tuning is quite sharp and a vernier dial should be used, otherwise, you are likely to pass over the signals. It should be remembered that *you hear no squeal in this circuit,* since it works exactly like a crystal set. The tuning, therefore, is absolutely silent—hence, the tuning motion must be slow if you want to hear the far-distant stations. It goes without saying that you will not be able, with this hook-up, to receive the DX stations unless the locals are silent. But you will be surprised at the great clarity of the signals.

If you do not care for very sharp tuning, then you may construct a 3-tube set along these lines. merely adding a 2-step amplifier, and the signals will come roaring in, as with the best 4-tube circuit.

This set, mind you, gives you quality and no distortion at all.



Note simplicity of panel. Only one vernier tuning dial is used. The indicator knob below is the potentiometer. No filament switch is used. Instead, two automatic filament jacks are incorporated in the set.

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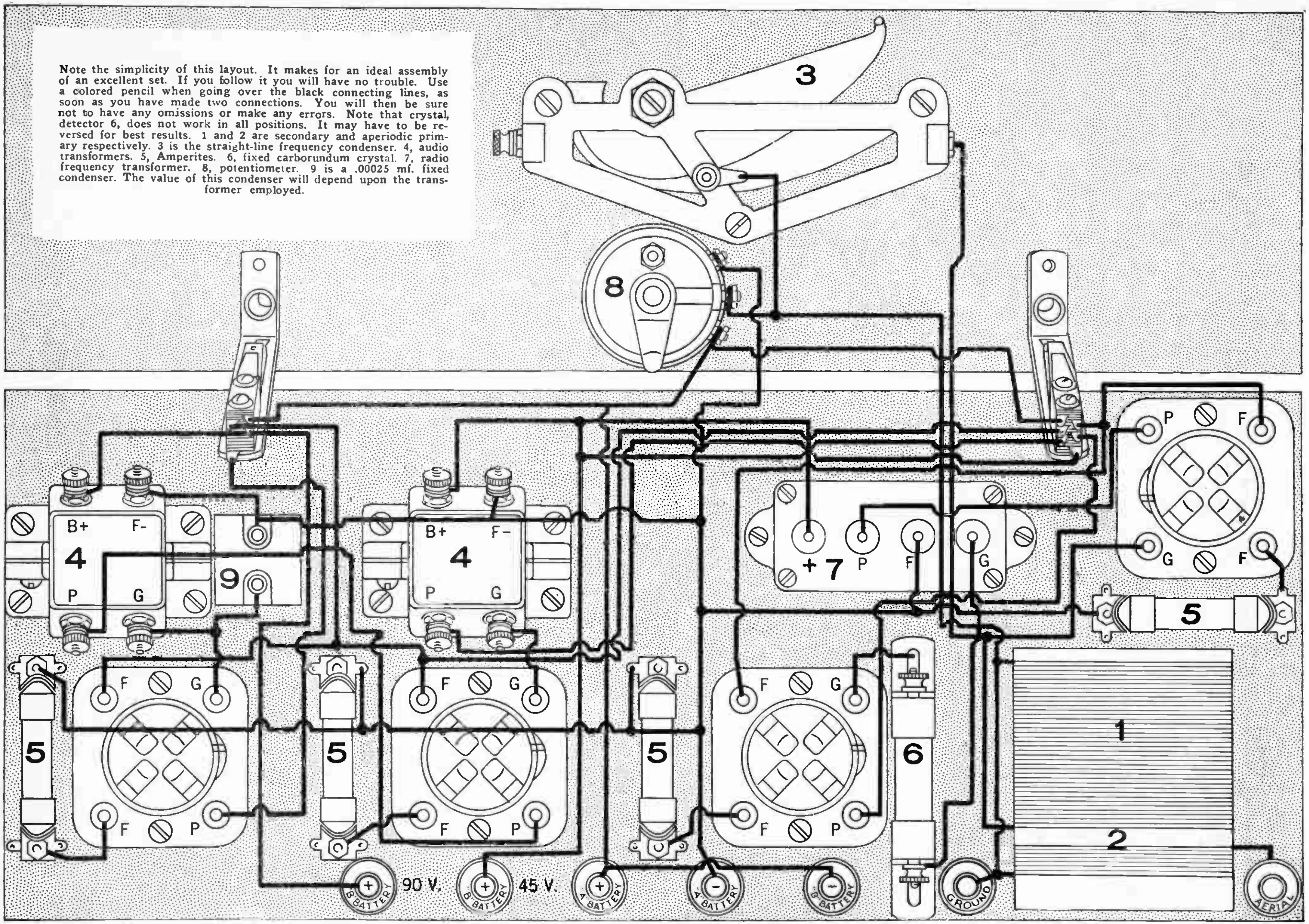
Note the simplicity of this layout. It makes for an ideal assembly of an excellent set. If you follow it you will have no trouble. Use a colored pencil when going over the black connecting lines, as soon as you have made two connections. You will then be sure not to have any omissions or make any errors. Note that crystal, detector 6, does not work in all positions. It may have to be reversed for best results. 1 and 2 are secondary and aperiodic primary respectively. 3 is the straight-line frequency condenser. 4, audio transformers. 5, Amperites. 6, fixed carborundum crystal. 7, radio frequency transformer. 8, potentiometer. 9 is a .00025 mf. fixed condenser. The value of this condenser will depend upon the transformer employed.



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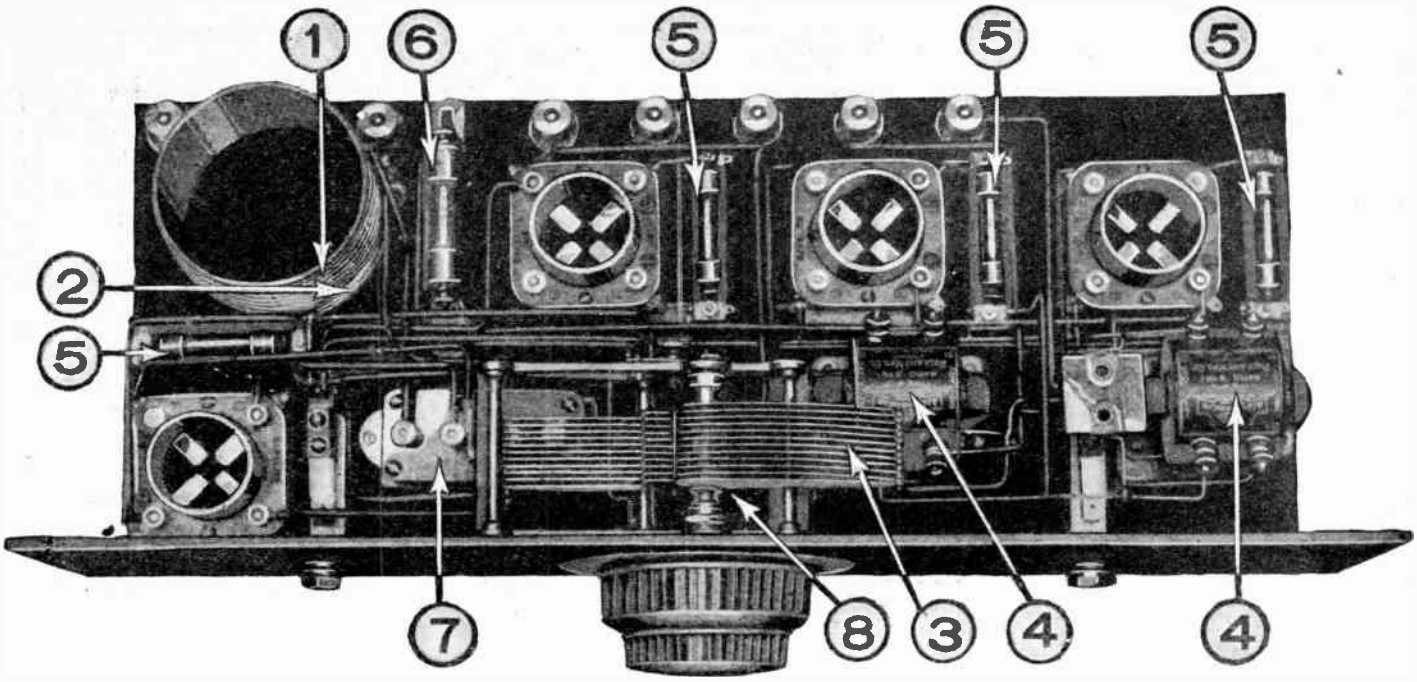

The numbers here correspond to those on the drawings in the preceding pages. Note the compactness of this set.

THE INTERFLEX-FOUR

The original circuit gave such good results it seemed a pity that it should not be used in a real set. So the writer set about rectifying this, and the Interflex-Four, shown in Fig. 2, as well as in the accompanying photographs is the result.

This set has been used for some time by the writer and he heartily recommends it to those who wish to have a set of great simplicity, where there is practically but a single control to be handled, where sharpness of tuning is desired, and where most of all, clarity of signals and absolute absence of distortion is wanted. Also, the set should be good for DX work.

All of this is incorporated in the Interflex-Four, and the writer particularly recommends the set to your home folk who do not know much about radio, and do not care to handle many dials, which as a rule, confuse them.

The set is simplicity itself and can be constructed easily by anyone. Although it contains only four tubes, the writer has made repeated comparisons between some of the well-known five-tube sets and this one, and he has yet to find one which gives louder reception and is as clear as the Interflex-Four.

Furthermore, the tuning can be done in a fraction of the time of the standard five-tube sets so much in vogue now.

The circuit, as will be seen from Fig. 2, comprises one stage of radio frequency, coupled to the fixed crystal detector. The second tube, therefore, is not the detector tube but is an amplifier. The third and fourth tubes are amplifiers as well.

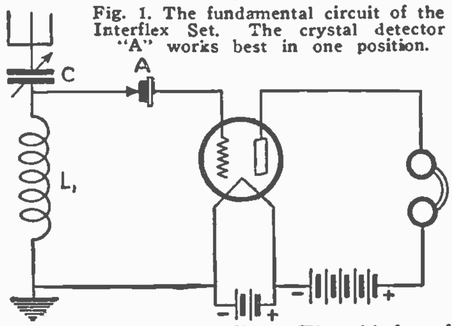

Fig. 1. The fundamental circuit of the Interflex Set. The crystal detector "A" works best in one position.

From this it will be seen why these four tubes equal five or more in the conventional tuned radio frequency sets.

CONSTRUCTIONAL DETAILS

The usual panel and baseboard are used. Two filament control jacks, (the one at the left being for the phones—the one at the right for lour speaker) are used. The writer recommends the use of a straight-line frequency condenser. A potentiometer of 400 ohms *must* be used. A lower-resistance one is not recommended, because no really sharp DX tuning can be accomplished with it. No rheostats of any kind are used Instead, automatic filament resistances, which work exceedingly well in this circuit are used throughout. This does away with two extra controls, which are not needed in the circuit.

The inductance consits of a bakelite or other good tube three inches in diameter, three inches in length. The aperiodic primary consists of 10 turns of No. 20 D.C.C. wire. A blank space of 5/16 inch is left between the primary and the secondary. The secondary consists of the same wire, of which 50 turns are wound upon the tube, which almost fills up the remaining space.

Note in the connections that a jumper lead is connected between the ground and the

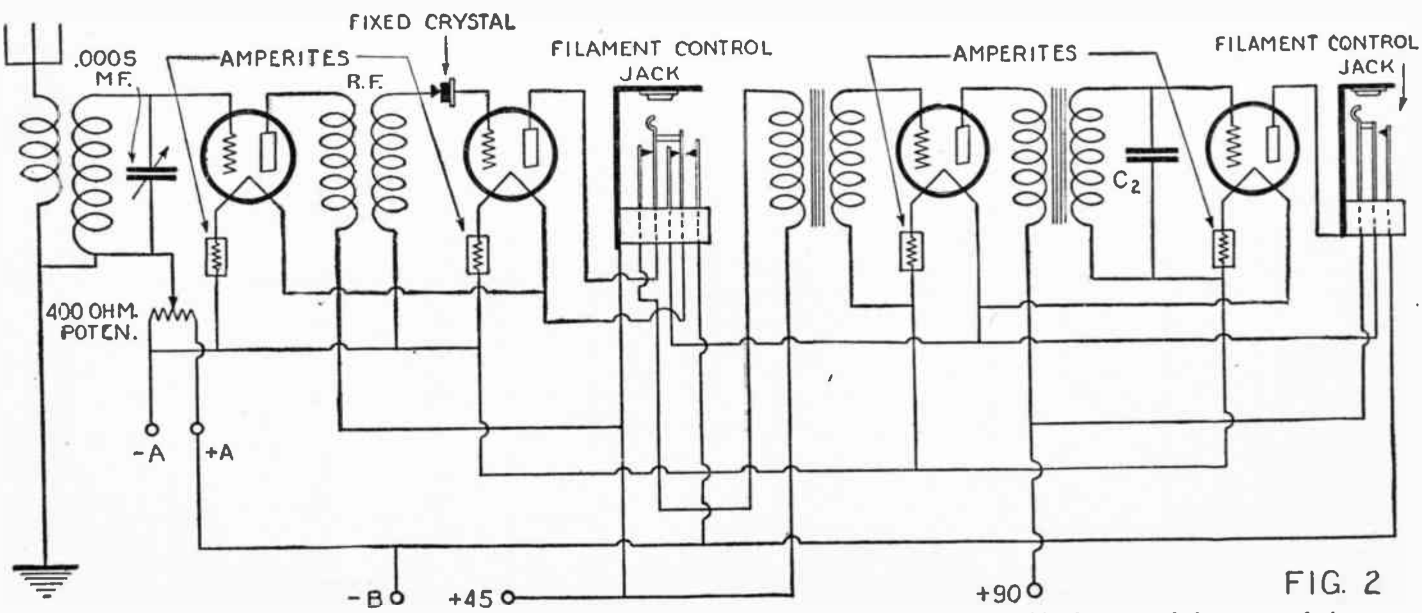

Fig. 2. Diagram of connections for Interflex-Four, consisting of one stage of radio frequency amplification, crystal detector, and three stages of audio frequency amplification, of which two stages are transformer-coupled. No switch is used in this circuit. The automatic filament control jacks are used instead. Note particularly that, for best results, the aperiodic primary should be grounded on the filament side. Condenser C_2 is to be used only if set develops an audio frequency howl.

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filament side of the inductance. This increases the power of the set somewhat. It is also better for DX.

The crystal detector may be any good crystal, and the better the crystal the better will be the results. But here the writer wishes to make a few remarks: If the crystal detector is too sensitive, and if it takes too much time to adjust, the writer recommends that it be not used. Static and strong signals will invariably knock out its sensitivity and render the whole set useless. So many reflex set users have found, to their sorrow, that the crystal detector is usually the rock upon which the whole set founders.

If galena, which is the most satisfactory in some respects, is employed, use only the so-called "million-point" mineral, which has a granular surface. This is the "argentiferous galena". And if possible get away from the adjustable feature, because when laymen have to use a set it should be so built that it cannot be tampered with.

There are several good fixed detectors on the market now which, if made by reliable concerns, can be trusted to work out satisfactorily. The writer must be specific here and wishes to say that he uses, and has been using for months, a carborundum fixed crystal detector which, while not perhaps as sensitive as galena, is certainly the most stable thing he ever came across, and he has worked with all of them. He has used a single detector for many months now, and has had the set operating during the worst static of the summer, when lightning could be seen, and when tremendous static crashes came out of the horn. Nevertheless, in no case has this crystal refused to work, nor has its usefulness been impaired. Its stability, therefore, is its one saving grace, and one reason why the Interflex-Four has been such an outstanding success with the writer.

The fixed crystal, as will be noted, is mounted between brackets and looks somewhat like a fuse, when mounted. It is put in this position and never changed. With this particular crystal, as with many others, it was noted that it must be used in one direction only. Reversing it would greatly reduce the signal's strength.

The coils marked "RF" comprise a standard radio frequency transformer, such as may be purchased at any radio shop. Not all radio frequency transformers work satisfactorily in this set, and it may be necessary to try several before the right one is discovered. The writer has tried both the air-core and the iron-core, and while several of the iron-core type worked well, in many cases, the air-core type was found to work better.

PARTS NEEDED FOR THE CONSTRUCTION OF THE INTERFLEX-4 CIRCUIT

1 Panel and baseboard, 7 inches by 18 inches.
1 .0005 variable condenser, straight-line frequency type.
1 Tuning inductance; tube, 3 inches in dia., wound with 50 turns of No. 20 D.C.C. wire. Antenna inductance, six to ten turns of the same wire.
1 Radio frequency transformer, 220 to 550 meters.
4 Standard 201-A type sockets.
4 Amperite resistances.
1 Fixed crystal detector with mounting.
1 Double-circuit jack.
1 Filament control jack.
2 Audio frequency transformers.
1 Potentiometer, 400 ohms.
1 Fixed condenser, .002 mfd.
1 Vernier dial.
Binding posts, bus wire, screws, nuts, etc.

On the audio frequency side two standard transformers, ratio 3 to 1 are used. A good transformer should be used here in order to increase the signal strength. If the set has a tendency to howl or whistle, it is probably the fault of one of the transformers. In that case, it is suggested that you use a small fixed condenser, C-2, as indicated. This may be of .00025 capacity.

If the set has been completed according to the instructions given here and in the layout, it should be noted that the second tube voltage should, with a good tube, be not more than 22½. While some tubes may require 45 volts, the writer does not recommend it. Nothing is gained by it but a waste of current, and distortion of the signals. The total "B" battery voltage is 90 volts for all the other tubes. The writer has used 201-A and 301-A tubes, although any other tube may be used.

WHAT THIS SET CAN DO

The writer has given a log of stations pulled in on a single evening. All of these were on the loud speaker and it should be noted that all of them were received while the locals were going. It should be noted also that such stations as KDKA, operating on 309 meters and WGBS, operating on 316, could be separated nicely without interference from each other. Also station KDKA, 309 meters and WPG, Atlantic City, 300 meters, could be tuned in easily without interference from each other.

The writer is well aware of the fact that these are not records by any means, and that a super-heterodyne or a good 5-tube radio frequency set may tune more closely and more sharply, but the writer maintains that for a single-dial control, with very little fussing with the potentiometer, the results are not easily duplicated with other sets.

Furthermore, this set tunes from 550 meters down to about 200. This is not a theory, but actual fact. Most sets that claim this range find it impossible to tune down even to WRNY, on 258 meters.

On local stations the potentiometer setting is not critical, while on DX work it needs more or less attention. The writer recommends that this set be used with aerials of a total length of not more than 75 feet. This includes the length of aerial plus lead-in. A long aerial makes for more interference. A good indoor aerial may be used if absolutely necessary, although the writer does not recommend it.

It will be noted that this set is entirely automatic, as the telephone plug or loud speaker plug automatically lights the bulbs. No switch of any kind is used.

The Balanced Interflex Circuit

By HUGO GERNSBACK

Member American Physical Society

IN this article we describe the first real single-control tuned radio frequency set described so far. It has but one dial or one single control — no compensation of any kind. Its volume is tremendous. It does not howl or squeal, and brings in the distant stations, all merely by turning one lone knob. It is a set which should be particularly popular with the old folk who do not wish to be bothered with more than a single knob. Stations can be logged with a single row of figures.

IN foregoing pages, I described the Interflex Four. This constitutes a circuit wherein a crystal detector is placed right in the grid circuit of a vacuum tube.

Excellent as this circuit is for quality, quantity and DX ability, it still has two controls; namely, the condenser tuning control and the potentiometer control. Ordinarily, in radio parlance, the Interflex Four would be called a 1-dial set. Where two controls are used, however, it requires a stretch of the imagination to call two controls one control.

It has always been my secret ambition to produce a multi-tube circuit which has but a single control, not just a single tuning control and then, stuck away in some obscure corner, some potentiometer or some compensating condenser control, or whatnot.

The Interflex Balanced Single-Control Set described here is the result of ideas on single-control sets which I have cherished ever since I wrote an editorial on the subject, which appeared in the February, 1923, issue of *Radio News*. I believe sooner or later all sets will have to come to real honest-to-goodness single control, by which I mean *just one knob*, and nothing else.

The ideal set should not oscillate; that is, it should not howl and produce shrieks from 200 meters up to 600 meters. Stations should come in without any disturbing noises, and all the time there should be only one control or one knob to accomplish this.

The circuit described here does all of these things and quite a good many besides.

ONE NIGHT'S PERFORMANCE OF THE BALANCED INTERFLEX

Station	City	Dial Setting	Wave Length
WNYC	New York	92	526
WEAF	New York	89	491.5
WJZ	New York	85	454.3
WQJ	Chicago, Ill.	74	447.5
WTAM	Cleveland, Ohio	73	389.4
WSAI	Cincinnati, Ohio	55	325.9
WGR	Buffalo, N. Y.	54.5	319
WGBS	New York	53.5	315.6
WAHG	Rich'd Hill, N. Y.	52.5	315.6
KDKA	Pittsburgh, Pa.	50	309.1
WTAS	Elgin, Ill.	49	302.8
WPG	Atlantic City, N. J.	48	299.8
WCAU	Philadelphia, Pa.	40	278
WMAK	Lockport, N. Y.	39.5	273
WJAZ	Chicago, Ill.	39	268
WRNY	New York	32	258.5
WGCP	New York	30	252
WNJ	Newark, N. J.	28	233
WOKO	New York	19	233
WODA	Paterson, N. J.	17	224
WIBJ	Chicago, Ill.	13	215.17

The Balanced Interflex takes in the entire broadcast range

THEORY OF THIS SET

The Balanced Tuned Interflex Four-A

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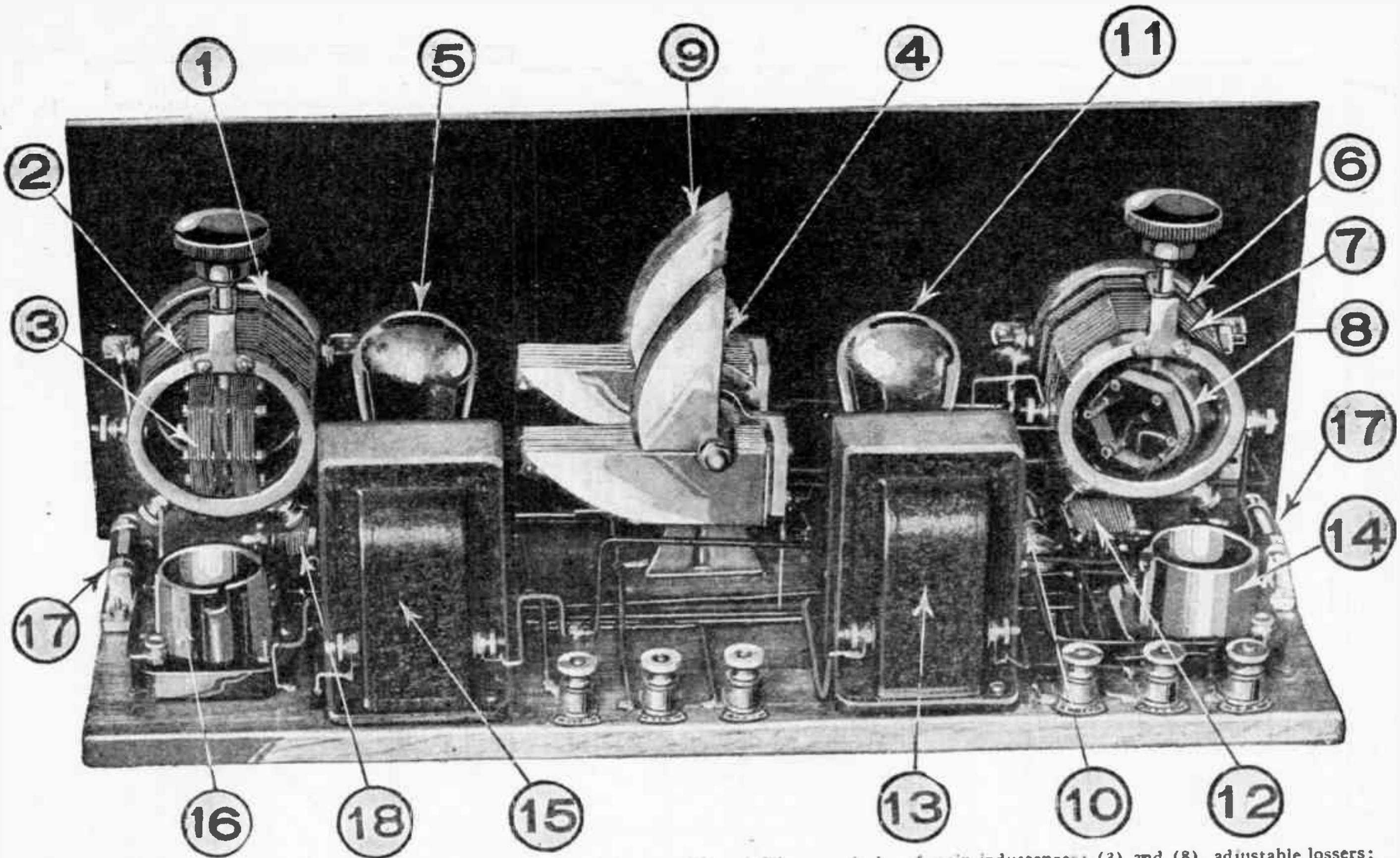


Rear view of the Balanced Interflex. (1) and (6), aperiodic primary; (2) and (7), secondaries of main inductances; (3) and (8), adjustable lossers; (5), (11), (14), and (16), tubes and sockets; (17) automatic resistances; (12) and (18), automatic filament control jacks; (10) crystal detector; (13) and (15), audio frequency transformers; (4) and (9), straight-line frequency condensers, linked.

comprises one stage of tuned radio frequency, crystal detector and three stages of audio frequency amplification, of which the two last stages are transformer coupled.

In all tuned radio frequency circuits, if the set howls and squeals on regeneration, it is necessary to provide losses. There are several methods of obtaining such losses, but the one most customary now is to place the inductances in the magnetic field of the condenser in such a way that there are certain absorption losses. But it is apparent that this is a very crude way of accomplishing these losses. In the first place, moving the coils even 1/64 of an inch closer to or further from the condensers will make a tremendous difference in signal strength. Furthermore, the losses are not always fully realized, and in spite of some constructors' claims, the majority of the sets thus made squeal and howl most annoyingly.

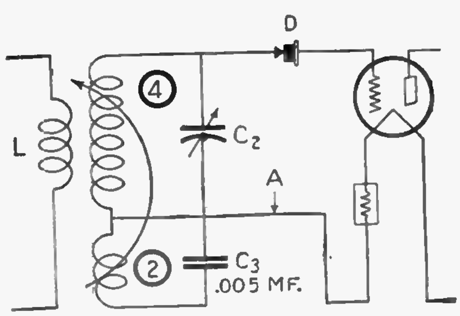


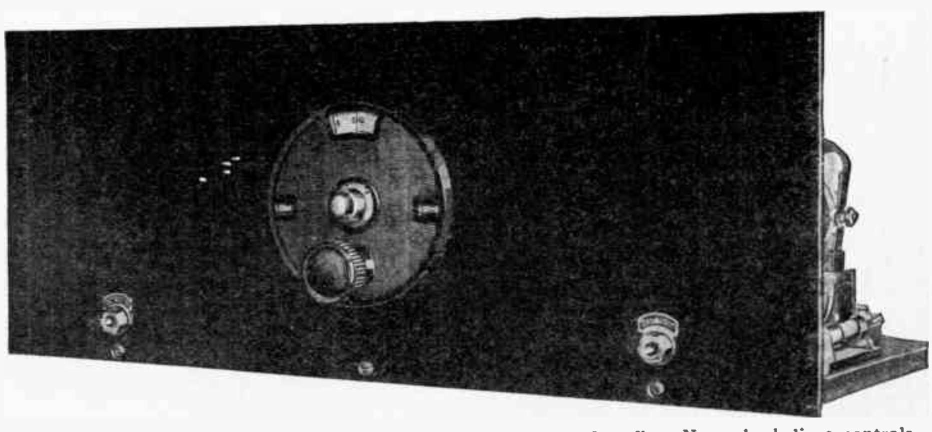
Fig. 1. Theoretical circuit of the Balanced Interflex. L 4 and L 2 constitute variocoupler. C 2 and C-3 represent the adjustable losser grounded to the filament. Crystal detector D is in the grid circuit, making the first tube a detector-coupled amplifier. Tuning is accomplished by condenser C-2.

The coils could, of course, be made adjustable so that they could be moved toward or from the condenser. This, however, would necessitate a number of extra controls, which are not wanted. Furthermore, *no two sets ever work alike,* because there are certain differences of tubes, differences of condensers, differences in coils, and a hundred other points which are apt to throw the set out of balance, with no means of rebalancing it.

I have thought of overcoming all these defects by using an original method which, to the best of my knowledge, has not been described before.

Granted that we must have certain losses in order to do away with excessive oscillations, and that a set works best just below oscillation, the following method was adopted: Fig. 1 shows the fundamental circuit, where we have an ordinary variocoupler, in which L is the untuned aperiodic primary, 4 is the secondary, 2 the tickler. It will be noticed that the connections are rather novel and that the tickler, 2, in connection with condenser, C3, is used as an ADJUSTABLE "LOSSER". By means of this arrangement it now becomes possible to adapt the set not only to whatever local conditions there may be, such as aerial, ground, as well as tubes, batteries, but to dozens of others, which we all know vary in every locality and in every set.

Referring again to Fig. 1, it will be noticed that the circuit from the grid of the tube to D, through coil 4 and through connection wire A, back to filament, is a closed oscillatory circuit, while the losser circuit is independent and does not enter directly into the workings of the regular circuit. The tickler circuit 2, with its condenser, might just as well be disconnected from the closed oscillatory circuit, if this were desired, and although the results will then not be quite as good in all cases, the principle still remains the same.



Note the pristine appearance of the real one-control Balanced Interflex. No make believe controls stuck away in a corner here. 'Phone and loudspeaker jacks left and right respectively.

In this particular circuit, if the tickler coils, of which two are used in the Balanced Interflex, are correctly adjusted, this set does a most surprising thing. The ticklers can be adjusted at the lowest available wave, say 200 meters, so that the circuit is on the point of oscillation. If correctly adjusted, impossible as this sounds, *the same condition will prevail through the entire broadcast range up to 600 meters.*

In other words, stations of 200 meters up to 545 meters will come in with the same intensity, with the stations in between as well.

In Fig. 2 the complete circuit is shown. It will be seen that we have two ticklers, 3 and 8 shunted with .005 fixed condensers.

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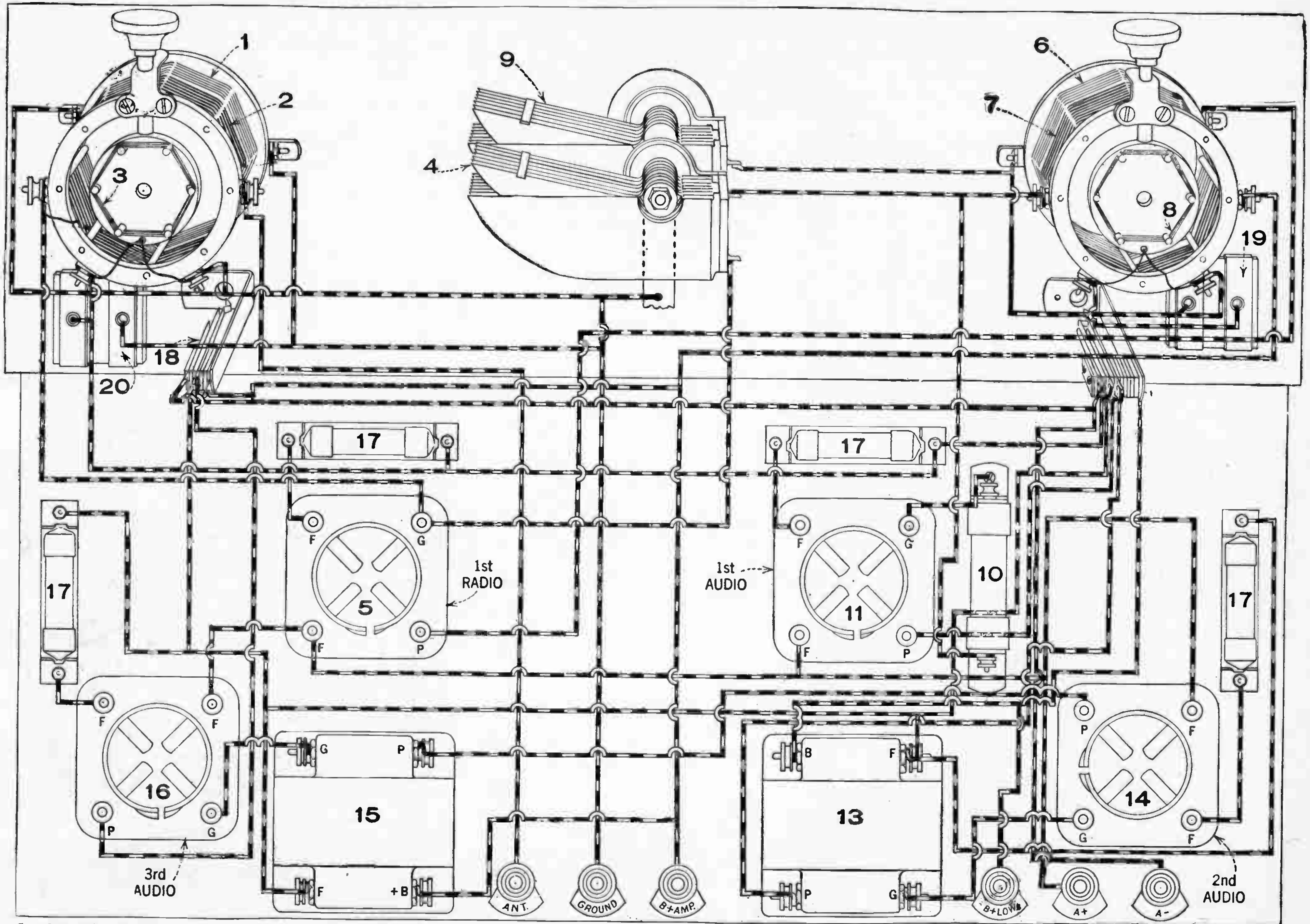

Complete wiring diagram of the Balanced Interflex Circuit. Particular attention is called to the new method of showing the wiring. It is not only easy for you to follow, so that you are not likely to make mistakes, but, most important of all, when you complete two connections, you can run a colored pencil over the dotted tracer line connecting them, as a check on your work. By the time all the lines have been traced, your set is completely wired. Try it and see how well it works out. No chance of mistakes or omitted wires. NOTE: For best results make sharp turns, but keep the corners of all wires well-rounded.

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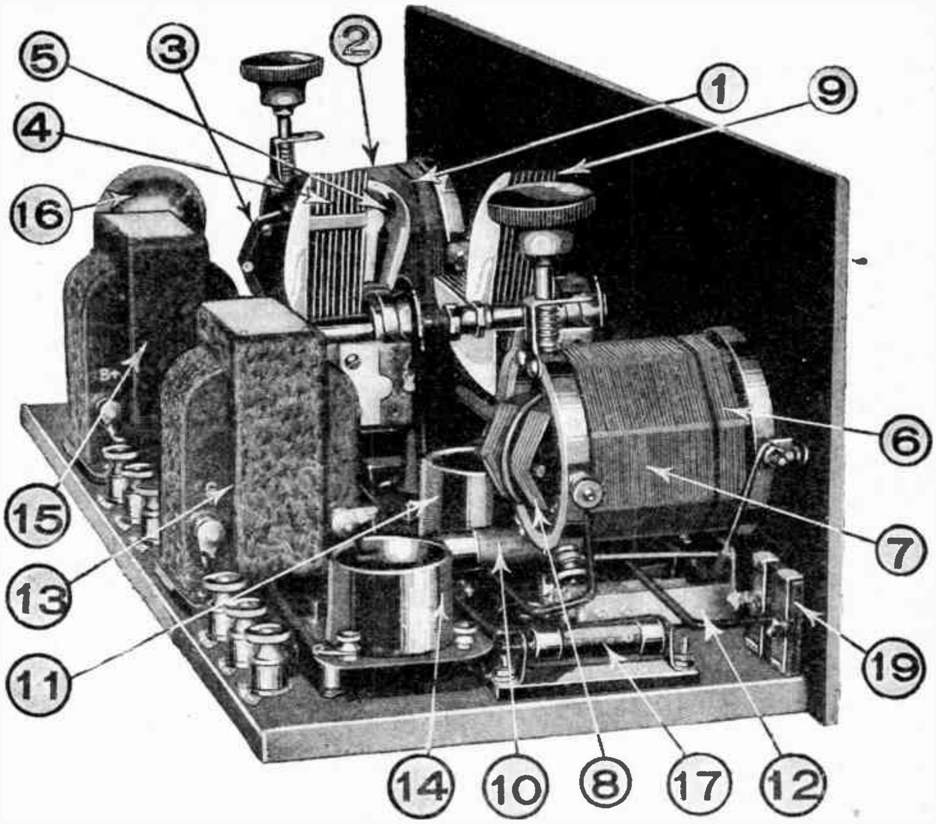
In order to produce a circuit with but a single control it was necessary to link the two variable condensers, as is shown in the photographic reproductions. The connection is also indicated in the dotted line, S-1 in Fig. 2.

Reverting to Fig. 2 it might be thought that the tickler 8, with its condenser 19 should be grounded to the filament of the second tube at 17. The connection exists, although it is not immediately apparent. You may trace the connection from condenser 19 through connecting wire A to the rotor of condenser 9, then through the connecting link of the two condensers S-1 to the rotor of condenser 4. Thence the circuit goes down through tickler 3, which you will notice is grounded on the filament 17. Tickler 8 might, therefore, be said to be in series with tickler 3.

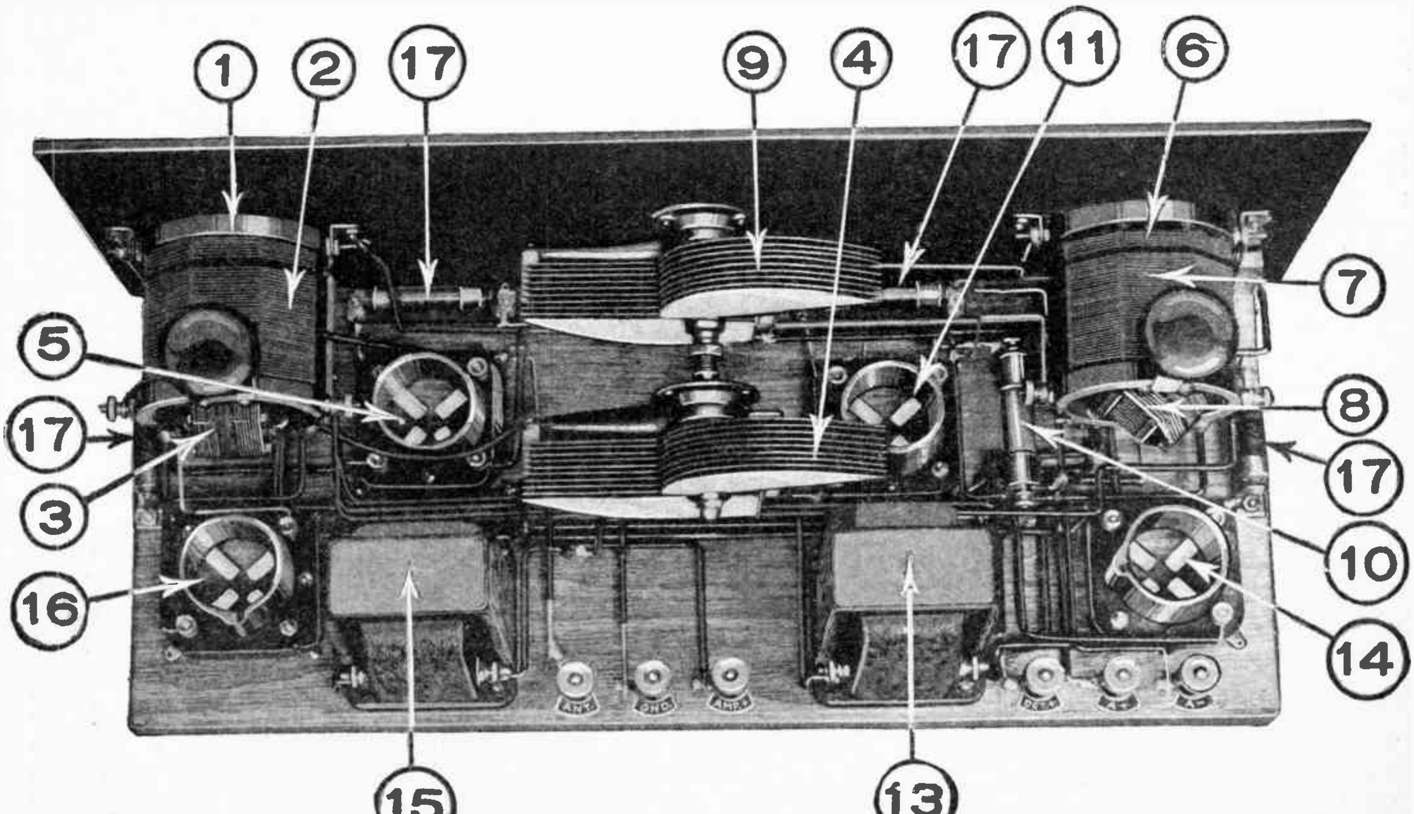
The photographic illustrations show this set as it appeared when completed. The variocouplers used here are factory-made, but for the constructor who wishes to build his own, I have shown in Figs. 3 and 4 how the variocoupler can be built at little expense. It should be remembered, as will be seen further down, that once the ticklers are adjusted they are never touched again. Hence, the construction of the ticklers need not be extraordinarily good, because they are used only when the set is first put into operation. The illustrations 3 and 4, I believe, are clear enough to give all the details. Ordinary well dryed cardboard tubing, which has been either shellacked or dipped in hot paraffin, should be used. The tickler construction is very simple. Merely use a 1½-inch piece of tubing, through which passes a threaded 6/32 or8/32 rod, which is attached to the tube by means of ordinary hexagon nuts, as shown. The bearings can be punched right into the cardboard and no fear need be felt that they will wear out, because the ticklers are not used enough, as has been mentioned. Flexible leads go from the rotor to binding post, as shown in Fig. 3. I believe the drawings are so complete that nothing else need be said about this.



This is a side view of the Balanced Interflex Circuit, giving a good idea of the mounting of the variocouplers and the adjustable lossers. The figures used are the same for all illustrations. (19) here is the condenser C-3 shown above in Fig. 1.

THE DOUBLE VARIABLE CONDENSER

We now come to the next important consideration, and that is the double variable condenser. In the Balanced Interflex I found it advisable to use a straight-line frequency condenser, which for many reasons is the most desirable. Two of these were coupled on one shaft, as will be seen by the photographic illustrations. Of course, you can use either a straight-line frequency condenser or any other condenser, for that matter, to suit your needs. In Fig. 5 I have shown the means of coupling the two condensers. The only other additional piece which you will need is the



View of the new circuit, taken from above, showing arrangement of the various parts. The same figures are used throughout and are also repeated in the ceircuit on page 28. Note the mechanical linking between the straight-line frequency condensers (4) and (9) and the neat arrangement of all the components.

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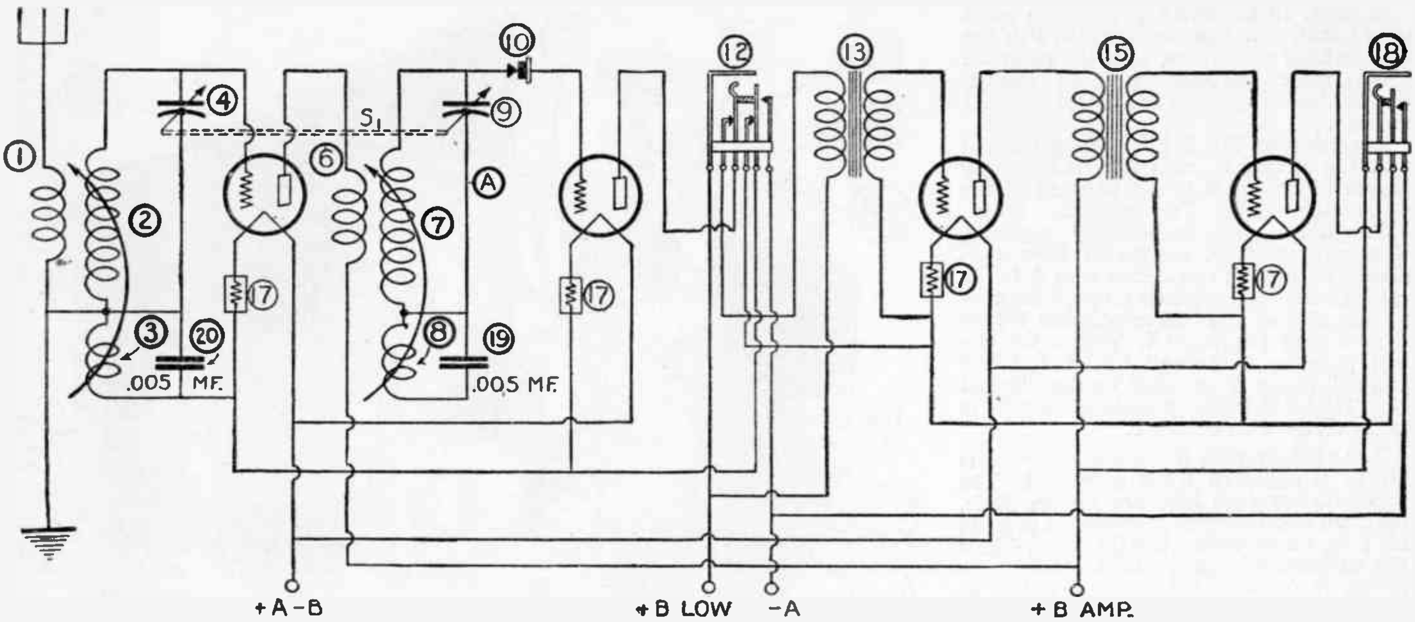

Fig. 2. The complete circuit of the Balanced Interflex. (1) is the aperiodic primary; (2) secondary; (3) adjustable losser; (4) and (9) mechanically linked condensers; (6) untuned radio frequency primary; (7) tuned radio frequency secondary; (8) adjustable losser; (10) crystal detector; (12) and (18) automatic filament control jacks; (13) and (15) audio frequency transformers; (17) automatic resistances (Amperites); (19) and (20) fixed condensers.

connecting sleeve, which any machinist will be glad to make for you at small cost. When buying the condensers it is necessary to be on the alert to see that you select one in which the shaft extends not only on the side which carries the dial, but on the opposite side as well, because, if it does not, you cannot make a connection to the second condenser.

Quite a few condensers on the market have a shaft that is extended, and which usually has a slot at the end. If it has not, you can easily provide one with a hack-saw so that it will fit the tenon of the sleeve, as shown. The set-screw is quite important, for reasons which will be apparent later.

There are also on the market today condensers in gangs of two that you may buy ready-made, and if you use them, it is, of course, not necessary to provide any connecting sleeve, because such double condensers are usually built upon a single shaft. The adjustable sleeve method is the better, however, as you will see below.

The two condensers shown in the illustrations are supported by means of a bracket between the two. In other types of condensers it would be better to have an end bracket, as some of these condensers are rather heavy and should be supported at the rear end.

The set shown here was made with a panel 7 x 18 inches while the baseboard measures 7 x 17 inches. This was done to save space and make a compact set. I do not, however, recommend these measurements to the average builder, because there is too much cramping; the panel should be at least 7 x 21. with a sub-base 7 x 20, if possible. Or even 7 x 24 panel with base 7 x 23 can be used. It will be noticed that the variocouplers are mounted right on the panel. This necessitates drilling holes in the front panel, which have to be filled up afterward. If this feature is not desired, the variocouplers may be placed upon the baseboard, but in that case we must use the larger baseboard, because with the smaller size there would be no room left. The set can then be wired as shown in our wiring diagram.

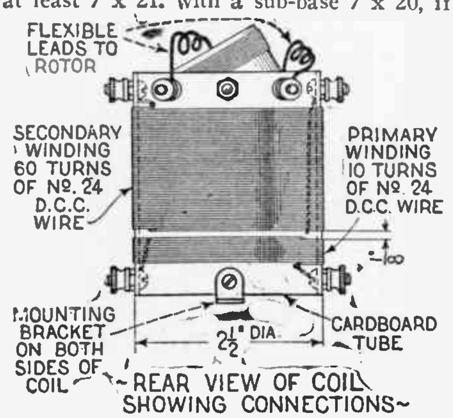

Fig. 3. This shows the constructional details of the variocoupler which can be made readily by any experimenter.

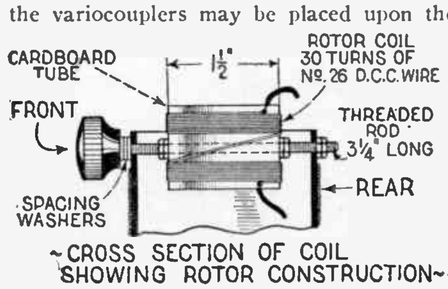

Fig. 4. Constructional details of the adjustable losser described in the article which can be readily made by any constructor.

This wiring diagram, by the way, also shows a new wrinkle. The connecting lines are drawn in a peculiar manner, with a purpose in mind. As connections are made, a colored pencil is run over the lines, which will show you which connections are completed. If you follow this procedure, you will leave out no connecting wires.

A front view of the set is also given, which shows the simplicity of the set. There is only one knob and the turning of this knob will not only bring in the locals, but the DX (distant) stations as well, without any other control whatsoever. The phone jack for head-phones is at the left, while the jack for loud speaker is at the right. When through using the set, the listener pulls out the plug, which automatically disconnects all the vacuum tubes. There is no switch on this receiver.

OPERATION OF THE SET AND SPECIAL INSTRUCTIONS.

This is a world in which you cannot hope to get anything for nothing. By this I mean that when you have reduced the usual six or seven controls in your set to a single one and still expect to get exactly the same results, if not better, than with the old controls, you must of necessity compensate for this. AND IT IS IN THE FULL COMPENSATION OF THIS SET THAT ITS SUCCESS LIES. As I mentioned in the Interflex Four, I recommended the Carborundum detector because to me it seemed most stable of many tried. I recommend to the builder of this set that he try this detector as well as several others. As a matter of fact, it becomes necessary to have several fixed detectors, because it will be found that not all of them are suitable for this set. Not every detector will work, and I have found that the detector that is too sensitive will make the set howl and squeal, which is exactly what it is not supposed to do, and does not do if the detector is well chosen.

You will understand, of course, that the "B" battery minus goes to plus "A". This saves one binding post in the set when you connect it.

As will be seen, no rheostats are used in the set. These are supplanted by automatic resistances or Amperites, which work very nicely. If the set is completely wired as per instructions, and if the correct materials have been used, we are now ready to tune the set.

It will be found that on locals the set, if the connections are right, will work immediately, although it may squeal and howl. It now becomes necessary to adjust the tickler controls. THE WHOLE SECRET OF THE SET LIES RIGHT IN THESE TICKLER CONTROLS. As I said before,

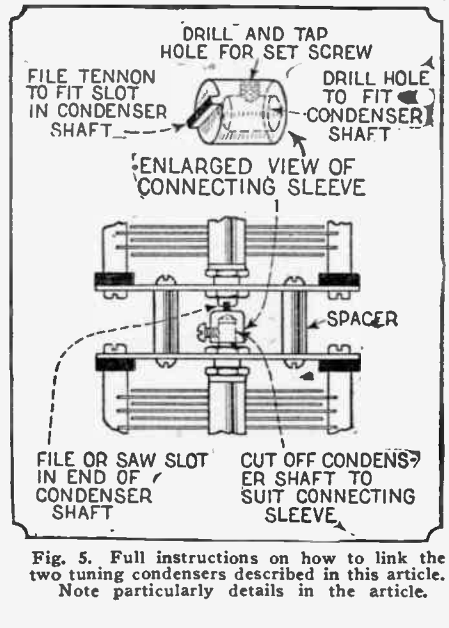

Fig. 5. Full instructions on how to link the two tuning condensers described in this article. Note particularly details in the article.

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in a world in which you cannot hope to get anything for nothing, it will be found that a little work must be put in to adjust these two coils in proper relation. Proceed as follows:

Tune in the lowest possible station, say around 210 or 220 meters. Adjust your tickler controls in such a way that the station comes in loudly without squealing. By turning both tickler controls VERY slowly you will find a point which is just below the oscillation. That is the correct point. It will be found that, as you turn the condenser tuning control, the stations will snap in with a startling loudness without being accompanied by any squealing or howling throughout the entire range of 200 to 545 meters. If there should be howling or squealing at any of the higher stations, the ticklers are not adjusted correctly. It may be necessary to turn one tickler all the way around and try working it back the other way. Sounds should come in not only loudly but without distortion of any kind. *If distortion exists, the ticklers are incorrectly adjusted.*

It will take you a little while to become familiar with this adjustment, but once you "get the hang of it," you will be astonished at the power and selectivity of the set.

If, despite everything, the set still howls, then the trouble lies in the coupling between the two condensers. In other words, the condensers do not balance the inductances. In that case the condenser sleeve, as shown in Fig. 5, should be loosened and one of the rotors of one of the condensers advanced or retarded ⅛ of an inch more or less. This can best be determined by experiment. In the set which we see illustrated here it was found that for best operation the outside rotor was almost ⅛ of an inch out of step with its mate. With a little experimenting you can find the correct point, after which the sleeve may be tightened. This should stop all squealing, and the set may now be said to be perfectly balanced.

There may be other reasons for squealing and before attempting to adjust the condensers, please bear the following important considerations in mind: No two tubes are alike. It will be found necessary in most cases to switch around the four tubes; this often remedies the trouble. Also, as stated before, the fixed crystal detector may be at fault. A detector that is too sensitive causes howls. You will also notice that as you insert a new detector into its holding brackets, you have to retune the set slightly.

(*Continued on page* 81)

The Regenerative Interflex

By HUGO GERNSBACK,

Member American Physical Society

In this article the author demonstrates a single control regenerative set in which but one dial—one control—is used. All other controls are fixed, once set. This is a "Golden Rule" set, inasmuch as it does not squeal or howl despite the fact that it is based upon regeneration.

IN THE last few pages of this book, I described the Interflex Four and the Balanced Interflex. Both of these sets used the principle of radio frequency amplification, with a fixed crystal inserted directly into the grid circuit. During the past summer I have occupied a great deal of time and study in the design of a regenerative single control receiver. By "single control" I want to make it plain that when I say "single control" I mean exactly that.

Right along, this or that article has appeared, featuring a single control, when in reality the set had as many as seven controls. Perhaps it had a single tuning dial, but, stuck away somewhere, there was a potentiometer, a stabilizer, a tone control, several assorted rheostat knobs, and whatnot. All these masqueraded under the name of "single control" sets. I wish to emphasize again that even if a number of controls are filament rheostats, *these are, nevertheless, controls*, because in most of such sets no DX can be effected unless the filament voltage is regulated for each station.

The one-control set should be just what it is called—"one control"—one dial and nothing else. You should, by turning the one tuning dial, be able to get DX stations readily, while the locals are on, providing, of course, that the stations are not right on top of each other, when not even the best set in the world can separate them.

In other words, the single dial should take care of everything. It is this ideal for which I have striven and I believe that in the Balanced Interflex, as well as the present Regenerative Interflex, these aims have been realized to a great extent.

When I first started to experiment with the Regenerative Interflex, it seemed simple enough merely to place a crystal into the grid circuit and use the ordinary tickler for the feed-back. I soon found out, however, that I was all wrong, and, as a matter of

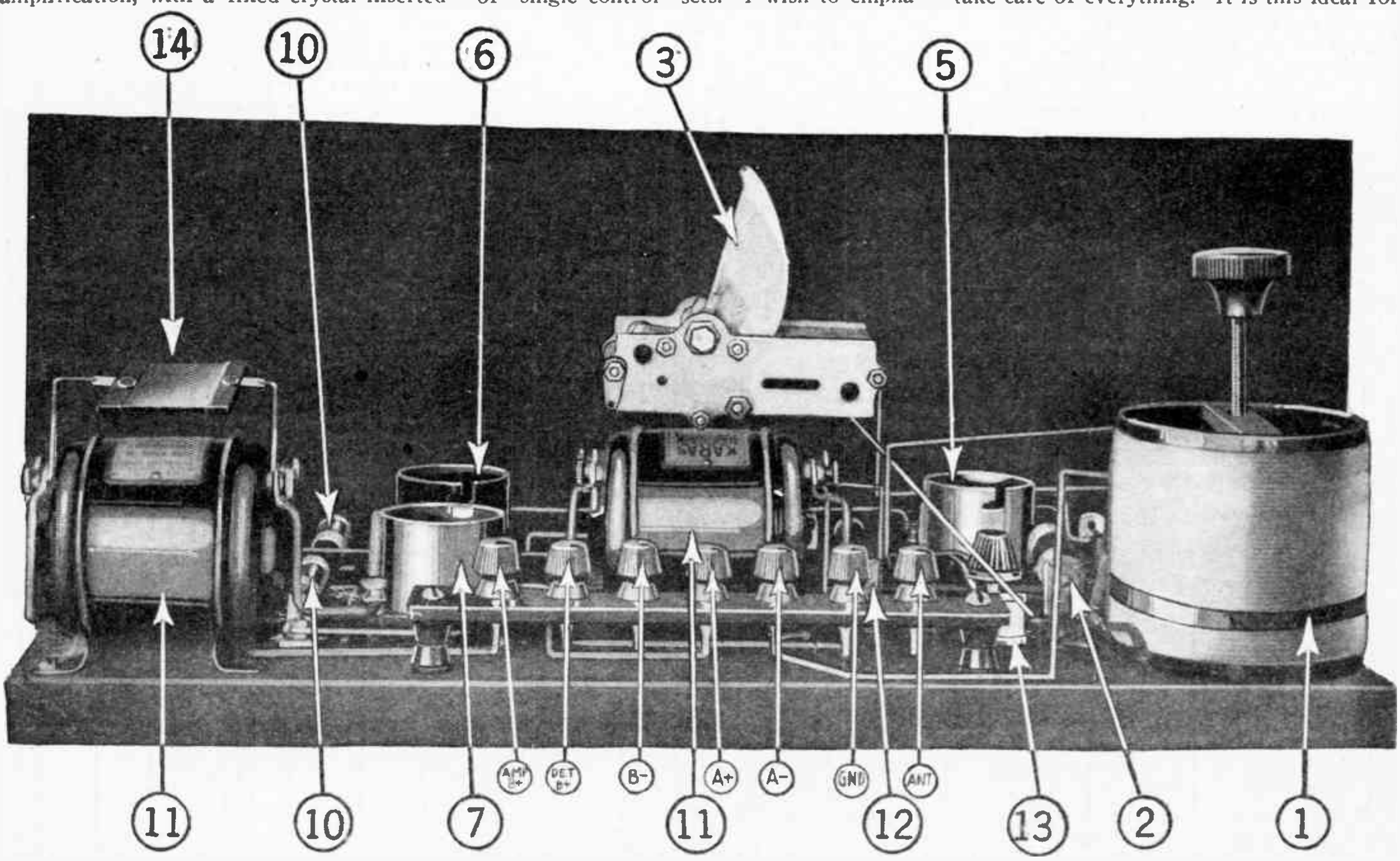

Fig. 7. A complete rear view of the Regenerative Interflex. The numbers shown are identical with those shown in Fig. 4. Note the simplicity of this set

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fact, some 400 distinct and separate experiments had to be made before the circuit had been fully realized.

Let us first see what happens in the fundamental circuit shown in Fig. 1. Here we have first a crystal detector inserted into the grid circuit. The crystal, in order to operate correctly, must act as a detector. *That means that the tube to which it is connected becomes an amplifier.* We now feed back energy from the plate to the grid circuit. It is evident that the crystal (2) is not only a detector but also acts as a resistance, and if this resistance becomes too great, the set will not oscillate (squeal). If the resistance of the crystal is too low, the set will over-oscillate, and then it becomes difficult to stabilize the circuit. Note that the usual grid condenser and grid leak are missing from this circuit.

As is to be expected, no two crystals are alike in characteristics. I have found, as I have stated in my former articles on the *Interflex* series, that the only satisfactory crystal of any stability is the carborundum type. It is ideal for this circuit and, as a matter of fact, is more stable than a vacuum tube itself. But, just as the vacuum tube, crystal detectors vary in their resistance and other characteristics. So, in order to adapt different crystals to different tubes, it is absolutely necessary to use a filament rheostat (13). This rheostat is adjusted only once. It need never be adjusted again, except whenever the batteries run down. *With normal voltage, the rheostat is never never touched.*

What This Set Does

ONE single, solitary control—NO MORE!

A set your grandmother can operate.

Fair loud speaker volume on a single tube for local stations.

Tremendous volume from three tubes, equaling or bettering most four-tube sets.

No squeals, no howls.

A great distance-getter—1,000 miles under average conditions on the loud speaker.

A set adaptable to ALL *local conditions.*

Extreme sharpness in tuning, so that you can separate locals from DX stations.

All this and more is accomplished in the REGENERATIVE INTERFLEX, *fully described in the accompanying article.*

It is not possible, in this circuit, to use an automatic resistance on the first tube, as the regulation is very critical. So much for the crystal end.

The next important consideration was to devise a coupler which, once set, could remain in the same position for all wavelengths—a feat that usual couplers cannot accomplish. The reason is that with the usual coupler, the rotor cuts both the high and the low potential field of the coil, so I devised a new coupler which I term the "Flexo-Coupler," shown in Figs. 2 and 3. It will be seen here that the tickler is a 25-turn honeycomb coil, which moves up and down vertically. It usually works best in the position shown in Fig. 2; that is, nearly all the way down. By this means it is possible to place the ticker in such a position that *its maximum efficiency is reached not only in regards to the secondary, but also to the primary,* which means that, as in the Balanced interflex, you can adapt this set to your local conditions as to aerial and ground, which you usually cannot do with the ordinary variocoupler. It cannot be accomplished even with a three-honeycomb coupler, as here there is too much angular displacement, which is missing in the "Flexo-Coupler" tickler.

The "Flexo-Coupler" is easy to make and no other instructions need be given, as everything is shown in Fig. 2. The idea is to move the honeycomb coil up and down by means of a screw thread until the best position is found. This position is usually found when listening in to a DX station. Then leave it in that position. The "Flexo-Coupler" and the crystal in the grid accomplish two things, namely, a good stabilization of the set and, second, a "broadening of the regenerative effect," if we may term it such, which broadening, however, does not affect the sharpness of the tuning. By this I mean to say that the set can be adjusted in such a way that the tube will be just below the point of oscillation for the highest as well as for the lowest wavelengths.

I have also found that with practically all crystal detectors it is necessary to have a stabilizing condenser (4), which is a very small one, several types of which are on the market. They are usually provided with a screw at the top, and by screwing this up and down you get a variation of from 2 to 20 micro-microfarads. These are low priced condensers, selling for about fifty cents or a dollar.

If the constructor wishes to build a one-tube set, he should go about it as shown in Fig. 1. Such a one-tube set, by the way, *will bring in local stations with a fair volume on the loud speaker,* a point that may be of more than passing interest. The one-tube set, as far as distance is concerned, will, of course, do the same thing as the three-tube set, except that for long distance or DX, you will have to use a pair of 'phones, whereas the three-tube set will bring in, not only the local, but distant stations with great volume.

STATIONS LOGGED ON LOUD SPEAKER IN A SINGLE NIGHT

Station	City	Dial Setting	Wave-Length
WNYC	Local	96	526
WCX	Pontiac	95	516.9
WEAF	Local	93	491.5
WOC	Davenport	92	483.6
WEEI	Boston	91	475.9
WJZ	Local	88	454.3
WOR	Local	83	405.2
WHAS	Louisville	79	399.8
WGY	Schenectady	76	379.5
WHN	Local	73	361.2
WMCA	Local	68	340.7
WBZ	Springfield	66	331.1
WGR	Buffalo	62	319
WGBS	Local	61	315.6
KDKA	Pittsburgh	59	309.1
WPG	Atlantic City	57	299.8
WORD	Batavia	53	275
WHAR	Atlantic City	52½	275
WFBH	Local	48	273
WRNY	Local	46	258.5
WGCP	Local	43	252
WREO	Lansing	55	285.5
WODA	Paterson	36	224
WIBO	Chicago	35	226
WOK	Chicago	30	217.3

The Regenerative Interflex takes in the entire broadcast range.

The tuning being identical for one- and three-tube sets, I shall describe the tuning for the single-tube set first. After the "Flexo-Coupler' has been built, and the set wired as shown in the illustration, the tickler is screwed practically all the way down in

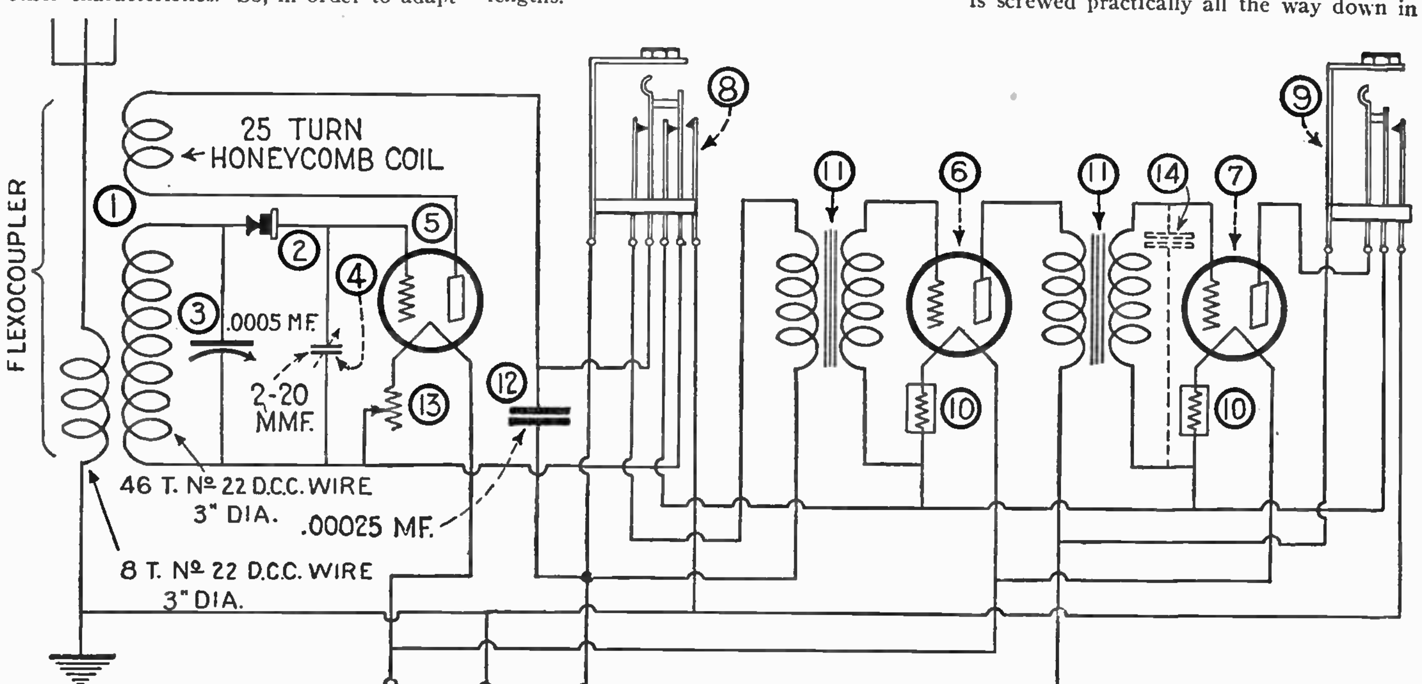

Fig. 4.

Complete circuit diagram of 3-tube Regenerative Interflex Circuit. (1) is the Flexo-Coupler, (2) crystal detector, (3) variable condenser, (4) Small balancing condenser, (5) detector-coupled audio amplifier tube, (6) second audio tube, (7) third audio tube, (8) and (9) filament control jacks, (10) Amperites, (11) audio transformers, (12) fixed condenser, (13) carbon type rheostat.

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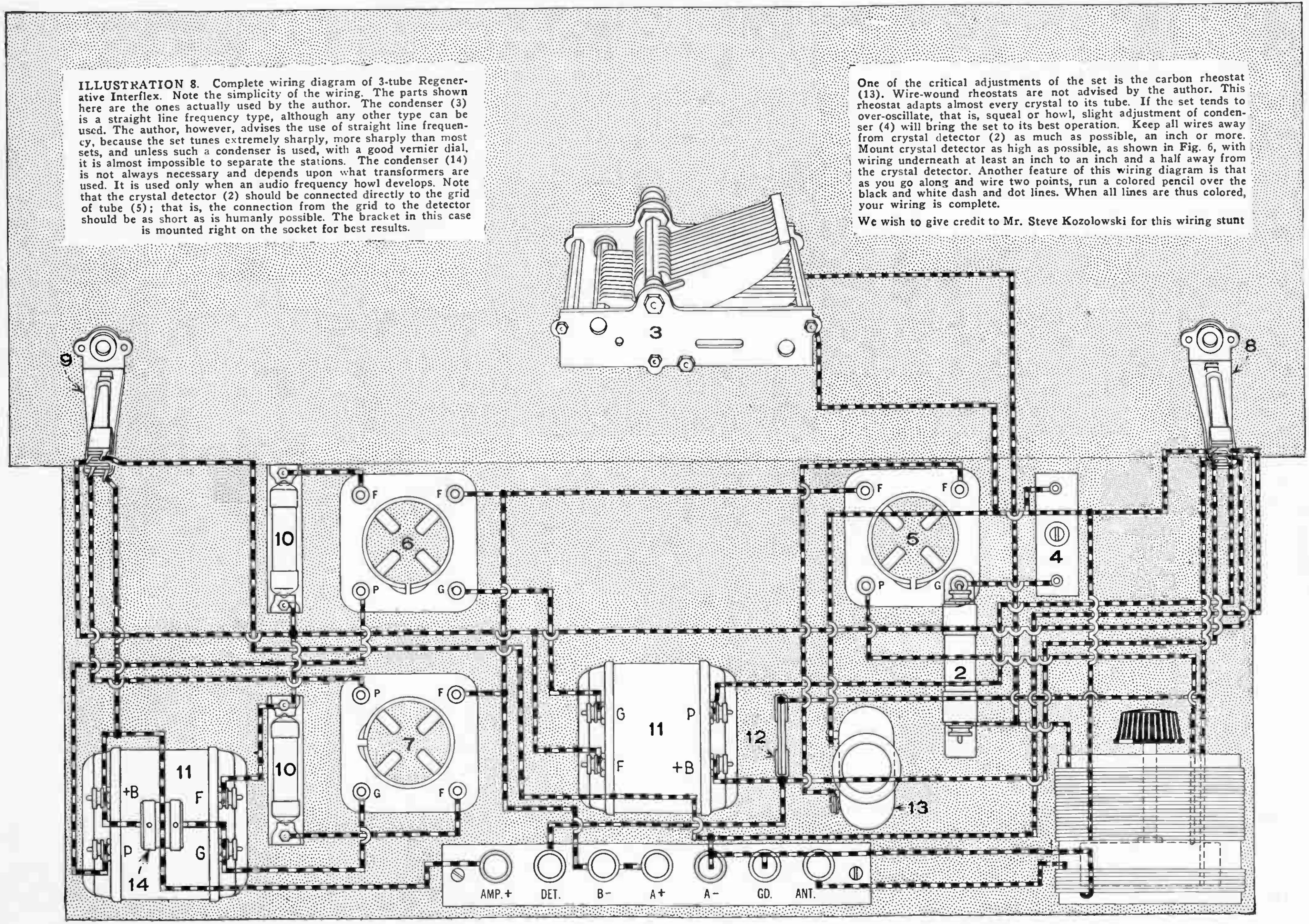

ILLUSTRATION 8. Complete wiring diagram of 3-tube Regenerative Interflex. Note the simplicity of the wiring. The parts shown here are the ones actually used by the author. The condenser (3) is a straight line frequency type, although any other type can be used. The author, however, advises the use of straight line frequency, because the set tunes extremely sharply, more sharply than most sets, and unless such a condenser is used, with a good vernier dial, it is almost impossible to separate the stations. The condenser (14) is not always necessary and depends upon what transformers are used. It is used only when an audio frequency howl develops. Note that the crystal detector (2) should be connected directly to the grid of tube (5); that is, the connection from the grid to the detector should be as short as is humanly possible. The bracket in this case is mounted right on the socket for best results.

One of the critical adjustments of the set is the carbon rheostat (13). Wire-wound rheostats are not advised by the author. This rheostat adapts almost every crystal to its tube. If the set tends to over-oscillate, that is, squeal or howl, slight adjustment of condenser (4) will bring the set to its best operation. Keep all wires away from crystal detector (2) as much as possible, an inch or more. Mount crystal detector as high as possible, as shown in Fig. 6, with wiring underneath at least an inch to an inch and a half away from the crystal detector. Another feature of this wiring diagram is that as you go along and wire two points, run a colored pencil over the black and white dash and dot lines. When all lines are thus colored, your wiring is complete.

We wish to give credit to Mr. Steve Kozolowski for this wiring stunt

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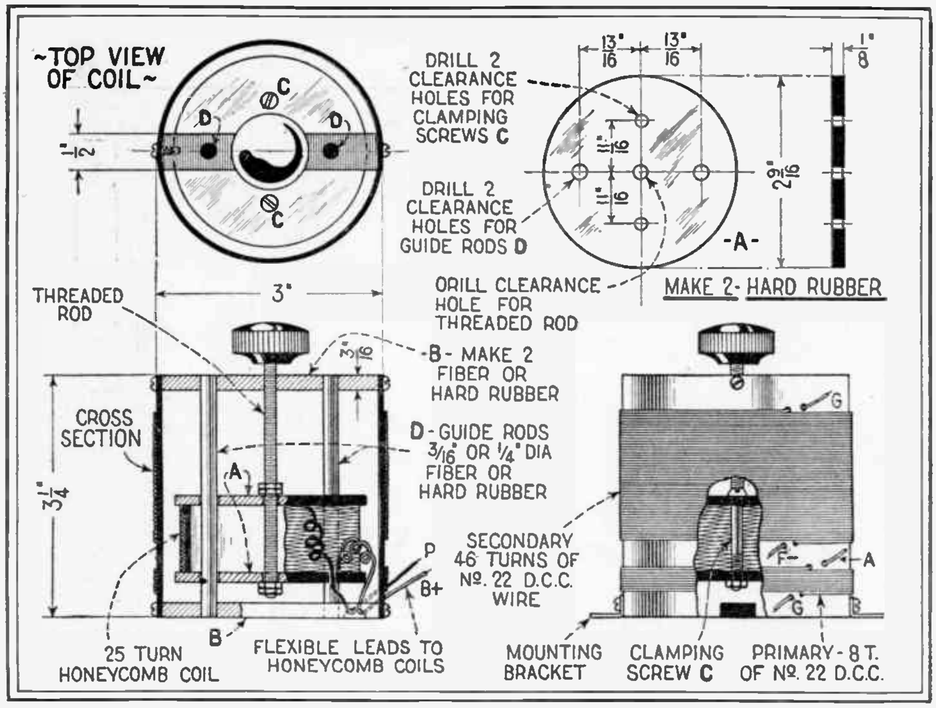

Fig. 2. Complete constructional details on how to make the Flexo-Coupler. Any constructor can make this coupler with simple parts. Note that guide rods (D) must not be of metal, as this will give rise to losses.

about the position as shown in Fig. 2. The connections are all shown in Fig. 1, but I should state here that the condenser 12 is most important, as without it the set will not oscillate. You may try also to change the + lead of this condenser to the — lead of the "B" battery. The condenser 3 can be a straight line frequency or any other good variable condenser. The rheostat 13 should not be a wire-wound rheostat, as these usually do not regulate finely enough. A carbon rheostat, such as the Bradleystat or Filkostat, is advisable.

An important point to remember when building this set is that the tickler leads are most important. Do not solder them on at first. *The set will work only with the tickler leads connected in one way.* After you have found the proper way by reversing the leads you can solder or otherwise connect the leads permanently.

When everything has been mounted, the set should be tuned as follows: Adjust the tickler as mentioned above, and then begin tuning with the single tuning condenser 3. If the set does not oscillate immediately—that is, if it does not squeal—move the tickler up or down until the set squeals loudly. Then work the tickler back a trifle. Now begin tuning for the lowest possible wavelength. You will find in most cases that the set squeals. Do not touch the "Flexo-Coupler" at all, but adjust the balancing condenser 4. It is advisable to use a screwdriver with a wooden handle or a sharpened piece of wood, because of capacity effects. Keep screwing down *slowly* to increase the capacity of the small condenser until the squeals stop. Now begin to adjust the rheostat 13. Should the set emit a hissing, mushy sound, like steam escaping, the detector has been overloaded. Carefully adjust rheostat 13 until the hissing-steam sound has vanished completely. If you reduce the filament voltage too much you will find that the volume of the set diminishes. This is, of course, not what you want, and you must strive for a happy balance, using rheostat 13. *Note that this control is very critical* and must be just so. You will find that ⅛th of a turn makes a vast difference in the results, particularly on DX stations.

You may try now to readjust condenser 4, and the tickler of the Flexo-Coupler, until you finally bring the set to its highest efficiency. While this may all sound complicated, it really is not, because you can balance a set and bring it to its highest efficiency within 20 minutes, providing directions are followed carefully and the proper materials have been used.

Always remember that you cannot get anything for nothing in this world. The usual regenerative set, as you probably know, has at least three controls: condenser, tickler and rheostat. These three controls are all used all of the time. It stands to reason that, in order to eliminate two controls, you have to put in a little more work in the first place, to save work afterward. *The set works normally when the stations snap in with a "quenched hissing" sound,* which preceds the actual sounds from the broadcast station. There should be no squeal, no howl, through the entire broadcast range, if the set works normally. If there are squeals or howls, an adjustment of condenser 4 or rheostat 13 will usually smooth out the trouble.

Another important point to remember right here is that the carborundum detector, as well as any other detector, works best only in one position. If the set does not work right, reversing the detector leads will usually eliminate the trouble.

As to the "B" voltage, it is best to use 22½ volts. More than this should never be found necessary. I need not say here that practically all types of tubes can be used, such as 201A or 301A type, UV-199 or C-299 type, and others.

BUILDING THE THREE-TUBE REGENERATIVE INTERFLEX

Figs. 4, 5, 6, 7, and 8 show the complete set. Fig. 4 shows the complete wiring diagram. This is exactly the same as the fundamental circuit shown in Fig. 1, except that there has been added a two-step amplifier, with two automatic filament control jacks. For the two last amplifier tubes the automatic resistances 10 are excellent, rheostats not being necessary at all.

The same method of tuning should be observed in this set as has just been mentioned for the one-tube set. When the loud speaker plug is inserted into the filament control jack 8 *the set should work the loud speaker on a single tube for local stations,* or stations located not further than ten miles away. This is a good test for the set, and unless the sound comes in with fair volume for the locals on the loud speaker, with a single tube, it is not working normally and should be adjusted until it does.

It will be found that when using all three tubes the sound received is terrific and as good or better than many four- and five-tube sets. If an audio howl develops, it may be necessary to put in a condenser, 14, as in some crystal detectors complete rectification does not take place and some of the radio frequency current passes through the transformers, thereby causing a howl. This usually can be determined by placing the fingers across the secondary of the last transformer, or sometimes by placing the fingers over one of the primary and one of the secondary connections of that transformer. Place condenser across the correct leads. The capacity of condenser 14 is about .001 m.f.

As I mentioned above, stations should snap in with a quenched hissing sound, and on locals the volume should be exceedingly loud. At my residence I can easily tune out the local stations, WGBS and WAHG, both on 316 meters, and bring in KDKA, 309 meters, Pittsburgh, 275 miles distant, with better volume than the local stations. The same is true of WTAS, Elgin, Ill., 302 meters, 700 miles away.

The set tunes so sharply that, providing there is a leeway of two or three meters on DX station, I can get practically any station on the air within a radius of 1,000 miles. This result was obtained in the middle of September, when the weather was still very warm and a good deal of static prevailed. As the nights get cooler, there should not be much trouble in excelling this record at any time.

I call particular attention to the fact that if single control is wanted, the "Flexo-Coupler" becomes necessary. I have not found any variocoupler on the market that

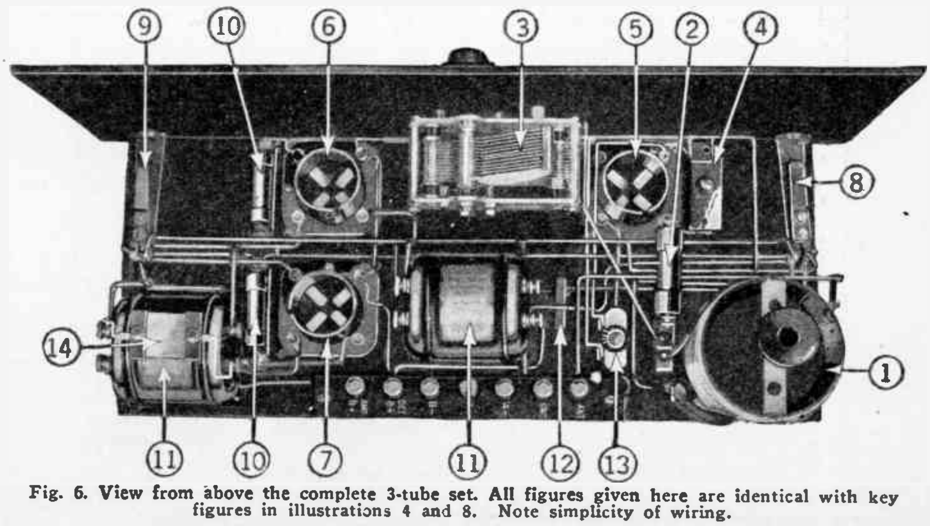

Fig. 6. View from above the complete 3-tube set. All figures given here are identical with key figures in illustrations 4 and 8. Note simplicity of wiring.

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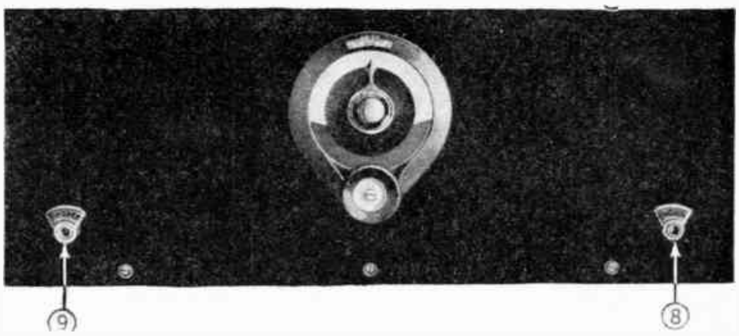

Fig. 5
Note particularly the simplicity of tuning this set. One dial—one control. The locals as well as DX stations snap in and out with great volume and excellent quality, merely by turning the one knob. Jack 9 is for one tube use; jack 8 controls all tubes.

would work this set with a single control without readjusting the tickler. In the "Flexo-Coupler," the tickler stays in its best position at all times without further adjustment.

In order to operate this set successfully the builder must remember the following few simple instructions:

1. Place the detector in such a position that a very short wire connects one end of the detector to the grid of the tube. Better yet, mount the crystal detector right on the grid binding post, as shown in illustration 6. The other end of the crystal detector is sensitive to strong currents, by which I mean that no wires should come within two inches of it, except the connecting wire that goes to the secondary. *Keep all wires and everything else away from it.* Even the "Flexo-Coupler" itself should not be too near, as the lines of force extending from the coupler will sometimes create trouble with the detector.

2. Don't forget to reverse the detector. Find out in which position it works best. Be sure that the detector terminals are tight, as loose connections often will defeat the working of the set. If you have several detectors available, these might be tried out. I do not advise an adjustable detector or a galena detector, because it is knocked out very quickly. A good, stable detector can be made by using a brass point on a good piece of silicon, and pouring sealing wax around the point, thus making a permanent detector. It is not, however, quite as sensitive or as stable as the carborundum type.

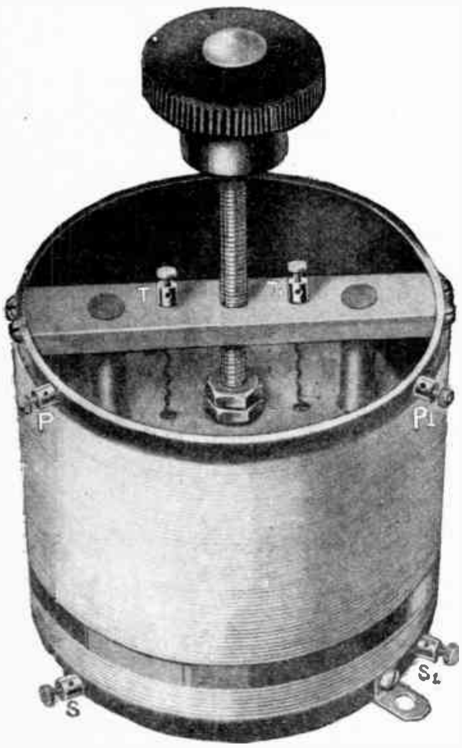

Fig. 3
Full view of the Flexo-Coupler, designed by the author. In this new coupler, the tickler is moved up and down vertically for close adjustment.

3. Not all tubes work alike. Some tubes oscillate (squeal) more easily than others.

PARTS FOR REGENERATIVE INTERFLEX

3 sockets.
2 A.F. Transformers.
1 S. L. F. Variable Condenser .0005 mfd.
1 Carborundum Crystal Detector.
1 Carbon Pile Rheostat.
2 Amperites.
1 Filament Control Jack (double open circuit).
1 Filament Control Jack (single open circuit).
1 Flexo-Coupler.
1 Fixed Condenser .00025 mfd.
1 Fixed Condenser .001 mfd.
1 Variable Condenser (2-20 mmf.)
1 Panel 7 x 18 inches.
7 Binding Posts.

and some of the poorer varieties do not oscillate at all. If the set does not oscillate, switch the tubes around until you find the arrangement that works best.

4. Rheostat 13, I must repeat, is a most important part of the set, and is very critical. If adjusted correctly, the set will reproduce beautifully in the natural tones without any distortion whatsoever. The set then becomes a quality set in all respects.

5. The condenser 12 is also important, because without it the set does not oscillate, as once mentioned. Its capacity also may change for different tubes, different crystals, etc., and before wiring up the set permanently it is best to try out a few condensers to find which one works best. Try also to change the + lead of this condenser to the — lead of "B" battery, as explained before.

6. As the set tunes with razorlike sharpness, it is necessary to use a vernier dial, since it is almost impossible to tune in DX stations with the usual dial.

7. As to the "B" battery, I have mentioned already that the first detector coupled amplifier tube 5 should use 22½ volts, but here again a definite rule cannot be laid down. I have had some amplifiers that work best on 16½ volts, and others that worked best on 28½. For that reason, I recommend that you use a tapped "B" battery, in order to get the best available voltage.

8. Always remember that if you change batteries, or if you change tubes or detectors, *you must rebalance your set*, and most of the balance will be found in the rheostat 13. The rest of the fixed controls are not so important, as a rule, and are not touched. I have used a three-tube set of this kind all summer, and the only time I touched the permanent controls was when I took out a tube or installed a new set of "B" batteries. The set has given a great deal of pleasure and satisfaction, and has required no attention whatsoever, after being once properly balanced. Contrary to general belief, the crystal detector used (carborundum) has been a marvel of stability, despite severe surges of static and other abuse. I daresay it is more stable than most tubes.

Those who used the old type carborundum detector some fifteen years ago will remember that it worked best with a potentiometer and a small voltage impressed upon it. Of course, I tried that combination in the Regenerative Interflex and with interesting results. I may come back to this at a later date.

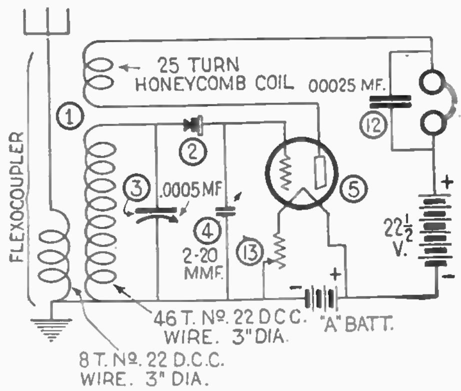

Fig. 1. The fundamental circuit of the Regenerative Interflex, showing the crystal detector, 2, in the grid circuit.

A Noiseless Intermediate Amplifier

By G. C. B. ROWE

The present amplifier will be found exceptionally valuable on account of its characteristics which tend to cut out the noise and at the same time increase the selectivity of the complete set.

WITH the advent of summer time, the bug-bear of static and atmospheric noises always comes to the fore. The users of the Super-Heterodyne are confronted with this nuisance more than the same listeners with other types of sets, since the intermediate frequency amplifier employed in it tends to pass more miscellaneous noise than straight tuned radio frequency sets or those of the single circuit class on account of the low frequency to which the intermediate stages are tuned.

The principle involved is simple in the extreme, being a combination of resistance coupling amplification with the addition of a sort of trap circuit in the form of a tuned circuit placed across the connections between the separate stages working in conjunction with the resistance coupled amplifier.

With the addition of small value blocking condensers in the grid and plate circuits, two of the tubes function as detectors on the low frequencies, those in the audio range, while giving intermediate frequency amplification to the desired signal. Through this process of elimination, practically every

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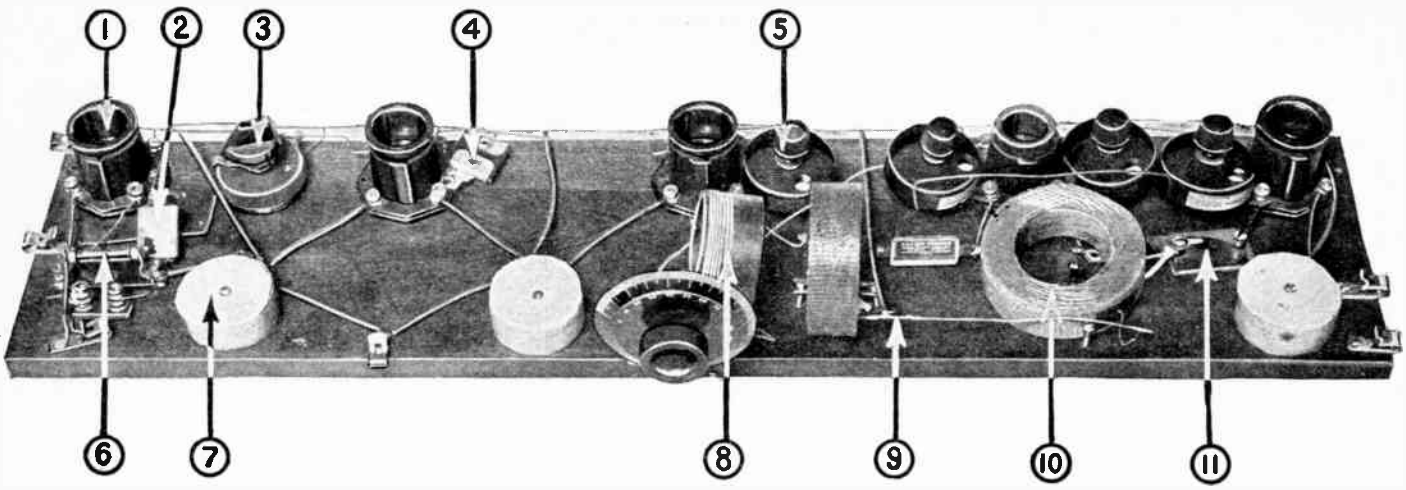

Layout of apparatus on baseboard. Above is a view of the laboratory layout of the new interference eliminating amplifier. 1 is the second detector socket, 2 fixed condenser across the secondary of the last tuned intermediate frequency transformer, 3 rheostat. 4 another intermediate condenser, 5 condenser for tuning the intermediate trap, 6 grid leak, 7 intermediate frequency transformer, 8 tickler, coupling the plate circuit of the second detector to one of the trap coils, 9 resistance, 10 trap coil, 11 grid leak and condenser.

wavelength but the one desired is cut out before the signal reaches the second detector and the audio frequency stages.

By referring to Fig. 1, the action of the circuit may be easily explained. The first detector and oscillator are of the standard type. No deviation from the regular Super-Heterodyne hook-up is noticed until the first tube of the intermediate frequency is reached. A standard transformer is connected between the first detector and the first intermediate frequency tube. The grid circuit of this tube functions in the standard fashion.

In the plate circuit, however, the connections are changed. Instead of the intermediate frequency transformer, there is a resistance, a tuned circuit and a grid leak. The action of this circuit may be easily explained.

The heterodyned signal delivered to the plate circuit of the first detector is passed through the transformer PS to the grid circuit of the first intermediate frequency amplifying tube. Here it is again amplified. It is well to note that everything passing the first detector is also amplified to some extent. This includes static, atmospheric noises, other signals than the one desired on account of the broadness in tuning of the tuned grid circuit of the first tube, and a certain amount of extraneous noise arising from the transformers, the tubes and the oscillator.

All this noise is amplified, but the nature of the coupling between the first amplifier and the second tend to reduce it in the following manner: The condensers C_2 and C_3 are of small capacity, .00025 mfd. or less. Experience will show that the static and tube noises are of audio frequency and are usually loud in ratio to the signal intensity. Therefore, the size of C_2 effectually prohibits their passage onto the grid of the next tube. The only possibility left to them is to take the alternative path through the resistance R_1, which is approximately of 25,000 omhs value. Here they are dissipated in the form of heat, leaving only the higher frequencies to pass on.

Now the desired signal at the intermediate frequency, in this case 6,000 meters, passes through the small condenser with relative ease and travels on its way toward the grid of the next amplifier. And here is where the trap circuit L_1 C_4 comes in. This circuit is tuned exactly to the intermediate frequency by the cut and try method, *i. e.,* using a small variable condenser or else adding or subtracting turns from the inductance. When the signal reaches this point, with the oscillatory circuit tuned exactly to the intermediate frequency, all that part of it which is not in resonance with the trap circuit dissipates itself by following the inductance to the grid return.

However, since the trap circuit is tuned exactly to the intermediate frequency which it is desired to pass, an infinite resistance is created and the desired signal prefers rather to travel on toward the grid of the next tube. Thus it is seen that all the extraneous currents traveling along with the signal on account of the broadness in tuning of the first circuit or due to other causes, are eliminated, thus making the set much more selective.

The same line of action is repeated in the second resistance stage. The last two are of the usual transformer coupled type and are standard in every way. There are followed by the second detector and two audio stages.

The detector and oscillator are of the standard type. The tuning coil A may be made by winding 64 turns of No. 18 S.C.C. wire on a 3-inch tube. The condensers F and E are both of the .0005 variety and are variable. The pick-up coil D may consist of 10 turns of No. 18 wound at the end of the oscillator inductance tube, which is also three inches in diameter. The plate and grid coils B and C for the oscillator may consist of 40 turns for the former and 64 for the latter, separated about half an inch from each other, on the tube.

Fifty kilocycles were selected as the best intermediate frequency at which to amplify, so of course it will be necessary to purchase three transformers designed for that frequency. And here it might not be amiss to note that, for the sake of efficiency, it is probably better to purchase these instruments than to attempt constructing them.

The condenser C_1 is used to tune the transformer secondary and if it is necessary, the manufacturer of the transformer will furnish a notation with it as to the proper value for this capacity.

The resistance R_1 is of 25,000 ohms value and is fixed. Since it is not in the least critical, any resistance which will fall within 20 per cent. of its rated value will suffice. The trap circuit consits of a 400-turn honeycomb coil shunted with a .001 variable condenser.

The resistance R_2 may be of about three megohms if the 199 or 299 type tubes are used. It will be noted from the photographs that this form of tube was used in the experiment. There was no mechanical or electrical reason for their use, however, and the 201A or 301A might serve as well.

In the hook-up no audio frequency is shown. Any type amplifier may be added.

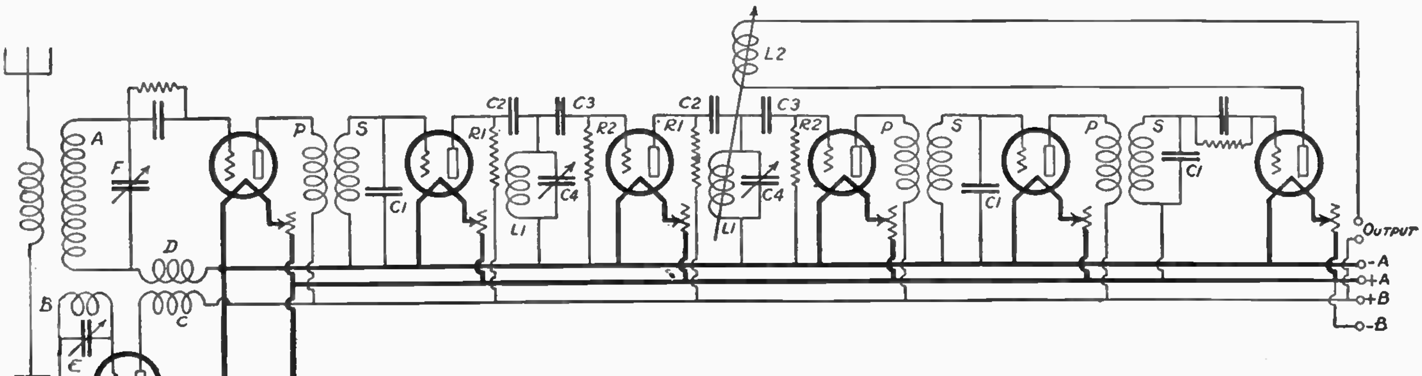

Fig. 1. Circuit diagram of Super-Heterodyne receiver using as intermediate frequency amplifier the system outlined in the accompanying article. A is the tuning coil. Condensers E and F have a capacity of .0005 mfd. (23 plates), B and C are the oscillator coils and D is the pick-up coil. L1 is a 400-turn honeycomb coil and C4 is a 43-plate condenser. L2 is 10 to 20 turns on 3" tube. Use an oscillator coil designed for the intermediate frequency transformers selected.

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The Counterphase Circuit

By J. T. Carlton

A two-control receiver employing the toroidal form of coils for coupling the R.F. stages. Several novel features are embodied in the receiver which will be of considerable interest to all.

THE ideal receiver, under present conditions as viewed from the standpoint of the broadcast listener should be capable of operation with extreme case, selective enough to receive any desired station without interference from any other station, and sufficiently sensitive to insure coast-to-coast reception.

Such a receiver, moreover, must also function without impairment of the natural qualities of the program to be received; in other words, faithful reproduction of tone quality is absolutely essential.

To appreciate the basis on which the circuit described herewith is founded it is necessary to turn back for a moment to the point in the development of radio frequency amplification where "adding a stage of radio" to a regenerative set was considered an accomplishment. Greater range became possible because of the fact that signals primarily too weak to register an effect on the detector tube were strengthened sufficiently for detection.

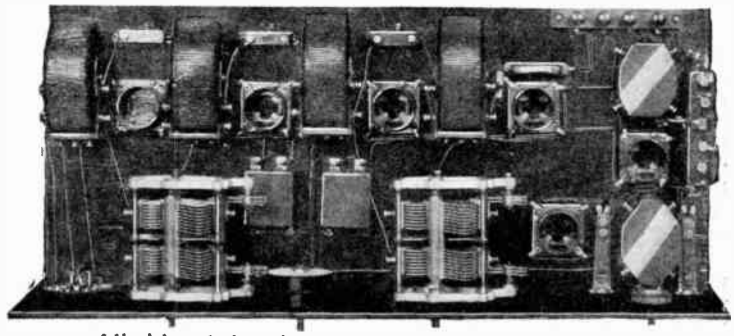
Adding more and more stages became the immediate aspiration of the multitude. Commercial refinements were rapidly introduced, resulting in more efficient apparatus, and a consequent increase in receiver efficiency and selectivity.

WHY "FEED-BACK" CIRCUITS OSCILLATE

But unfortunately, as increased efficiency became manifest the difficulty that is commonly known as "oscillation" also increased in importance. It was found that within the tune of each stage of an efficient low-loss set such amplification would occur that excessive plate energy would flow to the grid of the circuit through the capacity existing between grid and plate elements. The consequence of this feeding back of excess energy was undesirable whistles and howls whenever the receiver was in resonance or exact tune with a signal.

When in resonance with an incoming signal, the grid circuit of the tube offers but small resistance to the flow of current set up by the signal to which it is tuned; this condition, of course prevails where the essential components of the receiver are designed for high efficiency. When only a small resistance is offered to the passage of a current a large flow will result. As the energy fed into the grid circuit is amplified through the tube, a much stronger signal current results in the plate or output circuit of the tube. When the set is tuned to resonance with the incoming signal the feedback may become excessive, and swamp the signal current. The circuit is then in an oscillatory condition—the undesirability of which is manifest through the whistles and howls that ensue.

To maintain the maximum signal current in the grid circuit we must maintain a condition of resonance in the tuned circuit, but to allow the use of the low resistance grid circuit we must have means of limiting their energy feed-back from plate to grid so that the signal will not be swamped by whistles and howls.



Photograph showing the arrangements of the apparatus in the Counterphase receiver. Note the position of the tandem condensers and the torodoical coils.

Photo courtesy of Bremer-Tully Mfg. Co.

If the tendency to oscillate were uniform at all frequencies the problem could be solved by any of several methods that are well known. But this is not the case. Oscillations are much more difficult to control on the lower wave-lengths, and with the confusion caused by crowding 90 per cent of the stations on the lower half of the broadcast scale, the futility of any method of fixed control becomes immediately apparent—whether the system employed be neutralization at some mid-frequency or the introduction of enough losses to stop the trouble even on the lower waves. The former method usually results in whistles and screeches at the lower end and weak amplification at the upper, while the latter plan, although it may give favorable results on the high frequencies, usually leaves the upper end dead.

With such considerations in mind, Harry A. Bremer evolved a method of control whereby the circuit might be kept at a point just below that of oscillation at all frequencies or wave-lengths. It will be remembered that the greatest amount of amplification, free from howls and whistles, is always secured at this point.

THE COUNTERPHASE CIRCUIT

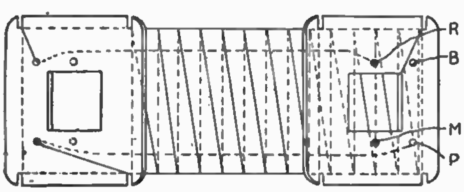
The desire was to provide an adjustable compensation for this tendency to oscillate that would allow maximum results at all frequencies rather than at only one. The "Counterphase" circuit now described provides a practical method of controlling three stages of radio frequency amplification with the same case and efficiency as if only one or two were used.

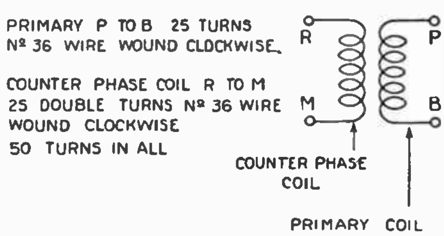
In this circuit on which patents are pending, semi-variable capacities are employed; that is, the ½ to 30 mmf. condensers are once adjusted and remain fixed thereafter.

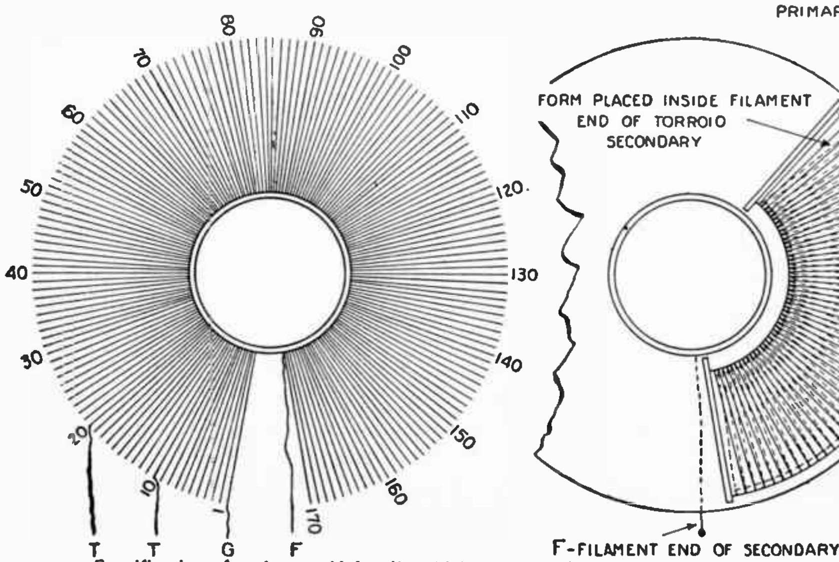
The means employed to secure the necessary variations to provide for controlling the oscillation tendency is at once new, simple and ingenious. In a condenser when the capacity is decreased the tendency to oscillate is increased. If we introduce a resistance in series with the condenser we will counteract this tendency. Each stage of amplification except the first, which is not difficult to stabilize, has its grid and plate circuits with like and reverse phase windings respectively coupled by fixed capacities in series.

Each stage is easily adjusted so as to prevent oscillation at any frequency by varying the series resistance. Decreasing the series resistance increases the tendency to oscillate, thus governing the amount of reverse phase energy necessary to suppress oscillations at the high frequencies.

An outstanding advantage of this method lies in the fact that there is no detuning effect noticeable, as a result of which it is possible to tune three radio stages as well as the detector with but two tuning controls instead of four. Indeed, it is possible to go on adding more stages of radio frequency if there were any practical reason for desiring to do so.







Specifications for the toroidal coils which are used for coupling the R.F. stages.

It is possible that a single control might be used if one were satisfied to accept the approximations which must always follow when an attempt is made to combine too many functions in one unit. In the writer's opinion, no normal two-handed person wants a radio set with only one dial to turn and if such desire should exist it is before he has operated either kind of set rather than *afterward.*

Considered as a whole, the efficiency of the Counterphase circuit is no doubt increased because it is unnecessary to introduce any kind of losses into the grid circuit, which is thereby allowed to remain in a low resistance condition.

The plate circuit inductances are wound in reverse phase to the primary windings of the same circuit. This reverse winding is coupled to an inductance which is in like phase with the grid winding, resulting in a reverse current opposing the plate current sufficiently to retard the flow of current from plate to grid. The values of the two auxiliary inductances are sufficient to feed enough reverse phase energy for the suppression of oscillations at any frequency within the broadcasting range.

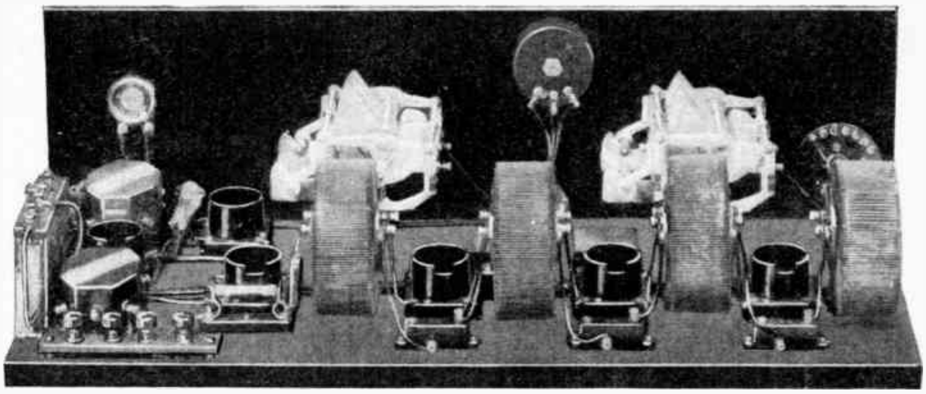
A NEW IMPROVEMENT

The variable resistance by the way, incorporates a further new idea. It contains two separate resistance elements on the same shaft. Since sensitivity is not required on nearby stations where volume must be reduced, the balancing arm is turned to zero on resistance R-1 before resistance is cut in on R-2 to decrease volume. On the other hand, when sensitivity is required we also want volume, so that the slider arm on R-2 turns back to zero resistance before the other becomes effective. We have, therefore, three stages of radio, a detector and the customary audio stages with but two tuning dials for selecting stations and a variable resistance which needs but slight adjustment to keep the receiver at the maximum point of efficiency on all broadcast frequencies.

The use of a hard detector tube allows all six tubes to be controlled by one rheostat, and if it is desired this may be placed inside the set, as its particular adjustment may be determined without difficulty, after which it need not be disturbed.

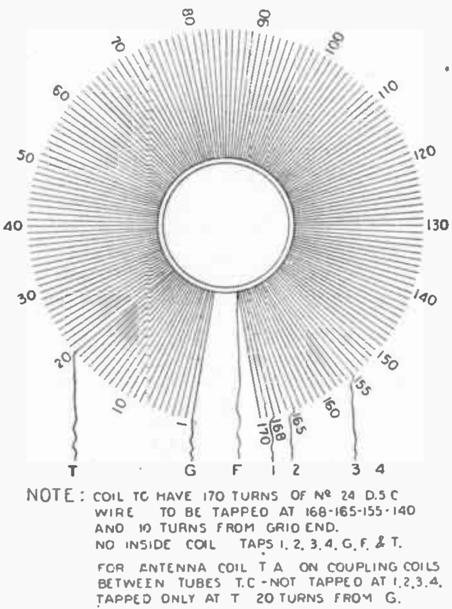
In the schematic circuit R-1 is the resistance that controls the feed-back, and R-2 is a resistance in series with the "B" battery, the effect of which is simply to decrease potential in the same manner in which a rheostat is used in a filament circuit.

Where it is necessary in tuning to cut out a resistance in order to suppress oscillations it will be readily seen that turning the knob still further results in cutting down volume and *vice versa.* In other



A photo of the Counterphase which employs the circuit diagram shown below.
Photo courtesy the Bremer-Tully Mfg. Co.

words, one resistance arm is always at zero when the other is in effect, and as each rotates about 270° there is a total of one and a half turns available between maximum sensitivity and minimum volume.



Specifications of the toroid connected to the antenna.

This newly designed dual resistance serves a double purpose in that it eliminates one extra control from the panel and simplifies tuning. After the station has been selected by the two tuning dials it is only necessary to remember that the resistance knob is turned in one direction to increase sensitivity and volume and in the other direction to decrease them.

Since maximum efficiency at all wavelengths is the prime object in this circuit a further refinement is added in the tandem condensers. A small "trimming" condenser is added to each section of each tandem. One of these is adjusted and fixed so as to make its combined capacity with the main section a trifle greater than the other main unit, and then left permanently in that position.

By regulation of the second, or panel unit in parallel with the second section it is possible to adjust the capacity to secure exact resonance between the two. It is necessary to use the panel "trimmer" however, only when tuning extremely weak signals. For all ordinary tuning it is not used.

SPECIFICATIONS FOR TOROIDAL TRANSFORMERS

Secondary, or outside coil, cross section 1½ inches square, or 1¾ inches in diameter, if round; 170 turns No. 24 double-covered wire, Core 1⅜-inch tube.

Primary wound on celluloid form made to fit 120 degree inside filament end of secondary consists of 25 turns No. 36 enamelled wire, space wound.

Counterphase winding, 25 turns No. 36 enamelled wire, space wound on same form between primary turns.

Counterphase condenser 1 mmf. to 30 mmf. variable.

Tuning condensers, double units, 350 mmf., with trimmers of 25 mmf.

1 mfd. fixed capacities across "B" battery and across "C" battery.

.001 mfd. across detector plate to filament.

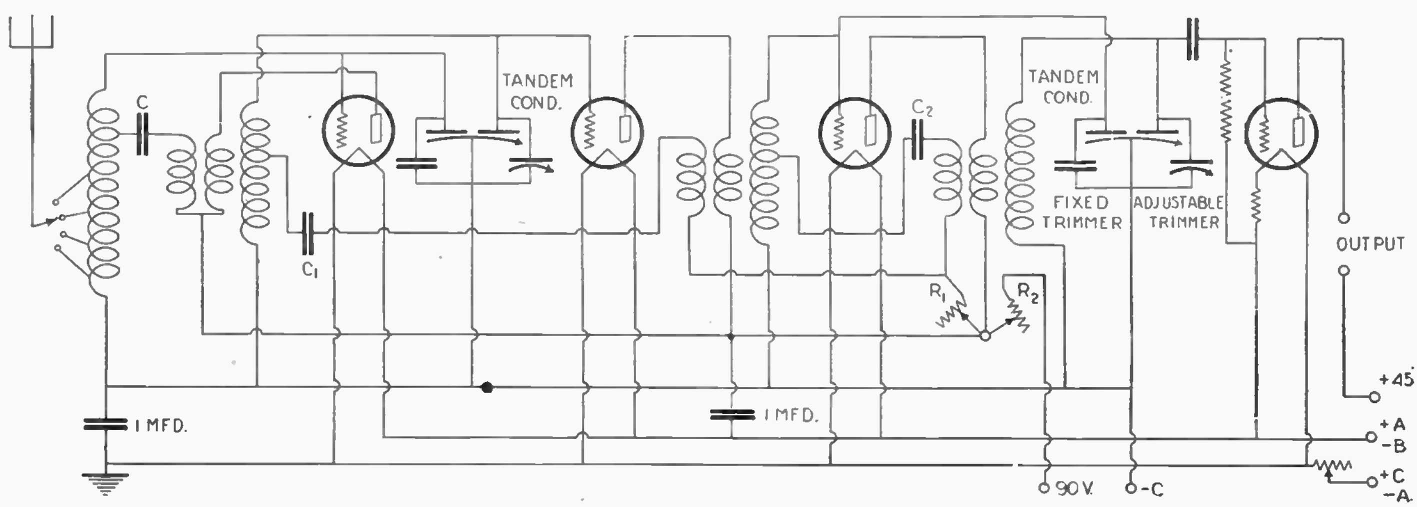


Diagram of the Counterphase circuit, showing how the tandem condensers and the toroidal coils are arranged.

A Really Portable Set

By the Staff of Radio News Laboratory

This receiver, developed in the RADIO NEWS *Laboratories, is recommended to any fan who wants a really portable set.*

THERE have been various portable and not so portable sets designed for summer use. The chief trouble with most of them is that the designers and engineers consider anything portable that takes up less space than a soap box and may be transported with a car with less engine strength than a Mack truck.

And, again, many of them are built in such a fashion as to be barely efficient enough to pass muster in the show room, since the chief controlling idea seems to be to build a super-heterodyne in less than the number of square inches usually allotted to a detector and two audio frequency transformers.

When the *Radio News* Laboratories started on its design, it first of all selected a hook-up which would give a fair degree of volume and selectivity, be of extreme simplicity in operation and, above all, be rugged and light. The results may be seen in the accompanying photographs.

Our experience in the past with the crowding of stations at the lower end of the dial readings has taught us a good lesson, and since at last the straight-line frequency condenser is available, it was thought very desirable to use this type of condenser in the set. It is clearly shown in the photographs and the diagrams. The condenser may be the same as that pictured in the articles by Hugo Gernsback on the Interflex set, in this book.

For maximum sensitivity and volume with the least number of tubes consistent with a portable outfit, a reflex circuit was selected as the proper type to be employed. Here there may be a healthy howl raised by those initiated into the operation of this particular principle. However, a glance at the drawings will show that the arrangement of the apparatus and the method of wiring have been carefully thought out, with stability as the chief idea.

The use of aperiodic radio frequency transformers is, of course, for good reason. A portable set should be as simple and as stable as possible. Tuned stages would add hopelessly to the complication to be dealt with, therefore such a circuit was not used. The loss of efficiency in the set as compared with tuned stages is not sufficient to pay for the added difficulties encountered.

In constructing the set, the first step is to prepare the baseboard. It is cut from half-inch stock, 7½ inches wide and 21 inches long. Two such boards are needed. One serves as the battery compartment bottom and the other as the base for the mounting of the instruments.

After the baseboard is cut, the panel is drilled and the variable condenser, the jack and the potentiometer-rheostat mounted. It will be found best to leave the mounting of the loud speaker until last, since the business of wiring will be greatly expedited thereby. After the sockets, the condenser and the resistances have been connected as in the drawing, the radio frequency transformers and the audio transformers may be installed.

After all connections are made to these units, the by-pass condensers and the crystal detector are put into the circuit.

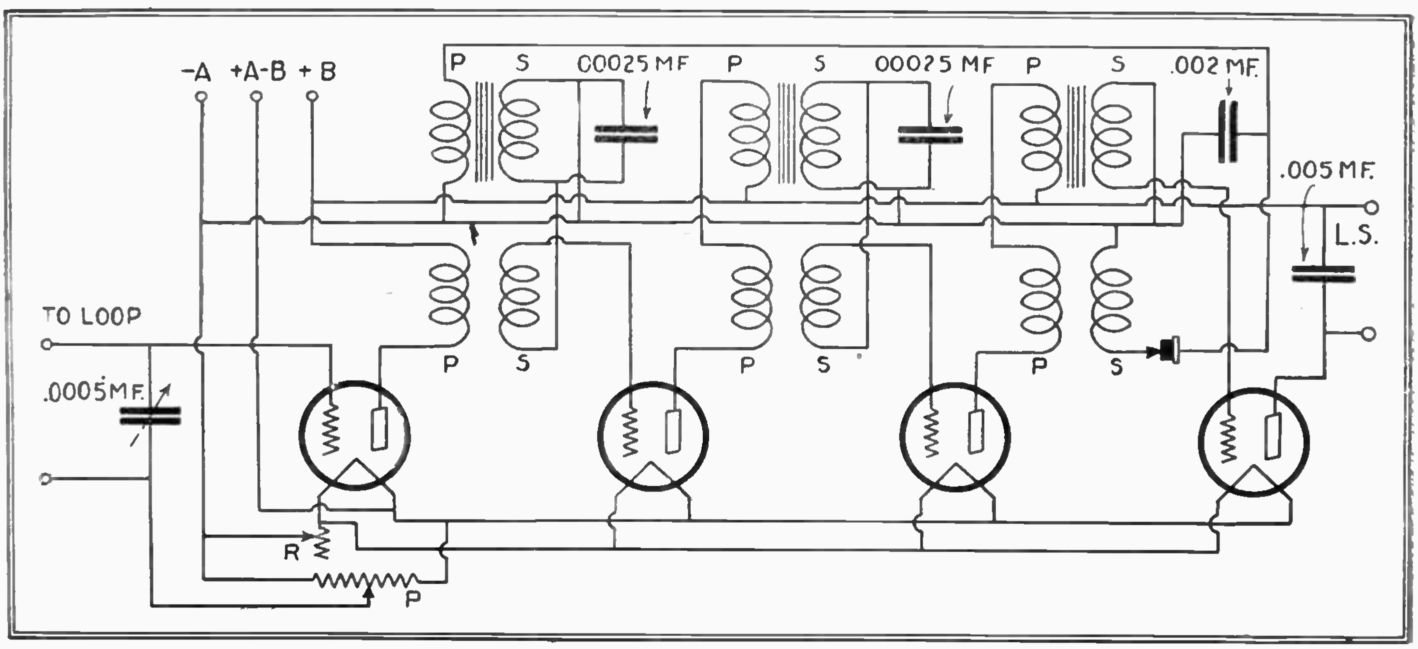
The main tuning condenser, which is placed across the loop, should have a maximum capacity of at least .0005 mfd. The by-pass condensers across the secondaries of the audio frequency transformers are all of the fixed mica type and have a capacity of 0.00025 mfd. The third transformer does not have a by-pass condenser in the set shown in the photographs. The transformer used in the present instance had sufficient distributed capacity in the windings to pass the radio frequency. The builder may find, however, that he needs one for the best functioning of the set. Its use may be determined only by trying the set with and without it.

The next point of importance is the crystal detector, which is of the fixed type. In the set described, carborundum was employed. The characteristics of this crystal are so well known as to need no discussion. For constant and acceptable operation under the most adverse conditions it cannot be beaten. Its ruggedness surpasses that of all other crystal rectifiers.

Panel view of portable set. Condenser dial at left, horn in center, potentiometer and rheostat at right.

The last step in the assembly of parts is the mounting of the loud speaker. It consists of an ordinary unit attached to a small Radion horn. A covering of some sort may be placed over the opening of the horn, but this is not necessary.

The horn is held in place with a brass angle strap fitting snugly around it and bolted to the panel.



Reflex circuit diagram of the four-tube portable receiver, using crystal detector.

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After the assembly of the parts is completed, the battery case should be constructed. This necessitates two bits of ¾-inch finished stock 8 x 3½ inches. These are placed flush with the ends of the baseboards, with the front setting half an inch inside the front line of the baseboards.

Then the paneling for the case is put on. The best material to use for this is three-ply, veneered stock, three-eighths of an inch in thickness. The two end-plates measure 8¼ x 11 inches. The front panel, which fits under the regular panel, measures 21 x 4 inches.

The panel and the end-plates are held together with brass angles and machine screws. The rear holds the loop.

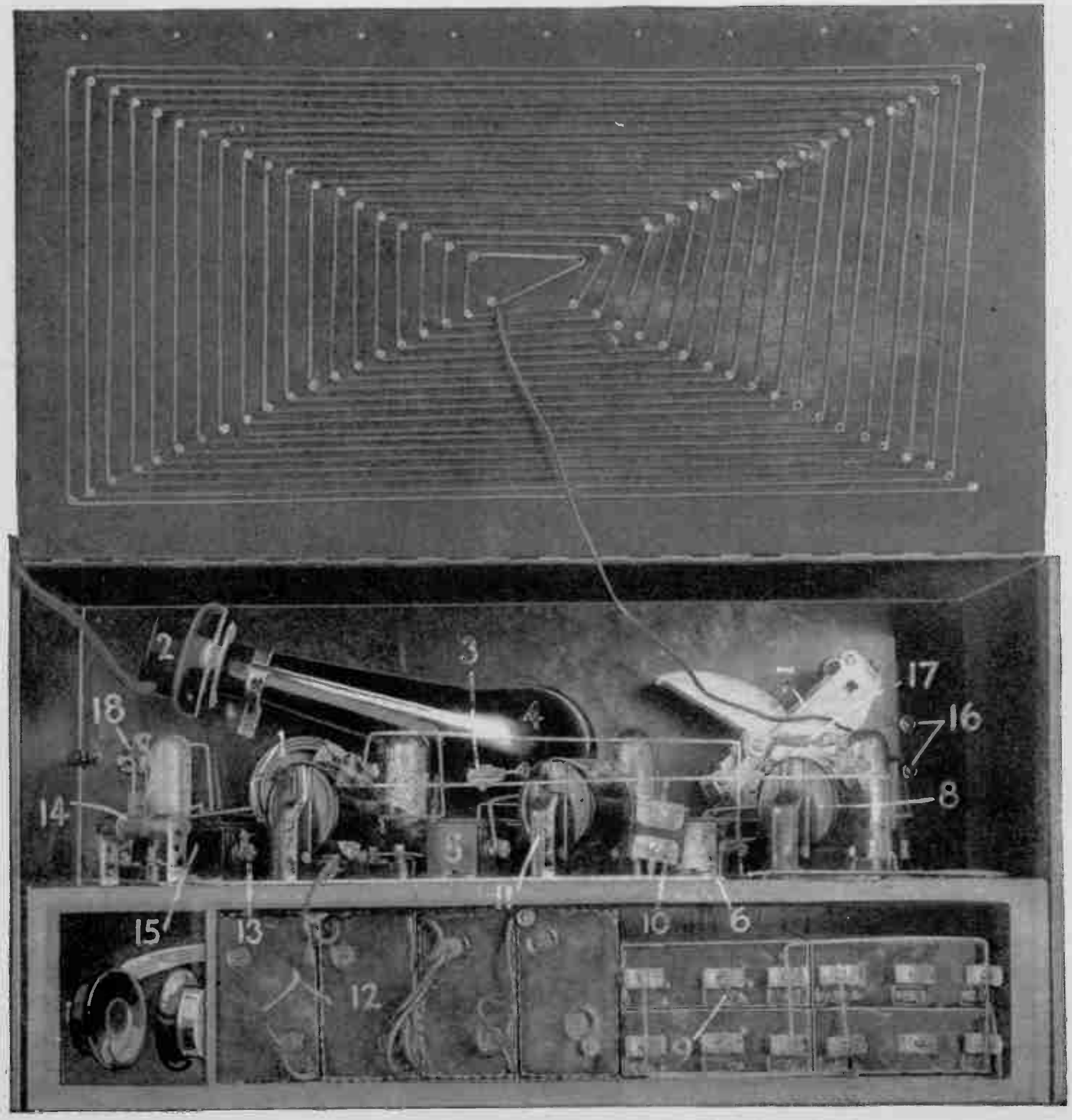
The rear piece is 11½ x 21½ inches, while the top is 8½ x 22. The loop is built in the larger piece. It consists simply of twenty turns of flexible wire cable wound on tacks driven into the board. Two leads are taken from the loop to the binding posts on the front of the panel. The top and bottom are fastened with a running hinge, so that they may be placed over the set for protective covering. The handle, which may be of leather, is attached to the center of the top piece. A set of hooks or latches are placed on the two pieces in order to hold them to the remainder of the set.

The tuning of the set is the simplest possible. The loop is connected and the filament rheostats turned up. The variable condenser is then varied until the signal comes in when the potentiometer is adjusted for the greatest intensity of signal. There are actually only two controls on the set. It is light, compact, rugged and—truly a portable set.

The operation of the set meets all the requirements that one could impose. It is very selective, both on account of the potentiometer control, and of the use of the straight-line frequency condenser. There is absolutely no crowding of the stations at the low dial readings, and it is a very easy matter to tune exactly to the peak of any wave.

The volume of the output of the receiver is likewise very satisfactory, as is the quality, and this set represents about the best type that an experimenter could build for portable use, other than, perhaps, a super-heterodyne, which, as a rule, would cost considerably more to construct than this one.

The range of the set is from 550 meters to 200 meters, which includes the total range of the present broadcasting wave-lengths. If it is desired to go to the shorter wave-lengths, as may be desirable in the near future, all that is necessary is to provide a tap on the loop. This has been done in this set, the tap on the loop being controlled by a two-point switch on the panel.



Interior of the portable receiver. The numbers correspond to those on the opposite page.

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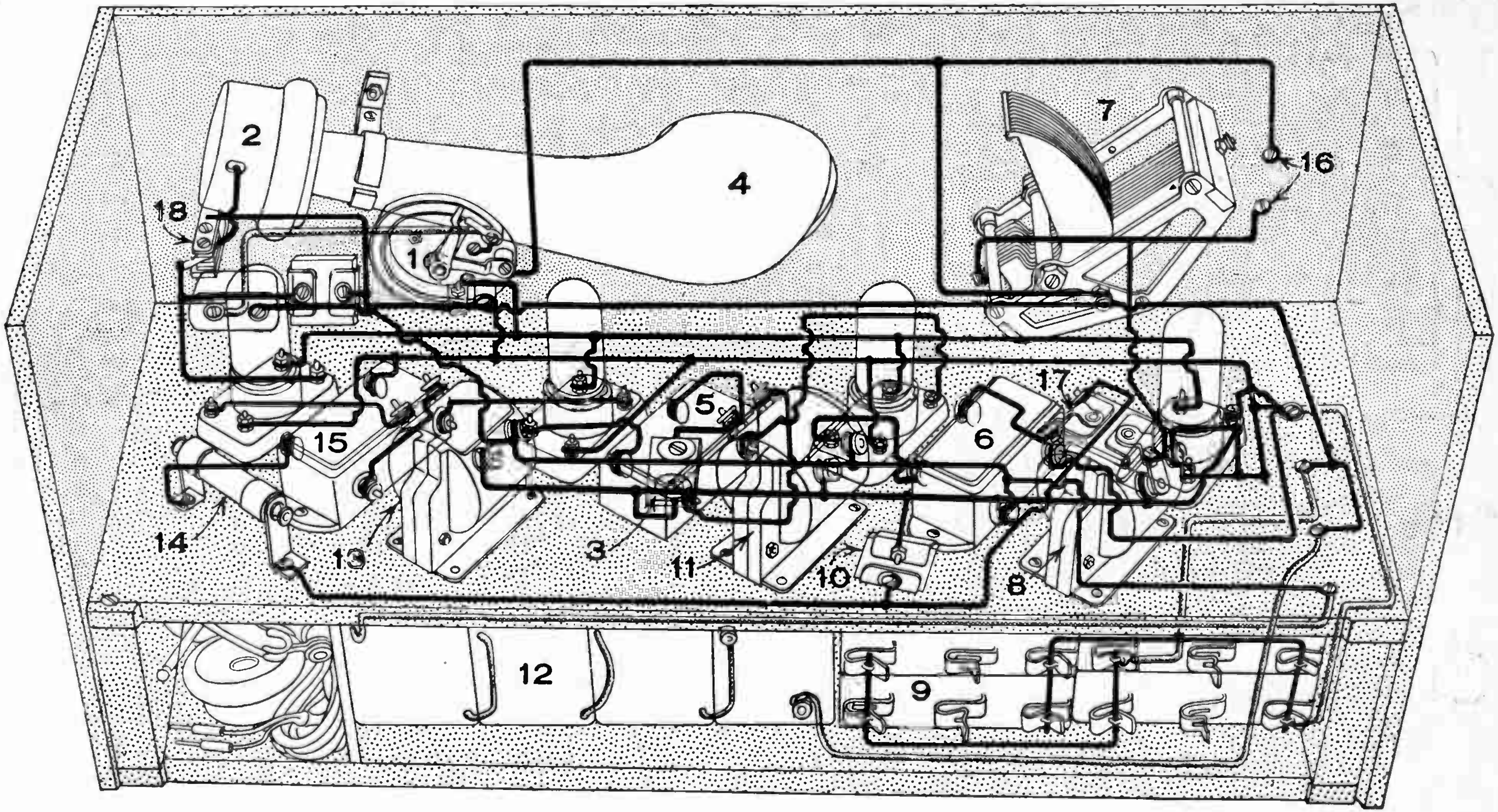

PERSPECTIVE LAYOUT OF PORTABLE SET

1. Combined potentiometer and rheostat, 400 and 30 ohms, respectively. 2. Loud speaker unit. 3. By-pass condenser. 4. Horn. 5 and 6. R.F. transformers. 7. Straight-line frequency condenser. 8. A.F. transformer. 9. "B" batteries. 10. By-pass condenser. 11. A.F. transformer. 12. "A" batteries. 13. A.F. transformer. 14. Crystal detector. 15. R.F. transformer. 16. Loop binding posts. 17. By-pass condenser. 18. Phone jack.

World Radio History

The Hoyt Augmentor Circuit

By FRANCIS R. HOYT

This receiver is an interesting one for the experimenter, as it has several new features. The set shown was constructed in the RADIO NEWS *Laboratories and gave excellent results.*

IN presenting this new system of radio reception, it will probably be well first to set forth its general electrical characteristics from an operating point of view, and then proceed to point out its chief virtues, before entering into a discussion of the principles of operation.

Signal augmentation, as the name implies, is a system of radio frequency amplification or magnification in which the initial signal is augmented by a properly phased signal impulse of exactly similar character; this reinforcing impulse, however, has as its source a circuit which is entirely independent from that to which it ultimately comes to add its effect. The details of this action and reaction will be seen shortly, so for the moment suffice to say that the general electrical characteristics to the ear—or from an audible point of view—are somewhat similar to the well-known regeneration system. Although it will be obvious shortly that this apparent similarity ends with the audible characteristics and that, unlike regeneration, the circuit does not radiate energy, cannot be made to distort a signal and is not subject to body capacity effects.

The distinguishing features of this new system might be set down in the following fashion:

1. Extreme selectivity
2. Sensitivity
3. Tone quality.

Whatever degree of popularity it has attained and is attaining can be attributed to these three qualifications.

THE FUNDAMENTAL CIRCUIT

The fundamental augmentation circuit shown in Fig. 5 bears a striking superficial resemblance to two familiar types of radio circuits. This resemblance has led to its being confused with those circuits by the casual observer.

First: The variable coupling between the

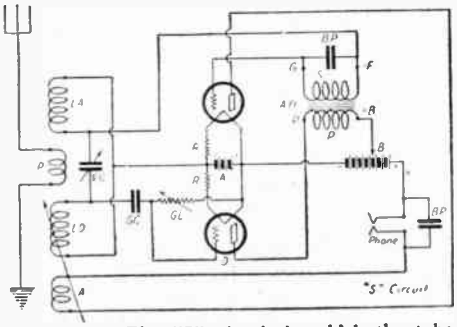

Fig. 1. The "S" circuit in which the tube functions as both an A.F. and R.F. amplifier.

"Booster" and the grid coil (designated LD on the diagram) bears an outward similarity to the tickler form of regeneration; second: the parallel disposition of the two tubes, one at either end of the secondary inductance, appears to approximate "push-pull" circuits. The following description of the operation of the augmentation system may be of some assistance in dispelling those illusions.

An incoming wave of radio frequency energy passing through the primary coil (P) coupled to the secondaries LA and LD, would cause a corresponding voltage variation across the outside terminals of these secondaries which are connected to the grids of two tubes. This voltage would be of opposite polarity or phase at opposite ends of the coils. Consequently, the grid of one of these tubes would receive a positive charge, while the other would be acted upon by a negative impulse. Now, one of these tubes is connected as an amplifier and the other as a detector (having a grid condenser in its grid circuit), therefore, when the amplifying tube is acting to magnify the positive impulse the detector tube is simultaneously rectifying or detecting the accompanying negative flow. Here the "Booster" coil comes into play, the magnified energy of the positive charge appearing in the plate circuit of the amplifying tube passes through the booster coil, where it is placed in the proper phase to lend its additive effect or augment the negative impulse at that moment being detected. The degree of this auguementation is regulated by the percentage of the coupling.

THE "S" CIRCUIT

The feeble radio frequency currents traveling through the augmentation or amplifying tube do not begin to load this tube to even a small degree of its amplification possibilities. It was, therefore, a logical conclusion that the tube should be so connected in the circuit that it could perform additional duty.

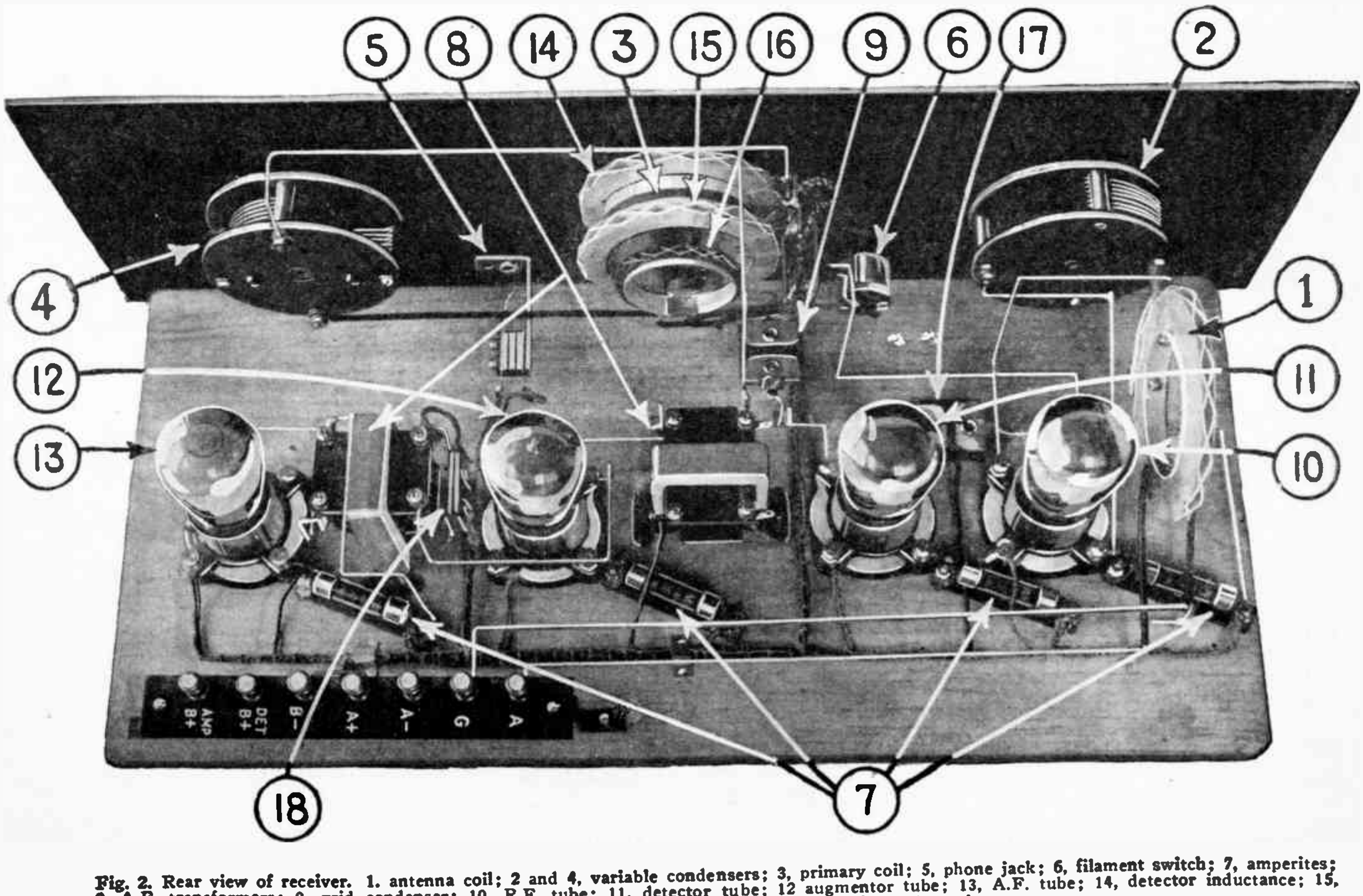

Fig. 2. Rear view of receiver. 1. antenna coil; 2 and 4, variable condensers; 3, primary coil; 5, phone jack; 6, filament switch; 7, amperites; 8, A.F. transformers; 9, grid condenser; 10, R.F. tube; 11, detector tube; 12 augmentor tube; 13, A.F. tube; 14, detector inductance; 15, augmentor inductance; 16, augmentation coil; 17 and 18. by-pass condensers.

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By the circuit combination shown in the diagram, Fig. 1, the augmentation tube is made to function both as a radio and as an audio frequency amplifier. This may be called a reflex arrangement, although the performance characteristics are somewhat different.

After the signal has been detected in the detector tube and changed from a radio to an audio frequency impulse, it is communicated to the primary of an audio frequency transformer whose secondary has been connected in series with the grid lead of the augmentator tube. In this way, audio frequency voltage variations taking place in the primary of the transformer are transferred to the grid of the tube after having been magnified or "stepped-up" by the transformer. Upon reaching the grid of the augmentation tube these voltages cause an increased current to flow in the plate circuit and this is accompanied by an increased response in the phones.

A small condenser is connected across the terminals of the secondary of the transformer to permit the incoming radio frequency currents to reach the grid of the tube. These currents would otherwise be retarded by the choking effect of the secondary winding.

APPARATUS AND VALUES

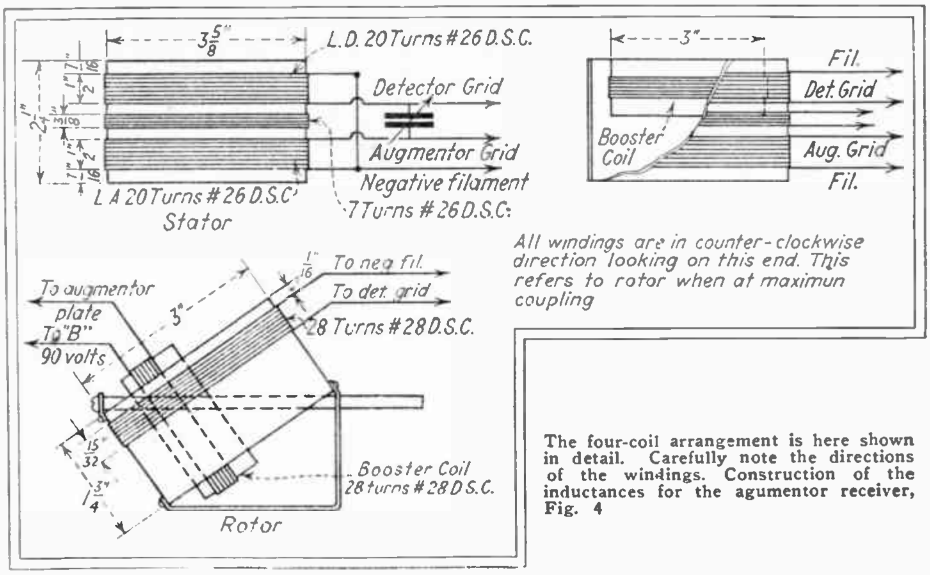
In the diagrams referred to in the preceding paragraphs, the various pieces of apparatus have been designated by symbols and no values have been shown. These values will be given later or will be found on the wiring diagram for the four-tube receiver—the symbols used are herewith explained:

LA—Augmentor inductance
P—Primary
LD—Detector inductance
A—Augmentation coil

The above four windings make up the augmentor coil.

Panel View of Augmentor receiver.

VC—Variable condenser
A—Augmentor tube
D—Detector tube
R—Amperites
GC—Grid condenser
GL—Grid leak
BP—Bypass condenser
AFT—Audio transformer



The four-coil arrangement is here shown in detail. Carefully note the directions of the windings. Construction of the inductances for the agumentor receiver, Fig. 4

The values for all of the various pieces of apparatus except the grid leak (variable), which should be from 1 to 6 megohms; the variable condensers, which are of .0003 mfd. capacity, and the coils, which will be given later, have been shown on the schematic diagram of the four-tube set.

It is important that the bypass condenser in the semi-reflex stage be of reasonably accurate capacity, .00025 mfd., and it is also necessary that a variable grid leak of reliable make be employed.

Since the Augmentor circuit is exceptionally stable, particularly in the matter of filament control, it is considered that better operation is secured through automatic filament control devices, such as the amperite, than by manual control or rheostats.

Straight-line wave-length condensers should by all means be given preference, and vernier attachments or vernier dials will be found necessary.

CIRCUIT WIRING

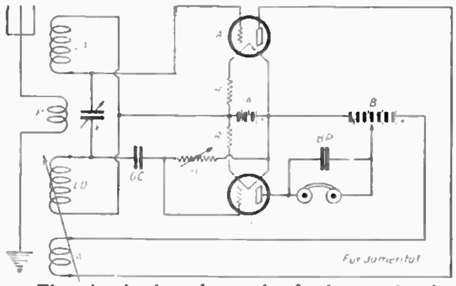
The augmentation system can be built up into receivers comprising any number of tubes from two to the practical limit, or, in other words, it is a principle of operation or fundamental circuit to which radio frequency and audio frequency amplification can be added at will.

The schematic wiring diagram for a four-tube set is shown in the illustration, Fig. 3, and a rear view photograph of a receiver of this type is shown in Fig. 2. This receiver is exactly the same as that shown in the schematic diagram shown in Fig. 3 below.

This rear view photograph, Fig. 2, also serves to illustrate the preferred arrangement of the physical apparatus, the relation of the augmentor coil to the condensers and indicates how admirably this receiver lends itself to cable or "harness" wiring.

COIL CONSTRUCTION

Fig. 4 is an illustration of an augmentor coil which has been designed around standard sizes of tubing and of simple solenoid winding with the object in view of affording a construction which can be made up in the home. While the low-loss coils manu-



The circuit that shows the fundamental principle of this interesting receiver.

factured expressly for this circuit are quite naturally to be preferred, nevertheless, there are those experimenters who prefer to construct their own coils and to those who carefully follow the data given, a very satisfactory set of coils can be constructed from these specifications.

The rotor consists of a 1¼-inch length of 3-inch outside diameter bakelite tube, while the stator is a 2¼-inch length of 5⅝-inch bakelite tube.

The augmentor coil is wound on the rotor and is made by winding 28 turns of No. 28 D.S.C., beginning the winding 1/16-inch from the edge.

The LD or detector inductance is first wound on the stator, beginning 7/16-inch from the edge and consists of 20 turns of No. 26 D.S.C. wire. A space of ⅜-inch is then allowed and the LA or augmentor inductance is completed by winding 20 additional turns of No. 26 D.S.C. wire.

The P or primary winding is wound in the center of the ⅜-inch space above referred to and consists of 7 turns of No. 26 D.S.C. wire.

The direction of the turns of the windings is shown in the illustration, Fig. 4, as well as the proper terminal connections.

When the rotor is assembled in the stator, it should (at maximum coupling) mount so that it will be midway of the stator, or in other words, ¼-inch on either side below the outside edge of the stator tube. This is shown in the drawing.

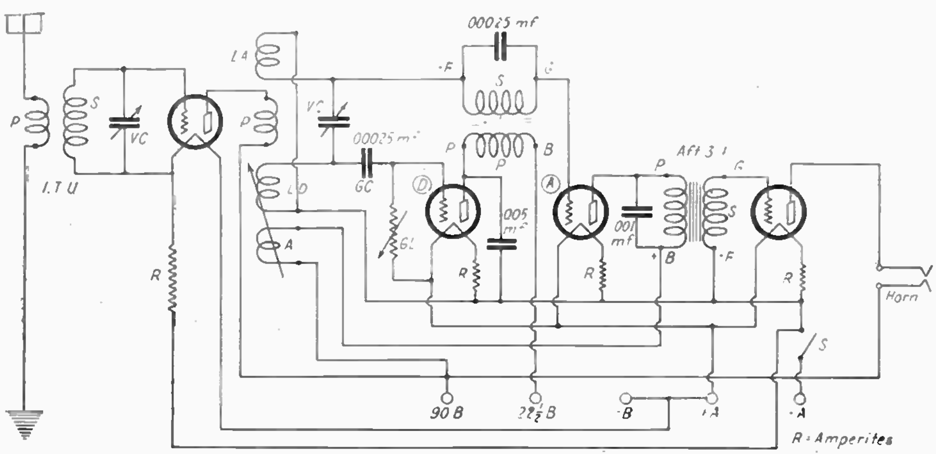


Fig. 3. Circuit diagram of the Augmentor receiver. D is the detector tube and A the augmentor tube.

"Push-Button" Radio

By BRAINARD FOOTE

The experimenter who enjoys building novel sets should be greatly interested in this method of selective switching by remote controls.

IF you're an avid DX fan don't bother with this. But if you happen to be one of those inexhaustible experimenters who like to tackle new stunts and thrives on novel accomplishments, here's an idea that may appeal to you.

Have you ever thought of the possibility of a radio outfit whereby a light touch upon the proper button brings forth entertainment from the desired broadcasting station? A set, furthermore, so constructed that all of the electrical apparatus necessary to actual reception, together with the storage and "B" batteries, is relegated to the attic, empty room or vacant closet? Where the living room is fitted up with nothing more formidable or unsightly than a small row of push-buttons and a loud speaker?

HOW WE DO IT

One man made a remote control set by having one tuning dial run by a reversible electric motor. This takes as much skill as adjusting the dial by hand, if not more, and it isn't easy to tell just where the dial is set. The arrangement which seemed more certain to me involves a row of magnets and a separate tuning system for each of the local stations that would be cut into circuit by the proper magnet and push-button. Inasmuch as distant stations aren't wanted, there is little use for radio frequency amplification. The set then incorporates a simple regenerative detector and two stages of audio frequency amplification.

Fig. 1 gives a general view of the outfit. At the left end of the baseboard the magnetic controller and contacts may be seen. Next come the coil and the individual condensers and finally the three tubes and the audio transformers. A fixed coupler is employed, with a tap for the antenna and a plate winding through which regeneration is obtained. The primary of the first audio transformer acts as a radio frequency choke, the feed-back being adjusted by a fixed coil and adjustable capacities for each station.

THE CIRCUIT

Connections appear in Fig. 3, except those for the push-buttons and magnets. The audio frequency portion of the set is of the customary type, using two transformers. Coils L-1 and L-2 may be wound on the same length of tubing—a cardboard cylinder about 4 inches long and 3 inches in diameter serving nicely. L-1 consists of 45 turns of wire in the neighborhood of No. 24 in size, preferably double-covered. L-2 is started with a ⅛-inch gap between the coils, and has 20 turns of wire. The tap for the antenna connection will depend upon the size of the antenna and its capacity. It is placed near enough to the filament or ground end of coil L-1 to provide good volume without interference among the local stations to be received. Usually, the tap goes at the tenth turn, or less, if interference is encountered.

The tuning condenser C-1 and the regeneration condenser C-2 are similar. These are seen beneath the coil in Fig. 1. Two pieces of wood, about ⅜ of an inch thick and measuring 10 by 2¼ inches, form the clamps by which the plates are fastened. There are two fixed plates in each condenser, cut 10 by 2¼ inches also. For separators, pieces of photographic film are the most satisfactory. A discarded roll may be obtained from any photo store. Four sheets measuring 10 by 2¼ inches are cut from it. The plates may be of thin zinc, aluminum or brass—the thinner, the better. Holes are drilled with a No. 27 drill for 3 No. 6 wood screws that are to hold the condensers to the baseboard or table on which the set may be assembled. One screw is placed at the center and one at each end. In assembling the condenser, one of the 10 by 2¼ metal plates is laid on the table first, then one of the film sheets, next the other film sheet and finally the second metal sheet. The wood strip goes on top to clamp them together. For connections, lugs may be left extending from each plate as it is cut, or lengths of magnet wire may be soldered to the plates.

THE AJUSTABLE PLATES

The condensers, as explained so far, have two stator plates each, but no movable plates. There are to be enough movable plates to provide one for each local station. Since reception of the New York stations was the factor controlling the construction of the set illustrated, it was first necessary to know what stations were received with good volume with a three-tube regenerator at the location in mind. These proved to be as follows:

No. 1 WNYC, No. 2 WEAF, No. 3 WJZ, No. 4 WOR and WJY, No. 5 WHN, No. 6 WGBS and WAHG, No. 7 WFBH and WBBR, No. 8 WAAM.

Station WMCA was included in the list at first, but it was finally omitted because the interference from WHN was too strong. This accounts for the fact that, although nine controller magnets are shown in the photo, but eight are considered in the construction. Eight will probably be sufficient for most locations, as there are usually one or two "poor stations" for every listener in the metropolitan area. Some stations operate jointly on the same wave-length, making it necessary to have but one contact magnet for both.

Each station is tuned separately by its own fixed condenser, the stator or fixed plate of which is common to all of the condensers. These plates have just been described. The adjustable plates vary in size from a mere narrow strip, perhaps 1 inch by ⅛ inch for the shortest wave-length of WAAM, to a sheet 1½ by 2 inches for WNYC, the longest wave-length. The wide range of capacities obtained in so small a space is due to the closeness of the plates—a few thousandths of an inch representing the separation given by the photographic film. A length of magnet wire is soldered to each plate or fastened to it by a short machine screw and nut, and the capacity regulation is made by sliding the plate in and out with the fingers or a pair of pliers. The capacity of the body does not seriously interfere with this adjustment because the adjustable plate is connected to the filament side of the circuit. It is best to push the plate in between the fixed plates to almost the proper point, and then obtain the final setting by using a piece of bakelite rod or wooden stick as a lever. The regeneration condenser is adjusted in a similar way, just below the "squealing" point. The actual width of the plate is best determined while the set is in operation, the plates being made narrower with a pair of shears. The screws clamping the condensers should be set up until the movable plate is gripped firmly, but may still be slid in and out. Before these movable plates can be made, however, it is necessary to build the controller.

THE MAGNETS

If eight stations are chosen for the push-button set, sixteen magnets will be needed. One-half pound of No. 26 double-covered wire will be more than sufficient. For the magnet cores, 16 iron stove-bolts with flat heads are employed, these being ¼ of an inch in diameter and about 2½ inches in length. The thread should run nearly to the head and two nuts are needed with every bolt. A hand-drill capable of holding a ¼-inch drill in its chuck will expedite the winding. It may be clamped in a vise, the wire measured off and guided back and forth with one hand while the drill handle is turned with the other. Forty feet of the magnet wire suffice. One wrap of friction tape is placed on the bolt first and two or three wraps on the finished winding. The coil is placed next to the head of the bolt and should be about one inch in length. It is not necessary to "layer-wind" the magnet. In actual use, the coils become warm if the current is permitted to flow for several minutes, but since these magnets are but for use limited to two or three seconds at the most, this factor is of little consequence. Fig. 4 illustrates the magnets and their mounting.

The framework for the magnets is made of four wooden blocks. The inside measurement should be about 3 by 10 inches and

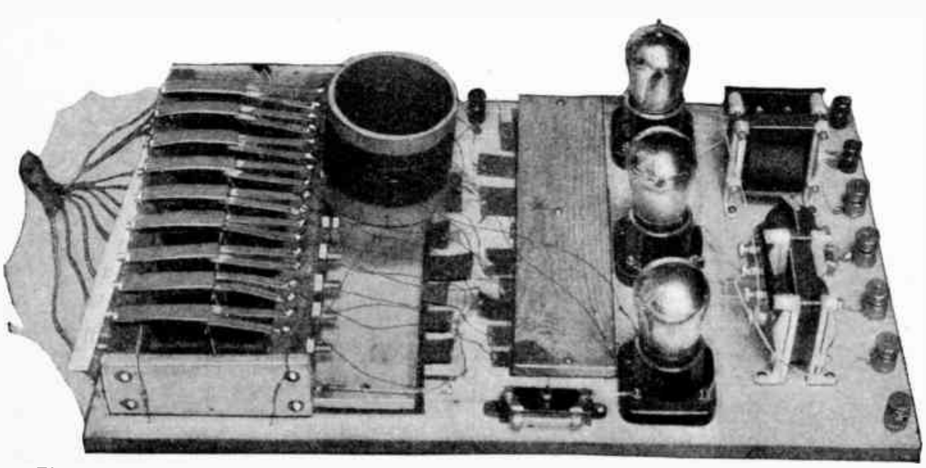


Fig. 1. At the left are the magnetic controllers and contacts, with the cable leading to the remote control board. The coil is above the board that holds in place the individual condensers.

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the height about 2 inches. The magnets are mounted in a row, eight to each side-piece of the frame, on the horizontal center line and about one inch apart. They should be opposite, since one is to pull an armature to the "on" position and the other to pull it back to the "off" setting. The space should be about 3/16 inch, this being adjusted after the connections are made and ready to test. The armatures are cut from a sheet of galvanized iron about No. 26 in gauge, each being ⅝ of an inch in width and 2¼ inches long. Pencil marks ¼ of an inch in from each end indicate points where the armatures are bent. The axis for the armatures is a length of heavy galvanized iron wire (No. 12 will do) held in holes in the end-pieces of the frame. A piece of this wire can be employed to bend the end of the armature, as shown in Fig. 4. The first bend for this end may be made by clamping the armature in the vise with the wire and the finishing bend may be done with a pair of pliers. The upper end is bent to an angle, as illustrated.

The springs are cut from very thin sheet phosphor bronze. The sheet used in the set described was 10 thousandths of an inch in thickness. Springs A and B are one-half an inch wide and the end of spring B is bent nearly at right angles, so that a movement of the armature to the left will raise it and permit it to rest on top of the armature. Springs C and D are ¼ of an inch wide, and are in line with each other, as seen from the side. Moving the armature to the left thus closes four contacts at once. To improve the contact, the ends of the contact springs may be silver-plated electrically, or all contact points may be tinned with the soldering iron. The latter method will require a little sandpapering now and then to improve the conductivity. The magnets are individually adjusted so that the motion is as short as possible. The springs are held by short wood screws, and are bent by lifting or depressing with the fingers. The magnet positions are easily changed by loosening the nuts and re-adjusting them. The armatures must not grip the axels too tightly, and a few drops of oil on the sloping top of the armature and at the axle will improve the operation. The armatures are spaced by stringing two or three 8/32 nuts on the wire between them. To attach the controller frame to the baseboard, two screws may be introduced from beneath the base. Should the "off" magnets operate sluggishly, two dry cells in series may be put in at point "X," Fig. 5.

MAGNET CONNECTIONS

The "off" magnets operate in unison, through a series-parallel arrangement. Thus a single "off" button serves to turn off the set and detune a given station. The push-button may be of the "flush" type, mounted in a row of holes of suitable diameter drilled in a hard-wood block. The buttons are made in a simple manner from a length of ¼-inch bakelite rod. Nine holes are drilled in a neatly planed and sandpapered oak block about 2 by 7 inches and 1 inch thick. The holes for the buttons are located ¾ of an inch apart. Fibre washers having ¼-inch holes encircle the buttons, being glued in position. The ends of the buttons are filed down slightly and sandpapered to move freely in the washers.

The bottom of the block is hollowed out with a chisel, 1½ by 6½ inches. Nine short contact springs are fastened in with small wood screws, with their ends projecting over the holes directly under the buttons. A common contact plate is screwed in position also, in such a manner that a push on any button brings its spring into contact with the common plate.

Next a suitable location for the receiving set, batteries and aerial and ground leads is chosen. Then the proper point for the control buttons and the loud speaker is selected. The push-button block is most convenient for use when it rests on the living-room or library table. A piece of felt may cover the bottom. Twelve connecting wires are needed, for which from two to four pounds of bell wire will be necessary, depending upon the distance to be covered. These wires are cut to the measured length and bunched into a "cable." Strong black thread or twine serves to tie the wires together and they may be taped where they are visible in the room. The wires can be run through a hole in the floor and thence to the destination via the cellar ceiling, or it may be more convenient to run them along the baseboard of the room.

Fig. 5 gives the connections for the cable and controller systems. A battery and voltmeter or battery and lamp are used to "test out" the various wires, and to do this, it is convenient to bring the push-button end of the cable into the receiving room and leave it there while adjusting the controller. The loud speaker wires are put on first and then the negative "A" battery wire to the common plate or common posts of the push-button block. Next the "off" button No. 9 is connected and the "off" action of the armatures tested. One push of the "off" button should pull all of the armatures back into the "off" position. In practice, only one at a time will be set to "on," however. The individual "on" contacts are connected next, it being advisable to arrange the controller contacts and push-buttons in the order of station wave-lengths. This is followed in the figure.

Before attempting to tune the station, it is extremely important to make certain that there are no short circuits anywhere—as between the magnet windings and their cores—and that all contact springs open and close as they should when the proper buttons are manipulated. The connections of Fig. 3 do not include the magnet and push-button connections, but are those for the tuning

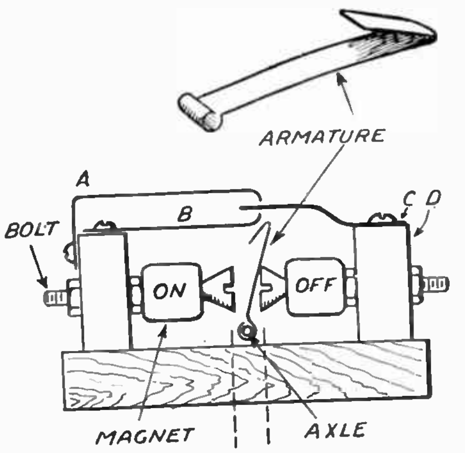

FIG. 4

The details of the switch for tuning in stations by pressing a button.

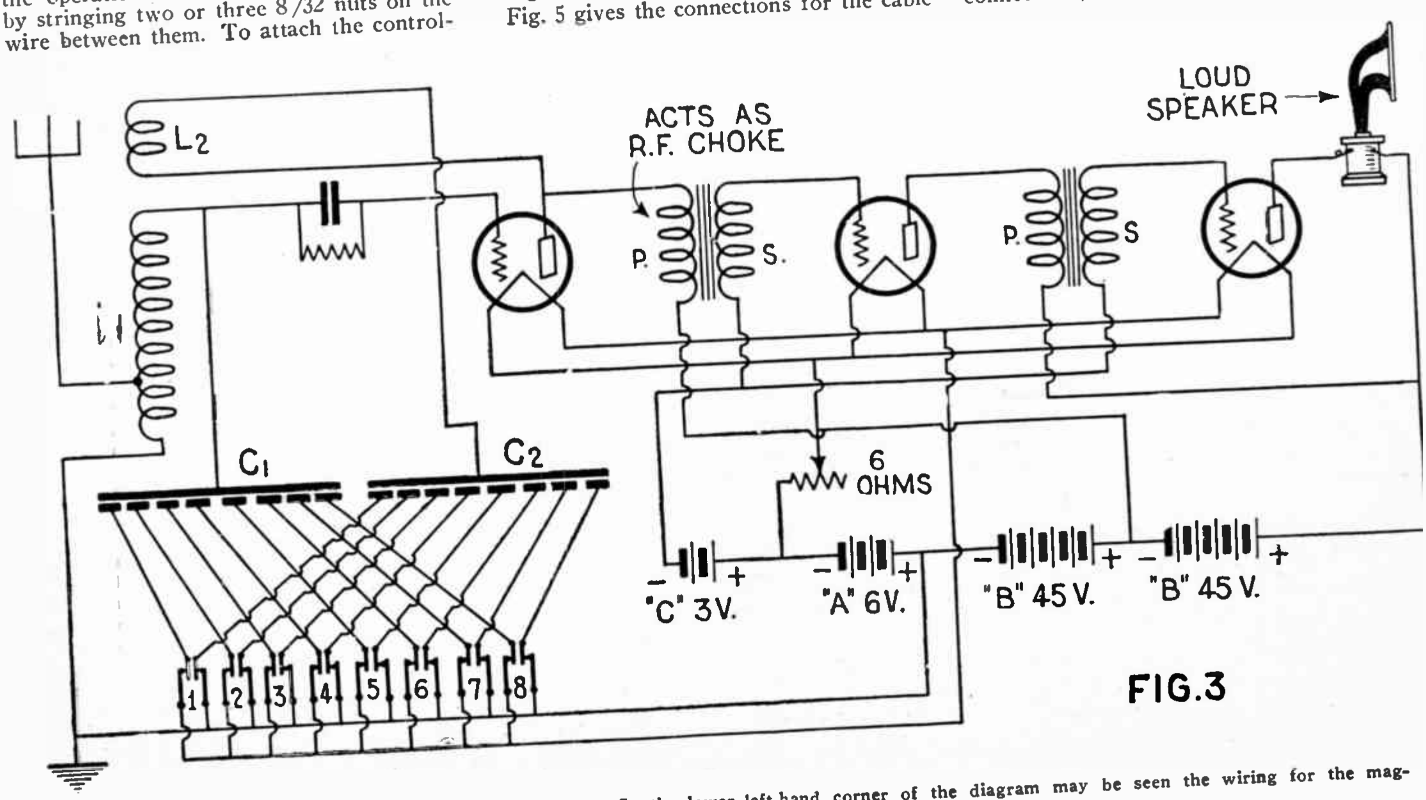

FIG.3

The circuit diagram of the "push-button" radio receiver. In the lower left-hand corner of the diagram may be seen the wiring for the magnetic switches.

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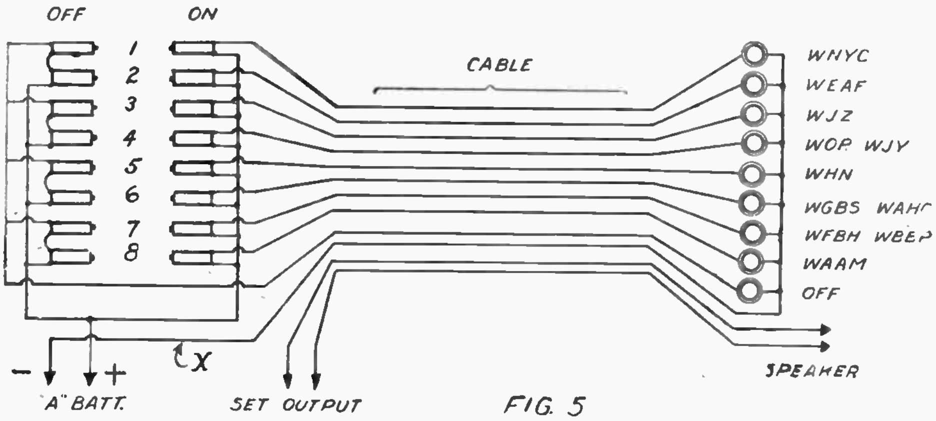

FIG. 5

How the switches and the push-buttons are connected. The connecting wires may be made into a cable.

and amplifying circuits exclusively. The condenser contacts of the controller are shown side by side, whereas they really would appear one behind the other in a side view.

TUNING UP

The late afternoon and evening is the best time for adjustment of the individual condensers, since the stations will be in operation. Starting with the station of shortest wave-length, the corresponding button is pushed to bring the armature into position and close the contacts. This lights the tubes and makes contact to the proper condenser springs. The condenser strip for this station, in this case WAAM of Newark, may have to be very small—a strip about half inch wide being used at the start. It is then "pared down" with the shears until it may be pushed nearly all the way in between the two fixed plates of the tuning condenser for correct tuning. Meanwhile, the regeneration condenser is set for good sensitivity without actual oscillation. When the circuits are very close to oscillation, the capacity of the hand may interfere, and it is for this reason that a stick is helpful in making the final touches on tuning and regeneration.

When the first station is tuned so that it may be switched on and off at will, the next one is adjusted for similarly. As the wave-length increases, it will be necessary to use larger sheets of metal for the movable plate of the condenser. In each case, the minimum possible width is employed, so as to allow plenty of room for those of still longer wave-length. Trouble will probably be experienced first with some of the contacts, but this can be corrected by bending the springs so that no short circuits occur. The circuit used is such that no harm will result should a "short" occur between the plates of the regeneration condenser. The 45-volt "B" battery will be connected across the primary of the first audio transformer and a loud click will be heard in the speaker should this happen.

OTHER APPLICATIONS

Listeners in centers like Chicago, Philadelphia, Boston, San Francisco, etc., where three to ten broadcasters are on the air, may easily adapt the suggestions of this article to their own needs. For each station to be received, two magnets are required and a set of contacting springs. As for the push-buttons there is one per station and one additional button whereby the set is turned off. In a city where there are only three or four main stations, as in Philadelphia, for instance, the listener may provide one or two extra contacts and magnets for the best DX stations. On favorable nights, these stations can be received. The fact that two local stations, often divide up the time on the same wave-length simplifies matters a good deal. In Philadelphia there are WOO and WIP on the same wave-length and WLIT and WFI also. In New York we have WOR and WJY, WAHG and WGBS, and WBBR and WFBH in dual operation.

In closing, let's sum up once more the principal advantages of push-button radio:

1. Every station accurately tuned, ready to be heard.
2. Quick and simple action in transferring from one to the other.
3. Elimination of unsightly wires and apparatus from living room.
4. Absence of radiation caused ordinarily by carelessness or inexperience in tuning.

Neutrodyne Receivers

By A. L. GROVES

Because of the popularity of Neutrodyne receivers at the present time we believe this article by Mr. Groves will prove of considerable interest to our readers. There are a number of little improvements that Mr. Groves has worked out that will no doubt be of benefit to many.

TAKING all things into consideration, the Neutrodyne method of reception is one of the most satisfactory systems for reproducing broadcast programs. It is second only to the Super-Heterodyne, which employs many more tubes than the Neutrodyne.

Just what form the receiver should take depends upon the desire of the individual, but whichever of the forms given here is selected, there will be little cause for regret.

In its most condensed form the Neutrodyne circuit consists of two stages of tuned radio frequency amplification with the tube capacity neutralized to prevent regeneration. To this may be added audio frequency amplification in the usual manner.

For best results in such a circuit the two radio frequency tubes should be type UV-201A or C-301A and the detector type UV-200 or C-300. The audio frequency amplifier tubes should also be UV201As orC301As. All of these tubes require a 6-volt "A" battery, and from 45 to 90 volts may be used on the plates of the amplifier tubes as the "B" battery. This should be tapped at from 18 to 22½ volts for the detector.

Such a set will reproduce speech and music much more clearly than the usual types of receivers. Fairly strong signals on an ordinary regenerative receiver will be equally as strong and much clearer on a Neutrodyne of this type, and selectivity will be many times greater, but signals which have been received faintly on a *good* regenerative set may be entirely inaudible on this type of Neutrodyne. However, the difference will not be great and the loss in the faint, distant signals will be compensated for by greater clearness and selectivity and the ability to re-set all dials instantly to any given wave-length or station. Also it will be noted that the decrease on the weak signals will be much more noticeable on the shorter wave-lengths than on the longer ones. Such a set may be used with dry cell tubes provided not more than 45 volts are used as the "B" battery in conjunction with correct "A" battery. The over-all results with such tubes, however, will be very, very poor. If the use of dry cell tubes is compulsory, a considerable improvement can be made by adding a very small coil and condenser in the plate circuit of the radio frequency tubes as shown at X in Fig. 1. The coil may be composed of 10 turns of wire on a 3-inch cylinder and the variable condenser given just enough capacity to allow the set to be completely neutralized by the neutrodons in the regular manner. The coil is then left strictly alone and the operation of the set performed in the usual manner. The arrangement will not, however, compare with the use of the recommended tubes.

Rear view of a five tube Neutrodyne receiver showing the arrangement of the instruments. This consists of two stages of tuned radio frequency amplification, a detector and two stages of audio frequency amplification.

REGENERATION ADDED

The standard Neutrodyne circuit can be considerably improved for reception of weak signals and a more uniform action over the entire range of broadcast wave-lengths by adding regeneration in the plate circuit of the detector tube. This may be conveniently and easily accomplished by connecting an ordinary variometer designed to cover wave-lengths between 200 and 600 meters in detector plate circuit, as shown in Fig. 2.

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With such an arrangement, using six-volt tubes the set becomes equally as sensitive to weak signals as the very best regenerative receiver, at the same time retaining the desirable qualities of clearness, volume and selectivity. It will be noted that the increase in sensitivity caused by regeneration is more noticeable on the short waves than on the longer ones.

While such a set will operate very well on small aerials, or even on a loop, it is not at all recommended for this class of work. The aerial, acting almost entirely as a collector and not being tuned direct, should be made as long as conveniently possible, up to 350 or 375 feet total length of single wire. It should run as directly away from the instrument as possible and preferably from 40 to 60 feet high, especially at the end away from the instrument.

With such a set and aerial as described, all Class B stations within 200 and 250 miles should be easily received any time during the *day* under average winter conditions. If two stages of audio frequency amplification are added, loud speaker reception of such stations should be accomplished with ease, even at mid-day. Under favorable conditions considerably greater distances can be covered.

Being highly selective there is practically no interference between class "B" stations on such a set and aerial, as long as the stations stay tuned to their assigned wavelength. For instance, my station is located less than 40 miles from WCAP and WRC, which stations use a wave-length of 469 meters. On the next higher wave there are two Texas stations, WBAP and WFAA, both of which are more than 1,200 miles from me, yet the Washington stations can easily and completely be eliminated while receiving either of the Texas stations. Likewise WLW and WSAI operate on 309 meters, while Oakland, Calif., KGO, operates on 312 meters. The difference in scale reading between these two waves is only about three-quarters of a degree, yet either of the Cincinnati stations can be completely tuned out and KGO received with ease.

Photographs herewith show views of the regenerative Neutrodyne with two stages of audio frequency amplification. The panel is 7 inches high and 34 inches long. The instruments are so placed that all leads are extremely short and direct as possible. No fancy wiring is tolerated. After the set is constructed as carefully as possible, the neutralizing condensers are adjusted in the regular manner and trials made to determine if beat notes or regenerative clicks can be heard under any condition over the entire range of wave-length while the variometer is at its minimum inductance value. The job should not be considered complete until all oscillations have been eliminated.

EXACT READINGS

It will be noted by this time that all dials do not read exactly the same for any given wave-length. This is due to several causes, chief among which is the almost impossible task of making condensers and inductances of exactly the same values and the fact that the first dial is somewhat influenced by the aerial and ground system and the third dial is usually still more influenced by the different characteristics of the detector tube and detector circuit from those of the two radio frequency tubes and circuits.

However, if standard neutroformers are used, the dial readings should not vary more than four or five degrees at most.

Select some station operating on or slightly above 400 meters, WHB on 411 meters is usually selected for this purpose; make careful note of the position of each dial and then figure the average reading of each. Loosen slightly the dials on the condenser shafts and, holding the rotary plates stationary while the dial revolves, set all dials to the average. Then listen for the station again and see that it tunes in with a maximum intensity with all dials at exactly the same figure. If this operation has been performed correctly all other stations in class B and C range of wave-lengths should tune in with the dials reading with not more than one degree of difference. If such is not the case another further average is necessary. The work consumed in this process will be amply repaid in simplified tuning.

As the different stations are heard, a log should be made of the dial settings of each, so that they may be tuned in again at any future time. The variometer dial is, of course, only used when signals are not strong enough without regeneration, so this adjustment may not be taken into consideration most of the time.

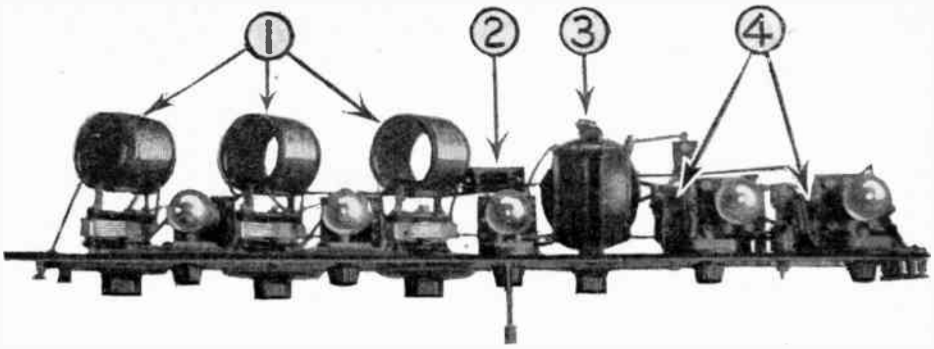
Should a station not be brought in at exactly the same setting at different times do not blame the set. It is only necessary to remember that all transmitters do not stay absolutely on their assigned wave. Note the standard wave stations as given by the Bureau of Standards and calibrate the set by them as far as possible.

If experiments with commercial models have proven unsatisfactory, it is suggested the accompanying diagrams be studied and the set rewired according to one of them, taking particular care that a rheostat is used for each tube, connected as shown.

Under no circumstances try to force loud signals by using too much "B" battery; 67½ volts will prove sufficient and under no circumstances should more than 90 volts be used. It will be found well worth while to place the component instruments on the panel strung out in order approximately as indicated in the wiring diagram rather than attempting to save space by the use of a short panel and a sub-base.

SEPARATE UNITS

In building a non-regenerative receiving set of the Neutrodyne type,



Top view of the Neutrodyne set showing the position of the apparatus. No. 1 shows the Neutroformers; 2 is the grid condenser; 3 is the detector plate variometer; and 4 shows the A. F. transformers.

Front view of the Neutrodyne receiver shown above. Separate rheostats are used for each tube. The small knob and dial on the right center of the panel is the regeneration control.

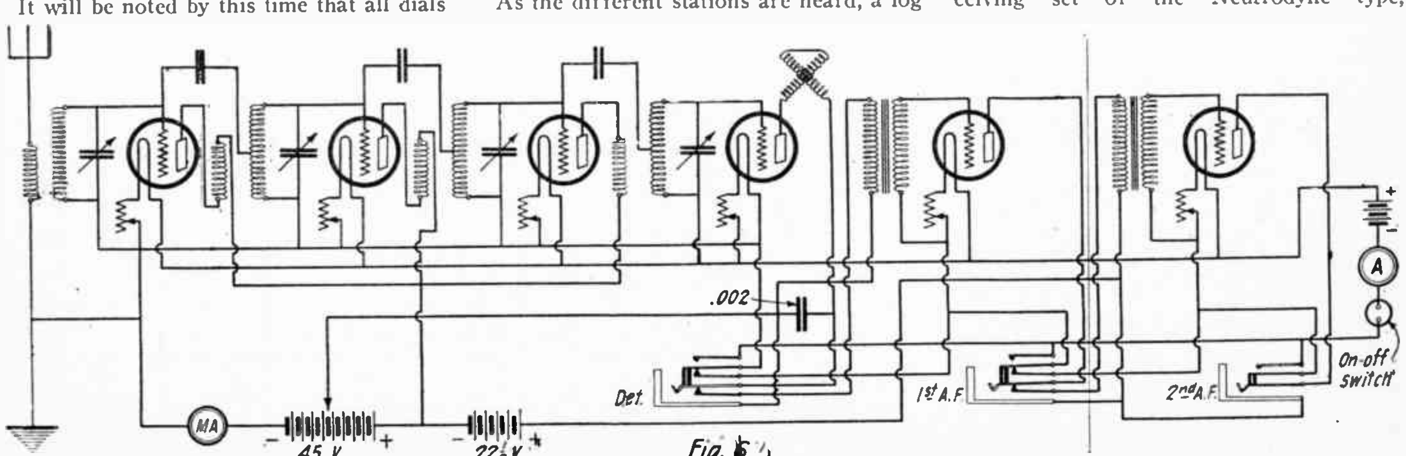


Fig. 3. Better results may be had when UV-199 tubes are used by employing three stages of R.F. amplification. The tuning of such a receiver will be extremely difficult. Here is the circuit. Filament control jacks are employed on the detector and audio frequency amplifier tubes.

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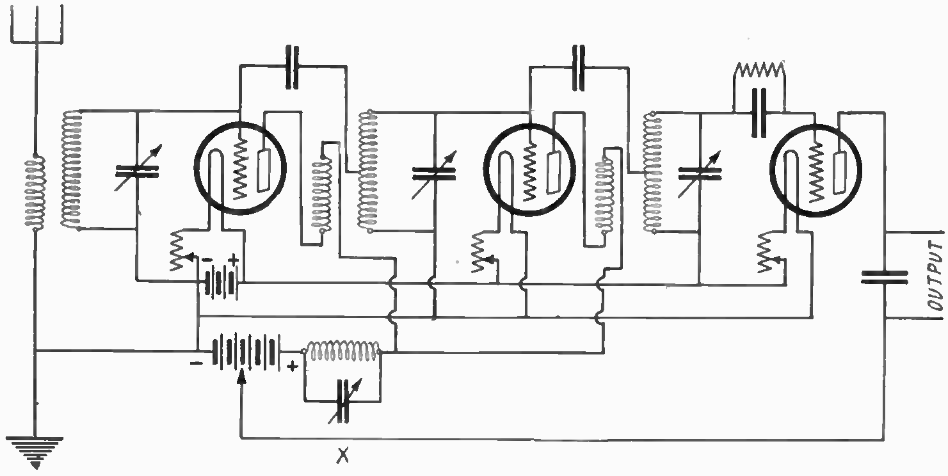

Fig. 1. Circuit diagram of a standard three tube Neutrodyne. If UV-199 tubes are employed better results will be had by using the coil and condenser shown at X.

plus two stages of audio frequency amplification, the panel should be at least 7 by 30 inches and if regeneration is added, as in Fig. 2, an additional 4 inches must be added to the length of the panel. It pays well to arrange the instruments after this fashion, but if it is not desired to have one panel this length, it is recommended that the main tuning unit and the audio frequency amplifiers be built separately. If this plan is followed, a standard 7 by 21 inch panel should be used for a non-regenerative Neutrodyne and a standard 7 by 24-inch panel for the regenerative instrument. The audio frequency amplifier unit including the filament control jacks, etc., should then be made on a panel not less than 7 by 10 inches.

If it is impossible for the owner of a Neutrodyne to get up a fairly long aerial, much better signal strength and distance will be obtained from a short aerial by replacing the first neutroformer with a fixed coil. Thus only two neutroformers are used, the first having its place taken by the coil and condenser unit which is connected to the grid of the first tube in the well known single circuit manner. All aerials having total length of less than 150 feet should, by all means, use this system if greatest volume and distance is desired. For all ordinary purposes, the coil should be made by winding 75 turns of No. 24 D.C.C. wire on a 3-inch bakelite tube. The condenser should be of approximately .0005 mfd. capacity.

Care must be exercised in placing this coil and condenser so the minimum coupling between this unit and the adjacent neutroformer results.

Should one wish to make a Neutrodyne especially for UV-199 or C-299 tubes, desiring results rather than great simplicity in tuning, the three-stage method will prove exceptionally good. The set is constructed as the one shown in Fig. 1 except the addition of one neutroformer. A 6-volt "A" battery, either a regular storage battery or four dry cells reduced to below three volts by a suitable rheostat of 50 or 60 ohms resistance on each tube, is recommended and not more than 45 volts of "B" battery must be used on the plates of any of the tubes. Due to the design of factory-made neutroformers, it is advisable to use standard size tube sockets with adapters to fit the small tubes rather than to use sockets designed especially for these tubes. Even then it may be found necessary to connect one or more of the neutrodon condensers directly across the grid and plate terminals of one or more tubes to prevent oscillations. A milliammeter, with a scale reading of 10 to 50 milliamperes, connected in series with the "B" battery will greatly aid in properly adjusting the set. No great difficulty should be experienced in adjusting the set so it functions properly over the entire range of class B and C wavelengths, through many slight changes in the adjustments of the neutrodons may be necessary before the job is finally complete. See Fig. 3 for connections.

Where very short aerials are used, the first neutroformer should be replaced by a fixed coil, as described before, in which case only three neutroformers will be required. Such an arrangement, plus two stages of audio frequency amplification, has given loud speaker reception with fair regularity during the winter months from stations 1,000 and 1,500 miles away, using an inside aerial less than 20 feet long and not over 10 feet above the ground. It is, however, recommended that for better results the audio frequency tubes be either UV-201As or C-301As in conjunction with an extra 22½- or 45-volt "B" battery. Such a set is shown in the accompanying photographs. With one stage of audio amplification signal strength of distant stations is equally as great as on a regular five-tube non-regenerative, two stage audio set. The advantages of clearness, freedom from tube noises, decrease in the strength of static, etc., when only one stage of audio amplification is used, is not to be overlooked.

AMPLIFICATION.

Two stages of amplification are, of course, necessary for good reception from far distant stations, or for reception of distances over 100 or 150 miles in the daytime on a loud speaker. No better key to the clarity and volume of reception is necessary than the plate milliammeter already mentioned. Not only will it tell when the circuit is ready to break into oscillation, either in the radio frequency circuits as described, or by too much regeneration in the detector circuit by a drop or wave motion towards the zero end of the scale, but it will tell you the instant the audio frequency amplifiers are becoming overworked and distorting on the brink of signals by a wavering towards the maximum position of the scale. This will be indicated some time before the average listener can detect the distortion, or at least before it becomes at all serious. For good pure *undistorted, understandable music,* the plate milliammeter should always remain practically stationary. Then, and only then, can the operator be certain the set is reproducing just what is being sent out by the transmitter of the distant station.

After the six tube set as described has been put in excellent working order and the builder feels he is capable of going a step further, and if, a storage battery is at hand for the "A" battery, the UV-199 or C-299 tubes may be taken out of the radio frequency sockets and their places filled by UV-201A or C-301A tubes and the detector tube may be replaced by a UV-200 or C-300 detector, by changing the detector rheostat, or any tube desired may be used as the detector.

Using the plate milliammeter for a guide, as before, the circuits are again carefully adjusted, first starting on the longer waves, say about 500 meters, adjustments are made until the radio frequency circuits cannot be made to oscillate under any condition. Then gradually drop down the scale to 475 meters and then to 450 meters, etc., and repeat the process until all trace of oscillations in the radio frequency circuits is eliminated.

No trouble should be experienced in tuning down to 300 meters without serious effects from oscillations even when fairly strong signals are being received. Below 300 meters more serious effects will be noted and it is doubtful if the set can be made free from this trouble much below this point, but even so, the trouble can be avoided to a great extent by slightly detuning one of the dials or reducing the filament current on one or more tubes, in which case ample signal strength and distance will be maintained. However this arrangement should be considered a strictly class B and C wave-length receiver and when receiving from such stations, the distance covered will be great. Such a set is an ideal daylight receiver and coupled to a long aerial as previously recommended, stations having a 500-watt rating should be received up to a distance of 400 or 450 miles at midday during the winter.

I hope the foregoing will serve to benefit many who desire to increase the efficiency of their receivers, and I am sure the results obtained will be in direct relation to the care exercised in the building and adjusting of these sets.

Fig. 3 is the complete wiring diagram of a six-tube receiver. Locations of the meters, etc., are given, as well as the method of wiring the filament control jacks.

Exactly the same method is used on the other circuits in adding two stages of audio frequency amplification to them.

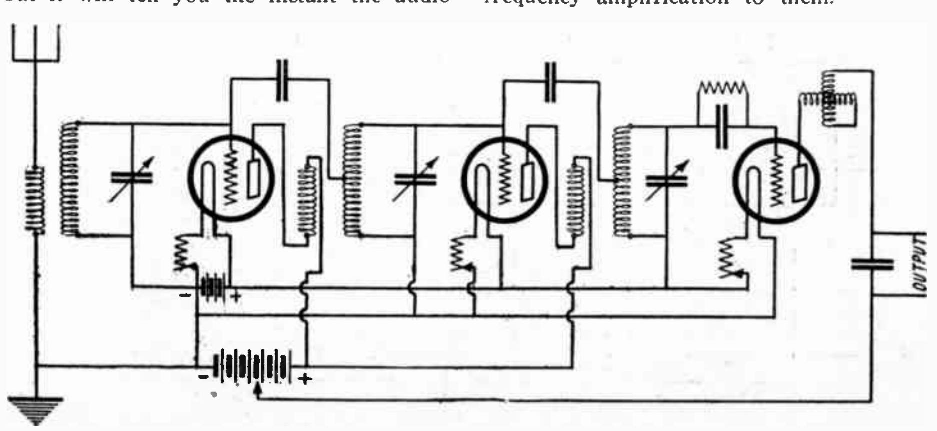

Fig. 2. A standard three tube Neutrodyne receiver with a variometer in the plate circuit of the detector for regeneration.

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A New Super-Heterodyne

By McMURDO SILVER, A.I.R.E.

In this article is described a super-heterodyne receiver of a new type, which can be built in a very compact style.

THIS latest six-tube super-heterodyne has been called the "super-autodyne" since this name is justified by the use of but a single tube functioning as both detector and oscillator rather than the customary separate detector and oscillator tubes heretofore employed. This tube is termed the "autodyne" tube, whereas the separate oscillator is generally called a "heterodyne" tube. From this the derivation of "superautodyne" follows logically. The entire circuit is still of the "supersonic" type, since the frequency of the incoming signals is changed to that of the long-wave intermediate R.F. amplifier.

The circuit of the super-autodyne is shown in Fig. 1. The first tube, marked VI, is the combination detector-oscillator, connected in a balanced bridge circuit. Tubes V2 and V3 are the two intermediate frequency amplifiers, functioning at sixty kilocycles, and feeding into the second detector, V4, and then into the customary two audio amplifiers, V5 and V6.

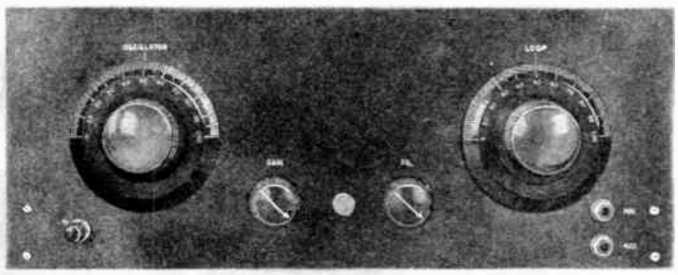
AUTODYNE FREQUENCY CHANGER

The first portion of the circuit that appears to be radical is the autodyne frequency changer, the circuit of which may best be considered when isolated in Fig. 2 The problem which has been satisfactorily solved here is the prevention of the oscillator section of the circuit from reacting upon the loop or antenna circuit. This is somewhat difficult, since the two circuits must be arranged to feed into the same tube, which must oscillate at one frequency and "detect" at another, the actual separation of these two frequencies being but sixty kilocycles throughout the broadcast range. In terms of wavelength, the oscillator must be operated at ten meters away from the loop circuit at 200 meters, and about sixty-five meters away at 550 meters in order to produce the necessary beat for the long-wave amplifier.

The solution of the problem by the use of a bridge circuit is due to a Signal Corps engineer, Jackson H. Pressley, and is very effective. Condenser C1 tunes the oscillator grid circuit, made up of coils L2 and L3, which are really a continuous winding tapped at the center. This circuit is caused to oscillate by means of the tickler, L1, coupled inductively to L2, L3 in the usual fashion. The grid condenser and leak R1, C3, aid detection, but do not interfere with the oscillator circuit. The loop or antenna circuit, represented by B1, B2, tuned by condenser C2, is connected to the mid-point of L2, L3 and at the joint between CX and C. If we assume a condition of balance to exist between what may be considered the bridge elements, L2, L3, CX, C, then energy induced into this circuit from B1, B2, C2 will divide equally across the arms of the bridge, all going to waste except the voltage drop across condenser CX, across which is connected the tube's grid and filament. Further, since the loop circuit is connected to the bridge circuit at points of neutral potential, the bridge or oscillator circuit will not react upon the loop system.

With this arrangement, radiation due to the oscillator energy feeding into the loop circuit is automatically eliminated, since the system is so balanced that this cannot occur, unlike the usual "super" circuit where a separate oscillator feeds directly into the detector grid circuit. With a properly designed super, radiation at its worst is not a very serious problem, however, since the oscillator-to-loop coupling is, for best results, so loose as almost to preclude radiation from the loop or antenna system.

So far this system looks excellent, except for the single point brought out above, *viz.*, that the incoming signal is divided and only a small portion used to cause detection. Since the detecting efficiency of a tube is proportional to the square of the applied signal voltage, it is vitally important that maximum potential be delivered to the tube terminals. How, then, is the apparent deficiency to be made up, since in the autodyne circuit less than half the signal voltage is applied to the tube, the balance being lost in the bridge?



Panel view of the six-tube super-heterodyne receiver, which is remarkably compact, being but 18 inches in length. Fig. 4.

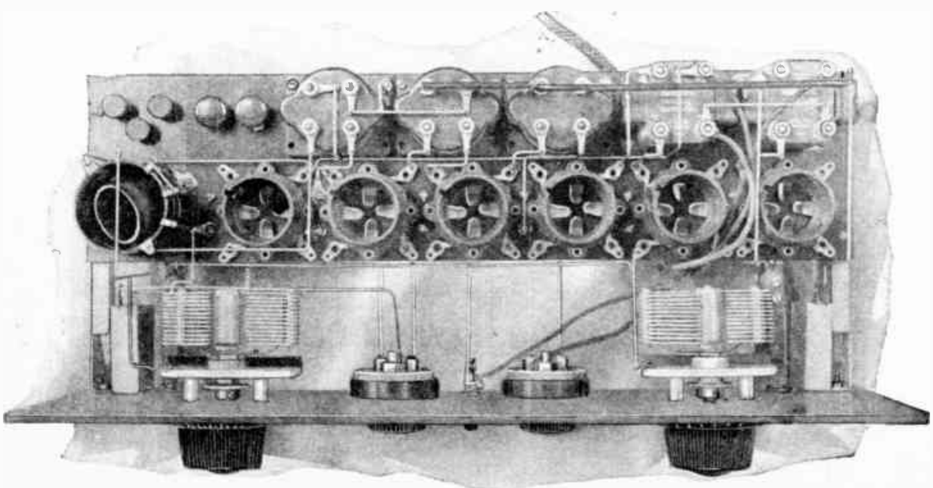
USE OF REGENERATION

That this deficiency is made up is evident in a comparison of the autodyne frequency changer with a standard separate detector and oscillator frequency changer, for the signal strength is equal from either system, and frequently in favor of the autodyne. The actual manner in which this occurs appears to be due to regenerative amplification caused by the tickler, L1, the original purpose of which was to cause the bridge to oscillate. However, at the same time as it accomplishes this, it feeds a portion of the signal energy back into the bridge circuit where it reinforces that portion of the signal in the bridge circuit used for rectification, resulting in an even stronger signal than would at first glance be expected from the system.

Were this regenerative amplification to be carried out to the limit, it would be necessary only to feed the signal energy in the plate circuit back into the loop circuit directly by means of an additional tickler in series with L1, but coupled to the loop or antenna coupling coil at B1, B2. The result of such an arrangement, carefully carried out, is a tremendous increase in the sensitivity of the receiver as a whole, as well as an increase in selectivity. This latter condition is due to neutralizing, in the usual fashion, the loop circuit resistance by regeneration, a condition which does not occur in the original balanced circuit of Fig. 2, since the loop circuit is so balanced as not to react or be reacted upon by the oscillator circuit. Hence, any regenerative amplification obtained in a balanced condition is merely through the reinforcing of that portion of the original signal in the bridge circuit utilized for rectification.

Having decided to use regenerative amplification in the autodyne, we see that a second tickler is necessary, or some other means of feeding the signal in the plate circuit back into the loop circuit. A simple method at once presents itself—a slight unbalancing of the bridge, allowing a portion of the signal energy feed from L1 into the L2, L3, CX, C circuit to get into the loop circuit. Of course, along with this comes a portion of the oscillator energy, but it is indeed a simple matter so to adjust one of the balancing condensers, CX, C, that just the required value of unbalance be obtained.

This results in sharpening up the loop tuning condenser and considerable strength-



This top view of the receiver shows how the gang vacuum tube sockets are placed in relation to the transformers on the shelf.

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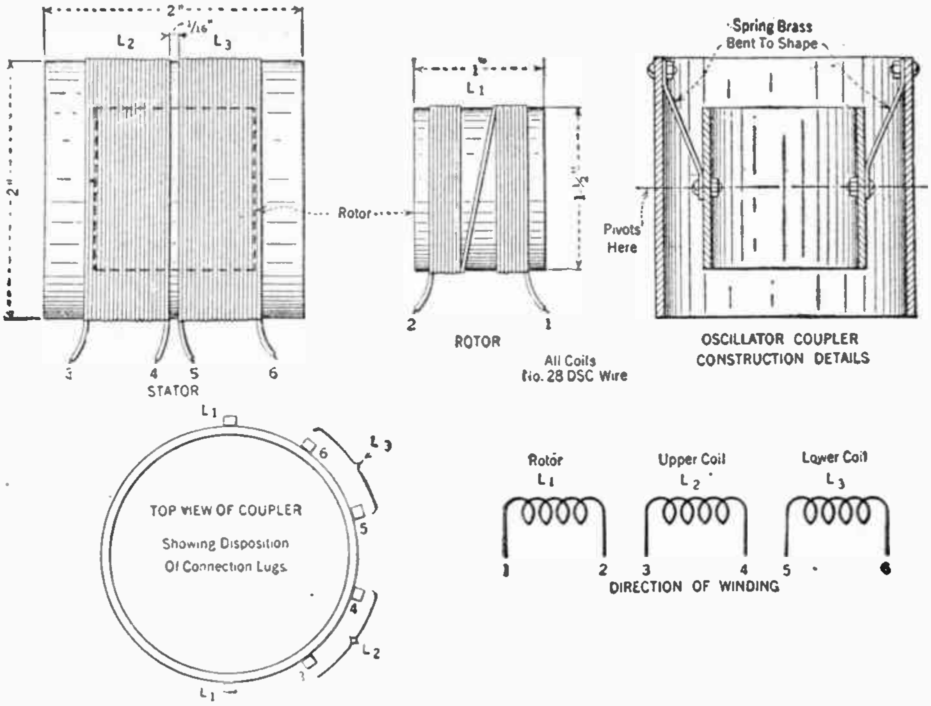


Constructional details of the oscillator coupler. These plans should be carefully followed to obtain maximum efficiency.

ening of the received signal, at the expense of a slight (but entirely negligible) tendency to radiate. The tuning, as a whole, is broadened slightly, due to reaction of the various circuits, but this is easily controlled by one of the balancing condensers, and is rather desirable, since the system is astonishingly sharp when perfectly balanced.

The only other unusual feature about the super-autodyne illustrated is the intermediate amplifier, which uses but two intermediate stages rather than the conventional three. This is made possible by the use of exceptionally efficient intermediate transformers, operating in a highly regenerative condition. This two-stage amplifier gives practically the same over-all voltage gain as could be obtained from three stages, though it would be possible to obtain proportionately the same results from any good transformers.

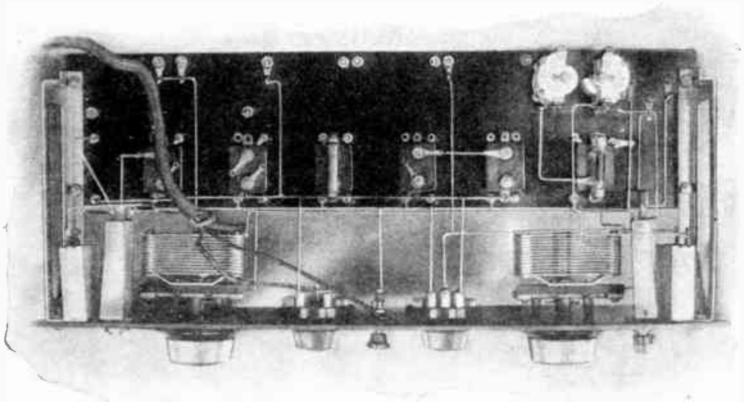
THE OSCILLATOR COUPLER AND GENERAL ASSEMBLY

The oscillator coupler may be made by winding two sections separated 1/16 inch on a 2¼-inch tube, each section containing 28 turns of No. 28 D.S.C. wire. The rotor coil also consists of 28 turns of the same size wire on a 1½-inch tube, rotatable within the stator tube.

Constructional data on the intermediate transformers and filter may be found in Fig. 3. It is suggested, though, that unless the builder has adequate measuring facilities that he purchase these already tested and matched.

In wiring the receiver, a well-tinned iron should be employed in conjunction with resin-core solder. A small amount of paste may be used on each connection if desired, but not on any of the fixed condensers. Here, connections may be soldered to lugs or to the condensers directly.

Only two connections can be put on the panel alone. These are a connection between the rheostat and potentiometer and one between the potentiometer and S1. Bus-bar should be used, straightened, carefully bent and cut to proper length before any attempt is made to solder it in place. A long piece of bus-bar should not be soldered to a lug and then bent and twisted until it reaches the other lug to which it is to be soldered. Each piece should be bent to fit properly, cut to size and then soldered in place.



The under side of the shelf that supports the gang tube sockets and the intermediate and audio frequency transformers. This method of arranging the instruments makes for short wiring.

CONNECTIONS

The "A" battery should be connected to its lead, one tube inserted in a socket, switch closed, and rheostat R4 just turned on. If the tube lights, it should be moved from socket to socket to see that all "A" connections are correct. The positive "A" battery lead should then be connected to the B 45 and B 90 posts. If the tube lights, the wiring or assembly is faulty and should be checked. The tube should light only when the "A" battery is connected to the "A" leads.

The remaining batteries may be connected and the loop leads run to posts B1, B2 and B3. If the loop is spiral, B1 goes to the outside lead, B2 to the center tap and B3 to the inside end. Any standard loop may be used.

The tuning is quite simple. The tubes should be adjusted to proper brilliancy by means of the rheostat, and the potentiometer set just to the positive side of that adjustment where a "plunk" is heard as it

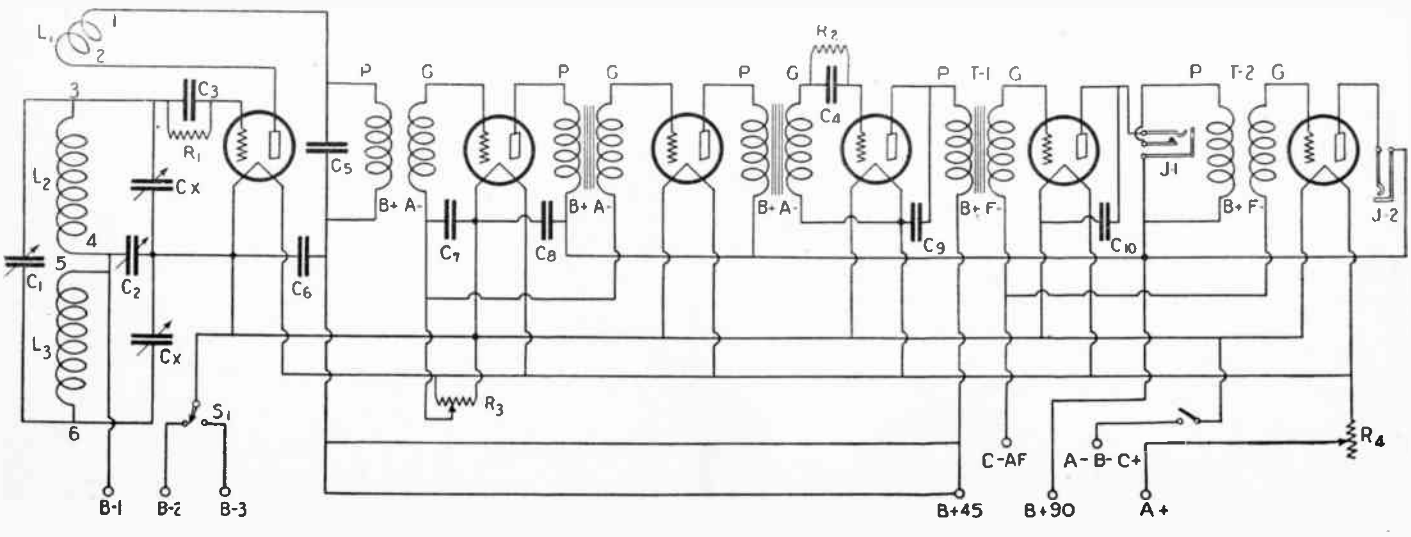


Fig. 1. Circuit diagram of the six-tube super-heterodyne reciver. The first tube on the left is the combination detector-oscillator, then come two tubes used as intermediate amplifiers, a detector and two A.F. tubes.

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is turned to the right or negative side. When it is properly adjusted, no squeals at all will be heard—when improperly adjusted, many will be heard. Reference to your tuning chart will show approximately how the dials should be set for different wave-lengths.

Balancing is done by first setting both small condensers all the way in. Then, as the tuning dials are rotated, clicks will be heard. If one of the balancing condensers is turned out, a point will be found where no clicks can be heard. The condenser connected from grid to filament will generally have a low setting, while the other balancing condenser will be all the way in. Once the receiver has been balanced, it should be tuned for several days and then gradually unbalanced by adjusting one of the condensers (CX). If this is done on a weak station, an increase in signal strength will be noticed. If the set is too far unbalanced, however, the selectivity will suffer.

CONSTRUCTION

The practical construction of a receiver embodying the super-autodyne circuit, with either a balanced or slightly unbalanced bridge circuit, is extremely simple and will readily be understood by reference to the various photos and diagrams accompanying

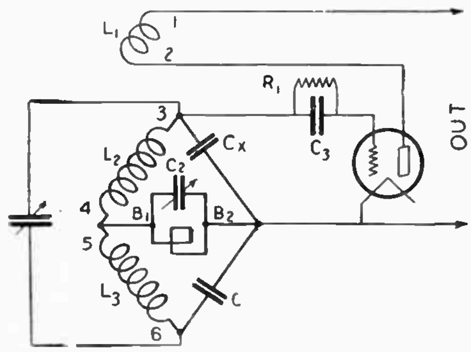

Fig. 2. The autodyne frequency changer, part of the circuit which oscillates at one frequency and detects at another.

this article. The actual list of parts necessary is given. They may be of standard manufacture, but should be carefully selected to conform with the general specifications, since for the design illustrated the electrical and mechanical requirements have been very carefully worked out to give best results.

Tools required: 1 hand-drill with drills and countersink; 1 soldering iron with resin-core solder and non-corrosive paste; 1 side-cutting pliers; 1 screw-driver; hammer and centerpunch.

As soon as the material has been procured, each item should be carefully examined to see that all screws and nuts are right, and lugs placed as shown in the photographs, so that those on the various instruments will point in the best directions for short leads. Socket springs should be bent up to make good contact with the tube pins. Condenser bearings should be adjusted to give the desired tension.

The front panel may be laid out with the

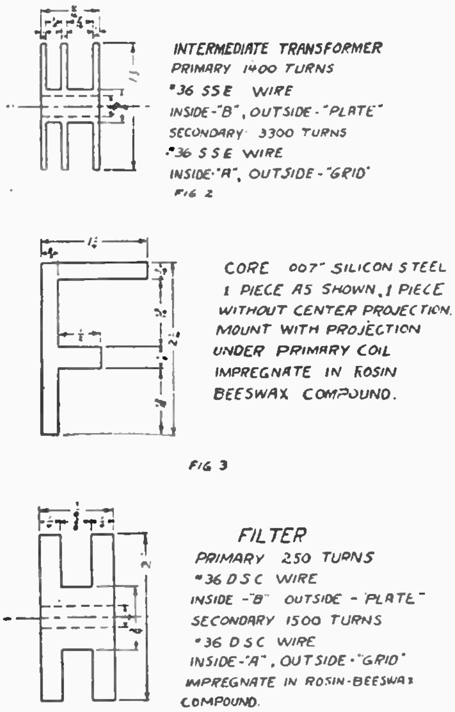

Fig. 3. Details of intermediate frequency transformers and filter.

aid of a rule and scriber, after which the hole locations should be punched with a centerpunch or nail, and a hammer. After drilling the holes, the panel may be grained

2	(C1, C2)	.0005 condensers
2		4-inch moulded dials, vernier type preferably.
1	(R4)	6-ohm rheostat.
1	(R3)	240-ohm potentiometer.
3	(B1, B2, B3)	Insulated top binding posts.
1	(J2)	1-spring jack.
1	(J1)	2-spring jack.
1	(C5, 211)	60 K.C. filter with matched tuning condenser.
2	(210, 210)	60 K.C. matched intermediate transformers.
1	(L1, L2, L3)	Coupling unit.
1		6 gang 199 or 201A socket shelf.
2	(T1, T2)	3½ to 1 audio transformers.
2	(C7, C8)	.5 mfd. by-pass condensers.
2	(C3, C4)	.00025 mica condensers with leak clips.
2	(C9, C10)	.002 mica condensers.
1	(C6)	.0075 mica condensers.
2	(C, CX)	.000025 balancing condensers.
1	(R1)	.25- or .5-megohm leak.
1	(R2)	2-megohm leak.
1	(S2)	On-off switch.
1	(S1)	D.P.S.T. switch.
1		5-lead color cable.
1		Pair shelf brackets.
1		Panel 7x18x⅛ in.
29		6/32 R.H.N.P. ¾-inch machine screws.
2		6/32 R.H.N.P. 1½-inch machine screws.
31		6/32 N. P. nuts.
1		length spaghetti.
10		lengths bus-bar.
25		soldering lugs.

with fine sand-paper and oil, rubbing in one direction until the original polished finish has disappeared. After wiping the panel off with alcohol, indicating marks for the dials may be scratched as in Fig. 4 and filled with Chinese white.

The Tropadyne Circuit

By CLYDE J. FITCH

There are constant improvements being made in the Super-Heterodyne receiver. Here is one that has been developed by Mr. Clyde J. Fitch. A saving of two tubes as well as an increase of selectivity is obtained with this new circuit called the Tropadyne.

SINCE the original appearance of the first Super-Heterodyne circuit there have been numerous improvements made in its design. Many of them have been along the line of increased selectivity, others have sought to combine tubes, but this latest one does both. It is well known that a properly constructed receiver involving the Super-Heterodyne principle will receive more stations with greater clarity and volume on a small indoor loop aerial than any other receiver, no matter what its refinements, using a large outdoor collecting agency. So there is little wonder at the constantly increasing popularity of the Super-Heterodyne.

Briefly, the Super-Heterodyne principle involves changing the wave-length of any incoming signal to a certain definite intermediate wave-length. This change in the period of the wave is effected very simply. The user of a regenerative receiving set well knows the squeals and whistling sounds which are heard in his head telephones the instant the receiver is set into oscillation. These squeals are caused by the superimposition of a radio frequency wave generated by the receiver and that of an incoming signal. The two meeting in the detector circuit cause the production of what is termed a beat note, the tone of which is determined by the difference in the two frequencies. The superimposition of the two frequencies is called heterodyning. The heterodyning note can be changed, by shifting the dial, from a very high pitched squeal to a note so low that it passes from the range of audibility. In the Super-Heterodyne this "squeal" is made above the range of audibility. Nevertheless, all of the audio frequency modulations placed on the carrier wave at the transmitting station are faithfully reproduced at the new radio frequency affected through heterodyning.

It has been found that while making the squeal very high so as to be inaudible, the detector circuit of a regenerative receiver is detuned from the signal, thus decreasing its efficiency and the squeal becomes weaker and weaker as the pitch of the squeal rises. For this reason the standard Super-Heterodyne employs a separate tube for the oscillator and a separate detector tube to detect

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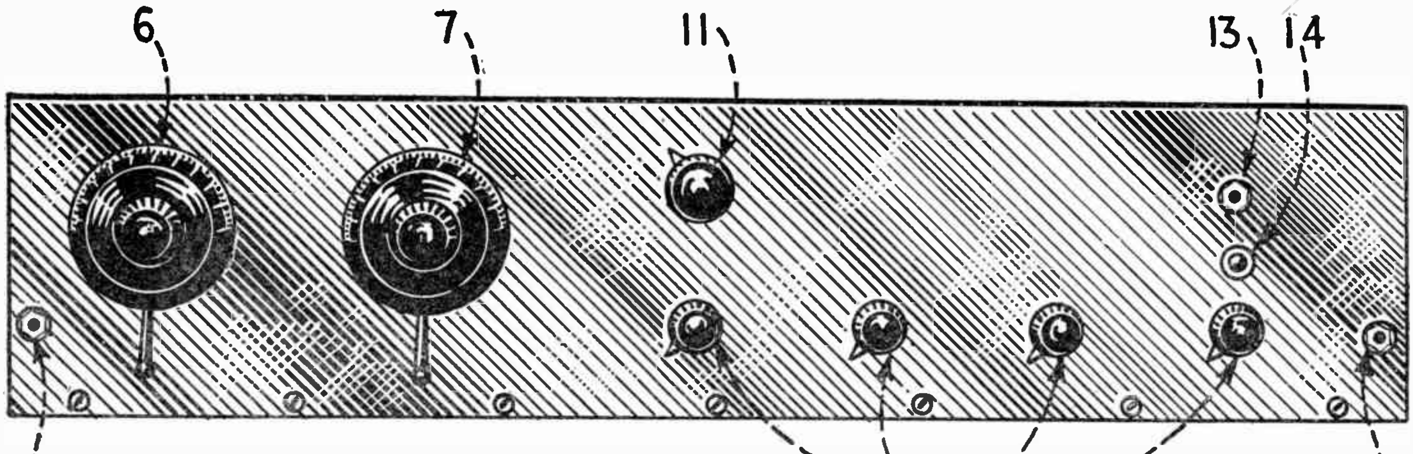


The front view of the completed Tropadyne receiver. The following numbers designate the different controls; 6 is the tuning dial; 7 is the oscillator dial; 8 is the loop jack; 11 is the potentiometer; 12 shows the rheostats; 13 is the detector and amplifier jacks; 14 is the filament switch.

the inaudible squeal, also called the beat note. This requires two tubes to do the work of one, which is objectionable. Experimenters have tried using two tuned circuits on the one detector tube, making it a self-heterodyning or autodyning detector. The object was to tune one of the circuits to the signal frequency and tune the other circuit to the oscillating current frequency; but tuning one circuit detunes the other and one finds himself first swinging one dial and then the other and getting nowhere. This disadvantage is entirely overcome in the Tropadyne circuit. The Tropadyne employs a self-heterodyning detector having two independently tuned circuits in the grid circuit of the tube so arranged that tuning one has no effect on the tuning of the other and stations are easily and quickly tuned in. This is the main advantage of the Tropadyne circuit; the elimination of one tube from the standard Super-Heterodyne circuit.

It was just pointed out that the oscillator and first detector in the Super-Heterodyne give a new wave-length or frequency to the signal by producing beats. The two tubes, therefore, act as a frequency changer. In the Tropadyne circuit one tube acts both as oscillator and detector, and is a frequency changer. This is where this circuit gets its name; *tropaia* from the Greek, meaning change, and *dyne* meaning force.

Fig. 1 shows the Tropadyne circuit. Only one tube is shown, which is merely a frequency changer when used in a Super-Heterodyne receiver, and may be used with any type of Super-Heterodyne now in existence. As shown in the diagram, it is arranged for both loop and outdoor aerial, the loop being connected in the circuit through a plug and jack. The plate coil with terminals marked "+B" and "P" is coupled to the oscillator coil, "G" "F" and the tube is continually generating an oscillating current, the frequency of which depends upon the setting of the oscillator condenser. It will be noted that one side of the oscillator coil is connected to the grid of the tube and the other side is connected, through a one-megohm grid leak, to the filament of the tube. The tuning or loop circuit, is connected between the electrical center, or nodal point, of the oscillator circuit, and the filament of the tube. The grid condenser is placed between the oscillator circuit and the tuner circuit. The electrical center of the oscillator circuit is approximately at the center turn of the coil. In practice, this connection is not critical. It may be two or three turns either side of the center, without seriously decreasing the efficiency.

HERE is a remarkable Super-Heterodyne receiver which we warmly recommend to our readers. It has several new and unusual features. In the first place only six tubes are used giving as much volume as the average eight tube Heterodyne. The selectivity of this set is unusual. Inequalities of the intermediate transformers have now been done away with by tuning each transformer. After the transformer has been tuned, it can be left this way, no further tuning being necessary.

This system makes for maximum sharpness and maximum volume. Another outstanding point of superiority of the Tropadyne circuit is that it practically does not radiate, thereby not interfering with other nearby receiving stations. Most Super-Heterodyne circuits, as is well known, are powerful radiators.

—EDITOR.

Although radio frequency currents are flowing in the oscillator circuit, none of this current passes into the tuning circuit since the potential difference between the electrical center of the oscillating circuit and the filament of the tube always remains constant. Therefore, tuning the oscillator circuit has no effect on the tuning of the loop circuit.

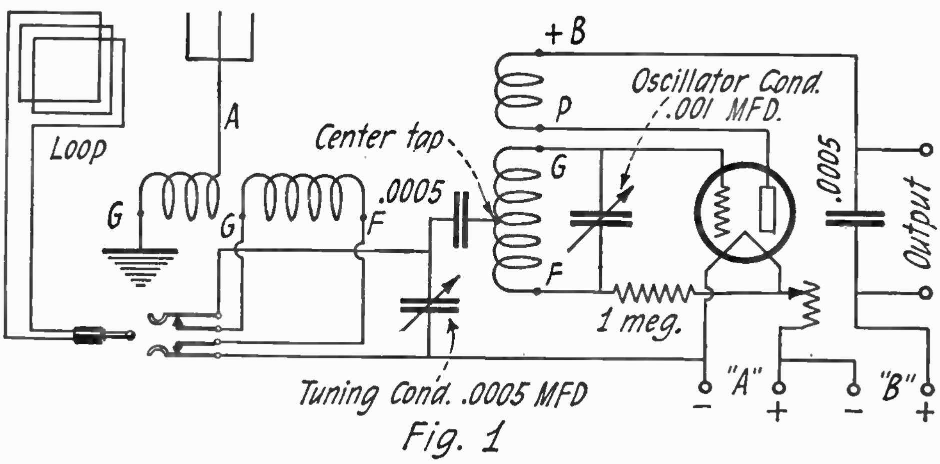
The incoming signal current flowing in the loop or tuning coil circuit, is impressed on the filament of the tube and the center of the oscillator coil. The current divides equally at this point, part flowing through the upper half of the coil to the grid of the tube and the remainder flows through the lower half of the coil to the grid leak. As the signal current divides equally thru the oscillator coil, one-half flowing in one direction and one-half flowing in the other direction, the two oppose each other and prohibit current flowing in the oscillator circuit. Both the oscillator and tuning circuits may be tuned independently to the same or different wave-lengths. This is a condition that has never before been attained by a single tube.

There are many variations that may be made with this circuit, employing the same underlying principle, but the arrangement shown gives the best results.

It will be well for the amateur builder to follow carefully the various directions given in this article. Failure to do this may result in failure of the resulting set to operate. Strict attention to details always pays.

By tuning the loop circuit to the frequency of the incoming signal, the signal current is impressed upon the grid and filament of the vacuum tube. By tuning the oscillator circuit to a different frequency from that of the incoming signal, which current is also impressed on the grid of the tube, a beat note is produced in the plate circuit. This beat note may be audible, depending upon the adjustment of the oscillator condenser. If it is audible, it may be heard in telephones connected to the output terminals. In a Super-Heterodyne however, the beat note is made inaudible and is amplified by the intermediate amplifier which is connected to the output terminals.

It may be well to note that by tuning the antenna circuit to an incoming signal, this signal is impressed upon the grid and filament of the tube and is, therefore, repeated



The principle of the Tropadyne circuit is shown here. Although only one tube is used for the detector and oscillator, it will not radiate and will cause no interference to other receiving sets.

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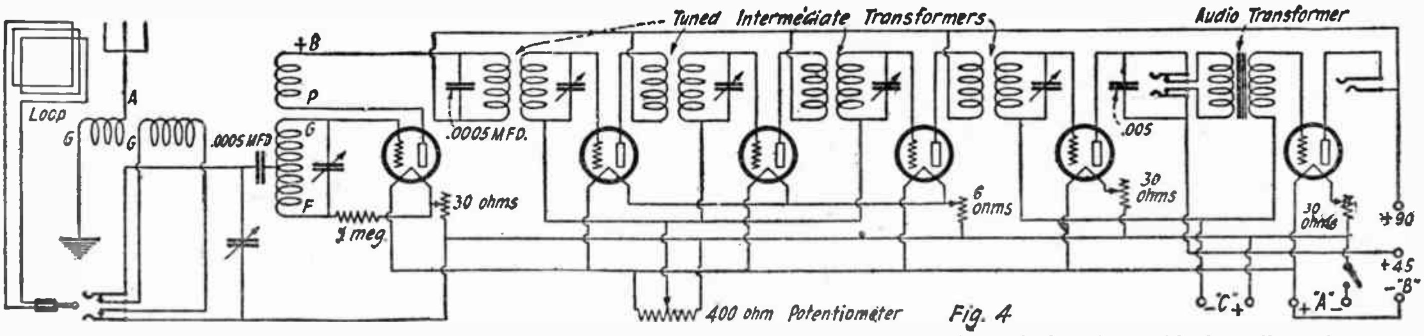
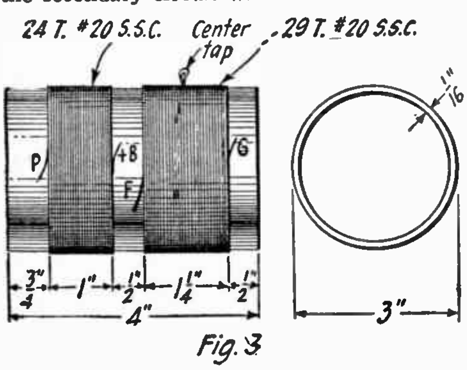


Schematic diagram of the Tropadyne circuit. Although only six tubes are employed, it compares favorably in volume with the ordinary Super-Heterodyne using eight tubes. The 1 meg. unit should be variable, with a 0.5 to 5.0 meg. range.

in the plate circuit. By means of the plate coil this amplified signal current is fed into the oscillator circuit and is further amplified by the phenomenon of regeneration. It is assumed in this case that the coupling between the plate and oscillator coils is variable and that the coupling is adjusted to a point just before the tube starts to oscillate. This makes a single tube regenerative receiver and the signals are heard in a telephone headset connected to the output. While adjusting this receiver the tube will sometimes generate an oscillating current in the oscillator circuit. But as stated before none of this current passes into the antenna circuit and hence this one-tube regenerative receiver is non-radiating. Some engineers have proven mathematically that if it is possible to transfer a radio frequency current from a primary circuit to a secondary circuit, the action is also reversed and a radio frequency current flowing in the secondary circuit will be transferred to



The oscillator. Plate turns, 10 to 24. Grid, 29T. for .001 mfd. variable and 51T. for .0005 mfd.

the primary circuit. They have, therefore, stated that the only possible way to prevent an oscillating regenerative receiver from radiating into the antenna is by the use of a blocking tube. This hypothesis is disproved by the Tropadyne.

Since the object of regenerating in a receiving set is to apparently nullify the resistance of the antenna circuit, if the set does not regenerate into the antenna the efficiency, as far as DX reception is concerned, is greatly impaired. Therefore, it is doubtful if the one-tube non-radiating regenerative set will become very popular. Of course the sensitivity can be increased by employing one or two stages of radio frequency amplification before the regenerative detector tube.

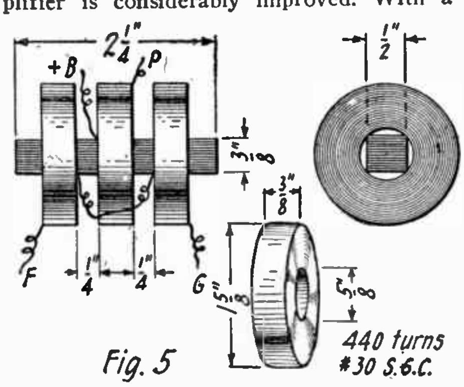
Figs. 2 and 3 show the complete details of the antenna coupler and the oscillator coil. The drawings are self-explanatory and need not be described here. The end connections of the windings are lettered according to the lettering on the diagram, Fig. 1. In the diagram the coils are shown reversed in order to simplify the diagram, that is the terminals "P," "G" of the oscillator coil are shown adjacent to each other in the diagram, whereas actually they are at opposite ends of the insulating tube. The object of bringing these leads out at opposite ends of the tube is to decrease the electrostatic capacity between the plate circuit and the grid circuit of the tube.

These two coils should be constructed according to the drawings and mounted as shown in the illustrations. At the right of the photographs are shown the tuning condenser, oscillator condenser and antenna and oscillator coils. The frequency changer tube, which is the one shown in Fig. 1, is placed between the two condensers. This arrangement makes the connections very short.

The accompanying photographs also show the intermediate amplifier and the audio amplifier. The set shown has six tubes, the first of which is the frequency changer, and the next three the three-stage intermediate amplifier. The fifth tube is detector and the sixth is a one-stage audio frequency amplifier. For most purposes one stage of audio frequency amplification is sufficient, although for volume on DX stations, two stages are recommended.

The set shown has a 7 x 30-inch panel. This allows ample room for wiring. Although it is not advisable to crowd the instruments of a Super-Heterodyne, it is possible to mount a seven-tube set on a 30-inch panel. The two condensers, one potentiometer, four rheostats, three telephone jacks and a filament switch are mounted on the panels. The illustrated layout may be changed to suit individual requirements.

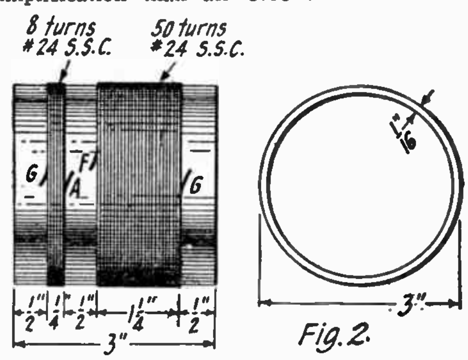
The Tropadyne principle, described above is shown in Fig. 4 as incorporated in the complete six-tube Super-Heterodyne circuit. This circuit, with the exception of the connections of the first tube, is similar to the standard circuit. It will be noted, however, that no grid condenser and grid leak are used for the second detector. It has been found that a vacuum tube detector distorts signals, especially if they are very strong. This distortion has been practically eliminated from the second detector by operating the tube on the lower bend of its characteristic curve. This is accomplished by connecting the grid return lead to the negative side of the "C" battery, which acts as a grid bias for the audio amplifier tube. This applies a negative potential to the grid of the detector and, therefore, very little or no current is absorbed by the detector, and the selectivity of the intermediate amplifier is considerably improved. With a



The construction of the iron core intermediate transformers. Note spacing of coils.

"C" battery of nine volts and a plate voltage of 45, the selectivity is so great that powerful local stations, otherwise broad in tuning, are tuned in and out with the vernier alone. This battery does not decrease the volume and the quality of reproduction is remarkable.

The question of air core or iron core intermediate frequency transformers is a much mooted one. While the air core type is very selective, it requires condensers for tuning each stage of amplification to the same wave-length. Usually fixed condensers are employed for this purpose, but it is difficult to obtain fixed condensers of uniform capacity and the result is that the amplifier operates at two or more wave-lengths. When this occurs, the same station is received at several settings of the dials. Iron core transformers, on the other hand, are very broadly tuned and give higher amplification than air core transformers.



A coupler having an untuned primary is used. Both primary and secondary are wound on the same tube.

These transformers are so broad in tuning, however, that it is difficult to receive DX stations while local stations are operating. Manufacturers of iron core transformers usually supply one air core transformer, tuned by fixed condensers, for use in either the first or last stage of amplification. This air core transformer (often called a coupling, or filter transformer) is supposed to make the amplifier more selective, a situation not always obtained in practice. These disadvantages have been overcome by using the semi-iron core intermediate frequency transformers which are shown in Fig. 5.

The complete details of this transformer are shown in the illustrations. It will be noted that a variable condenser is permanently mounted on each transformer. This condenser is connected across the secondary winding and in this way each transformer may be accurately tuned, making the intermediate frequency amplifier very selective and efficient. "Rico" mica insulated variable condensers are used because they occupy less space than those employing air dielectric. These condensers have a maximum capacity of .0005 mfd. and, in connection with the coils used the transformers may be tuned to any wave-length ranging from 2,000 to 7,000 meters. Although the coils used in these transformers were wound by machine in the manufactured type they

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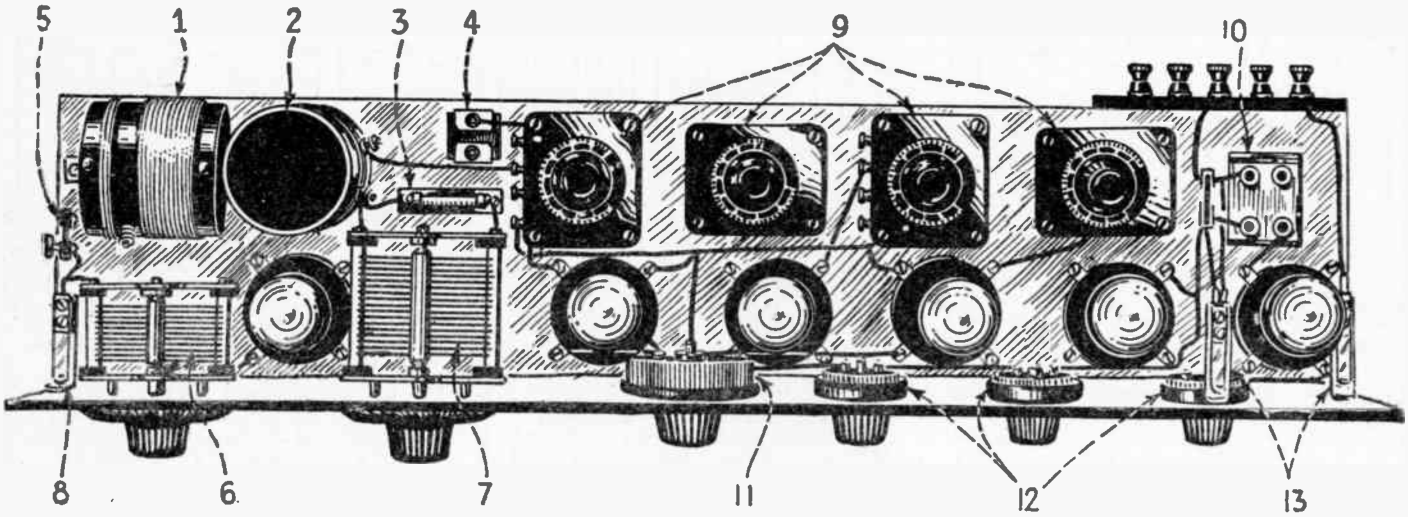


Top view of the Tropadyne showing the neat arrangement of the apparatus. The numbers designate the following instruments; 1, the tuner; 2, the oscillator coil; 3, the grid leak; 4 and 5, fixed .0005 condensers; 6, the tuning condenser; 7, oscillator condenser; 8, loop jack; 9, tuned R.F. transformers; 10, A.F. transformer; 11, potentiometer; 12 rheostats; 13, jacks for detector and loud speaker.

may easily be wound by hand, haphazardly, on a suitable form, or spool. The number of turns, which in this case was 440 in each coil, is not critical. Two coils connected in series form a secondary and one coil forms a primary. It is important to separate the coils at least ¼ inch. The core iron used is exceptionally thin, japanned silicon steel. This steel may be obtained from manufacturers of iron core radio frequency transformers and is not the same as that used in the construction of audio frequency transformers. When constructing these transformers, it is important that all coils be wound in the same direction and placed on the core, as shown in the illustrations. The leads are lettered to correspond to the vacuum tube connections.

As stated before, the Tropadyne principle may be incorporated in any Super-Heterodyne receiver. Those who already have a seven or eight-tube Super-Heterodyne may take out one tube by changing over to the Tropadyne circuit and in doing so may improve the efficiency and decrease the operating expense of the set. Some experimenters have reported phenomenal results by converting this tube into a one-stage short wave radio frequency amplifier before the first detector instead of removing it entirely. For ordinary purposes, such extreme amplification is not recommended.

If the six-tube Tropadyne receiver has been built according to the specifications given, little trouble should be experienced in operating and tuning distant stations. After the construction of the set has been completed the tuned intermediate transformers should be adjusted for maximum efficiency. This is accomplished by tuning in a nearby station that comes in loudly. The dials of the transformers should all be set at about 80 degrees. After the station is tuned in with the oscillator and tuning condenser, the potentiometer should be turned towards the positive side of the filament until the amplifier does not oscillate. Leave the last transformer set and slowly turn the dials of the others, one at a time, and leave them set at the positions in which the station is received at its loudest. It may be necessary to change the setting of the oscillator dial slightly after adjusting the transformers. It will be noticed that the adjustment of the transformers is not very critical when receiving loud local stations, but is very critical when receiving distant stations. It is well to adjust the transformers again after tuning in a DX station. Once the transformers are adjusted, they need not be changed. Should the oscillator squeal when the dial is turned toward the minimum, the oscillator filament rheostat should be turned down slightly. 201A tubes are recommended.

Practically as good results may be obtained from this set when using a loop aerial as when using an outdoor aerial, but as many already have outdoor aerials, it is well to build the antenna coupler into the set. A 15- or 20-foot indoor aerial gives excellent results with this circuit and occupies less room than a loop. In regard to the sensitivity of this set, it has been compared side by side with other Super-Heterodyne sets employing more tubes and the Tropadyne was not only more selective, but received the distant stations just as loudly and clearly as the other sets. The sensitivity of the six-tube Tropadyne set was found to be practically the same as that of other seven tube Super-Heterodyne receivers.

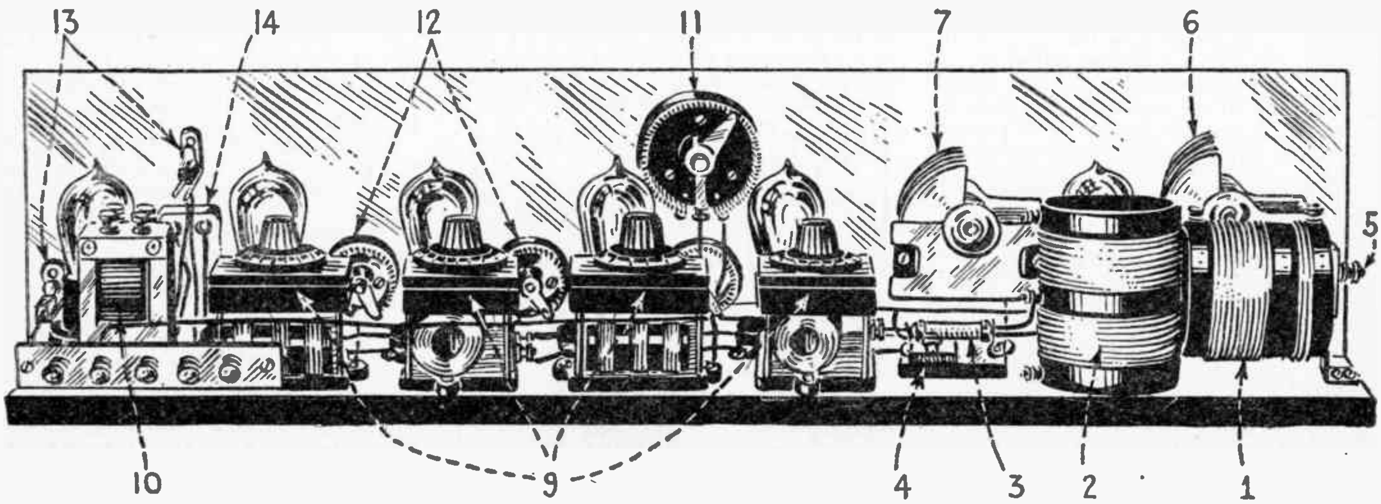
INSULATOR MADE FROM TELEPHONE RECEIVER CASE

There are doubtless many fans who have in the junk box a discarded telephone receiver from their early days in radio. Maybe they have been tempted to throw it away, but refrained hoping that some day "it might come in handy." Well, here is a way to utilize it and incidentally save the price of a stand-off insulator.

Through the hole in the cap of the receiver, from which the magnets and coils have been removed, place a wood screw large enough to support the rest of the receiver when it is attached to the wall. Between the head of the screw and the cap is placed a washer. Care must be taken in screwing the cap to the wall since, if the screw is driven in too tightly, the cap of the receiver will crack. In the other end of the receiver, through the hole that is used for the connecting wires, there is placed a bolt that will fit tightly. This bolt is fatsened with a nut (again exercising care not to screw the nut on too tightly) and on the end of the bolt is placed another nut for fastening the wire that is to be insulated.

This insulator will be found to be useful and very efficient to the fan who is overhauling the antenna.

Contributed by G. A. Kappel.



Rear view of the Tropadyne receiver. The spacing of the R. F. transformer coils can be clearly seen. The numbers and instruments correspond to those shown in the upper photograph. Sides of Tropaformers cut away to show construction.

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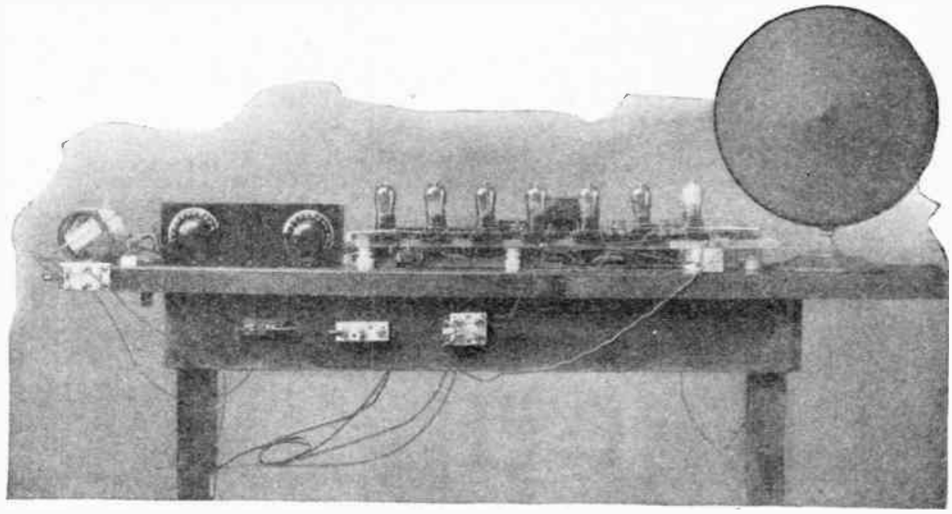
Some Super-Heterodyne Notes

By WILFRED TAYLOR

MR. TAYLOR regales the builders of Super-Heterodynes and teaches them efficiency, in this article. He does it entertainingly, too.



Above is a view of the completed Super-Heterodyne built for the experiments dealt with in this article. It was constructed a unit at a time and then completely assembled.

I HATE to think how many tons of perfectly good newsprint have been gummed up with more or less informative articles on the fearsome Super-Heterodyne circuit, but here goes another—which I hope will be a bit different from its predecessors. Most hardy souls approach the cantankerous critter on its blind side, gentle it a bit with strange incantations and then try to mount—with more or less success; you have to be a Graduate Engineer, a Radiotrician, an R. E., or a combination of all three to get a look-in on this game—maybe. As a matter of fact, building a Superhet and making her "het" is about as difficult as pulling a pan of milk off a top shelf; if you don't believe it, just toddle along with me for about three pages of this patter and I will show you.

Another thing: Don't believe all this tosh about the superiority of factory built sets; why do people pay fancy prices for hand-made furniture instead of getting it from G. Rapids? Why dig up a fabulous price for a hand-made Swiss watch instead of carrying an Ingersoll? No factory on a production basis has ever existed which can begin to compete with the dexterous hands of a skilled mechanic.

THE SUPER-HET CLASS

If you are to be in the Super-Heterodyne class, you must have a "laboratory"; I have one—a peach; is consists of an old kitchen table and about four instruments of precision I got at a hardware store around the corner.

Having acquired a laboratory, you install it over behind the kitchen sink, so the missus and the kids won't be apt to molest it, and so you will be near a cold water pipe. Then you will fill the old dudeen, put your feet on the mantelpiece, and, having the aforesaid cutty drawing well, commune with yourself thusly: "Now just what do I expect of a radio receiver? Do I want a bit of Chippendale, or do I want radio? Is WBZ good enough for me, or shall I reach out into the silences of the night and bring in the whispering voices of far countries? I don't know a blamed thing about radio but it seems to me that, when the novelty wears off, I will get good and tired of WBZ; ergo, I will build a receiver which will get WBZ *and* which will be so darned sensitive that I will be able to hear the flies crawling on the Gatun Locks." Just so; your decision will simplify matters a lot. A radio receiver is just like a pair of shoes—you wouldn't buy a pair of dancing pumps to go duck hunting with; don't try to build *Louis Quinze* furniture, or a lunch box set, and expect to get much in the way of faint signals.

WHAT TYPE OF SET

Just about here a horrid thought disturbs your crystal-clear thinking: Bill Jones has a three-tube "calamityplex" (smouched from McLaughlin) with which he brings in the West Coast three nights a week: yea—he brings in the West Coast, it is true, but if he gets through the static, code and *interfering stations* once or twice in a season, he sure has done something to write home about. You may hop into a Ford and start for Chicago; you will get there. (some time) provide you don't hit a washout or a blizzard; but if you wish to be reasonably centain of getting there with neatness and dispatch, you board the Twentieth Century Limited, hand over the price of the Ford to the porter, and settle back in your seat to enjoy the scenery *en route*. The three-tuber will get you to Chicago, weather permitting, but your arrival will be all mussed up and distorted; the multi-tube set, particularly the Super-Heterodyne, will get you there serene and refreshed, with a volume and clarity of tone in a class all by itself. We will build one of these three-tubers right now, and later you will see the difference yourself. And when some lad tells you a husky tale about tuning in China, don't doubt his word—perhaps he did—but run a buzzer audibility test on his set before accepting his implied assertion that he has the most sensitive receiver on the map—he may have —and then again he may had a bit of common freak reception with a set not sensitive enough normally to get a station in the next county.

THE ANTENNA

If you have that rare commodity, a yard, you will proceed to take stock of the possibilities for erecting an antenna. Right here I wish to state that your final results will be directly proportional to the care with which you put up this bit of clothes line.

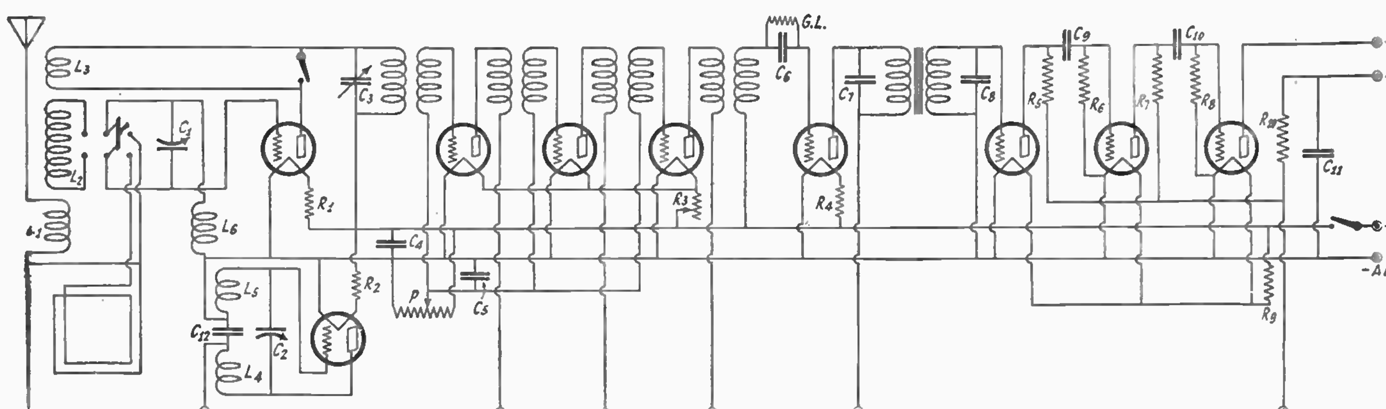


Fig. 6

L1—15 turns No. 14 D.C.C. on 3-inch tube; L2—50-60 No. 14 D.C.C. on 4-inch tube; L3—24 turns No. 24 D.C.C. on 3-inch tube; L4—36 turns No. 18 D.S.C. on 3 5-8-inch tube; L5—36 turns No. 18 D.S.C. wound on same tube ½-inch apart; L6—15 turns No. 24 D.S.C. on 3-inch tube. C1—.0005 mfd. variable condenser; C2—.0005 mfd. variable condenser; C3—.001 mfd. variable condenser, mica; C4—.005 mfd. condenser; C5—.5 mfd. by-pass condenser; C6—.00025 mfd. condenser, and grid leak mounting, .005 mfd. bolted to above; C7—.002 mfd. condenser; C8—.00025 mfd. condenser; C9—.006 mfd. condenser; C10—.006 mfd. condenser; C11—.5 mfd. by-pass condenser; C12—.005 mfd. condenser; R1, 2, 4—20- to 30-ohm fixed resistances; R3—6-ohm rheostat; R5—.25-megohm resistance; R6—.5-megohm resistance; R7—1-megohm resistance; R8—.1-megohm resistance; R9—¾ amperite; R10—.005-megohm resistance. P—400-ohm potentiometer.

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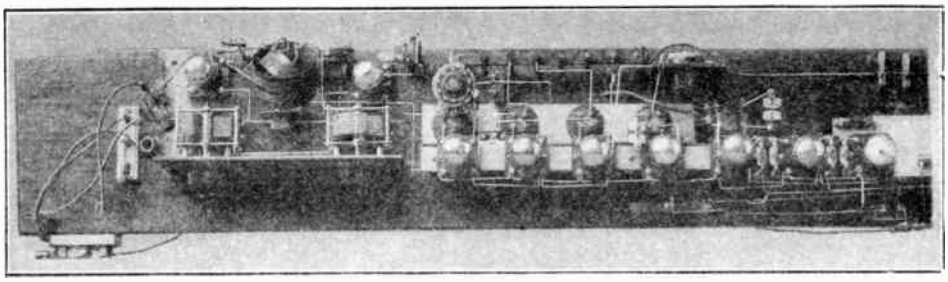

Above is a top view of the completed instrument containing the tester and matched parts described. Note the location of the components and their relation to each other.

Get hold of any one of a dozen articles on this subject which have appeared in *Radio News* and follow directions implicity. *Use solid copper* wire,, No. 14 or larger, insulated (unless you wish to polish the oxide off it once a week), using any length you can get into the space available; keep it away from trees and at least 10 feet above housetops; get it as high above the ground as you can and use glass or glazed porcelain insulators. Spend time and such funds as are necessary to make this a work of art. Then get a fussy streak and hook up to that cold water pipe for a ground—and be more than usually fussy, because a first class ground is of the utmost importance.

If you decide that a loop may be useful at times, install a double pole double throw switch where the antenna comes to your table, fasten the terminals of one end to the proper ends of your secondary coil, the other end terminals to the loop and the middle ones to the tuning condenser, then put a husky single pole single throw switch across the tickler leads so the tickler may be shorted out when you use the loop, and you will be all set for either. This arrangement is shown in the circuit diagram at Fig. 6. I have bought or made every conceivable kind of loop and find that four turns of 16-strand lamp cord (single cord) on a six-foot box frame is as good, or better, than any. Ground the filament end of the loop and it will lose its directional effect and be much more sensitive; if you get rid of its directional effect,you will avoid the necessity of swinging it all over the room in order to get different stations in different directions. A small, pivoted loop helps to tune out unwanted stations—if these stations are in another direction than the one you want (which they never are), otherwise it is an unmitigated nuisance.

If you are perfectly certain that your antenna and ground, or loop, are as good as time, money and patience can make them, we will proceed to build the best two circuit tuner that we can devise.

This is a "laboratory instrument," remember, so we will dispense with all pretenses to "looks," efficiency being our middle name. Procure a piece of panel about 5 or 6 by 14 inches; screw a ⅞-inch square wood strip to the bottom of this panel, and to each end attach a .0005 mfd. variable low loss condenser with vernier dials. Screw the strip holding the panel to the table top about five inches from the front edge and a foot from the left end (see Fig. 1). Six inches back from the panel and to the rear of the right-hand condenser screw any standard bakelite socket; fasten a 20-ohm rheostat to the right of this socket, close to it, by means of a small brass angle-brace or a strip of panel arranged by same as the condenser panel.

Take plenty of time and make yourself a coil as follows: Saw three rings ½ inch wide from a 4-inch hard rubber tube; saw six strips of hard rubber ½-inch wide and 8 inches long; fasten these strips to the rings by means of 6/32 machine screws and nuts—the middle ring need not be fastened, as the wire pressure will hold it in place (see Fig. 2). On this frame wind 60 turns of No. 14 D.C.C. wire, winding the wire *double*, that is, two strands at a time. Solder both ends to the screws used to fasten the strips to the rings; remove *one* wire; this should give you a single wire coil, wound practically on air with a good sized air space between turns. There will be no shorted turns and little capacity.

For a primary, wind 10 turns of No. 14 D.C.C. on a piece of 3-inch tubing and swing this in one end of the large coil; use a lolly-pop stick for an axis, if nothing else more pretentious is handy. For a tickler, wind 24 turns of No. 24 D.C.C. wire on another piece of 3-inch tubing and swing this in the other end of the large coil. All this will take time, but it is time well

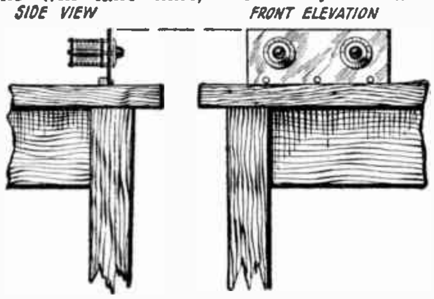

Fig. 1

The peculiar method of mounting the various parts on the experimenter's table is shown above.

spent; you can't buy a coil at any price, which will prove as good.

Having completed the coil, hook it up with socket and right-hand condenser as per the diagram of Fig. 3; connect any kind of audio amlifier you have around the place, and I will wager you never saw a better three-tuber in your life.

This circuit is the *sine qua non* of the Super-Heterodyne. If it is extra good, your Super will be extra good, and if it is poor you might as well spare the expense of a radio frequency amplifier. Build the receiver with the utmost care; scrape every contact clean, so it shines all over; do *not* use lugs—use the nipple-nosed pliers shown in the photo; do not use any more solder than is absolutely necessary—none at all where a good mechanical contact can be maintained. If you wish to make a permanent job, and you are not a dyed-in-the-wool radio bug if you don't change the whole works within a week, put a drop of solder on top of the nut after it is drawn tight so that it will not work loose (a faintly possible contingency); use No. 14 tinned (not plated) *round* bus wire and make the bends with your fingers so that the bends are *curved* and not angles (see Fig. 4). The grid leak and condenser should be mounted on the socket and the necessary wire run from the grid condenser to the tuning condenser, not vice versa.

The secret of a good receiver is low loss, low resistance; you get them by clean metal-to-metal contracts, wire of ample size, air as a dielectric—and the best instruments you can get.

Hook up the filament battery, run 22 volts "B" to the detector and 45 to the amplifier, put in 201A's throughout, and see what happens. Play with this circuit for two or three nights until you find out how it behaves and until you find where some of the stations come in on the dial; keep a dial record. Add or take off turns from the secondary winding of the coil until KSD comes in at 95 on the dial; the range of the set is then established.

By this time you will have become acquainted with the performance of a standard three-tube double circuit regenerative receiver; now we will make a Suped-Heterodyne of it, and you will be able to judge for yourself as to its merits. A large slice of grandmother's pumpkin pie is worth nine million Emerson dissertations upon it.

You have the most sensitive detecting arrangement you can get, and you have made the signals louder by using an audio amplifier, but there are faint stations in the background that you can just hear, but are not able to bring in distinctly. You cannot add any more audio frequency amplification without making so much noise that you cannot distinguish anything, so you look about for some other means of bringing in these faint signals. If you intensify the signal before it hits the detector, you will be all set; this can be done in several ways as is quite well known, the

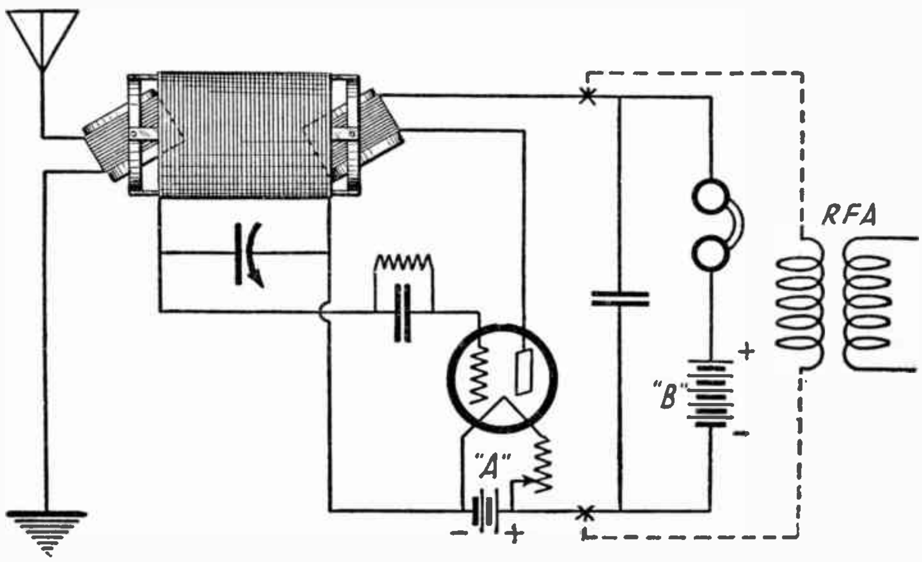

Fig. 3

The first step in the construction of the Super-Heterodyne is the assembly of the oscillator. The one illustrated above is the old familiar regeneration receiver before it is connected to the intermediate frequency amplifiers. Secondary form may need to be longer than specified.

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best, in my opinion, being the method known as the super-Heterodyne. We see, then, that a Super-Heterodyne is nothing more than a radio frequency amplifier added to a standard circuit, and some method of boosting the incoming signal to a predetermined value before it strikes the final detector. Neither difficult nor complicated, is it?

Now as to the building of this amplifier: You may do one of two things—pass the signal from the first tube to what is called the input transformer, or filter, or you may pass everything which comes to the first tube through the amplifier and then filter out the signal wanted. In either case a second detector picks up the signal handed to it and passes it along to the telephones or audio frequency amplifier just as it did in the simple tuner, except that the signal the second detector gets has been magnified tremendously, and the audio amplifier has a good fat signal to work on instead of a puny little one.

Whichever method you use, it is a good stunt to measure the height of the transformers and then mount the sockets on a shelf of this height so that the grid terminal of the transformer will be on a level with the grid terminal of the socket as shown in Fig. 5. You will thus be able to have the grid leads less than an inch long, and the centers of the transformers will be much futrher away from the centers of the tubes —a very desirable combination. Screw this shelf to the table about two inches to the right of the condenser panel; make it out of a dry wood strip 30 inches long, ½ inch wide and ½ inch thick. Mount sockets four inches on centers; there will be room at the right end for audio tubes if you wish to use it for that purpose.

I'm not dishing out any theory in this veracious chronicle—you can look over back numbers of *Radio News* and get more of it than any ordinary man can digest—so I will leave it to you to decide what transformers you will use. I have used five different makes and wave-lengths, including my own (which were rotten), and they all have their points of superiority; shut your eyes and grab the first one you touch—it will do the trick. The one used in this last Old Sleuth of mine is 3,000 meters (100 k. c.), and I think it is as satisfactory as any.

If you use an "input transformer," put a good variable condenser across the primary, and vary it until you get the best results. The circuit diagrams are all alike, with minor variations, and are very easily followed. If you use an output filter, this may be nothing more awesome than a choke coil, but it will have to be wound to take care of the particular transformer you are using; this is a nuisance and I doubt if it is worth the trouble.

The oscillator is not given enough attention in most of the sets I have seen. It is only a device for making a row, I'll admit, but it cannot function properly if it is junk. Use a standard commercial coil—the particular winding used is not vital—and wire

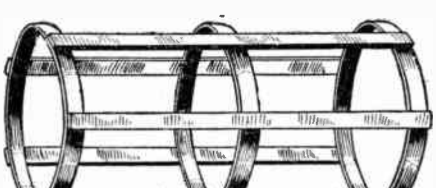


Fig. 2

Form that the tuner is wound on.

it up with as much care as you use on the rest of the set; hook it up to the other condenser, keeping it as far as possible from the first tube, and you will have completed the job. Now, however, comes in the fine "Eyetalian" hand of the lad who is looking for something a bit better than the good ones!

Almost every hook-up one sees calls for 45 or 90 volts on the plates of all the tubes. Consider, if you please, just what these various tubes are supposed to do. The first tube receives signals, some of them barely perceptible; suppose this tube is a little pond and the grid a cork; if the pond is glass-like in its stillness, the slightest breath of air will move the cork, will it not? Now, if a large stone is heaved into the pond, it will make the cork bob furiously—will it then perceive the faint breath of air? Not so you could notice it! Therefore, don't give the first tube *any* battery on its plate except the little it draws from the "A" battery through the tickler; put the tickler at zero and keep it there. Also, remove the grid leak and condenser, hook the grid to the negative leg—and do *not* use a "C" battery or do not put the rheostat on the negative leg—this grid should have the faintest possible negative bias for the reasons stated; in other words, keep the tube quiet. As a matter of fact, you now have a straight radio amplifier instead of a detector, which it never was, anyhow. Having picked up the feeble signal, don't dump it

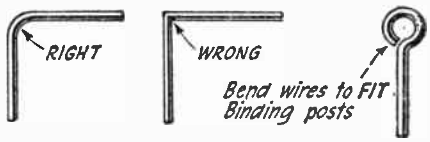


Fig. 4

The correct method of bending wire.

into a seething maelstrom in the next tube —give that one 16 volts, the next one 22, the third 35 and the detector (fifth tube), 22. Give the oscillator not more than 22, the first audio 45 and the second 90, if this seems best. We use entirely too much plate voltage on all our tubes in my humble opinion; give each tube its own "B" battery—and as little as possible at that; this will give a vastly more sensitive receiver, remove the unwanted communication between tubes and, incidentally, cut down battery expense because they last much longer.

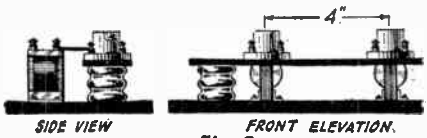


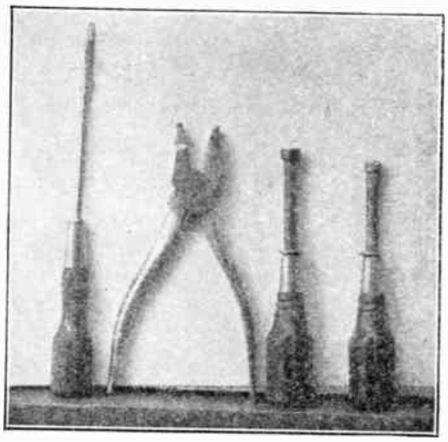
Fig. 5

Method of mounting tubes on shelves to shorten wiring.

Any audio frequency amplifier may be used with a Super-Heterodyne from a Western Electric power house to a resistance coupled affair. My present favorite is one stage of transformer (3½ to 1 ratio) and two of resistance; this delivers volume and freedom from distortion *in itself;* if WBZ is buzzing, as usual, you cannot eliminate the buzz.

This is an expensive set to build and an expensive set to run, but it is the simplest to build and much the simplest to operate—and I have constructed many kinds. Reflexing and second harmonic stuff reduce the number of tubes, but if a fellow wants a Super-Heterodyne, why build a makeshift? Cutting out one tube is like cutting out one celiar window in a half million dollar house—you'd never note the saving. You cannot get something for nothing, nor can you hope to sidestep any of the responsibilities of a multi-tube set and expect to get results comparable to those given by the set with a full complement of vitals.

Put in all the fixed condensers called for by the diagram you use and then take them out, one at a time, and see just what they do (if anything). You will find that no two circuits respond alike, and that you may have to vary the placing and values of the fixed condensers considerably.



The tools the author recommends in the construction of Super-Heterodynes.

And tubes! Ninety-eight per cent of all Super-Heterodyne troubles are due to the poor tubes dumped on the market. No two of them have the same characteristics and many of them will not function at all in this circuit. If you have any trouble, suspect the tubes *first;* change them all about until you find the best combination, and then mark them. After you get the tubes balanced, the set will work like Old Dog Tray; Old Faithful isn't in it for reliability.

Last, but not least, if you must have a cabinet, see to it that it is ample in size—that the instruments are two inches from the sides of the panel, and if your location is at all damp, use kiln dried oak soaked in hot paraffin for base, shelf and box.

I cheerfully admit all the shoutings about static and noise levels and what not, but when there is static of more than normal severity *no* receiver is a DX getter and *no* loop will relieve it; but when reception is good—um! Well, I'm glad I own the original of the go-getter I have told you about —it brought in French ESP on the night of November 24, 1924 when darned few in this country got 'em!

CONSTRUCTION OF AN INSULATING TUBE FOR COIL WINDING

Sheet celluloid, such as old photographic films, when rolled and cemented together with collodion, or a cement made by dissolving some scrap celluloid in acetone, or in equal parts of alcohol and ether, makes a first class tube upon which to wind inductance coils.

These old films, which range in size up to 12 inches by 14 inches, can be had for the asking from most any photographer, or from some doctor friend who does X-ray work.

First remove the gelatine emulsion from them by soaking in hot water and scraping. Hang them by two corners so they will be smooth when dry. Get a smooth round stick or bottle or mailing tube with a diameter a little less than the tube you wish to make. Wrap the celluloid tightly and smoothly around this core, and when one complete turn has been made, quickly smear a light coat of the cement over the whole surface. Then make another turn, keeping the entire outside face lightly coated with the cement. When you have from four to six layers, depending upon how thick you wish the tube to be, wrap the whole thing tightly in a cloth or towel and lay aside to dry for a few hours.

Remember to wrap tightly and smoothly and to apply only a light smooth coat of cement.

Contributed by Dr. William H. McKie.

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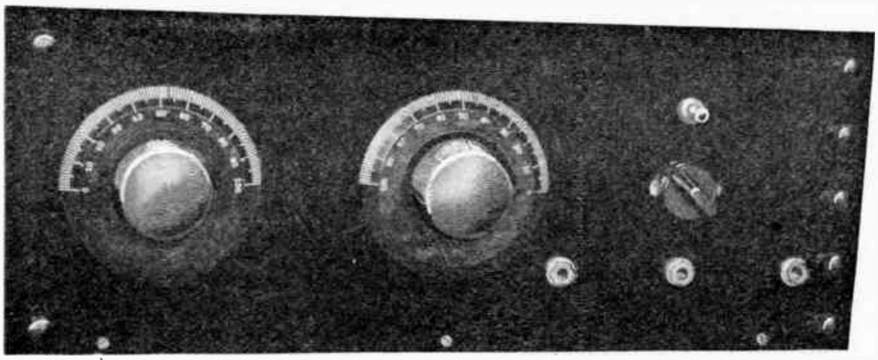
A Good Short Wave Receiver

By THE STAFF OF RADIO NEWS

In view of the constantly increasing activities in short waves, the importance of the band of frequencies lying between fifty and one hundred and fifty meters cannot be overestimated.



Above is a view of the front of the set described in this article.

ONE of the most remarkable recent radio developments is short wave radio reception. Station KDKA, Pittsburgh, now transmits its regular program simultaneously on short wave. The same is the case of WGY. These low wave-lengths have tremendous penetrating power, and can readily be received almost anywhere in the country by means of the set shown here. At these low wave-lengths, the efficiency is much greater. This set receives regularly, in New York, French amateur stations on wave-lengths of 70 to 120 meters. For the experimenter this set should prove of great interest.

—EDITOR.

WHEN the regular DX stations begin to pall and the old thrill no longer accompanies a 50-mile addition to the range of the set, it is time for the listener to look about for new fields to conquer. His logical course under these circumstances is to find a field in which knowledge is the exception and not the rule. With everyone telling of receiving the regular stuff, there ceases to be fun in retailing the experiences of the night before, that is, if one's friends have a handy bunch of experiences of their own similar to those being exposed.

The solution is short waves. The field is new. Even the expert scientists know little about it. And the good part of it is that it is extremely easy for the ordinary listener to build a set which will lead him into this new and alluring portion of America's greatest indoor sport.

And there is no deficiency in the number of stations to which the builder may listen. And location makes no difference since the broadcasters using the short waves put much more power into their tubes at the short wave-lengths than at the standard frequencies.

The set described in this article is very much like the ordinary regenerator. The only difference lies in the constants of the circuits. Such sizes have been chosen for the coils as to make the ordinary .0005 mfd. variable condenser usable in the circuit. In fact, if the builder has a regenerator already in working condition, only a couple of changes will be necessary for conversion of the set into an extremely efficient "short waver."

The panel is a standard 7 by 18 inch bakelite strip. Its drilling will depend upon the parts used, so no definite directions will be given for this operation. The apparatus should be placed as nearly similarly to the arrangement given in the photograph as possible for the sake of lead shortness. And when working at the higher frequencies this point is extremely important.

The tuner is of the aperiodic primary low loss type. And low loss in this instance means that the smallest amount of insulation possible must be used for supporting the coils. The tuner shown in the illustration employs the stagger method of winding, but straight winding will serve just as well if the spacing between the turns is equal to the thickness of the wire.

The primary consists of about six turns of heavy wire—No. 14 will serve excellently—spaced broadly and wound over the secondary. The secondary consists of 14 to 16 turns of No. 18 D.C.C. wire; the tickler will have approximately the same number of turns, wound on a spider-web form. The secondary may be wound as shown by placing 15 large nails or pegs equally distanced around the circumference of a circle three and one-half inches in diameter. Any handy board will do to support the nails. Their heads must be removed before driving, so that the completed coil will slip off easily. The use of twenty-penny nails is recommended.

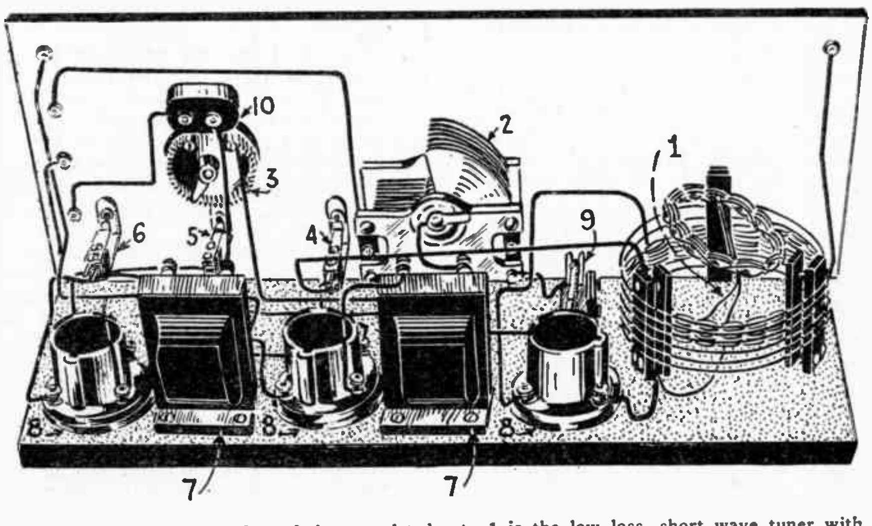
Below is a complete list of parts to be used in the short wave receiver. All instruments should be of the low loss type.

LIST OF PARTS

1 23-plate variable condenser.
1 Short wave coupler.
2 Audio frequency transfomers.
3 Sockets.
1 Grid condenser (.00025 mfd.) and grid leak.
1 Rheostat.
2 Amperites.
2 Filament control jacks for first and second stages.
1 Double circuit jack.
1 Filament Switch.
1 7x18 inch bakelite panel.
7 Binding posts.
Bus bar for wiring.
Follow the diagrams for placement of apparatus.

With the form completed, begin the coil at one nail, pass the wire on the outside of two of the nails, then to the inside of two, and then to the outside of two and so on until 11 turns have been made. The supports for the coil are simply four short strips of hard rubber or bakelite, each drilled at both ends. Two of the strips are placed on one side and two on the other, of the coil, diametrically opposite each other. The strips are used in pairs, one strip inside and the other outside, with small screws and nuts holding them together and clamping the coil between.

With the secondary in place, the primary is wound directly over the outside of the



Above is given a rear view of the completed set. 1 is the low loss, short wave tuner with aperiodic silver plated primary. 2 is the variable condenser of the low loss type; it is the standard .0005 variety. 3 is the filament rheostat for the detector. 4 is the filament control jack for the detector. 5 is the same thing for the first stage of audio frequency and 6 the jack for the second stage. The two low ratio audio frequency transformers are indicated at 7. The three sockets for the tubes are noted at 8 and the grid leak and condenser at 9. 10 shows the battery switch. The number of secondary turns control the wavelength range.

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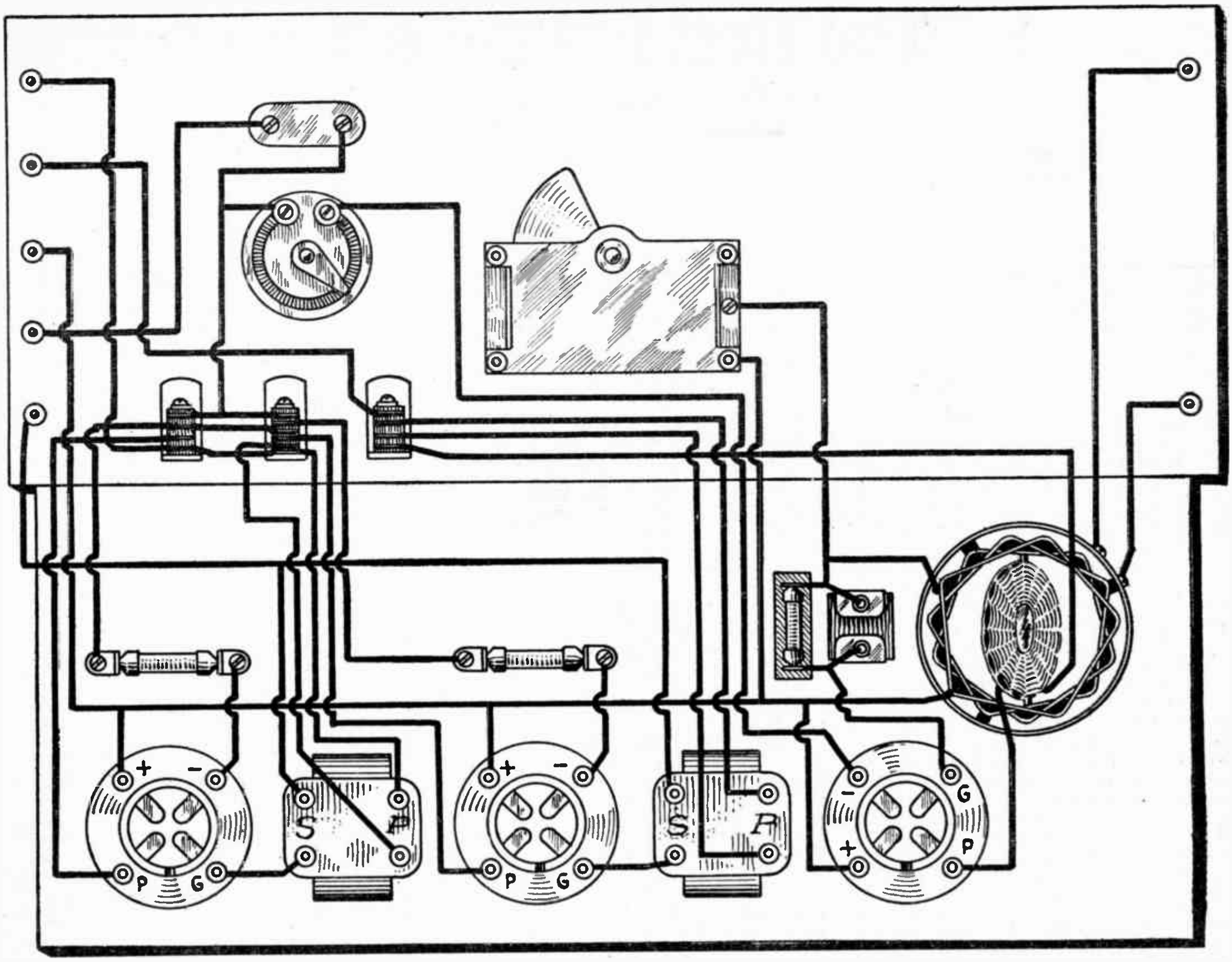


Panel and base board layout for the set including wiring scheme and placement of the apparatus is shown above.

supports. Extra drillings will have to be made to provide fastenings of the primary. The turns of this coil should be spaced according to the proportions shown in the photograph.

The tickler may be wound on a large spider-web form. The inside diameter of the tickler should be two inches. After the winding has been made in the regular fashion, consisting of 16 turns, the coil may be bound with thread and the form removed. This is accomplished by cutting the center out of the form and then removing the pegs.

It may be supported on a hard rubber or bakelite rod. If the rod is selected of such a size that it will fit a bushing, similar to those used with jacks or switches, it may be pushed through two of the spaces of the coil diametrically opposite. This coil should be so mounted that only one-third of it is below the top turn of the secondary winding.

Some experimenting may have to be done with the size of the tickler before the proper value is obtained so that control may be had over the whole range of wave-lengths.

The mounting of the tuning instrument should be such that the leads to the remainder of the apparatus are as short and direct as possible.. For this reason it will be found best to follow the layout of the instruments shown in the photographs.

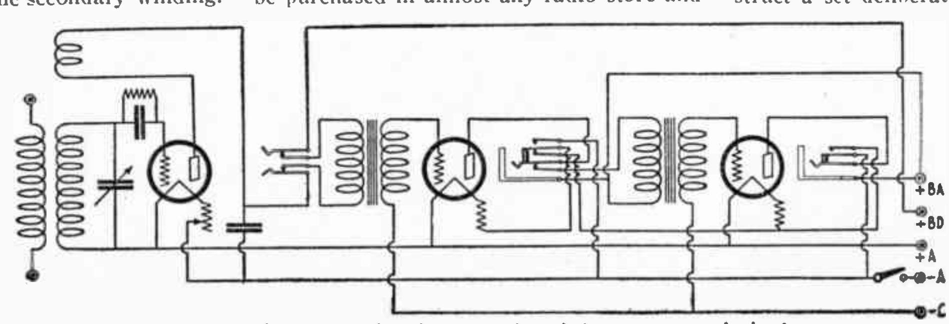
Filament control jacks are employed for the sake of economy and efficiency. Amperites or automatic control resistances are used to regulate the supply of current to the filaments of the two audio frequency tubes. A rheostat is employed in connection with the detector, however. Clarity and volume, together with a decided saving of "B" battery current are obtained with the use of a "C" battery in the grid returns of the two audio stages.

A variable grid leak will be found advantageous in the detector circuit.

A note must be added here for those who contemplate purchasing the tuner on the market and reconstructing it for use in the present set. The low loss type recommended is plainly shown in the photograph. It can be purchased in almost any radio store and only a few changes are necessary for making it available in the short wave circuit. Sufficient turns should be removed from the bottom of the secondary to leave the required number. The turns must be removed from the bottom of the coil so as to leave the tickler as near the secondary as possible. The tickler is reduced in the same manner from the inside out. The silvered primary winding may be left intact, as it is built to operate aperiodically.

Any condenser may be employed, but it would be best to find one with low losses. This characteristic may be checked by going through the reports of the Radio News Laboratories. This information is available for every instrument which has been submitted for test. The only method by which the efficiency of a condenser may be learned is through such tests as are made in the Laboratories. It would be quite silly to construct a set deliberately seeking low losses, and then incorporate a condenser with "mud" insulation of inferior design. A condenser should be judged by its high frequency resistance.

If the design given has been followed and care has been observed, the set will bring in all stations between 50 and 200 meters—and bring them in roaring.



The schematic wiring diagram showing the connection of the apparatus. A simple regenerator and two stages of audio frequency amplification is shown above. Vernier dials are advised.

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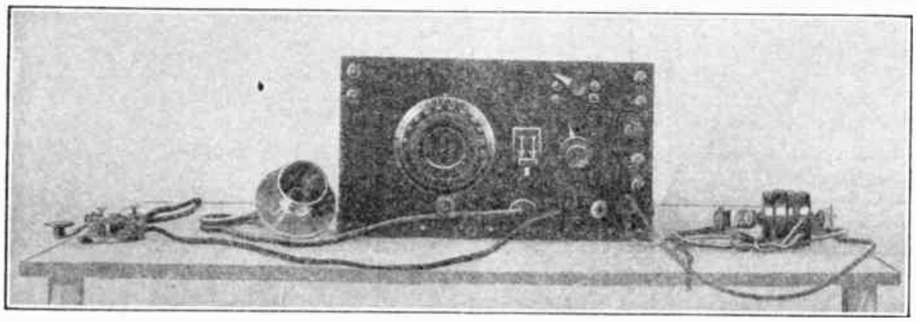
The Radio "Uni-Set"

By H. M. TOWNE, (1ADG)

The description of an excellent combination transmitter and receiver, simple of construction and highly efficient. As a transmitter, it can be employed for either C.W. or phone. Mr. Towne has given full constructional details.



A front view of Mr. Towne's "Uni-set." The two switches employed for shifting from transmitting to receiving can be seen on the panel, one in the center and the other above the potentiometer knob.

THE employment of the shorter wave-lengths has enabled radio communication over relatively great distances with surprisingly small amounts of transmitted energy. With the amateur wave bands of 40 and 80 meters and 150 to 200 meters, trans-continental communication has been repeatedly carried on during favorable night hours with transmitters of 5 watt rating, while the reliable daylight range of numerous amateur 5 and 10 watt transmitters is several hundred miles. Mindful of these performance records and the advantages of the small power outfits in the way of cost and simplicity, the writer desires to point out a still further utility in the combination of a short wave small power transmitter and receiving set into one unit which I have called the "Uni-Set".

In the design of any radio transmitter or receiver, there is essentially the same fundamental circuit. There is the coil system or tuning inductances together with capacitances either variable or fixed which, when combined with a vacuum tube, form an oscillating circuit with some measure of control of the energy feed-back from plate to grid circuit. In both the transmitter and receiver, the antenna is coupled either conductively or inductively to the tuning system. There is practically no transmitting circuit which cannot be used for reception of continuous wave telegraphy, and by providing control of the feed-back, voice reception becomes possible. Likewise, the majority of receivers used today are capable of transmitting which fact is fairly well substantiated by the squeals and howls heard on broadcast reception in communities where the density of broadcast listeners is great. (The meaning of the word density is left optional with the reader.) The three-coil Meissner transmitting circuit bears a rather close resemblance to the ordinary two-circuit receiving tuner, and was chosen for the fundamental circuit of the "Uni-Set". This allows inductive coupling of the antenna circuit, which is essential to the 75 to 80 meter transmission.

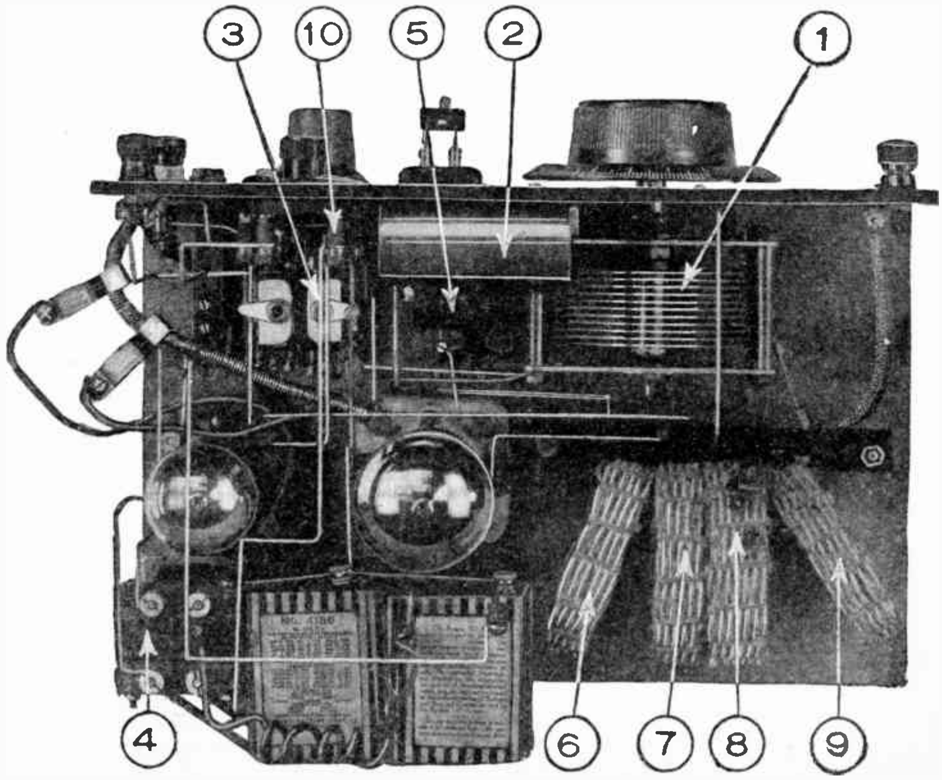
SWITCHING ARRANGEMENT.

The diagram of connections of the "Uni-Set" is shown in Fig. 1. There is one tuning control, which is the variable condenser VC, which controls the adjustment of wave-length for both transmitting and receiving. There is one other control which is used for receiving only and that is the potentiometer which provides for the adjustment of regeneration. It will be seen that the double pole double throw switch S^1 provides for changing the plate voltage on the oscillator tube from 45-volt "B" battery to 500-volt D.C. motor-generator supply or rectifier, which furnish the plate potentials for receiving and transmitting, respectively. In addition to throwing this switch S^1, it is necessary to close the double pole single throw switch S^2 when changing from receiving to transmitting. This inserts a .002 mfd. grid condenser with 10,000 ohm grid leak in series with the grid of the oscillator tube. When the switch S^2 is open for the receiving position, the grid condenser is .00025 mfd. with a 7 megohm grid leak. The closing of the switch simply puts a larger capacity grid condenser and lower resistance grid leak in multiple with the receiving grid condenser and leak.

THE TUBES.

In order that there be no unnecessary sacrifice in reception, one stage of audio frequency amplification is provided, using a standard audio transformer with a UV-201 A with 45 volts plate potential. As to the oscillator tube, I started out with a 201A, which was later replaced with a UV-202, a 5-watt tube. The latter tube required the addition of one 2-volt cell to my 6-volt storage battery, thus giving 8 volts for filament supply. The rated filament voltage being 7½ volts, it was necessary to insert a small series resistance between the "A" battery terminals on the "Uni-Set" and the filament, the resistance value being .22 ohm and of sufficient current rating for the 2.35 amps. filament current. Since the filament of the UV-201A amplifier tube must be supplied from the same "A" battery, a fixed resistance of 12 ohms must be inserted between the "A" battery terminals and the filament of the amplifier tube. This resistance with a filament current of ¼ ampere through it results in a 3-volt drop and thus gives the current value of 5 volts on the amplifier filament terminals. Of course, filament rheostats might be used, but they represent unnecessary controls and require much greater space than the simple fixed resistance of correct value. A battery switch is inserted between the "A" battery binding posts and the filament circuits which provides for "on" and "off" control.

It should be noted from the diagram that the "B" battery voltage and plate circuit inductance are adjustable on the oscillator tube for the receiving position of the switch S^1. These adjustments provide an initial regulation of the feed-back or regeneration so that the final control is accurately yet quite simply and easily accomplished



An interior view of the Uni-Set showing the position of the apparatus. Note the manner in which the coils are mounted. The parts in this photo are numbered the same as in the photo on the next page and are designated in that caption.

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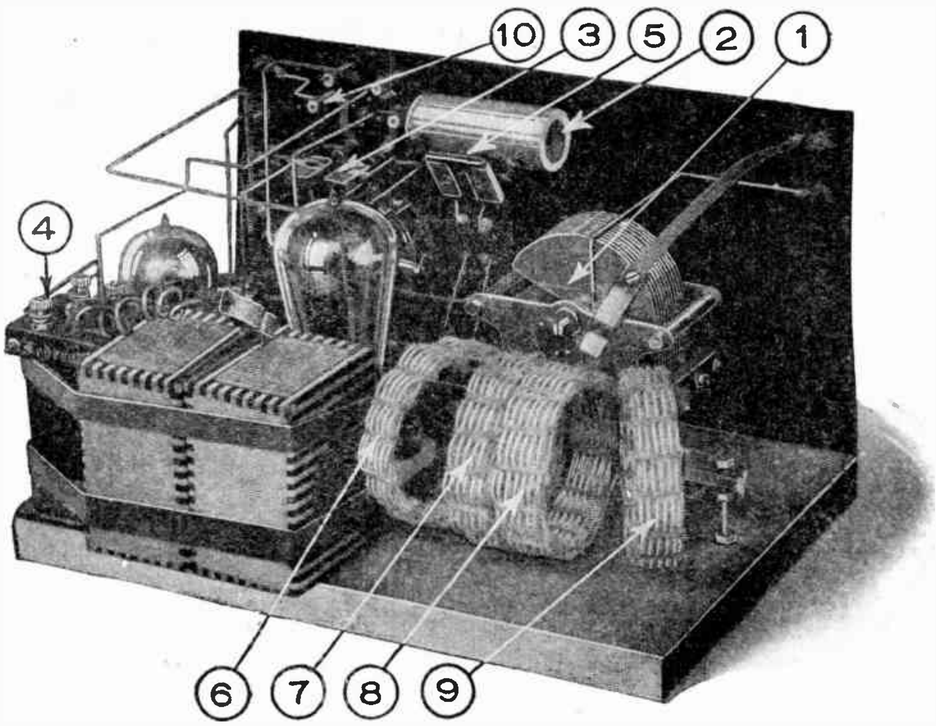
with the potentiometer. I have found that adjustment of "B" battery voltage alone (about 10½ v.) will give about the proper regulation so that perfect control of regeneration is had with the potentiometer. It should be noted that the adjustment of the potentiometer has no effect whatever on the oscillator when the switch S_1 is in the transmitting position. A .005 mfd. by-pass condenser shunts the radio frequency out of the potentiometer.

Separate jacks are provided for the telephone receivers, telegraph key, plate milliameter and microphone, the latter being used with the loop absorption method of modulation for voice transmission. For C.W. telegraphy, the key may be plugged in the plate circuit jack using an external series reactor and shunt condenser to minimize key clicks, or, the keying can be done in the grid and plate returns to the filament. I have been using the latter method, which in the set described has the slight disadvantage of requiring the extra operation of pulling out the key plug when changing from transmitting to receiving. It is desirable to remove the microphone plug from its jack when using C.W. telegraphy to avoid any absorption of energy in the modulating loop.

THE COILS

As will be seen from the photographs, the coil system employs low loss basket wound coils. These are three inches in diameter and consist of 16 turns of 16 D.C.C. wire, with the exception of the antenna coupling coil which has 20 turns total with taps at 5, 10 and 15 turns. These coils are mounted side by side on a paraffin treated wood strip, the whole support of the coils being afforded by inserting the end terminal wires tightly through small holes drilled in the treated wood strip. No screws or binding posts are necessary to such mounting. Some small variation of coupling is possible by tilting the coil to one side or the other. A close coupling of the plate coil to antenna coil is desirable, but the grid coil and modulation coil are preferably coupled more loosely by tilting them out of the plane of the two middle coils by an angle of about 40 degrees. When once adjusted, the coupling of all coils remains fixed.



A rear view of the Uni-Set. The parts are. 1—variable condenser; 2—transmitting grid leak; 3—receiving grid condenser; 4—A. F. transformer; 5—transmitting grid condenser; 6—grid coil; 7—antenna coil; 8—plate coil; 9—microphone coil; 10—double pole, double throw change over switch.

Needless to say, the variable condenser VC should be of low loss design and equipped with a vernier control which will in no way prevent a rapid movement of the rotor plates. It has a capacity of .0005 mfd. This condenser closely shunted around the 16 turn grid coil enables a wave-length range of from 55 meters to 202 meters, thus taking in both of the higher amateur wave bands.

THE ANTENNA SYSTEM

Along with a brief description of the operation of the "Uni-Set", I might first give dimensions of the antenna and counterpoise which I employ. The antenna is a single copper wire No. 10 B & S, 65 feet long, with an additional 21-foot lead-in. The horizontal portion is 50 feet above the ground on the far end and 24 feet at the near end. The counterpoise is a single copper wire No. 10 B & S, 65 feet long, 7 feet above the ground and directly under the antenna. This antenna and counterpoise with the full 20 turns of the antenna coupling coil gives a wave-length for the antenna circuit of 152 meters. With the switches S^1 and S^2 in the transmitting position, it is only necessary to go slowly through the range of the grid variable condenser to put the oscillator circuit in resonance with the antenna circuit, which condition will be indicated by maximum antenna current.

With the above described antenna system and the 5-watt oscillator with 500 volts

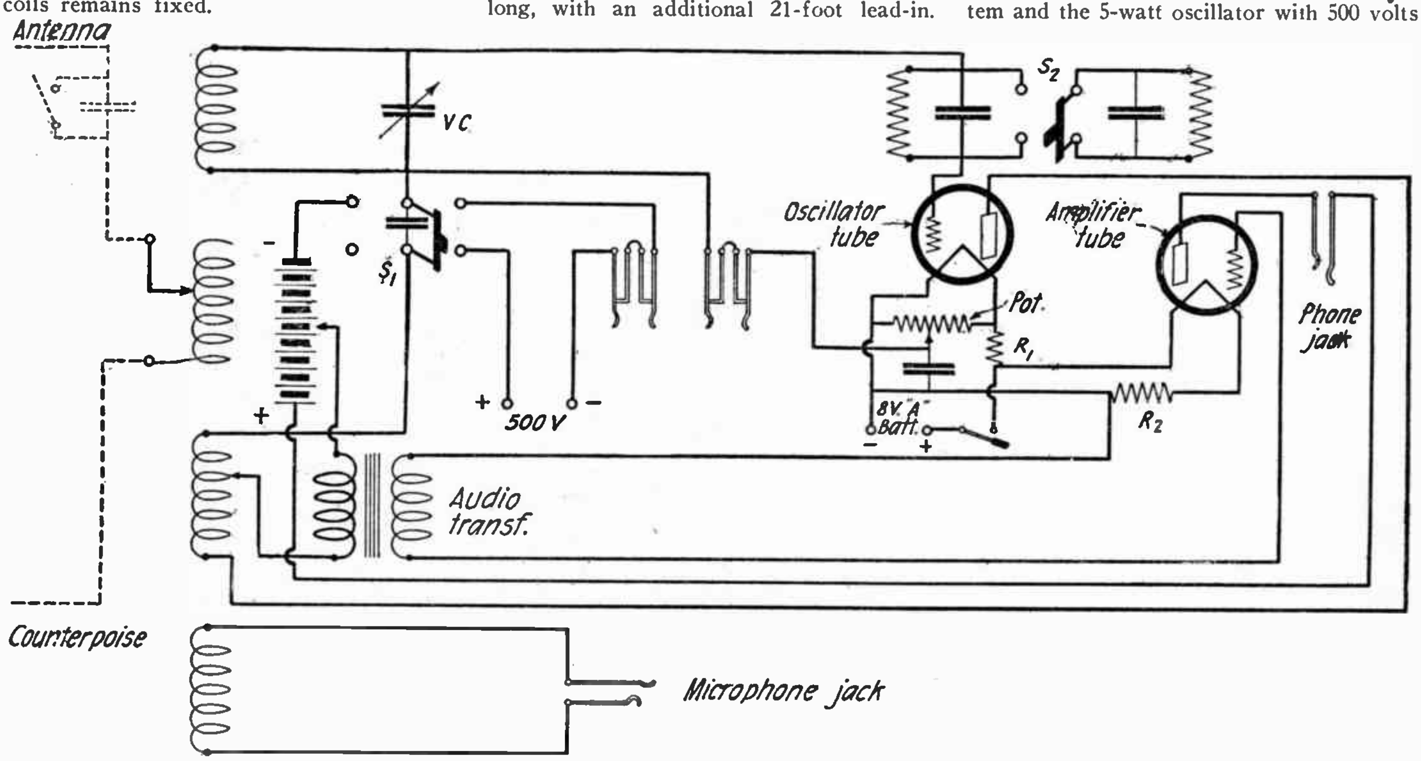


Fig. 1. The complete circuit diagram of the Uni-Set. The Meissner circuit is employed. Switch S changes the "B" voltage on the plate of the oscillator tube, for transmitting or receiving and the potentiometer controls regeneration or oscillation when receiving. Switch S2 throws the transmitting grid leak and condenser into circuit.

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plate potential, the antenna current is .8 ampere. For the 75- to 80-meter waveband, a series antenna condenser is inserted external to the "Uni-Set" and the clip changed to the 10-turn tap on the antenna coupling coil. This series condenser is adjusted to give the antenna system the desired wave, say 80 meters, and the grid variable condenser then adjusted for resonance. At 80 meters, with same oscillator and antenna system, the antenna current is .4 amperes. There will be these two definite settings of the condenser VC for transmitting; that is, a setting for each wave-length, 80 and 152 meters. Then the grid condenser VC must always be set back to one of these settings when changing from receiving to transmitting, the setting depending upon which wave-length is being employed at the time. This adjustment is not critical, particularly at the 150-200 meter range where one or two degrees either side of the optimum does not change wave-length or antenna current perceptibly. At the 75-80 meter range, the adjustment must be a little more accurate, but it is not critical at all.

"The proof of the pudding is in the eating", and so the writer has been losing sleep during the past couple of weeks to see if the "Uni-Set" might be worthy of a DX rating. I have been reported QSA on both waves, 80 meters and 152 meters, by amateurs in practically all districts with whom C.W. communication has been established. A general CQ call on 80 meters one favorable morning (2:40 A. M.) "raised" about five different Pacific Coast amateurs. Signals were reported being received with an audibility of 6 at Bahia Blanca, Argentina, S. A. (rDB2), on a two-tube "1BGF" receiver. The combination of D.C. filament supply from storage battery and a good 500-volt D.C. generator with a 10 mfd. condenser across the output to smooth out any commutator ripples results in producing a pure, penetrating D.C. note on C.W. transmission, which has caused favorable comment from practically all of the amateurs which have been worked and several have inquired if storage batteries were being employed for plate voltage suply.

The "Uni-Set" can be used with a UV-201A tube as an oscillator and 250 volts plate potential from "B" batteries or other plate supply and will give a daylight transmitting range up to 50 miles, with a night time range of several hundred miles under favorable conditions.

Of course, when the UV-201A tube is used, the ordinary 6-volt storage battery can be used and the fixed filament resistances altered to provide proper filament voltage. It will also be found that the smaller tube as an oscillator will probably require a slight change in the "B" battery plate voltage for the receiving adjustment. At 160 meters I obtained with the UV-201A oscillator an antenna current of 100 milliamperes, and voice was reported very QSA with excellent clarity eight miles away during daylight. While practically all of the communication with the "Uni-Set" has been with C.W. telegraphy, two or three tests on voice transmission have indicated very satisfactory performance, although, of course, the loop absorption method does not permit of modulating but a small amount of the output energy.

While the "Uni-Set" does not embody quite the facility of the permanently adjusted and separate transmitting and receiving units, and is perhaps not quite so efficient, it does posses a simplicity and utility which is appealing, particularly in conjunction with monetary saving. It can be quickly tuned up to any average amateur antenna and adjusted to various transmitting waves. On the receiving side, it is simple to handle, requiring only two controls which are the condenser VC and the potentiometer. During the present winter months the "6" amateurs (Sixth District, Pacific Coast) come in with fairly good audibility on the more favorable nights (this reception being at Pittsfield, Mass.).(The change of switches and VC adjustment for shifting from transmitting to receiving, or vice versa, requires about two seconds. When starting to work a station, however, it is best to make a notation of the dial setting of the VC so that on subsequent change-overs after transmission, the "Uni-Set" can be put back to precisely the same receiving adjustment without any exploring.

LIST OF MATERIAL REQUIRED TO CONSTRUCT THE "UNI-SET"

1 .0005 Low loss variable condenser.
1 5-Watt UV-202.
1 UV-201A amplifier.
1 Pyrex low loss tube socket for oscillator tube.
1 Ordinary socket for amplifier tube.
1 200-Ohm potentiometer.
1 Audio frequency transformer.
2 Single circuit phone jacks.
2 Double circuit phone jacks.
1 .00025 mfd. grid condenser for receiving.
1 .002 mfd. grid condenser for transmitting.
1 .005 mfd. condenser for potentiometer by-pass.
1 .005 mfd. condenser for by-pass on switch S¹.
1 Rotary type double pole double throw switch S¹.
1 "Baby" double pole single throw knife switch S².
2 22½-volt "B" batteries with taps.
1 Receiving grid leak resistance, 7 megohms.
1 Transmitting grid leak, resistance 10,000 ohms.
3 Phone plugs for use with key, microphone and receivers.
1 Fixed filament resistance .22 ohm for 2.35 amperes.
1 Fixed filament resistance 12 ohms for .25 amperes.
1 Battery switch for "A" battery.
6 Binding posts.
1 Panel 7 x 12 x ¼ inches.
1 Baseboard 7 x 12 x ⅞ inches.
Coil system as described.
1 Microphone transmitter.
1 Telegraph key.
1 Set telephone receivers.
1 .00025 Low loss variable condenser.
Miscellaneous screws, nuts and bus wire.

A Crack 40-80 Meter Set

By E. W. THATCHER

AND where is the man who said it couldn't be done? A review of the accomplishments in the field of amateur radio during the past would contain such stupendous developments as to stagger the most vivid imagination. Hazy dreams and aspirations of the past have become real experience—and not only that, but everyday experience to a great number of amateurs throughout the entire world. Communication across states, across continents, across oceans, to the antipodes has become the rule of the game. Communication of nearly three thousand miles at noon with less than one kilowatt input has been maintained with clock-like regularity. Through it all, we see growing that even increasing bond of friendship which comes through community of interest. National, geographical and racial barriers fall before the advance of amateur radio communication.

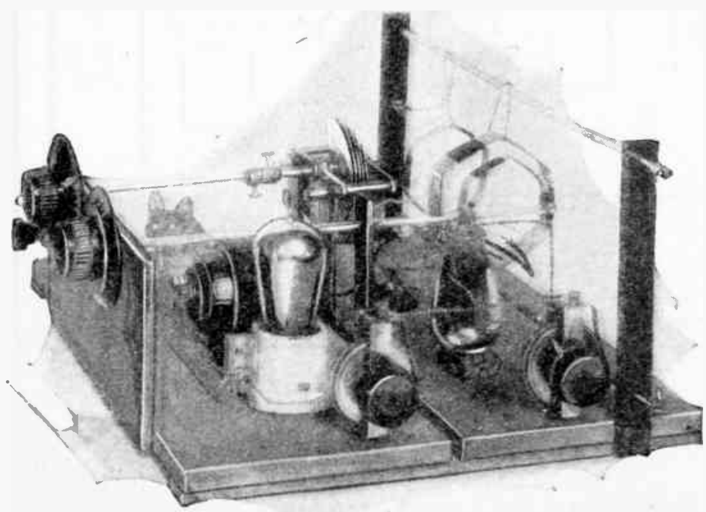


Fig. 2. On the left is the receiving equipment. The inductances are suspended from the horizontal glass rod. Note the fanned plates of the variable condenser.

This great advance in the art owes its existence to such men as John L. Reinartz, who are ever forging ahead, discovering new facts, and opening new fields of investigation. The readers of the RADIO NEWS will remember his monumental work on twenty-meter transmission.

The wave bands allotted to amateurs have been proven to possess widely varying qualities, but the concordant results of many experimenters makes possible a statement of the general characteristics of each.

World Radio History

BAND	DAYLIGHT CHARACTERISTICS	NIGHT CHARACTERISTICS
150 to 200 meters	Range, 0-200 miles Fading, nil Atmospherics, strong	Range, 0-2,000 miles Fading, bad Atmospherics, very strong
75 to 85.6 meters	Range, 0-400 miles Fading, nil Atmospherics, nil	Range, 250-5,000 miles Fading, slight Atmospherics, bad
37.5 to 42.8 meters	Range, 250-1,000 miles Fading, nil Atmospherics, nil	Range, 500-10,000 miles Fading, very slight Atmospherics, weak
18.7 to 21.4 meters	Range, 1,000-3,000 miles Fading, nil	Range, 4,000-??? Fading, nil
4.69 to 5.35 meters	Range, ?——?	Range, ?——?

While these figures are far from "hard and fast" they serve to give a basis of comparison on which to work. It can readily be seen that some of the bands have advantages peculiar to themselves and a particular kind of service. The purpose of this article is to present, in as concise a manner as possible, points in the construction and operation of a simple but efficient transmitter and receiver, capable of operation on either the 40-or the 80-meter band.

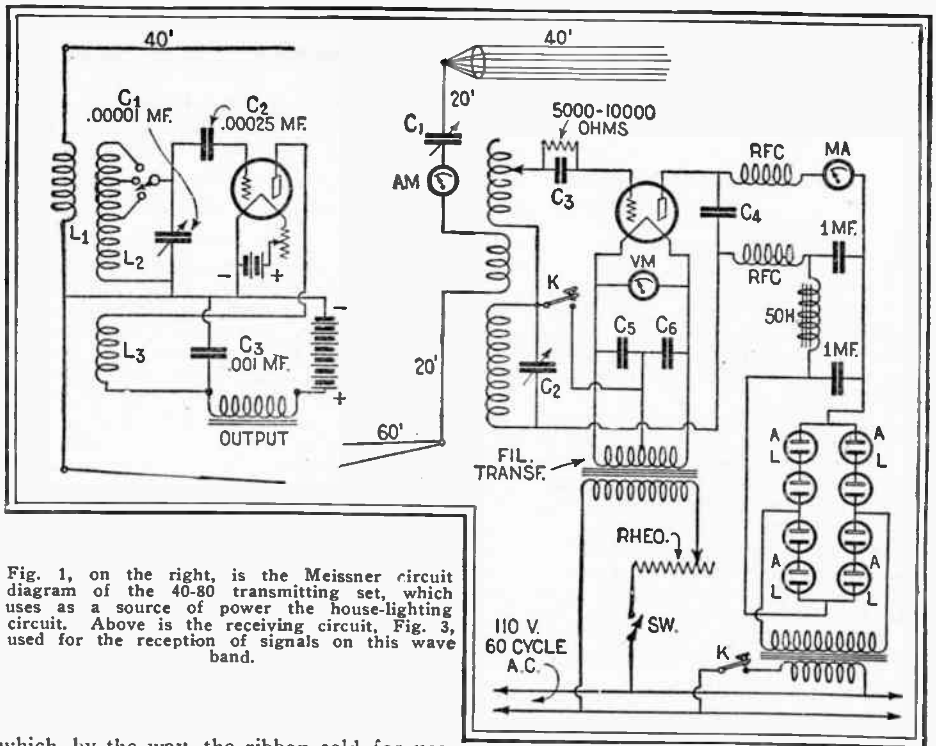


Fig. 1, on the right, is the Meissner circuit diagram of the 40-80 transmitting set, which uses as a source of power the house-lighting circuit. Above is the receiving circuit, Fig. 3, used for the reception of signals on this wave band.

THE TRANSMITTER

The transmitter employs one so-called 50-watt tube in a Meissner type circuit (Fig. 1). The arrangement was planned to reduce the length of the leads in the oscillating circuit.

The base is removed from the tube and mounted in an inverted vertical position. A small wooden box with a hole cut slightly larger than the tube furnishes the support, while the tube itself rests upon a small piece of sponge rubber. Around the edge of the box are fastened the condensers, C_3, C_4, C_5 and C_6 all of .002 mf. capacity. The left end of the box supports the grid leak. Thus all the leads are centered around the top of the inverted tube, and may be made extremely short.

The power for the plate is supplied by a transformer which delivers 1,500 volts either side of the center tap. An electrolytic rectifier, consisting of 40 lead-aluminum cells in a "bridge" circuit, gives a pulsating unidirectional current which is ironed out by two shunt condensers of one microfarad each, and a large iron-core choke.

The radio frequency chokes are wound with 250 turns of No. 26 D.C.C. wire on a 2½-inch cardboard tube. A convenient means of telling whether in the individual case the number of turns is sufficient is to draw the blade of a wood-handled screwdriver along the surface of the coil while the set is in operation. There will be a hot spark as far back as the R.F. gets in the coil and beyond that—nothing. For the voltage and power used normally in the writer's station, the R.F. was choked out about an inch from the bottom of the coil. The undertaker should be interviewed before using a metal-handled instrument or touching the steel shank of the screwdriver during the test.

The plan followed by the writer in making the inductances will prove the solution to one of the problems that always confronts the experimenter—that of building an inductance that is at once rigid, of low resistance and productive of low dielectric loss. Strips of heavy cardboard were cut, slotted so that they dove-tailed at the center, and wound with turns of copper ribbon in lateral slits made in the cross pieces. The pancakes are supported by two parallel glass rods, on which they may be moved at will. The coils in use at the present time consist of eight turns, each, of copper ribbon, for which, by the way, the ribbon sold for use as receiving antennae serves admirably.

The leads from the antenna and counterpoise are brought in through a panel of plate glass(an ex-windshield from an automobile, which was secured from the local garage at the cost of $0.00). Holes were pierced with an ordinary steel drill which had first been tempered in mercury.

A word as to the operation of this transmitter might well be added here. In the first place, the antenna was so constructed as to have a fundamental wave-length of 120 meters. The dimensions are here given as a guide in building one to operate in a similar way.

THE ANTENNA

A three-foot cage is suspended at a height of 55 feet and a lead-in 25 feet in length, of 8-inch cage, is brought down to the insulating panel in the window. The total length is 75 feet from the apparatus. The counterpoise is a single two-wire fan. The wires are separated at the point where the lead is connected at a 30 degree angle. The overall length is 80 feet and the fan is stretched 15 feet from the earth.

Now, with the antenna circuit disconnected from the inductance, the closed circuit may be readily tuned to a wave of 40 meters. The method of tuning will be described shortly. After this is done, connecting the antenna directly to the inductance will cause oscillations to occur on the third harmonic of the antenna fundamental; the resonance point will be indicated by maximum current registered on the antenna ammeter. This has proven a very effective method of operation.

For the 80-meter band the series condenser is inserted, and the natural frequency of the open circuit made to correspond to 80 meters. The closed circuit is brought to resonance by increasing the inductance in the plate and grid circuit, and tuning as a final adjustment with the plate condenser to maximum output.

THE RECEIVER

Here again "simplicity is the best policy" The circuit which has given the best results covers the wave bands from 10 to 125 meters. The coils are wound in an hexagonal form and made self-supporting by small strips of gummed tape. The winding form may be made by inserting pegs or spikes in a small board. After the wire is wound and the winding made secure, the pegs may be removed to facilitate freeing the coil from the form. See Fig. 2.

The method of mounting the coils is of particular interest. Two hard rubber strips were erected near the back of the baseboard. Two holes, an inch from the top, carry a glass rod from which the coils are suspended. Corresponding to this and directly below it is a copper tube. This tube is grounded, and then all points in the circuit which should be at ground potential are connected to it. The frame of the variable condenser also forms a part of this ground system.

The tuning parts are placed at the back of the board to avoid all capacity effects, and also to eliminate proximity to panels and other wiring. A small "dummy" panel is mounted at the front, and the two dials which it holds are connected to the secondary condenser and the ticker coil by means of glass rods. The latter is bound to the rod with a pair of rubber bands.

In all other particulars, the cut is self-explanatory. Fanned condenser plates, baseless tube (detector) and the one stage of audio frequency amplification are familiar details. It has been found possible (by inserting a small solder lug on the third, seventh, thirteenth and seventeenth (last) turns, to effectively cover all waves from 10 to 125 meters. The antenna coupling coil is of five and the tickler of eleven turns. All are wound with No. 16 D. C. C. wire.

Several receiving antenna systems have been tried at the writer's station. It is interesting to note that the one which has proven the most satisfactory under all conditions is that employing a single wire about 40 feet long, and stretched across the room as an antenna and another outside, 20 feet high, which acts as a counterpoise. This combination has ben found to give the greatest signal-static ratio, which is of great importance in reception, especially over great distances. No actual ground connection is used, as the counterpoise takes its place.

For night and day—summer and winter, a station which can operate on these two waves and can shift easily from one to the other as is true of the one here described, will be able at all times to cover the greatest **distance and maintain the most consistent** communication.

World Radio History

An Improved Laboratory Super-Heterodyne

By ERNEST R. PFAFF

Here is another Super-Heterodyne, which incorporates two rather novel ideas. One is the use of plug-in inductances and the other is the connection of the oscillator to the first detector.

WITH the advent of a new radio season, bringing with it receiving conditions differing immeasurably from those encountered last year, the time seems most opportune to present a description of an improved Super-Heterodyne, designed to meet existing American or foreign broadcast conditions.

Aside from the increased number of broadcasters, and their increased power, there is the extension of wave-length ranges to be considered. Last year 250 meters was the low limit in practical use. Today it is 300,000 cycles higher, or 200 meters. Few of last year's receivers will efficiently reach this new low limit, so that our really practical receiver must go down to 50 meters and up to 550. If it is desired to listen to the high-powered European stations, then this range must be extended to 2700 meters.

SPECIFICATIONS.

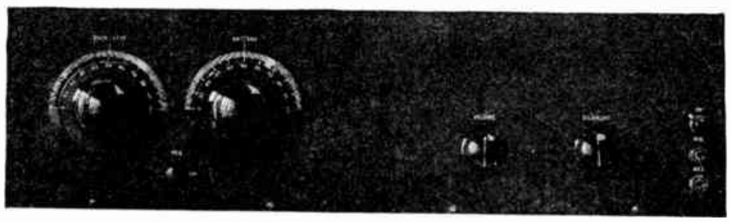
Possibly the first features to strike the eye are the interchangeable oscillator and antenna coil systems. Plug-in coils are used in each circuit, arranged to cover the desired wave-length range. Three coils are used in either oscillator or antenna circuit to tune from 50 to 550 meters. They are wound upon moulded bakelite forms.

If a loop is to be used, it is merely necessary to remove the antenna coil from its six-contact socket and connect the loop to three binding posts on the socket. For different wave-length ranges, both oscillator and antenna coils are merely plugged in or out, exactly as a tube would be. The oscillator coupling coil is connected in the filament return of the first detector rather than in the grid lead, which gives somewhat greater selectivity and permits of greater efficiency at short wave-lengths.

Straight-line frequency condensers are recommended, in order that maximum ease of tuning may be experienced upon the short waves.

Vernier dials may or may not be used, as desired, but it will be found somewhat difficult to tune the receiver without them. Some friction type should be used, if it is desired to take advantage of the single-control feature, which will be considered further on.

Most intermediate amplifying transformers and filters are carefully tuned at the factory to exactly the same operating frequency, the filter being provided with a measured tuning condenser of exactly the correct value. The iron-core type is recommended. With controlled regeneration these will give as great amplification as it is possible to obtain. The over-all amplification curve of the two-stage amplifier is very similar to that of an extremely good band-pass filter as used in carrier telephone work. This means that a band only wide enough to pass the desired signal receives amplification. In this particular amplifier, the width of the band may be varied by the volume control, from a width so great that selectivity and amplification are poor, up through a good operating condition, and on to a point where the frequency band passed is so narrow that little or nothing but the low notes of a station come through.



A front panel view of the new improved Super-Heterodyne. Note the simplicity of controls.

The audio amplifier suggested employs 3½:1 transformers. The size of the baseboard is great enough to permit the addition of an extra tube, so that a three-stage resistance coupled amplifier might be used, or a three-stage choke coupled amplifier, to be selected by the individual builder.

The circuit is not at all new, except for the use of a grid bias upon both detector tubes rather than the grid condenser and leak generally used. The reason for this is primarily one of convenience, since practically the sensitivity for either system appears substantially equal. However, a grid condenser and leak suited to broadcast reception with the first detector would be too large for good results on low waves. Further, regeneration control and selectivity improved slightly through the use of a grid bias.

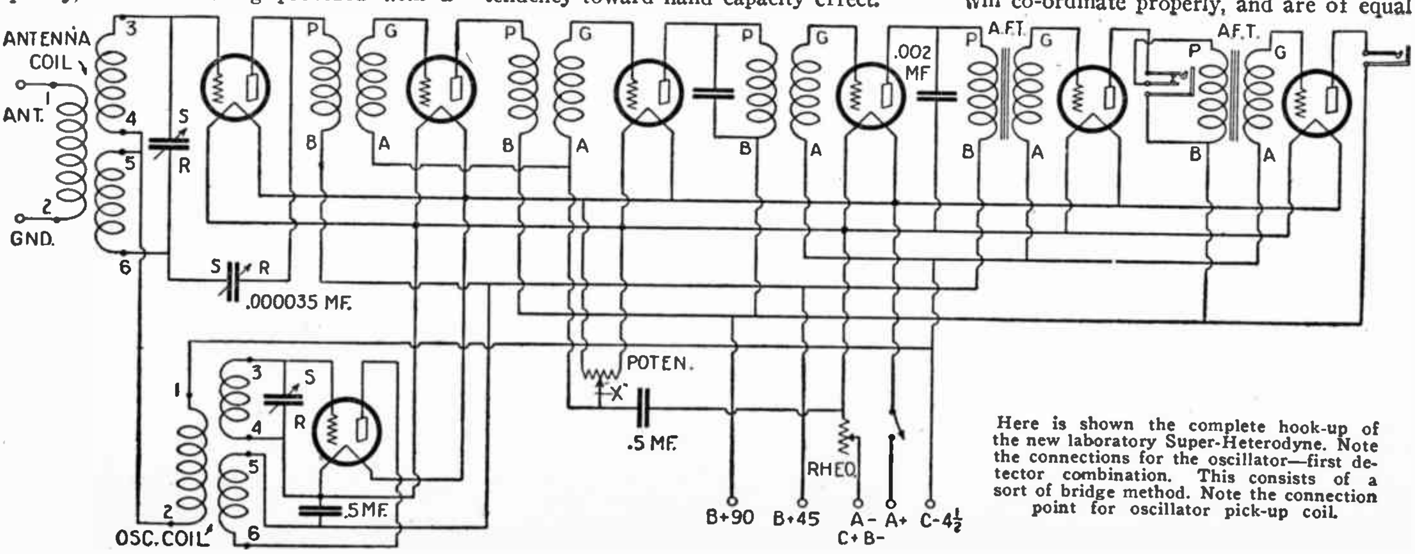
The positioning of the oscillator coupling coil is evident from a reference to the circuit. It will also be noticed that only the oscillator grid circuit is tuned, thus bringing one side of the oscillator tuning condenser to ground potential, and eliminating any tendency toward hand capacity effect.

The mechanical features of the set are quite simple. Photos are shown of the shielded model. An aluminum sub-base together with an aluminum panel shield is used. If the back, ends, and top of the cabinet in which the set is placed are also shielded, the selectivity obtainable will be remarkable. The choice between the shielded and unshielded methods of construction is quite simple. If the receiver is less than a mile from a broadcaster, then the shielded model should be selected, by all means. Though its assembly may appear a task for a tinsmith, it is really quite simple, since the aluminum works as easily as bakelite, and may be obtained cut to size. The unshielded model is entirely satisfactory for use outside a one-mile radius of a powerful broadcaster.

RESULTS.

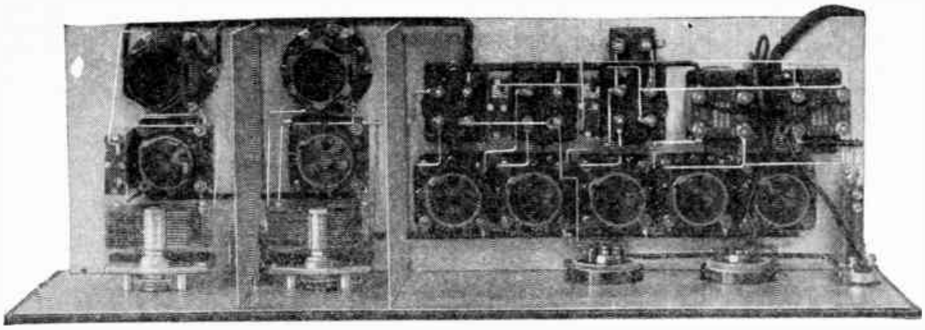
Generally, writers of constructional articles feel that their work is incomplete without a glowing tale of the wonderful results obtained from their particular circuit. The writer is no exception, nor is it assumed that the reader would wish to remain uninformed of what may be expected from the sets. During August a test was run in a building adjacent to a new steel frame hotel in the Chicago loop district. Some twenty out-of-town stations were logged between nine and twelve o'clock including coast stations. More were heard, but could not be logged due to terrific static and elevated railway interference—located less than 75 feet away. However, the important fact is that within a radius of but a few miles, some ten local stations were operating—three of them not half a mile distant. Yet the selectivity was such that no trouble was experienced in working.

Parts for this set should be selected which will co-ordinate properly, and are of equal



Here is shown the complete hook-up of the new laboratory Super-Heterodyne. Note the connections for the oscillator—first detector combination. This consists of a sort of bridge method. Note the connection point for oscillator pick-up coil.

World Radio History



This view of the new Super-Heterodyne shows the parts with two of the inductances in place in the receptacles. It also shows the building.

quality, since the results obtainable are dependent, in a large measure, upon the use of the parts selected.

A list of material is given in the accompanying box.

2 .00035 SLF condensers.
2 4" moulded dials, vernier preferably.
1 6-ohm rheostat.
1 200- to 400-ohm potentiometer.
1 2-Spring jack.
1 1-Spring jack.
2 Charted intermediate transformers.
1 Tuned filter with condenser.
7 Spring sockets, UX or UV.
2 3½:1 audio transformers.
1 On-off switch.
3 .5 mf. bypass condensers.
1 .002 bypass condenser.
1 .000025 mf. balancing condenser.
1 7x24x⅛" bakelite panel.
1 7½x23 oak or aluminum sub-base.
2 Coil sockets, screws, lugs, nuts, solder, spaghetti, etc.

If the completely shielded model is to be built, additional aluminum shielding will be required. The sub-base should be No. 8 gauge, while the balance may be No. 20 gauge, cut to fit the desired cabinet.

No specifications for the oscillator coils have been given. It is possible to use standare six-contact forms for these coils, which can be procured on the market, as these will plug into the sockets listed very nicely and are completely provided with hardware. They may be procured wound or unwound, as desired. The winding specifications are given below.

For the antenna coil, the stator tube should be wound with two equal sections, and the rotor with one section split for the rotor bearings as listed:

190—550 meters:
Rotor .... 40 turns per coil
Stator .... 43 turns per coil
90—210 meters:
Stator .... 16 turns per coil
Rotor .... 10 turns per coil
50—110 meters:
Stator .... 7 turns per coil
Rotor .... 6 turns per coil

For the oscillator system, the top stator coil is much larger than the bottom one, the larger being used in the grid circuit, the smaller in the plate circuit. For the rotor and pick-up coil, the winding specifications are as follows:

190—550 meters:
Large stator .... 84 turns
Small stator .... 25 turns
Rotor .... 40 turns
90—210 meters:
Large stator .... 32 turns
Small stator .... 14 turns
Rotor .... 10 turns
50—110 meters:
Large stator .... 14 turns
Small stator .... 10 turns
Rotor .... 6 turns..

In all cases, the stators are wound as one continuous winding, the top end being No. 3, the bottom end of this winding being No. 4, the top end of the next winding being No. 5, and the bottom end of this winding being No. 6. The rotor numbers are 1 and 2. These coils may be clipped in at will and adjusted to any desired position. After being once set, they need never be disturbed.

Any standard type of tube may be employed. The writer prefers UX-199 tubes up to the second audio stage, with UX-120 for the last stage. UX-201As, with the last stage UX-112, will give slightly greater handling capacity, higher "B" battery consumption and, possibly a little more volume.

CONSTRUCTION.

Should the aluminum shield be used, holes must be drilled in it to correspond with those in the panel, but so over-sized that no instrument will short on it, except the oscillator condenser, the frame of which goes to the negative filament line, which is also the shield.

If the sub-base is of wood, wood-screws will serve to fasten all parts to it, and it, in turn, to the panel. If an aluminum sub-base is used, machine screws (6/32) and nuts will be required.

The wiring is quite simple, requiring only the usual bus-bar, spaghetti, well-tinned soldering iron, non-corrosive paste and resin-core solder. No battery binding posts are provided, the short ends of the color cable being terminated directly at instrument binding posts, while the long ends go directly to the batteries.

The preliminary testing of the set is quite simple. It should first have only the "A" battery connected to it, and the tubes inserted in their sockets. They should, of course, light, and have their brilliancy controlled by the rheostat. The negative "A" battery lead should be left connected and the plus lead removed and touched first to the "B" 45 and then to the "B" 90 leads. The tubes should not light with either of these connections. If they do, an error has been made in wiring and must be corrected before proceeding further.

The tubes being in their sockets, the rheostat should be turned about seven-eighths on for storage battery tubes. The proper adjustment for UX-199 tubes (dry cell) may be arrived at by the use of a filament voltmeter, which is vitally important for use with this type of tube.

Two of the larger size oscillator coils and antenna coils should be put in their respective sockets, and the balancing condenser turned all out. Then, if the potentiometer is turned from its positive to its negative side, a "plunk" will be heard, followed by squeals if the oscillator dial is rotated. The potentiometer should be turned back far enough so that no squeals will be heard, in which pisition it should be left unless it is desired to vary the signal volume with it.

If the oscillator and antenna dials are rotated slowly, varying the oscillator through a range of 10 degrees above to 10 degrees below the antenna setting for each 2-degree step with the antenna dial, signals will be heard if any local stations are operating. An antenna not over 40 to 60 feet long, indoor or outdoor, and a ground, may be connected to terminals 1 and 2 of the antenna coil socket, or one just behind the antenna condenser and first detector tube. Selectivity may be regulated by adjusting the position of the rotor coil with the fingers. One set, it need not be disturbed. This is true for all sizes of antenna coils, for the different wave-length bands.

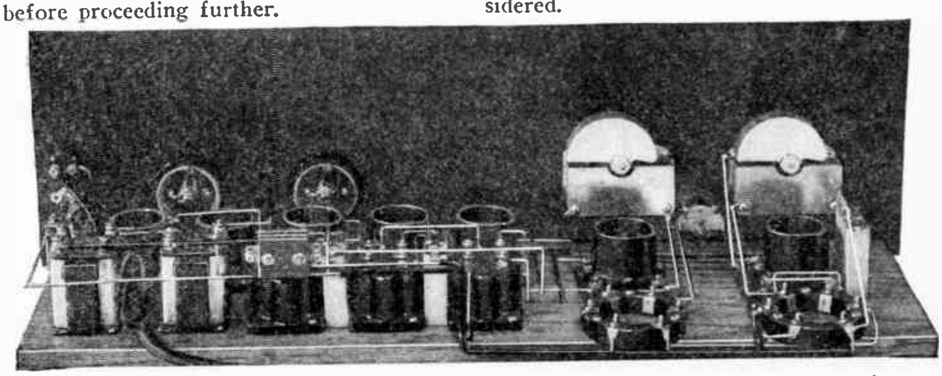
The oscillator coupling is not generally critical and the oscillator rotor should have its axis coinciding with that of the stator tube to start with. Selectivity may be improved by turning it slowly out. It will be found, however, that turning it a full 180 degrees around may increase signal strength on weak stations. In some extreme cases it may even be necessary to connect it in the first detector grid lead rather than in the filament return. This should be tried at once, should the receiver fail to operate properly.

In first tuning the set, few signals will be heard, due to the extreme selectivity. Therefore, it may be well to do away with the regenerative first detector circuit temporarily by reconnecting the circuit as suggested in the circuit diagram. This will render the ease of handling, but at the expense not only of selectivity, but of a considerable degree of sensitivity.

SINGLE CONTROL.

Using the non-regenerative first detector connection, the antenna tuning will be broad enough so that if the two tuning condensers are geared together, one knob may be used for tuning, thus simplifying control. This is as practical an arrangement as can be used in any super. The antenna tuning being broad, it is possible to vary both condensers at once, keeping them a uniform number of degrees apart, and yet still obtain the best setting for all waves on both condensers.

In view of the single-control feature the use of a loop has not been seriously considered.



This view of the new super shows the arrangement of the parts with the two receptacles for taking the inductances which are about 3 inches in diameter.

World Radio History

Suggestions that Improved One 5-Watter

By KEN ROYALE (KR), 5 OC

Mr. Royale has managed to point out here the importance of trifles in connection with transmitters. He has employed an actual case as an example, particularly to point out the usual details that are overlooked by the average beginner.

INSPECTION showed the antenna proper was O. K., five wire six inch twin cages separated 10 feet, and supported at a good height. Ground was also a good one. Lead-ins? Oh yes, well insulated, the leads going through three-inch porcelain tubes, to the set. As the tubes were large and well glazed it was immediately evident that their insulating qualities were very good, in fact superfluous, considering power. But, these two lead-in tubes were separated by only six inches and this formed, therefore, quite a condenser. This "condenser" for it was really nothing more nor less than exactly that, technically, introduced an enormous loss, and therefore was greatly reducing the range of the transmitter. This was easily rectified by separating the two lead-in tubes, by the height of the room, eight feet. This, theoretically, did not entirely eliminate the trouble, however, it did reduce it to a minimum, and for all practical and financial purposes sufficiently. The latter, by the way, was the most important, as usual.

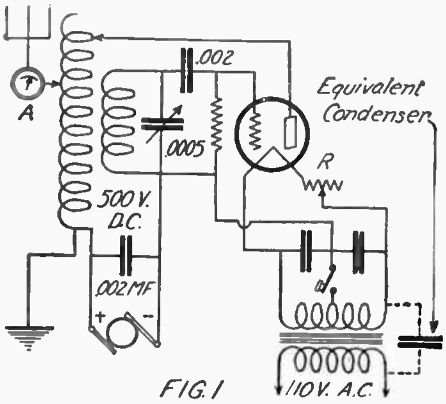


FIG. 1

The reversed feed-back circuit, the original arrangement employed by Mr. Royale's protege.

His actual transmitter used the circuit of Fig. 1. Of course such a set will work and under some conditions actually produce the most satisfactory results, but it is nevertheless, not technically correct. The results were now fairly good, but not as good as are actually obtainable. What, then, was there left for him to do?

A CIRCUIT CHANGE.

I advised changing his circuit to that of Fig. 2, because he had too long a ground lead, that put an excess potential difference across C, to ground, which was impressed on the condenser formed by the two windings, through the core of the filament supply transformer, resulting in a loss of energy. Then I told him to increase the number of turns in the antenna coil, as he only had 15, and needed about 25 turns, or a little less, to include the space between the plate tap and the ground. Then, I tried varying the resistance of the grid leak. He had been using one 5,000 ohm leak, simply because that was what had proved O. K. at some other station. The test revealed that 15,000 ohms was the correct resistance. This was obtained by connecting three of the standard units in series. These four changes in his transmitter and lead-ins resulted in an immediate improvement of results. He was fortunate, at that, for it is not so very often that an immediate improvement is noticeable. Often enough, bad conditions set in when a new system is tried, and fair conclusions are not obtainable until after a reasonable period of time. The actual additions to the transmitter, after all, consisted only in the grid leaks and one choke coil L., which was simply built on any diameter form handy by winding 275 turns of No. 28 D.C.C. wire, on, preferably, a cardboard tube with a little thin shellac or varnish on the last few turns at each end of the coil to act as a binder. The plate blocking condenser C did not have to be changed, as it was already of the proper kind; mica, .002 mfd., 4,000 volts test. The circuit shows the addition of a filter, consisting of an iron core choke coil, of about three henries, with condensers shunted across the line at either end. These were suggested, but not all installed. The addition of an efficient filter will give a better note and bring in more DX report cards.

He had become interested in the Meissner circuit, which is now fast becoming our most popular hook-up, due to its many advantages. He asked that I look over his experimental Meissner set; I saw immediately that his arrangement could not work efficiently. It consisted of three coils wound on a single form. The middle coil of the three, the antenna coil, was of 10 turns, with the other two coils wound as close as conveniently possible.

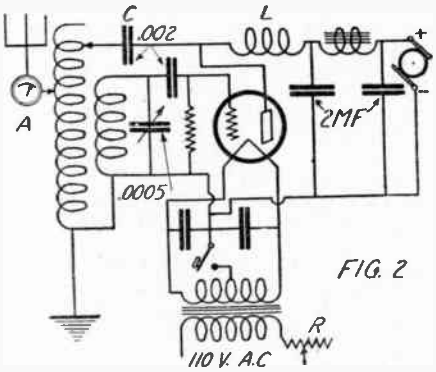


FIG. 2

The circuit of Fig. 1 was improved considerably by a few minor changes, as shown.

This arrangement with two variable condensers across the grid and plate coils respectively, resulted in his having parasitic oscillations in the plate and grid circuits, causing harmonics to be radiated. In these harmonics, small amounts of energy were being radiated, and of course the energy radiated on any wave other than on the main one is a loss. Remember this, although it may seem queer, the vacuum tube itself, in the Meissner circuit, does not oscillate. The only oscillating current present is in the antenna circuit. With the set as he had it, the tube oscillated feverishly off the wave he intended the set to work on, therefore, the divided energies of the tube did poor work.

THE PROPER METHOD.

The proper way for him to have constructed the set would have been to wind the plate and grid coils, which may be wound on any form having a diameter of about four inches, or that will go inside the end of the antenna inductance. Or, better still, make the coils "low loss" by winding them with No. 16 D.C.C. wire on pegs set in a 4-inch circle. If a condenser is used across the coils, each should have about 15 turns; however, if condensers are not used for tuning, and they are not absolutely necessary, the coil should have 25 turns. These coils should be separated at least four inches. The best method is to put one at each end of the antenna inductance, which is any conventional inductance, and tapped so as to obtain proper adjustment of wave-length. Different numbers of turns in the plate coil should be tried to find the most efficient point; the grid coil needed changing, for the 150 to 200 meter range. The grid leak values were much the same as in the reversed feed-back circuit, and the Meissener circuit to be used is shown in Fig. 3. He could have, if he so desired, eliminated the plate coil variable condenser, as this is an optional feature.

I advised the use of an inductive coupled transmitter, as a permanent installation, such as the Meissner circuit, for two good reasons: First, because the coupled transmitter emits, according to my observations, a steadier and stronger signal, and, second the coupled transmitter causes less interference with other amateurs and broadcast listeners, and transmits less key thumps, to which so much objection has been recently raised. Also harmonics are reduced to a minimum. In addition, as I have gathered from the opinion of different Supervisors of Radio, and other men of experience, it is the general decision to demand the use of inductive coupled arrangements, and this to be required by law, in the very near future. If you are using a reversed feed-back circuit, you can, with the addition of another coil, and a few changes in the circuit, even if the job is "haywire", realize an increase in antenna current and nine-times out of ten greater and more consistent DX. The coupled Meissner is more efficient than any direct coupled arrangement, so why dissipate time, money and patience on inferior arrangements?

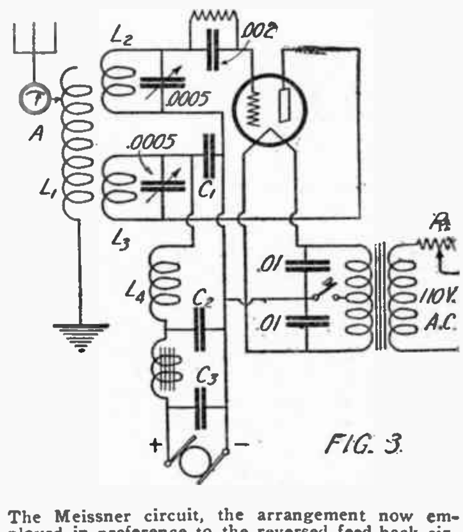


FIG. 3

The Meissner circuit, the arrangement now employed in preference to the reversed feed-back circuit. Fig. 3 is legal but 1 and 2 are not.

World Radio History

Low Loss Short Wave Set

By JOHN SCOTT-TAGGART

There are many experimenters who will welcome this description of the best tuner for work on the new short wave, high frequency bands. The description gives full details of construction.

EVER since the beginning of the repeating of broadcast programs on the short waves in the United States, and the entrance of the British Broadcasting Company on experiments of the same nature, there have appeared from time to time designs of receivers to be used in connection with these programs. The writer, in the present article, presents another design which he found exceedingly effective.

Following the first rule of this work, *i.e.*, low losses in all parts of the apparatus, the receiver differs in some respects from the standard hook-up which it follows. Care should be taken in the selection of the apparatus and in following the points of construction especially noted.

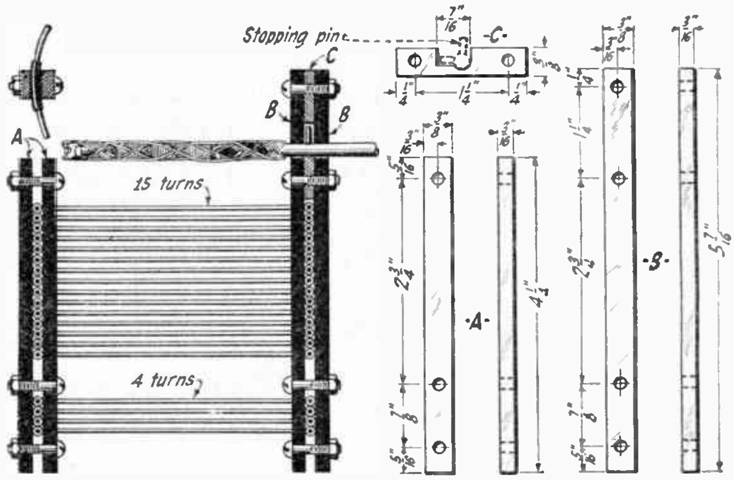


Fig. 1. Constructional details of the coupler. The sectional view on the left shows clearly how the frame is assembled and how the turns are clamped. Note the small piece of rubber tubing over the part of the wire which is clamped.

CONDITIONS FOR RECEPTION

The conditions for successful reception appear to be: First, the use of a *short* single wire aerial, preferably vertical, and very carefully insulated, with a short direct lead-in. Second, the use of as few tubes as is practicable, two for phone use, detector followed by an *efficient and silent* stage of audio frequency amplification. Third, keep all tuning and distributed capacities as low as possible. This point is not due to any vague mysterious "leakage" of signal energy due to stray capacities on the short waves, as is often and inaccurately stated, but because the *total* available tuning capacity is necessarily low, and these stray capacities often act as poor high-loss condensers and so must be kept down to a reasonable proportion of the limited maximum.

TURNING TO SHORT WAVES

On one-sixth of the ordinary broadcast wave-length we need one-sixth of the inductance *and* one-sixth of the tuning capacity (for the wave-length is proportional to the square root of the product of these according to the familiar formula), so that we may retain the ratio of inductance to capacity in the tuning circuit. So with an inductance of the order of 20 microhenries we must combine a *total* tuning capacity of not much more than .0001 mfd. (100 microfarads). This needs quite careful work in the design of the tuning inductance. The distributed capacity of the 15-turn honeycomb coil of a well-known type is near 20 mmf. and its natural wave-length is given as being close to 50 meters. Apart from its very appreciable radio frequency resistance, it is evident that such a type of closely wound fine wire coil is quite unsuitable for extremely short wave work, even if cut down to a small number of turns. The distributed capacity can actually be brought lower, by special types of winding, but at the cost of heavy dielectric losses and high radio frequency resistance through the use of fine wire.

REDUCE RESISTANCE

It is essential for success on the very low waves to have the radio frequency resistance as low as possible in order that only a minimum amount of regeneration will have to be used to bring the receiver into a sensitive condition.

While very little useful data on the subject is available, that which has been published shows that the high frequency resistance of wire increases with great rapidity with increase of frequency below 200 meters, and at 5,000,000 cycles (60 meters wavelength) is probably 5 to 7 (or more) times the direct current resistance even for the larger wire. Accordingly, it is necessary to break away from the practice of using wire that is easy to wind and cheap to buy and gives only fair results on the broadcast wave band, and to make the tuning inductance of a type purposely designed for short wave work. A lesson can be learned here from the transmitting fraternity, who are forced by the relentless logic of their aerial ammeter to give some heed to the quantitative efficiency of their tuning inductances. Their large air core coils of bare copper ribbon or rod represent the ideal, to which one must make some approximation in this instance. Hence the design indicated for the tuning inductance is that of an air core coil, well spaced, wound with No. 14 wire. As we are not dealing with high potentials and may allow some loss with the help of moderate regeneration we can use bare wire and a simple hard rubber, bakelite or wooden frame.

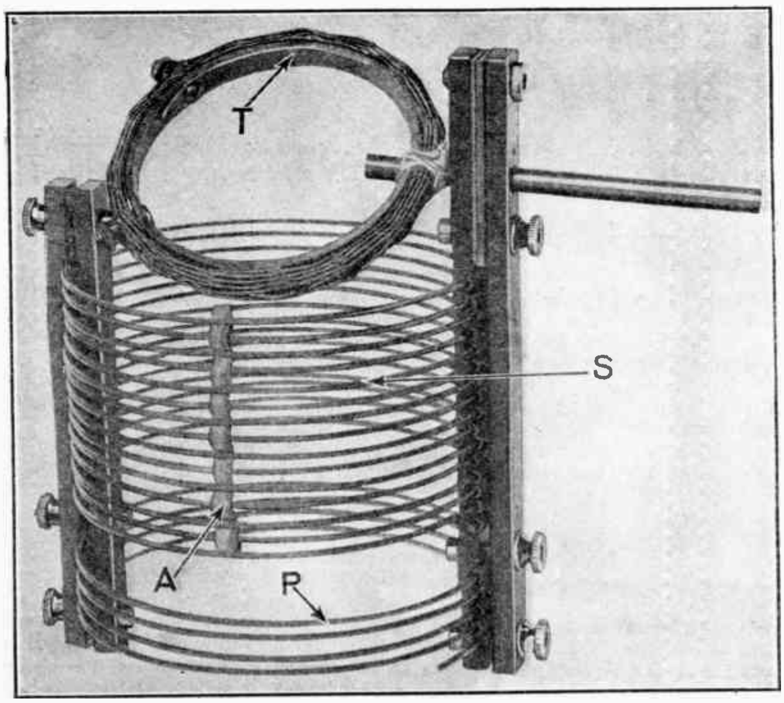


Fig. 2. The photo on the left shows the completed short wave coupler. P is the primary, S the secondary and T the tickler or feed-back coil. The rubber band shown as A may be used during the construction to hold the turns in place.

TUNING INDUCTANCE DESIGN

The design for the tuning inductance is indicated in the figures. Fifteen turns of No. 14 wire (which is stiff enough for such a purpose and has a fairly low resistance even on 60 meters) are first wound on a tube 3½ inches in diameter. The diameter should be about 4 inches when sprung off.

For the supporting frame, four strips of good insulating material are required and should be cut as shown in Fig. 1. Two "A" pieces are cut to the same size and clamped by means of three small screws and nuts, as shown in the section view. Two "B" pieces slightly longer are also clamped together in the same way, but are provided with an extra piece, C, acting as a bearing and at the same time as a stop to limit the motion of the feed-back coil. The sketch, Fig. 1, also shows how the wire may be clamped between the various insulating strips. Small pieces of rubber or spaghetti tubing are slid over the wire and used as a sort of cushion

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to hold the wire tightly between the clamping strips.

The feed-back coil is an ordinary spiderweb or duo-wound coil of about 10 or 12 turns mounted to fit inside of the secondary coil as shown in the photograph. The shaft upon which this coil is mounted should preferably be of insulating material and of the proper length to reach through the panel if one is used. It is advisable not to mount the short wave coupler directly against the panel, but a few inches behind, mounting it on the base by means of small angle pieces to hold it in place.

The number of turns may be varied depending upon the band of wave-lengths to be covered, but the same construction may be used for couplers designed for the reception of very short wave-lengths.

On account of the small maximum capacity permissible, direct coupling to the aerial is hardly practicable. Hence a fixed aperiodic primary coil is used with a very small series condenser, if a long aerial is used. For this purpose a coil of only four turns of No. 14 D.C.C. wire is wound on the projecting frame ends of the tuning inductance.

TYPES OF TUBES

The tuning range depends upon the stray capacities present. As ordinary types of tubes and standard types of panel mounting were desired, the writer investigated to what extent these lend unwelcome stray capacities.

Two panels with sockets in place, grid-condenser and leak, showed capacities from the grid connection to earth of 5 and 7.7 mmf. respectively. A lead of about a foot of stranded wire, fairly well isolated, gave the surprising figure of 5.5 mmf., a thing seldom realized among amateur constructors. As the zero capacity of the low minimum .0001 mfd. tuning condensers used was 6.6 mmf., the total casual capacities, apart from distributed capacity in the inductance, were approximately 24 mmf., even if short leads were practicable. With a tuning condenser range of 100 mmf., the wave-length range could not be very great. With the experimental temporary bench hook-up, involving a total of more than two feet of leads to tuning condensers, the actual range was found to be from 40 to just below 80 meters when loaded to some extent by an aerial.

WAVE-LENGTH RANGE

Unloaded, it was possible to go a little lower. With a .0002 mfd. tuning condenser and the aerial load the highest point was about 105 meters. These were repeatedly checked against harmonics of a heterodyne wavemeter.

At first the aperiodic primary was wound on the frame directly over the tuning inductance, but the distributed capacity to earth of this arrangement proved excessive. The measured capacity between the coils arranged thus was actually 30 mmf. The range, accordingly, was limited and not as

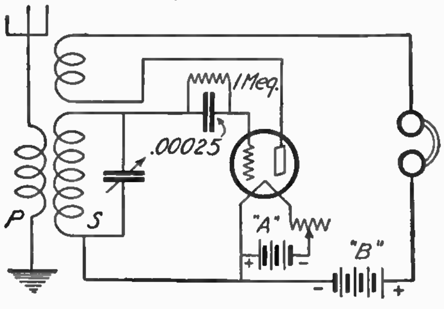

Fig. 3 shows a short wave circuit using coupler shown in Fig. 2.

low as it was desired to obtain. This was subsequently changed as indicated, the primary coil being arranged ½ inch below the other, with favorable results.

In order to keep the effect of stray capacities still lower and to give an effective but finely controllable regeneration, the grid coil may not be put between grid and ground, but arranged after the manner of a familiar type of transmitting circuit across grid and plate, with a blocking condenser in the plate lead. This forms a powerful circuit for use with loop antennae, if this plate condenser is a small, low minimum variable one. A center regenerative tap is needed in the tuning inductance and the grid condenser and leak are arranged in the conventional manner. Then no other regeneration coil is needed and stray capacities are kept at a minimum.

Another efficient circuit which may be used with this coupler is the Weagant or Reinartz, in which a series variable condenser is used to control the feed-back effect. This condenser may be of the 23-plate type, having a maximum capacity of .0005 mfd. connected in series with the feed-back coil.

THE RADIO CHOKE

The radio choke needed in this circuit must be a particularly good one; a layer wound solenoid which operated well on 400 meters was found useless. A very narrow slab coil of 300 turns of No. 32 enameled wire, wound edgewise in saw slots in a small wood frame, sufficed admirably and was easily made. The outside diameter was about 3 inches.

A two plate vernier condenser and at least a 6 inch handle on each condenser are quite necessary, as body capacity effects are very pronounced. So long as radio frequency leads are as short as possible and well insulated no other special features are needed in the arrangement of the receiver. The feed-back condenser was a two plate one, as a very low minimum is called for at times, and a maximum approaching .0003 mfd. An extension handle was fitted to this. A further control over regeneration is provided by the filament control.

HIGH AMPLIFICATION

As one has to rely on audio frequency amplification, a high degree of amplification was demanded of the tube. A fairly high ratio transformer was used. The resulting amplification was terrific, and great care had to be taken as to grid bias and arrangement of primary leads to avoid whistling. The effect of the high ratio tubes and efficient transformer coupled amplification can be judged when it is mentioned that a buzzer wavemeter a couple of feet away from the set gave an overpowering roar from the loud speaker. At first although real atmospherics were not very bad in the receiver, nothing could be done at all with three tubes until filter circuits were introduced into both detector and amplifier leads, consisting of audio chokes (audio frequency transformer secondaries) in series and 2 mfd. condensers across them as otherwise battery noises sounded like distant artillery barrage. Then, although the real atmospherics were very bad on the longer waves, on one occasion interfering appreciably with local broadcast reception, on 50 meters they were no more than an occasional swish or loud click, with the loose coupling and low resistance tuned circuits used.

A Simply Constructed Wavemeter

By JOSEPH RILEY

One of the most useful instruments that the experimenter can have on the bench is herein described. Its construction and operation are very simple and may be mastered with a little study.

IT is a pity that the average radio experimenter does not realize the advantage resulting from the possession of a simple wavemeter. If he did, there would be more of these wavemeters in existence, for it costs but very little to build one, and it can be calibrated with sufficient accuracy for many purposes by means of the carrier waves of the broadcast stations, or by means of the standard frequency signals broadcast by the Bureau of Standards.

The photograph shows the wavemeter to be described, which was constructed in *Radio News* laboratories. This consists of a well made 43-plate condenser mounted inside a box, having a top of insulating material. The two terminals of the condenser are connected to two pairs of binding posts, one pair on the side of the box, and the other pair on the top, as indicated.

Several coils were constructed to be used with this condenser to form a wavemeter. Specifications for these coils follow.

USES

This wavemeter may be used either as a wavemeter or as a wave trap. The circuit diagram is shown in Fig. 1, having the terminals marked as in the photograph. When used as a wave trap, the connection is as in Fig. 2, showing the terminals A and B, connected in the antenna circuit. This connection affords a simple way to calibrate the wavemeter roughly. The receiving set is tuned to the broadcast wave-length, and the wavemeter condenser is gradually turned until the signals disappear. This is the setting of the wavemeter which puts it in resonance with the incoming waves and the dial setting is to be plotted on the curve against the wave-length. Such a curve is shown in Fig. 5. There will be three such curves, one for each coil, for three different wave ranges.

A more accurate way of calibrating a wavemeter is to receive the signals on a three-circuit tuner, as shown in Fig. 4, having the tickler coil adjusted rather close to the oscillating point. Bring the meter to within about half a foot of the tuning coil and gradually turn the condenser dial. When the meter is in resonance with the incoming wave, a howling will be heard in the phones and the dial setting of the wavemeter can then be plotted against the wave-length of the station received as obtained from a list of broadcast stations.

There are many uses to which the wavemeter may be put, as for instance, the quick measurement of capacity and inductance, as well as the measurement of wave-length or frequency. To measure the capacity of a condenser, the capacity of the wavemeter condenser must be known for every setting as the comparison method is used. If the experimenter has no friends who

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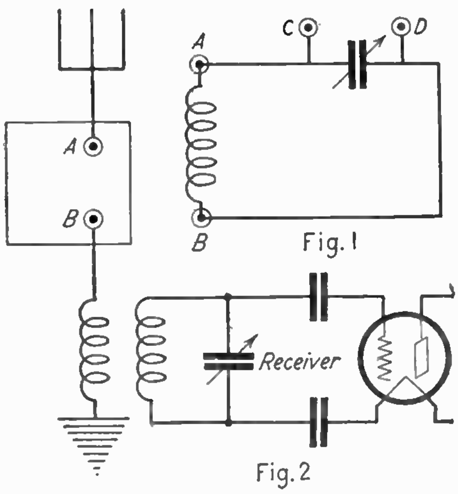
can calibrate his condenser for him, he can write to the manufacturer of the condenser and obtain a calibration curve which will be sufficiently accurate for many purposes.

CAPACITY

In making the measurement of a unknown condenser, the latter is connected to the points C and D of the wavemeter; having the unknown capacity set at the dial reading it is required to make the measurement. The wavemeter coil is then brought into proximity with the three-circuit tuner as in Fig. 4 and tuned to resonance. The capacity of the wavemeter condenser is noted, and the unknown condenser disconnected from it. The wavemeter is again brought into resonance with the *same wave* being received by the three-circuit tuner and again adjusted to resonance. The meter condenser capacity is once again noted. The difference between these two capacities of the wavemeter condenser is equal to the capacity of the condenser being measured.

To obtain the inductance of a coil, disconnect the wavemeter coil from the terminals A and B, and in its place connect the unknown coil. Bring this coil into proxim-

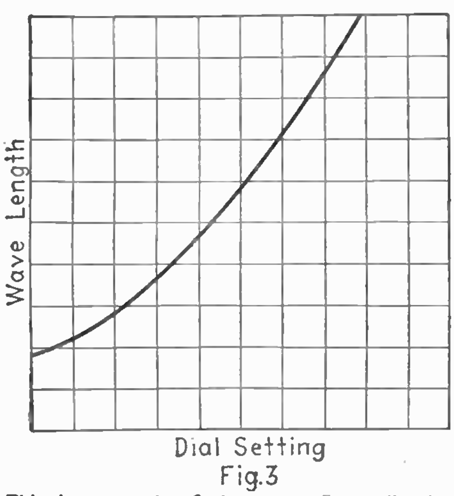


Circuit diagram of the wavemeter and its connections in the receiving circuit.

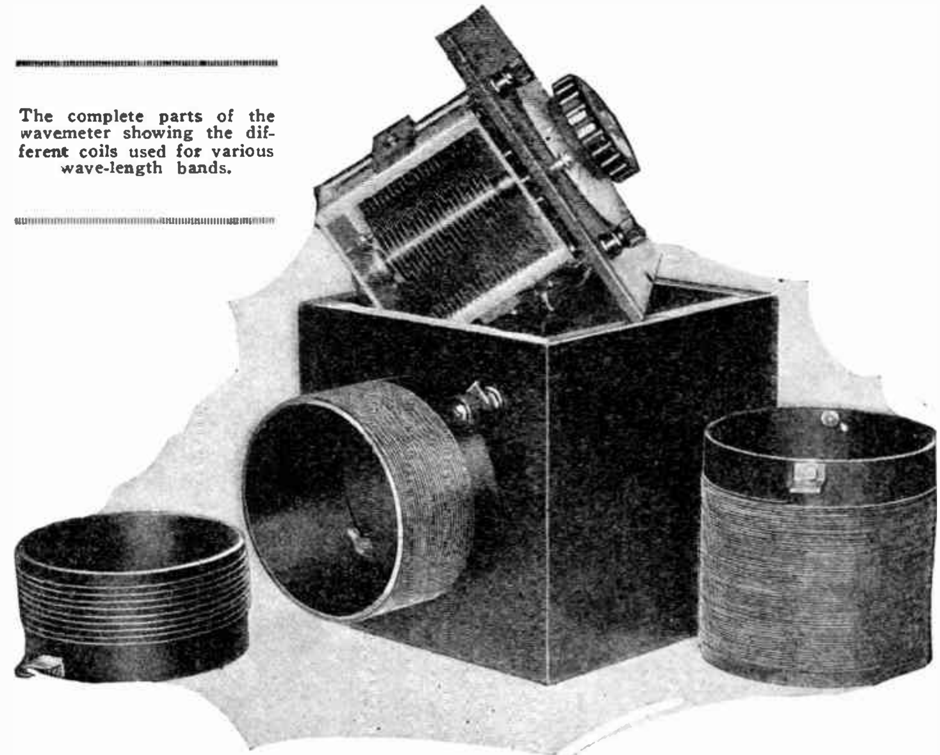
ity with the three-circuit tuner and tune in a station whose wave-length is known. From this wave-length and the capacity of the wave meter condenser, the inductance of the coil may be calculated by means of the following formula:

$$L = \left(\frac{\lambda}{1884}\right)^2 \times \frac{1}{C}$$

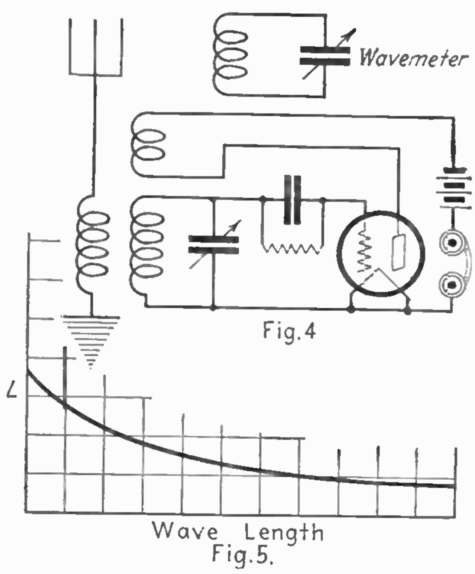
in which λ is the wave-length of the station being received in meters, L is the inductance of the coil being measured, and C is the capacity of the wavemeter condenser. In measuring the inductance of a coil, it is well to make the measurement of several wave-lengths as a check. The inductance will change with the wave-length, but will be found to change in a very orderly fashion, so that if the inductance be plotted against the wave-length, it will give a smooth curve of the shape shown in Fig. 5. This is contrary to what happens in the case of a condenser, for the capacity of a condenser is not changed with the wave-length.



This is a sample of the wavemeter calibration that can easily be made by anyone.



The complete parts of the wavemeter showing the different coils used for various wave-length bands.



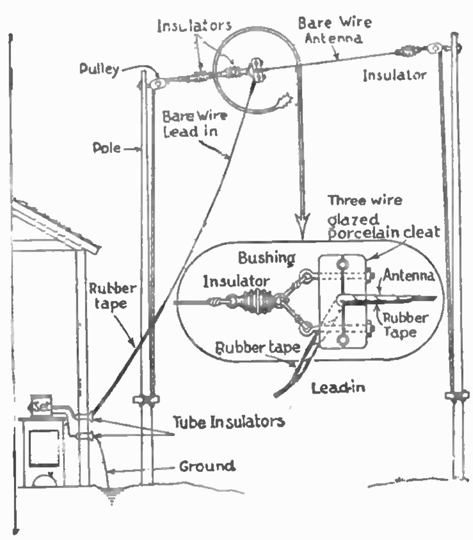
Method of calibrating a wavemeter with a three-circuit receiver. Below the diagram is a wave-length curve.

Having obtained the calibration of the wavemeter as shown in Fig. 3, it is a simple matter to determine the wave-length of any incoming signals. This is done simply by receiving signals on the three-circuit tuner, as in Fig. 4, bringing the wavemeter near it and tuning the wavemeter until whistling occurs. From the dial setting of the wavemeter condenser on the calibration curve, the wave-length of the station is immediately known. It will be noted that this is just the reverse of the method used in calibrating the wavemeter.

AN ANTENNA CLAMP

Although few radio fans realize it, one of the places where there is possibility of extremely large losses is the connection between the antenna and the lead-in. This possible loss may be eliminated by having the antenna and lead-in all one piece of wire, as described below.

The antenna clamp shown in the sketch is made from two porcelain clamps such as are used in house wiring. They should be of the "three-wire" variety, so that the antenna wire can be run through the middle groove and a bushing placed in the two outside grooves in order to prevent the cleats from breaking when pressure is applied to them after they have been placed in position. The antenna wire itself is insulated for about ten inches with heavy rubber friction tape at the point



An antenna insulator of this type is both cheap and efficient.

where it passes through the cleats and it is also insulated with the same tape for about twenty feet from the place where it enters the house. The drawing is self-explanatory, and if this system is followed, an efficient antenna should be the result.

Contributed by D. E. Phillips.

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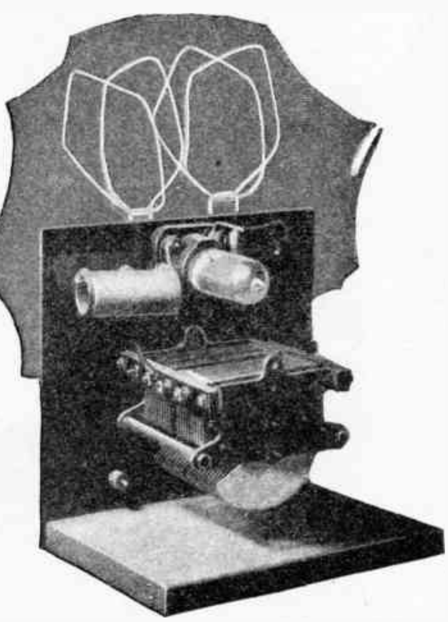
Discovering Unexplored

By JOHN L. REINARTZ



A view of the working arrangement of Mr. Reinartz' 5-meter receiver.

THE strangest things imaginable happen when we begin to work a radio transmitter at the ultra frequencies that lie below the two-meter wavelength band. The experiments herein delineated were begun only a short time ago and there are still many points in the collected data which are, so far, unexplained and many others for which only the merest guesses are at hand.

What strange characteristics and phenomena will we find when we finally reach and are able to control the frequencies which lie below 150,000 kilocycles (two meters) up to the frequencies of light? That is the question which will probably be asked when the peculiar effects, which are gained by making a half-kilowatt tube oscillate and generate frequencies somewhere in this band, are told.

To start at the beginning: Along with my work on 40 and 20 meters, I have been constantly pushing downward in the wavelength bands, seeking greater and greater frequencies. The huge increase in range for the same power input, gained with the use of the shorter waves, leads the experimenter who is after efficiency constantly in this direction.

EXPERIMENTING ON 2 METERS

Some weeks ago, after making my regular transmitter, shown in an accompanying photograph, work down to five meters, I decided to ascertain how high in frequency it was possible to make the tube oscillate. Accordingly, the clips of the oscillation transformer were moved closer and closer to the inside ends of the plate and grid coil and the tuning condensers were moved until the circuit was brought into resonance. The frequency was constantly checked as the clips were moved. That is, the record was kept until the lower limit of my wavemeter, which is slightly greater than two meters, was reached.

When the antenna circuit was connected to the tube and absorbed the power generated by it, the action of the set was regular in every way. The parts functioned as they should, and everything went off as usual.

But when the antenna and counterpoise were disconnected and removed from the tube, things began to happen which were most peculiar in nature and which, to date, I have not been able satisfactorily to explain.

Refer to Fig. 1, which shows a diagram of the half-kilowatt tube which was used in the experiments. This tube is the standard Radio Corporation product, being manufactured by the General Electric Company. It is rather old, has seen a great deal of service and is of old design.

About the only point of difference in the form of this tube and those now being manufactured by the company under the same designation is the location and shape of the grid lead, which runs from the element of the tube to the lug at the base which serves to make the outside connection.

The grid connection in question is formed from a small wire of some metal which is used in the regular tube construction. It leads directly from the supporting collar to a larger piece of wire which is carried through the wall of the tube to the base. But it is wound pig-tail fashion. *This seems to be of the utmost importance in the results obtained*—therefore, the detailed description of the difference.

PURPLE CORONA FORMED

When the tube was set into operation as described, without antenna or ground, as soon as the plate voltage was applied—in this case 3,000—the first point noticed was a dark blue-purple halo, or corona, which formed itself at both the narrow sides of the plate, as shown in the sketch. It was not like ordinary brush discharge, in that it seemed a bit more thin and was slightly away from the surface of the plates, there being possibly a sixteenth of an inch between them. The exact nature of the phenomenon cannot be described accurately. The nearest comparison which may be drawn is that of a spot of very dim blue-purple light seen through a very fine cloth or ground glass screen, with the edges of the spot diffused rather than brought to sharp focus. This was evident on both the small sides of the plate and has persisted in its original form since the first time it was noticed.

WE present an exclusive article on some very astounding discoveries made by Mr. Reinartz. While it may be said that nothing astonishes us anymore, when it comes to the wonders of radio, still we were not prepared for the latest wonder.

In experimenting with tremendous frequencies, Mr. Reinartz has observed some as yet unexplained phenomena whereby it seems possible now to actually look through cold solid metal plates with the naked eye.

While it is possible to look through metal plates by means of X-rays, it is necessary to use an intermediary, platinum-barium-cyanide screen. No screen, however, is needed with the Reinartz discovery.

What this discovery may mean in the future can only be dimly imagined now.—EDITOR.

Fig. 2. The ultra high frequencies do all sorts of peculiar things in passing through a tungar bulb, as may be seen above.

The second curious effect was found at the approximate center of the large side of the plate. Here, as shown in the diagram, another somewhat similar occurrence took place. At first. the spot of light covered a diameter about the size of a five-cent piece and was entirely covered with the glow. The characteristics of this light were very similar to the other, except as to the color, which was more of a pink-purple. It seemed, in other words, to be more of a blue-purple, similar to the first, with a slight tinge of red which was not entirely merged with the other.

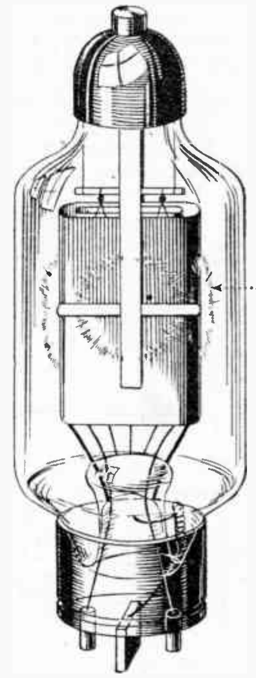


Fig. 1. The effect of ultra frequencies on the plate of a 500-watt transmitting tube is shown above. Note the small spot on the plate and the corona glow.

From time to time, as the tube was used again and again for observation of the phenomenon, the spot gradually grew in diameter until at present it is about the size of a silver dollar. With the increase in diameter of the spot, the intensity of the glow became less and less at the center—grading off to total blackness in the center and stopping abruptly at the circumference.

VISIBILITY ESTABLISHED

But the most important of all was the visibility established through the plate. This was noticed at the same time the other points were, and has given more concern as to explanation than have they. When the tube was put into operation and the light produced at the center and edge of the plate, simultaneously a spot occurred in the center of the plate in Fig. 1. It seemed at first to be an incandescent point on the surface of the plate, but investigation proved shortly that such was not the case. In spite of the light that showed on the surface and at the edges of the plate, it remained perfectly cold all during the demonstration.

Examination of the spot proved to admit of only one explanation, i. e., that there was a hole through the plate which made the filament, inside, visible! A revolving mirror

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Ultra Frequencies

1XAM, 1QP.

or various shutter movements before the spot served only to prove this point further. It could be nothing but a hole through the plate made by the emanations from the filament, or some other cause yet to be determined.

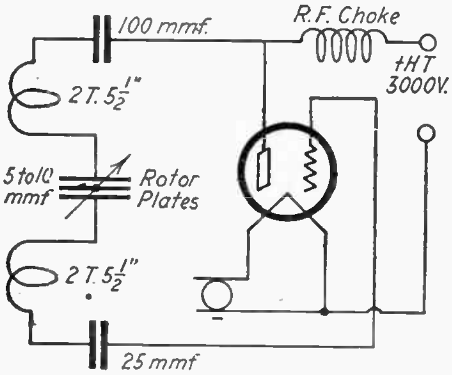
One theory which would serve well as an explanation of the formation of the hole is that some parasitic frequency is generated in the tube, when it is operating in the manner described, which has a new and unknown property. It might be rationalized by saying that the emission—whatever its nature—pushes the molecules of the plate metal into some sort of line, thus forming the hole and allowing the passage of the emission. A sort of parting of the Red Sea!

It is possible that the stream of vibrations from the filament simply crowds the molecules out to one side, in order to make room for their own escape.

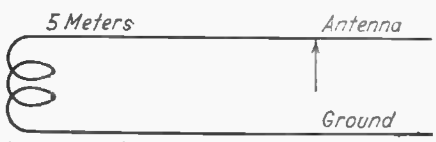
NOT A REAL HOLE

Of course, a thorough examination of the plate proves that there is not a real hole in it at other times than when the tube is operating in this strange manner. At five meters, working with or without an antenna, none of the phenomena noted above occur.

A test was made for X-rays with the aid of a dentist's film, and proved the ab-



A hook-up with values used by Mr. Reinartz in his 5-meter transmitter.



The arrow shows the position at which the Tungar bulb is placed in the antenna circuit of the 2-meter transmitter.

sence of this ray. A number of other tests of the same type were made but brought negligible results.

The low wave work led to a number of other experiments which proved exceedingly interesting, if not particularly enlightening. Among the most important of these was the behavior of a Tungar charger bulb when placed in the high frequency circuit. Refer to Fig. 2.

There occurred a number of phenomena in this investigation which are extremely similar to the ordinary Geissler tube discharge, but at the same time have characteristics which cannot be explained by the known laws. The foremost of these is the beading effect shown in Fig. 2a. If the finger is placed on the glass of the bulb, a line of current makes its way from the anode or cathode, as the case may be, to the tip of the finger. If it is gradually moved farther and farther from the elements of the tube so that the high frequency current must travel over a constantly lengthening path, the stream will gradually form itself into a number of globules or small spheres until, just before the cessation of current to the fingertip, each of these little balls will be entirely disassociated from the next, while the current is still traveling. The passage of the current is, of course, in the usual form seen in the Crookes tubes.

If heavy output is employed, numbers of bright spots, like small stars, will make their appearance at points along the elements of the rectifier bulb. What the reason is for such formations is not known. Possibly, it may rest in some inherent characteristic of the metal employed in the elements, or it might logically be the result of some electrical cause. The exact determination of the cause is yet to be made.

One of the most interesting demonstrations, which might well be used in teaching beginners, is the passage of the current along the wires of the elements. It actually *does* pass along the outer surface of them, with the very smallest amount of penetration possible. As a matter of fact, in many instances the current takes the form of a sort of rope, twining itself around the wires and so passing through the tube.

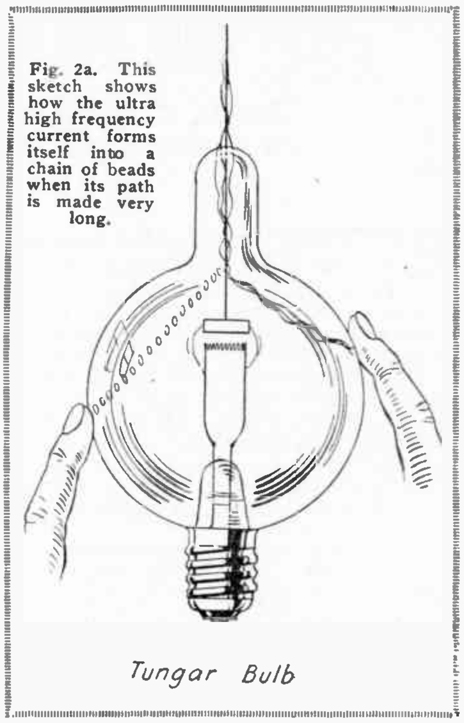
If the tube is held in the hand, the current jumps from the elements to the point of the flesh touching the glass, forming a sort of spot, as if making a condenser plate for itself. If the tube is suspended from the top—near the input terminal—the current will have a tendency to spread out, after the fashion of lightning.

This is the latest branch of the investigation and has, as yet, scarcely been begun—if the results which may be arrived at are considered.

Though it may mean anything or nothing, a test may be made with the same rectifier tube around the field of the oscillation transformer of a set working on five meters, which may result in some astounding revelations regarding the location of the maxima and minima in field strength.

To get back again to figures and something that is definitely and surely known. The transmission work on twenty and forty meters has shown the most peculiar characteristics regarding the distances over which the bands will work. The range for the forty-meter transmitter begins at the station at noon and with 100 watts input will cover between 2,000 and 2,500 miles. Then the local range changes until at midnight, the signals cannot be heard closer than 2,000 miles but beyond that point may be heard up to 2,300 or 4,000 miles. With the twenty-meter set, the signals may never be heard closer than 700 or 800 miles and at midnight may not be heard closer than 3,000 or 4,000 miles while the range at 100 watts extends to 7,500 miles. The twenty-meter band is almost worthless for the usual so-called local transmission at any time, day or night Of course, up to thirty or forty miles, shock excitation, so to speak, will enable the signals to be read with ease, but further than that, the audibility of the signal depends

Fig. 2a. This sketch shows how the ultra high frequency current forms itself into a chain of beads when its path is made very long.



upon distance. The observations were made after a thorough check of work done over a period of almost a year. All these tests were carried on with the half-kilowatt transmitter using 100 watts input. All conditions were covered and the rule which may be deducted from the work may be taken as empirical.

A peculiar thing is noted as to the field intensity. A portion resembling a halved torpedo at the end of the coil shows this characteristic. Practice will show that any increase in the power input will be expended three-quarters in increasing the range of audibility in the direction away from the transmitter, and the other quarter in increasing the range behind the curve or *toward* the station. This is a point which is important in designing a transmitter to work at these frequencies and to connect with a given point.

It is to be contemplated that the coming year will find more and more work being done in this quarter and the laws governing radio's actions in the new field more thoroughly known. Let's all work for it!

The lay-out of Mr. Reinartz's 5-meter transmitter which radiates into a 7-foot copper rod.

World Radio History

An Automatic Tickler Adjuster

Mr. H. G. Möller, a German physicist, has employed a milliammeter to adjust the tickler coil of a regenerative receiver Such an adaptation as this should prove of interest to American radio fans.

EVERYONE is more or less acquainted with the difficulties that arise in operating regeneration receivers. Their proper operation necessitates much experience and a skilled hand for the proper adjustment of the tickler coil. Otherwise either the regeneration will not be a maximum or—what happens quite as frequently—the antenna will be set in oscillation and the consequent re-radiation of the received signals will be superposed on waves radiated by the transmitter, resulting in whistling and squeaking noises in the receivers of the neighborhood.

To lessen this annoyance numerous methods have been suggested. There are a long series of circuits which, while allowing for complete regeneration, reduce the radiation to a small amount. These hook-ups depend chiefly on the use of several circuits which are not coupled back to the antenna circuit directly, but to a coil which is in comparatively loose coupling with the antenna. Should oscillations be set up in this coil through strong regeneration, very little energy will be transmitted to the antenna and, therefore, little will be lost through radiation. The interference with other receivers is also slight, if at all noticeable.

Such circuits, however, have the disadvantage that the reduction of damping which results from regeneration is applied to oscillatory circuits which by themselves have low decrements, while the greatest advantage of regeneration lies exactly in the reduction of the decrement (in other words, of the effective resistance) of the antenna for the desired frequency, below that for any other oscillations which may be received at the same time. The oscillation energy, just as much as the sharpness of resonance, will be considerably increased as a result of reduced decrement. Therefore, hook-ups with reduced antenna radiations achieved through a regenerative coupling with the secondary coil must pay dearly for this advantage and, for this reason, have not met with very wide approval.

Another method for the reduction of disturbances arising from regeneration is employed by the Telefunken broadcast receivers. The tickler coil is rigidly attached to the tuning condenser of the receiving circuit and adjustment is so made in the laboratory that for every desired frequency a definite regeneration will be established. According to the German government regulations, however, the receiver must not oscillate under any circumstances. The best regenerative coupling, therefore, cannot be easily predetermined, for the oscillation energy of various tubes differs by as much as 100 per cent. and depends also on the intensity of the filament current and plate voltage. It is, therefore, almost impossible to permanently establish the best regenerative coupling for more than a single wavelength. Through a slight excess over the most favorable regeneration, oscillation will promptly set in and a slight decrease of regeneration below this value will considerably decrease the volume. Therefore, broadcast receivers with tickler coupling automatically adjusted by the variable condenser are not very efficient for preventing oscillations in all cases, as the best regeneration cannot in any case be established.

Other arrangements for the elimination of disturbances arising from regeneration are so involved that they are practicable for the practiced radio experimenter only who requires no apparatus for this purpose anyway, since he knows how to manage his equipment and, in tuning, will have his antenna oscillating for only an instant at most.

Recently H. G. Möller, a German physicist known for his work on vacuum tubes, designed a device which, it is claimed, automatically adjusts the regeneration to a most favorable value.

This device of Möller's depends on the following phenomenon: If through a close coupling undamped oscillations are impressed on the receiving circuit, the grids of the vacuum tubes will undergo a potential variation. That is, the grid will be alternately charged positive and negative, while previously the grid potential was almost zero. During every interval of grid potential a number of electrons flow to the grid and then tend to return against the grid filament resistance. As a result of the high value of this resistance, the electrons cannot altogether leave the grid before the next positive interval, and therefore the grid will accumulate a negative charge. In consequence, the mean plate current which can be measured with a milliammeter is decreased, for the negatively charged grid tends to hinder the passage of electrons to the plate.

Möller connects a milliammeter in the plate circuit and employs the movement of the needle, in case oscillations start, to prevent by *mechanical* means any further increase of coupling. He does not, however, use an ordinary milliammeter, for no scale or pointer is needed here, but employs the device shown in our illustration. On the right side of the illustration an ordinary vacuum tube hook-up is represented. The tickler coil R is pivoted on a knob K and through a flexible shaft is attached to a cog-wheel Z, which is a part of the device for preventing excessively close regenerative coupling. This device is represented in light lines on the left side of the diagram, while the current-carrying conductors are drawn in heavy lines. Between the poles of the strong permanent magnet N S is a coil D, rotatively pivoted, as in the usual moving coil measuring instruments. A light pointer-like strip is rigidly attached to the coil. Its end is shaped into a hook which grips the teeth of the cog-wheel Z when the coil is slightly turned. Besides this, the pointer carries a transverse arm "C" which, upon the least motion of the coil to either side, opens one of the two contacts "A" and "B" and so breaks the plate circuit. Finally, there is a tension spring F acting on the pointer which, by means of the adjustment screw M, serves to make a fine setting of the coil D.

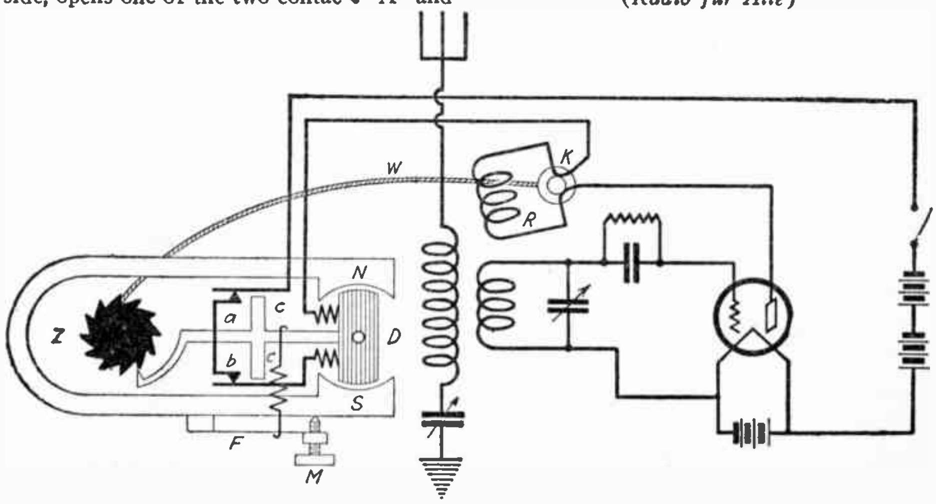
The operation of this apparatus is as follows: Both variable condensers of the receiver are set to the desired wave-length, while the regenerative coupling is quite loose. The knob K is then turned to make a closer tickler coupling, approaching the point of best regeneration. At the instant when this point is exceeded, oscillations begin which immediately cause the movement of the coil D, and consequently a turning of the cog-wheel Z, and a simultaneous interruption of the plate current at the point "A". The knob K is released and through spring action it is turned back slightly from the point of oscillation to the most favorable operating regeneration for radio reception.

Oscillations are set up even in the Möller apparatus, for the adjustment to the proper regenerative coupling depends upon them. The duration of these oscillations, however, is so short that hardly any neighboring stations will be affected by them.

A special advantage of the arrangement is that it can be installed in any receiving apparatus with regenerative coupling. In the illustration it is not indicated that by means of a gearing system the rotation of the wheel Z is made greater than that of the knob K. It should be observed here that the apparatus is apparently open to the objection that is not sufficiently sensitive. The tickler coil will be turned at most through an angle of 90 degrees, and this motion, of course, must be produced by a much greater rotation of the wheel Z, if the device is to fulfill its purpose. A special contrivance is provided to protect the pointer of the instrument when it grips the cog-wheel while the knob K is turned further. The instrument cannot in this way be damaged, even when one with unpracticed hand exerts an unduly great force in turning the tickler coil.

Naturally, only practice can demonstrate whether Möller's device will succeed. In this matter the question of cost plays a not unimportant role. Among all attempts in this direction, the device under discussion is without question the best and fulfills most satisfactorily the requirements.

(*Radio für Alle*)



R, the tickler coil is pivoted on a shaft, K, which is attached by a shaft W, to a cogwheel Z. Through the coil D, being revolved by the magnetic field set up by the plate current from the tube, the tickler is constantly automatically adjusted.

World Radio History

How to Make Basket-Weave Coils

Do you have difficulty in winding coils? We suggest the method below as a remedy

THE basket-weave method of winding coils is becoming increasingly popular with the amateur who makes his own coils, especially for short-wave work where a coil should be practically self-supporting so as to include a minimum of dielectric in its field.

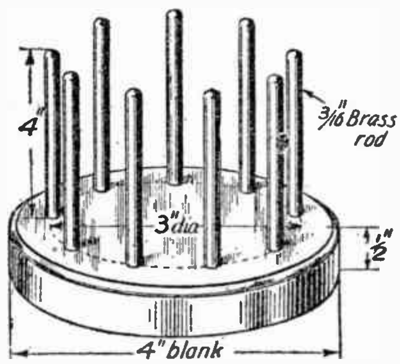


Fig. 1. Illustrating the base and arrangement of the spokes.

CONSTRUCTION

The writer, requiring a coil of this description for a certain type of receiving set that was under construction made up a special former for the job, which has since proved exceedingly useful whenever a coil has been wanted.

It should be mentioned here that the former described needs a 2 and a 4B.A. tap and die and the appropriate drills for its construction, but for the benefit of those who do not possess these tools an alternative method will be given at the end of this article.

The base is made of ½-inch brass, a blank 4 inches in diameter being obtained from one of the large metal merchants, though it could probably have been only ⅜ of an inch or ¼ of an inch thick without detriment to the finished former—which is shown in Fig. 1. The center of the blank was found and a 3-inch circle scribed on one surface. This circle was divided into nine equal parts and a center punch mark made at each division line. The division of the circumference into any number of equal parts is easily done by multiplying the diameter by 22/7 and dividing the resulting figure by the number of divisions required. This figure will not be *quite* accurate, but any slight inaccuracy can easily be corrected by "trial and error."

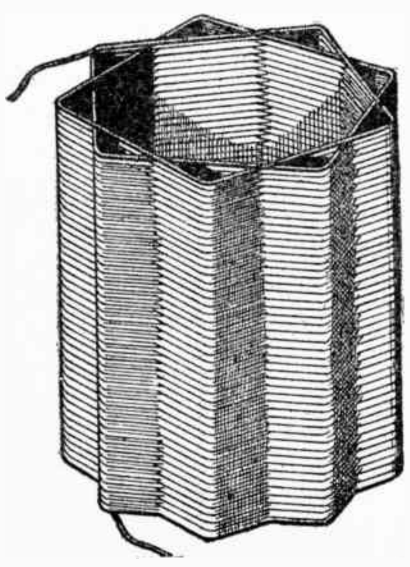


Fig. 2. The appearance of a single-weave coil wound on the former described.

BRASS RODS

A hole was drilled at each of the punch marks, a 2B.A. tapping drill being used. After this the holes were tapped out 2B.A, and the complete base was filed smooth and polished with sand-paper. The top edge had a groove cut in it on a friend's lathe just to finish it off and a coat of lacquer applied.

Next a length of 3/16" brass rod was obtained and 9 four-inch lengths cut from it. One end of each of these lengths was rounded off with a file and a little over one-quarter of an inch of the other end was threaded with a 2B.A. die. It was now merely necessary to screw the rods into place in order to be able to make basket-weave coils. The single-weave coil is the most usual and is shown in Fig. 2. But double- and triple-weave coils can be made if desired, and form interesting variations from an experimental point of view, as well as allowing more turns of wire to be accommodated on a winding of given length.

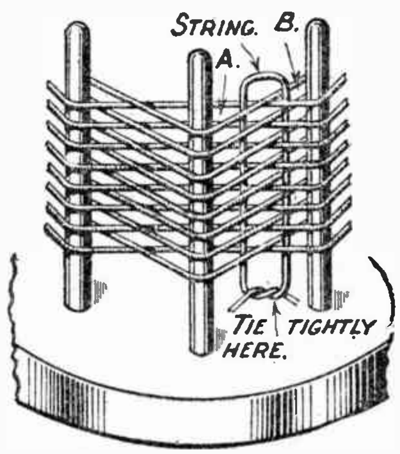


Fig. 3. The coil is self-supporting and secured with string.

It was also intended to wind special chokes for fifteen-meter reception; these, of course, need to be much smaller than those generally used, and so another circle, one inch in diameter, was scribed inside the first one. This was divided into seven parts and 4B.A. tapping holes were drilled. The pegs were made, of course, from 4B.A. rod. These pegs were made only two inches long but the same amount was threaded at one end of each. The chokes made on this former consisted of thirty turns of No. 24 S.W.G. D.C.C. copper wire.

The method of making these basket-weave coils self-supporting is shown in Fig. 3. First lift the coil so as to leave a space of ½ inch to 1 inch between the bottom of the coil and the base of the former. This can be done with a strip of metal beveled off at one end and inserted between the base and the bottom turn, or by means of a special lifting plate shown in Fig. 5. Next a piece of thin string or twine is slipped down the space, as shown at A, on one side of the crosing of the wires between the pegs and the other end slipped down the space B on the other side. The ends of the twine are now tightly tied to pull the winding together, and then knotted. After the crossings have thus been tied, it will be found that the coil can be slipped off the former as a unit and will be quite self-supporting.

MOUNTING

There are various methods of mounting these coils, but what is probably the sim-

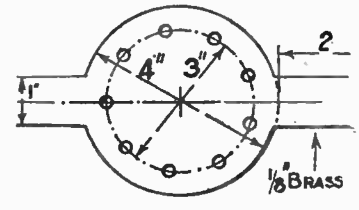


Fig 5. The "lifter" for raising the coil off the base before fastening.

plest is shown in Fig. 4. A is a piece of wood or ebonite cut down to slip into one of the spaces of the coil, as at B. About ½-inch is allowed at either end, by which the piece of wood or ebonite can be fixed to either the panel, some instrument, or the baseboard of the receiver.

Coils made on this former will be found to be very efficient and give a good tuning range on account of their low self-capacity, while for low-loss tuners they are undoubtedly one of the best types to use on short-wave work.

If the constructor does not happen to have the necessary tools for drilling and tapping the base and threading the ends of the brass pegs, another means of making the former is as follows: Drill the nine holes required in an inch-thick hardwood base with a drill which is a trifle smaller than the brass rod used for the pegs, and having cut these, drive them into the holes with a hammer until they are quite firm. As long as fairly light gauge wire is used in winding the coils, and undue tension is not put on the wire while winding, this will prove quite a satisfactory alternative. If too great a tension is applied to the wire the tops of the pegs will be pulled out of the vertical, and not only will the coils be conical, but after several turns have been wound the pegs will tend to become loose in their holes.

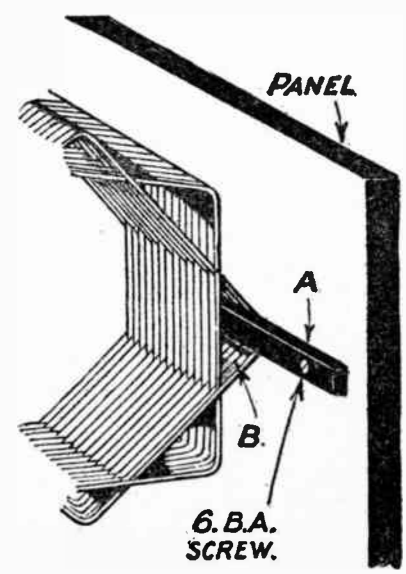


Fig. 4. A suggested method by which the coil may be mounted.

World Radio History

"B" Battery Eliminator from Standard Parts

By DONALD E. LEARNED

Here is a rectifier for supplying "B" current that anyone can construct.

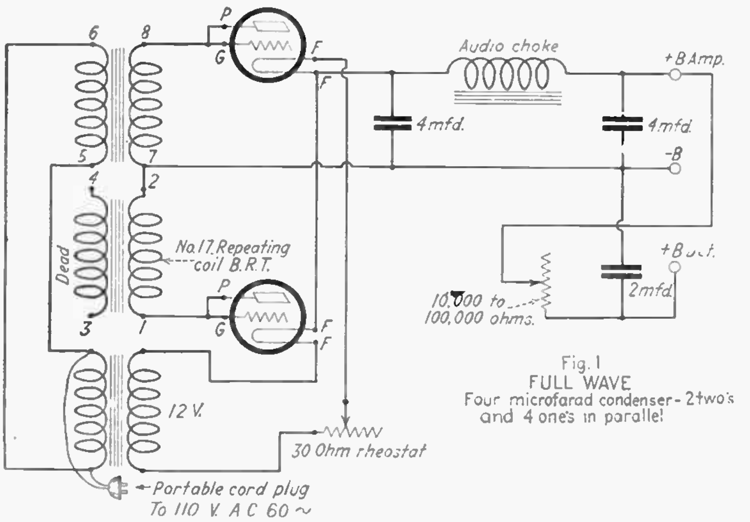


Fig. 1
FULL WAVE
Four microfarad condenser - 2 two's and 4 ones in parallel

A hook-up of the "B" battery eliminator. Reduced output will result if "audio choke" is of too high resistance (Remedy: use two in parallel), or, if tubes are poor (Remedy: use two in parallel, or use more suitable tubes). UV-201A type tubes are unsuited as rectifiers, except for short-time use, when two in parallel will temporarily serve.

PROBABLY the greatest nuisance connected with the operation of a radio set is the battery supply. "A" batteries lose their kick and the set no longer amplifies as it should. "B" batteries run down and develope high resistance cells, so that they cause howls, weak signals and loss of distant reception. Storage "B" batteries are some improvement, but they must be charged occasionally. Dry batteries are very expensive from the viewpoint of current cost; about two hundred times as expensive as commercial current.

However, to utilize commercial current, it is necessary to smooth it out, make certain voltage reductions, and highly desirable to interpose some sort of insulating device between it and the set. Devices which do the above operations are already on the market under various trade names, but the item of first cost makes many radio fans hesitate to invest.

These devices are not complicated, but the construction of them presents quite a few problems if the necessary transformer is built at home. However, a little shopping at the radio stores and at the second-hand telephone supply houses, will land the apparatus needed and an evening's work will complete the assembly.

Obtain from a telephone supply house a high impedance repeating coil and 5 two-microfarad condensers (10 one-mfd. condensers will do). The coil obtained should be wound with wire, 30-gauge or larger, and should have four separate windings of approximately equal resistance, any one of which should have sufficient impedance to use as the primary winding on 110-volt 60-cycle current. This coil should be tested as to insulation between windings at 220 volts 60 cycles by connecting one end of each winding to either side of the test voltage. The condensers should also be tested on the same voltage.

CHOKE COIL

An audio choke coil will be needed to act as a filter to cut out the hum of the supply current. This may be a telephone choke or retardation coil, the secondary of an audio transformer, or the primary of a bell-ringer transformer. Providing the unused winding is not short circuited, all windings may be left in place on the core.

In addition to the above apparatus, the following is also needed:

1 6- or 12-volt bell ringing transformer (must handle ½ or ¼ amp., respectively).
1 6- or 30-ohm rheostat for 6- or 12-volt respectively.
2 Tube sockets.
2 ¼-amp. amplifying tubes.
1 Variable resistance, 10,000 to 100,000 ohms
1 10-ft. portable cord and plug to connect to house circuit.
3 Binding posts, —B, +B Det., + Amp.
1 Box, panel and base, 7 x 12 inches in size; or one 7 x 12-inch mounting board.

Mount the apparatus in the cabinet, or on the mounting board, as preferred. The condensers may be stacked to conserve space, and fastened down by passing a leather strap over them, and securing the strap to the base with screws and washers.

Wire as shown in Fig. 1., windings 1-2 and 7-8 being connected to assist each other. The winding numbers are standard with most coils. Connect the portable cord to the primary of the bell ringing transformer and to either 3 and 4 or 5 and 6 of the repeating coil. Wire the filament circuit according to Fig. 1 for a 12-volt supply and according to Fig. 2 for a 6-volt supply.

ANOTHER FORM

Fig. 2 is given for the utilization of a telephone retardation coil, or a transformer of ratio 1:1 up to 1:1½. While this gives only half wave rectification, it will operate very quietly if the filter system (choke and condenser bank) is good. Specifications for the retardation coil are the same as for the repeating coil except that it has but two windings.

A word as to the operation of these plate-current supply devices. It sometimes happens that the user connects one to a set that has insufficient negative bias on the tubes, causing quite an audible hum, due to overload. This is hard on tubes as well as the user's ears. This outfit will supply sufficient plate current for eight tubes, if they are properly biased. Add "C" battery to the point where it begins to cut down on the signal on the audio stages, and on the radio stages if they are non-oscillating. The writer applied a 12-volt bias to the radio stage of his set, with a reduction from 20 milliamperes to 5 milliamperes in plate current and increase of signals. This conserves the life of the tubes as well.

CONTROL

Control the output voltage of the set may be had by adjusting the rheostat, and of the detector voltage by means of the adjustable resistance. And this last is a real control, too. Also keep in mind that the output voltage is from 155 volts on down, depending on the load. Do not turn the tubes high on a one- or two-tube set.

Old tubes will sometimes work very nicely in this outfit, but be sure to check them with a good tube, for a paralyzed tube may be so far gone that it will not pass enough current to keep the condensers charged. For an eight-tube set, nothing but the best should be used.

The writer will be glad to receive any comments on the above device, and will be glad to advise further on receipt of stamped self-addressed envelope.

SPECIFICATIONS OF WRITER'S OUTFIT

The writer used a Kellogg No. 17A repeating coil, No. 40A retardation coil for filter choke, a Dongan 6-8-14 bell ringing transformer, Kellogg No. 34 condensers (2 mfd. paper) and a Durham adjustable reistance. Output voltage on a four tube set, 135 volts, computed by milliammeter and counter emf. method, detector voltage variable from 45 volts to 6 volts calculated by substitution method. Voltmeters are not reliable unless checked with a milliammeter, as they consume a very appreciable proportion of the output current, thus lowering the voltage. The writer also recommends the use of VT-2 or U. V. 202-tubes in conjunction with an Acme 75-watt filament transformer for extreme load conditions.

Another form of the eliminator employing a different form of coil for supply only. Eliminator output can be determined with Jewell one milliamp volt meter designed for this purpose. Any transformer with a 1:2 or 1:3 voltage stepup ratio, 110 V primary and center tapped secondary, may substitute for the No. 17 Repeating Coil

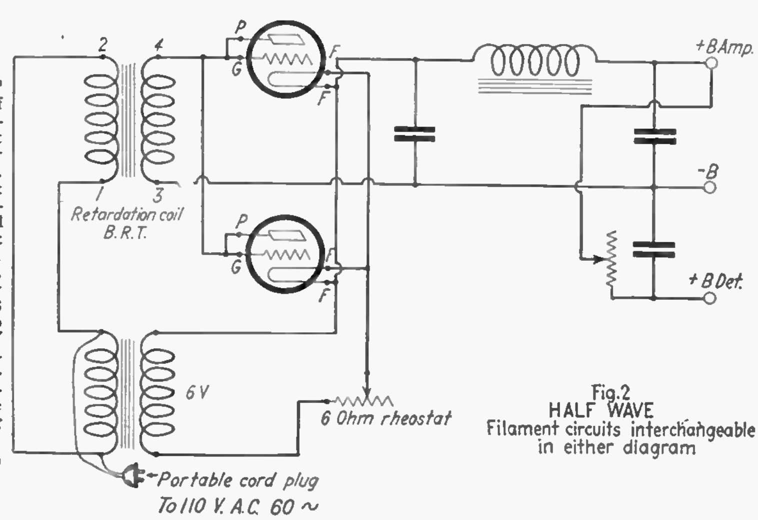


Fig. 2
HALF WAVE
Filament circuits interchangeable in either diagram

World Radio History

The Piezo Electric Oscillograph

By C. B. Bazzoni*

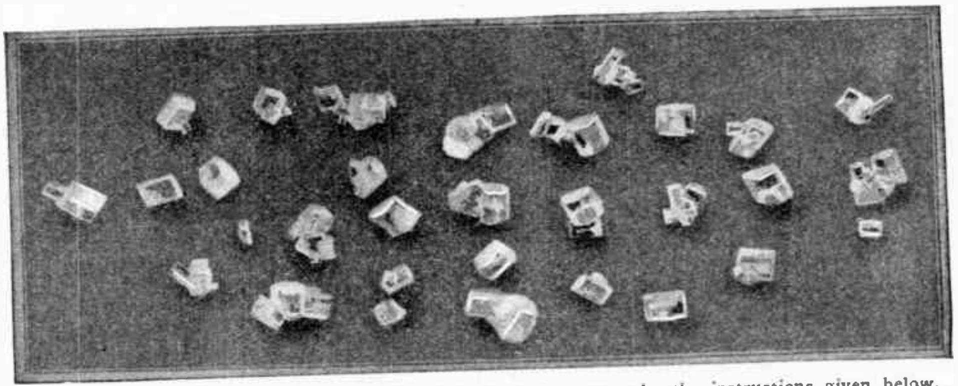
Some of the most interesting experiments in electricity can be performed with an oscillograph The construction of such an instrument is herein described.

THE general laws covering the flow of direct and of alternating electric currents in circuits, even of complicated design, have been known for so long a time that everyone interested in electricity is acquainted with them. The experimenter can thus predict with certainty the principal changes which will be produced in a given circuit by a current passing through it. The magnetic, the heating and the chemical effects are the most important and most easily observable results of current flow.

LITTLE KNOWN ELECTRICAL EFFECTS

On closer study it is found, however, that many minor electrical effects exist, such as the thermo-electric effects, the Seebeck, Thompson and Peltier effects, the Nernst, Ettinghausen, Hall and Leduc effects and so on, all of which are of interest although few are of great practical importance. Since most of these phenomena are unknown even by name to the amateur, a brief description of them may be of interest.

The *Seebeck phenomenon,* named, as are all the others, from its discoverer, is the ordinary thermo-electric effect. It is found that if, in a circuit made up of two different metals, the two metal junctions are kept at different temperatures a continuous although small current will flow. *Peltier's effect* is the reverse of Seebeck's. When a current flows through a junction of two different metals it heats them or cools them, depending on the direction of flow. *Thompson* found that a difference of potential exists between different parts of the same conductor when these parts are at different temperatures. *Hall* found that when a magnetic field is applied from above at right angles to a current-bearing wire a difference of electrical potential develops between the sides of the wire. *Nernst* and *Ettinghausen* showed that when two edges of a metal sheet are held at different temperatures and a magnetic field is applied at right angles to the sheet there will be produced a difference of potential between the edges of the sheet and also, conversely, that when a current is flowing through such a sheet set at right angles to a magnetic field a temperature difference appears between the edges of the sheet. *Leduc* found that if the temperature varies in the direction of a magnetic field passing at right angles to a metal plate, a transverse difference of temperature will develop between the edges of the plate.



Actual size photograph of "seed crystals" of Rochelle salt grown by the instructions given below.

These "effects" are all small—Seebeck's being the only one which has been put to practical use up to the present time. It will be observed that all of these phenomena have to do with an interrelation of heat and of electricity and magnetism. Under the electron theory both heat effects and current effects are believed to be due to the atmosphere or cloud of free electrons existing in the interior of conducting bodies. This being the case, it is natural to expect that relations of the kind described ought to exist. Without going into detail it can be said that some of the phenomena referred to above are satisfactorily explained by the present-day theories and some are not. The Hall effect is found, for one, to be particularly difficult to explain in full. The "effects" mentioned are by no means all that have been discovered. A number of others, interesting and important, are associated with the passage of current through substances.

CRYSTALLINE AND AMORPHOUS SUBSTANCES

We all know that matter in every form in which it occurs is made up of atoms having, on the average, a diameter of one one-hundred-millionth of an inch and, therefore, entirely too small to be perceived by any means at our disposal. There are in the known universe about ninety-two different kinds of atoms, each kind being characteristic of a particular chemical element. When these atoms combine in groups to form a chunk of matter they frequently show a preference for arranging themselves as if on a regular lattice-work, the atoms setting themselves at the joints of the lattice. This comes about because of the regular nature of the forces acting between the different atoms. If this building-up process proceeds regularly, atom by atom, until a chunk big enough to be seen is formed, the chunk will be found to have

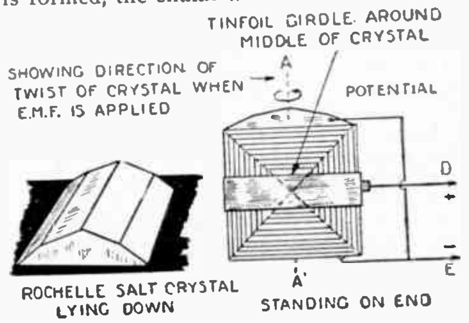


FIG. 1

The appearance of a Rochelle salt crystal. A good size for the oscillograph is approximately 2 by 1½ inches.

a regular shape with sharp and definite edges and corners. The shapes themselves may be various as obtained from different chemical compounds, as needle-shaped, cube-shaped, octahedron-shaped and so on, but for any one material the shape is always the same if the method of production is not changed. The usual way to bring about this slow building-up process is to dissolve the substance in a liquid and then slowly evaporate the liquid. The regular chunks of matter thus formed are called crystals. Modern physics has proved through the use of the X-rays that the atoms of all crystals are arranged in a perfectly regular and symmetrical manner, as if at the corners of a lattice-work, as mentioned above. The X-rays have also shown that nearly all forms of matter are crystalline, even though the crystals may be too small to be apparent. Substances which are entirely without a crystalline structure are said to be amorphous.

ELECTRICAL EFFECTS IN CRYSTALS

Crystals have been carefully studied by physicists not only as to their structure but also as to the way in which they react to heat, to light and to electricity and magnetism. Since we know how the atoms are arranged in the crystals it would seem that we have, in dealing with crystals, a better chance to explain what we observe in experiments than we have in dealing with ordinary solids about the interior structure

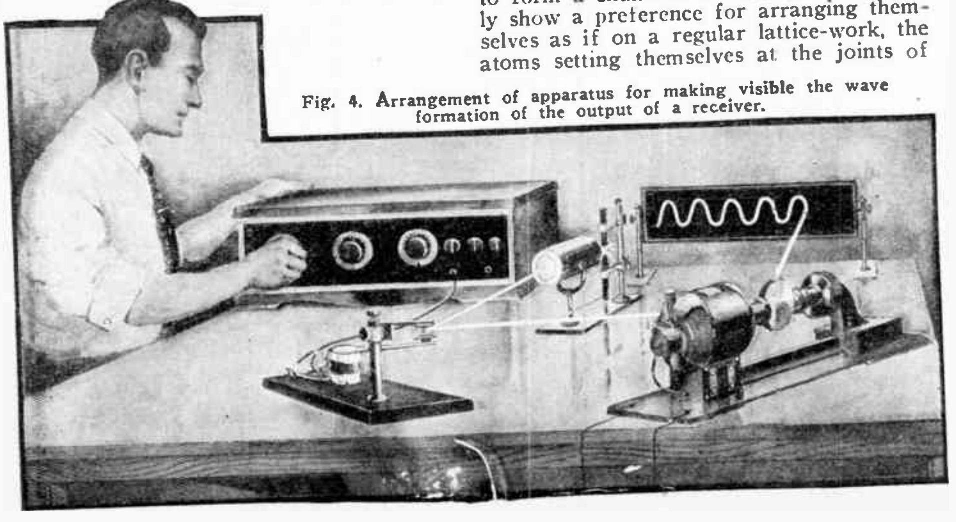


Fig. 4. Arrangement of apparatus for making visible the wave formation of the output of a receiver.

* Professor of Experimental Physics, University of Pennsylvania.

World Radio History

Some crystal groups of Rochelle salt which should be avoided. Crystal groups are useless as oscillographs.

of which we know nothing. Work of this sort is being carried out at present in many university laboratories of physics so that we may hope in the near future to know a great deal more about these things than we do now. As to electrical effects in crystals there are two that I wish to mention in particular; first,, the pyro-electric effect and, second the piezo-electric effect.

PYRO-ELECTRICITY

As the prefix *pyro* indicates, this is a heat effect. It has been found that certain crystals exhibit electric charges when heated or cooled. This effect is marked in tourmaline — a semi-precious stone frequently used in jewelry. When a tourmaline crystal is heated, one end becomes positively charged and the other end negatively charged; when the crystal is cooling down after heating the charges are reversed. This effect can be shown in opaque crystals of tourmaline, which are not useful for jewels and which are, therefore, not expensive.

It is interesting to note that if the crystal be broken up, each part exhibits the effects above described. Even if powdered, the effect still persists. If the powder be heated on a glass plate its particles will stick together in chains as iron filings do in a magnetic field. Quartz and fluorspar, as well as many other crystals, show this pyro-electric effect. No practical use has been made of this type of pyro-electricity up to the present.

THE PIEZO-ELECTRIC EFFECT

The prefix *piezo* of this somewhat formidable word indicates that the effect has to do with pressure. As a matter of fact, the piezo-electric phenomenon is found in the development of a difference of electrical potential between the ends and sides of a crystal when that crystal is compressed or stretched. This is not primarily a heat effect. As with pyro-electricity, piezo-electricity can be developed from a great variety of crystals; the details of the effect as to the amount and position of the charges developed being different in different crystals. The majority of experiments in piezo-electricity have been done with Rochelle salt, from which relatively large effects can be obtained and which is cheap and easy to prepare. Quartz crystals are more permanent and less breakable than Rochelle salt, but their piezo effect is much smaller. For some special uses tourmaline is preferable to either quartz or Rochelle salt.

THE INVERSE PIEZO EFFECT

It has been shown that the inverse of the piezo effect also exists; that is, that if differences of potential are applied between the ends and the middle of suitably selected crystals a stretching or compressing force will be developed in the crystal which may show itself in a warping of the shape of the crystal. The direction of this twist or warp is shown in Fig. 1. The principal purpose of this article is to describe an instrument making use of the inverse piezo effects in measuring changes of electrical potential.

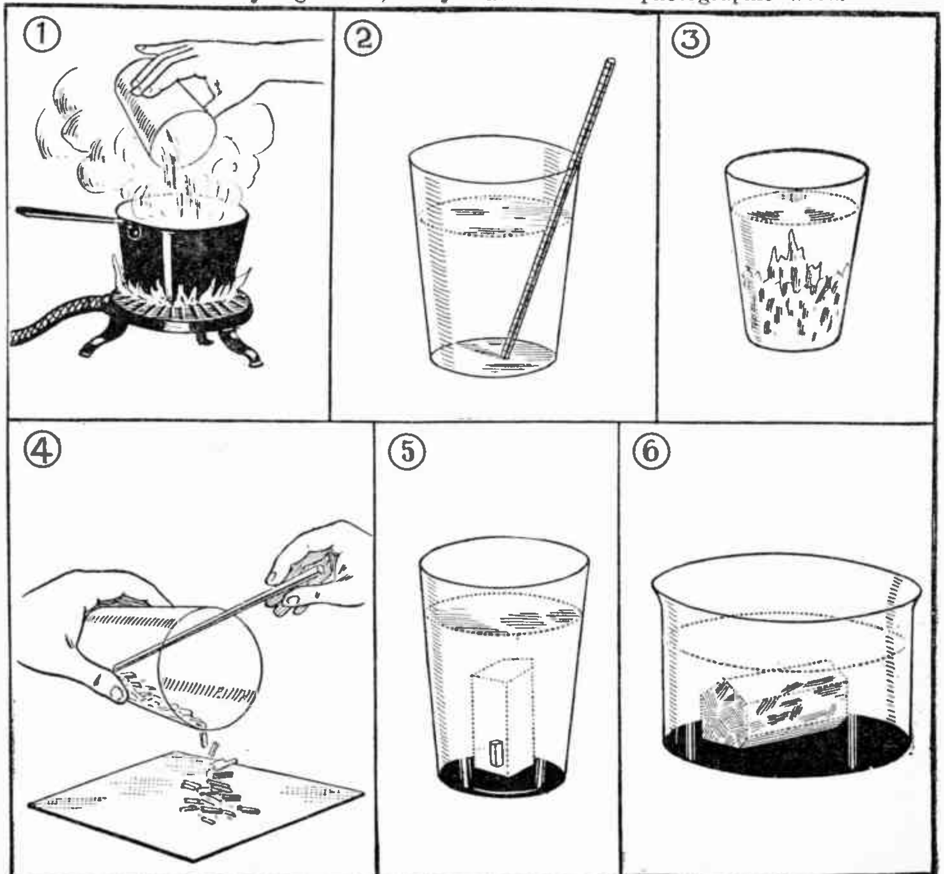
The twisting of the crystal about its axis due to the changes in the potential applied to it is nearly instantaneous, consequently the twistings and untwistings of such a crystal will follow very rapid alterations of potential such as we get in alternating current circuits. If the crystal be mounted so that its twisting can be readily observed, the arrangement can evidently be used to study the nature of the potential changes in such circuits. Instruments designed to do work of this kind are generally called "oscillographs." The piezo-electric oscillograph which we are to describe below was devised by Mr. C. E. Wynne-Williams of the University College of North Wales, Great Britain, and was first publicly described by him in February of the year 1925.

OSCILLOGRAPHS

Oscillographs of several different types have been invented in the past and have been in use in laboratories for many years. It would clearly be very difficult to find out exactly what goes on in alternating current and radio circuits without such instruments. The two most usual kinds of oscillographs are the "hair-pin pattern oscillograph," suitable for alternating frequencies up to 5,000 per second, and the "cathode-ray oscillograph," suitable for frequencies up into the millions, that is, in the radio range. An instrument of the first kind costs, with necessary accessories, in the neighborhood of $1,200. The second type costs complete about $150. No ordinary amateur is, on account of these relatively high costs, likely to possess one of these useful instruments. The piezo-electric oscillograph, which within certain limits will do the same work, can, however, be built for a very few dollars by anyone willing to spend the time necessary for the preparation of a suitable crystal Let us now consider in detail the proper way to prepare a crystal for this purpose and the proper way in which to rig up and use the crystal, once it is prepared.

PREPARATION OF THE CRYSTAL

Good-sized crystals of Rochelle salt suitable for piezo work can be grown by any careful amateur, but to avoid discouragement it ought to be understood at the start that real care and considerable patience are, excepting in the case of a lucky accident, certain to be necessary. In the first place, buy *one pound of Rochelle salt, chemically pure* and crystallized. This should be obtained in a sealed bottle from or through a druggist or chemical house. The cost will be about seventy-five cents. Buy also a quart or gallon bottle of *distilled* water, such as is used to refill automobile storage batteries. The cost of the water should not exceed twenty-five cents. Dissolve the whole of the Rochelle salt in about 10 *or* 12 *ounces of warm distilled water* in a *clean* glass vessel about six inches in diameter and about eight inches high, taking care at this and all subsequent stages to prevent the entrance of dust, small floating fluff or hairs and other foreign material. If this solution is too "strong" it will crystallize at once on cooling to room temperature, forming a mass of irregular crystals useless for piezo work. The strength must be adjusted so that crystals just begin to form at about room temperature. This critical adjustment may by chance be reached at once, but more likely it will take considerable time and experimentation. If the solution proves too strong add water; if too weak heat or boil to evaporate some of the water. The water may be measured in a graduate marked in ounces, such as is used in photographic work.



Method of growing Rochelle salt crystals. These figures show the routine of the process of forming the crystals. Great care must be taken to have the solution temperature and specific gravity just right.

World Radio History

Next, put a few tablespoonfuls of the solution into a saucer or flat dish and let it evaporate *quickly* in a draught of air or in a warm place. A considerable number of small crystals will thus be formed. These are called "seed crystals." Select a few of these seeds, perhaps an eighth of an inch long, which have formed on a flat part of the saucer and which have a shape flat on the bottom and arched on the top like those shown in the sketch in Fig. 1. These seeds are to be used as centers for growing larger crystals such as we need for our oscillograph.

Now cut a square of flat window-glass of such size that it will rest easily in the jar at the bottom of your salt solution. Clean this sheet, warm it and introduce it carefully into the solution. Next drop a selected seed crystal into the middle of this plate and set the jar in a place free from vibrations and disturbances where the temperature is steady. Level the jar with slips of paper under it until the glass plate is horizontal. Cover it with a sheet of paper and leave it strictly alone. If the strength of the solution is correct for the room temperature, if the temperature remains constant at the right value and if no dust has got into the jar the seed crystal will begin to grow within a few hours. After 18 to 24 hours it will have grown to a length of about two inches, which is long enough. Naturally the three "ifs" mentioned may cause trouble but, as I have said, any careful worker will certainly be successful in crystal growing after a few trials and adjustments to fit his particular facilities.

The dust trouble can be eliminated by filtering the solution hot before introducing it into the crystallizing jar. The necessary constancy in temperature can be better assured by putting the jar, during the crystallizing process, into a tin biscuit or bread box which has been wrapped with several layers of cotton batting or hair felt tied on with strings. The trouble of leveling the glass plate can be avoided by pouring into the glass jar enough mercury to float the plate, if mercury is available. These ideas are embodied in the drawing of Fig. 2. Crystals as large as 3 by 2 inches can be grown by this method but the larger the crystal the more likely are flaws and twin crystal effects to develop. The experimenter ought to be satisfied with crystals two inches by one and a half inches approximately. When these crystals are removed from the glass plate they will be found to exhibit a peculiar structure on the under face, as shown in Fig. 1. The crystal looks like four pyramids with their tips together. Fig. 1. shows in a general way what the crystal ought to look like. The crystal, after removal from the solution, ought to be dried carefully by keeping it at about 100 degrees Fahrenheit for three or four days. The sensitiveness of the crystal when used in the oscillograph is found to depend on the dryness. Sensitivity can also be increased by soaking the crystal in absolute grain alcohol for 18 hours or so immediately after removal from the crystallizing jar and before drying. However, under present conditions, some people have difficulty in obtaining grain alcohol.

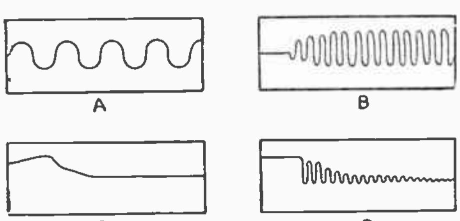


FIG 5

Appearance of some waves made visible by the Rochelle salt crystal oscillograph.

ELECTRICAL CONNECTIONS

Now, as has been indicated in Fig. 1, a twist is produced between the top and bottom ends of a Rochelle crystal of the shape shown when one terminal of a voltage supply is connected to the top and bottom surfaces and the other end of the voltage supply is connected to a girdle around the middle of the crystal, midway between the top and the bottom.

These electrical connections are made of tin foil cut to the proper shape and laid on with shellac. Tabs are left sticking out for connection to the potential wires. The girdle around the middle should cover about one-half the height of the crystal. After the shellac has been put on, the crystal must be again dried. We are now ready to assemble the complete instrument.

THE COMPLETE INSTRUMENT

The crystal may be mounted on a small board, as shown in Fig. 3. Fasten the crystal down with shellac and tin foil pads. A light arm of sheet aluminum, bent into girder form to give it rigidity, is next attached to the top of the crystal, as shown.

The overall length of this arm is something more than twice the length of the crystal. Face the upper side of the end of the arm with a thin layer of cork. Another similar arm, faced with cork on its lower side, is arranged to slide on a post set behind the crystal as shown in the figure. When this second arm is brought down over the arm attached to the crystal and a small piece of thin mirror, perhaps 1/16 of an inch square, is clamped between the two cork surfaces with its face vertical and parallel to the flat face of the crystal, the oscillograph is complete.

OPERATION OF THE INSTRUMENT

If now the electrical potential is applied

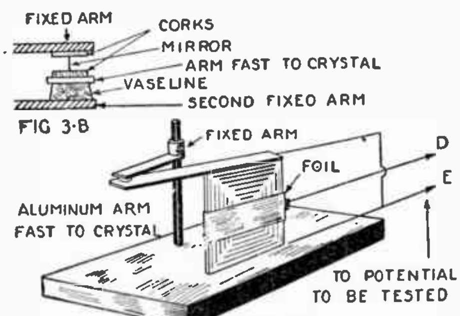


FIG 3

The appearance of the oscillograph, showing relative positions of its components. Fig. 3B. Device for damping.

between the wires D and E—if for example a 90-volt "B" battery is connected to these wires—the crystal will warp around its vertical axis and the little mirror will be tilted. If a beam of light is reflected from this mirror onto the opposite wall of the room the spot of light will move up or down when the potential is applied, thus showing the warp. If the crystal is a good one—there is quite a variation among crystals—150 volts applied between D and E ought to move the spot of light ½ to ¾ of an inch on a screen three feet from the mirror. If a 60-cycle alternating potential is used such as can be obtained from any ordinary wall socket, the spot will move up and down over a small range sixty times a second. The spot will then look to the eye merely like a line of light.

TO PRODUCE VOLTAGE CURVES

If this line be made to travel over a fixed screen or if a screen be moved across the line, a curve will be produced which will show how the e.m.f. varies during its cycle. The first method, that of moving the line across the screen, must be used in order to render the wave-forms directly visible to the eye. For this purpose a concave mirror, about 2 inches in diameter and of 18 inches radius of curvature, is mounted on a vertical spindle fixed so that it can be rotated at any desired speed by hand or, better by an electric motor. The beam of light after reflection from the oscillograph mirror, is made to fall on this rotating mirror and is thence thrown on the screen or wall. The movement of the rotating mirror throws the spot of light across the screen so that it no longer moves up and down in the same place but progressively across the screen, producing a wave-form, as pictured in Fig. 4. When the speed of the mirror is properly adjusted so that the spot of light travels over the same path on successive passages across the screen, a permanent wave-form will appear on the screen, where it can be studied in detail.

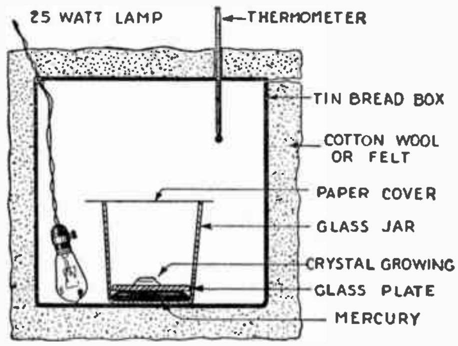


FIG. 2

To obtain well-shaped crystals it is necessary to keep a constant temperature, for which the above apparatus is used.

USES FOR THE OSCILLOGRAPH

Once this device is set up with its rotating mirror and a screen, a long series of interesting studies can be made. First the wave-form of the e.m.f. in the lighting circuit can be seen. A curve like Fig. 5A will result. Next an oscillating three-electrode tube circuit can be set up, to give a frequency of about 500 cycles a second—as evidenced by a good musical tone in the telephones. Leads taken to the oscillograph crystal from the plate and filament terminals of the oscillating tube will produce a figure on the screen like Fig. 5B. The way in which the crystal responds to a suddenly applied voltage can also be seen, merely by throwing the potential switch quickly. When the crystal is fresh an effect like Fig. 5C will probably be obtained, but when the crystal is several weeks old the effect may be more like D. When this second stage is reached a little damping of the motion of the crystal will improve performance. For this purpose another metal arm sliding on the post at the rear of the board can be brought up to within 1/16 inch of the oscillograph arm from below and a small drop of vaseline placed between the two arms (see Fig. 3B).

Now for the limitations of the instrument. If voltages greater than 1,000 are applied to the crystal it is liable to break down electrically and become useless.

The actual twist of the crystal is small, being for an average size crystal about one ten-thousandth of a radian (57.296 degrees) for an applied voltage of 200. This sensitivity compared to that of a hair-pin type oscillograph, is very small but for the purpose in hand it is sufficient.

Finally, to get striking results, a bright source of light should be used to furnish the beam which falls on the oscillograph mirror. An arc lamp with a screen with a pin hole in it in front of the crater of the arc is best. Crystals prepared as described have natural frequencies of 3,000 to 5,000 cycles. Because of natural resonance the crystals will not give a true picture of an applied e.m.f. having a frequency much above 1,000.

The cathode-ray oscillograph still remains the only instrument suitable for investigations in the high frequency range.

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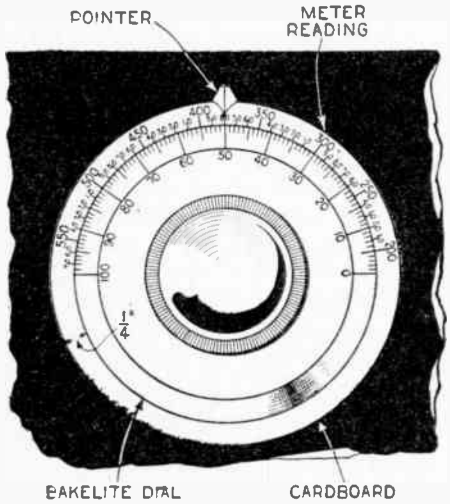
Radio Wrinkles

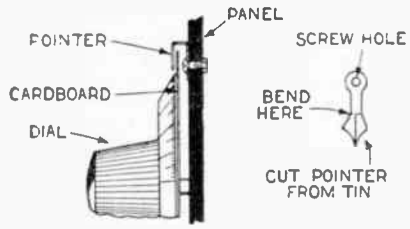
Short Cuts and First Aids To The Radio Experimenter

A METER READING DIAL

In the majority of cases in which sets can be logged, there are used more or less complicated systems for recording the dial readings and the corresponding wave-lengths. This can be simplified to a great extent by the use of the simple device herein described, in which the wave-lengths are read directly on the dial.

A circular disc, cut from either a good grade of stiff white cardboard or a piece of celluloid is prepared as follows: Place the material to be cut on a table and place on it the dial to which it is to be attached. Mark off on the material where the first and last divisions of the dial come and draw a line around the circumference of the dial. Between these two points, which are ap-





A dial and pointer that will improve the looks and operation of any set.

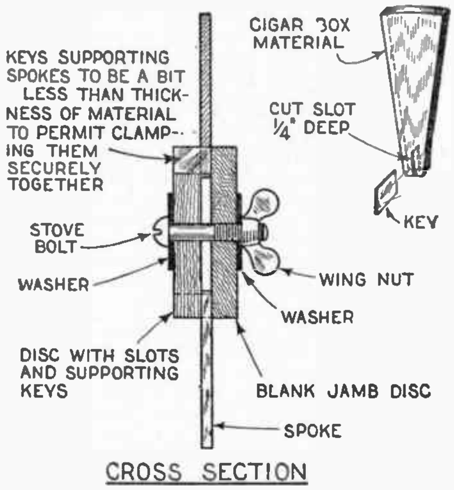
proximately 180 degrees apart, draw a concentric circle with a radius ¼ inch larger than the other. This is then marked off, as shown in the accompanying illustration, with numbers indicating the wave-lengths. This disc is then pasted to the back of the dial in such a position that its circumference is ¼ inch from the edge of the dial. The device should be a time-saver as the dials may be set directly in wave-length readings.

A pointer for this dial may easily be made of thin tin, as shown in the sketches in Fig. 2. This is fastened to the panel by means of a small bolt, after being bent as indicated in Fig. 2.

Contributed by Carl Schmuelling.

A LOW LOSS SPIDER-WEB COIL WINDER

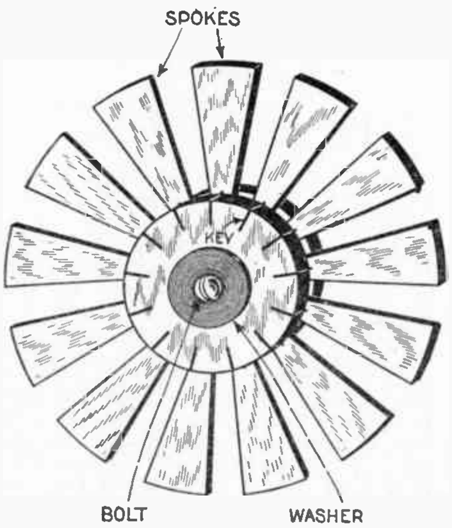
There are many different methods of preparing coil forms, the majority of them requiring holes drilled around the circumference of the disk. The form here described eliminates all such drilling and also pegs that wear and get loose in their sockets. The materials necessary are a side of a cigar box (straight grained), a 3-inch piece of hard wood from which the disks may be cut, a piece of strip copper about



Showing how the various parts of the coil winder are assembled.

1/32 inch thick, and a ¼-inch stove bolt. A fret or scroll saw is necessary to cut the slots.

Cut from the cigar box material 13 spokes as shown in the accompanying sketch, clamp them together and even them off with sandpaper, making them all the same shape. While the spokes are clamped together, mark off a center line (at the edges of the spokes which are to be clamped between the disks or the inside ends nearest center) and saw a slot ¼ inch deep. This slot acts as a support and centralizer for the



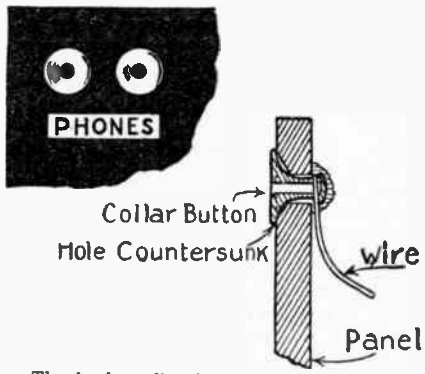
The final assembly of the winder is a simple matter, as shown above.

spokes, which slip into the key carried on one face of the disk, as described later. The slot permits the spokes to be slid off after the coil has been wound.

Next cut two disks from the 3-inch material and divide one of them into 13 equal parts on the outer circumference and draw lines to the center. A second circle is drawn ¼ inch nearer the center, which acts as a guide for the depth of the slots carrying the keys. These slots are also sawed with the scroll saw. The keys are cut from the thin sheet copper and fitted to the slots, the width being a little less than the thickness of the spokes. If these keys are exactly the width of the spokes when the disks are clamped together, it will be impossible to remove the spokes after the coil is wound. These keys are glued in the slots on one disk only, the other disk acting merely as a backing to clamp against. A ¼-inch hole is drilled through the two disks to take the stove bolt, which may have a wing nut to tighten with.

Slide the spokes on the keys and place the blank disk in position, clamping with the wing nut and stove bolt, using washers as shown. After winding coil, paint the intersections of windings with collodion and allow to dry about 15 minutes before removing from the form. The resulting coil will be one having as low losses as possible and in addition once made the form may be used indefinetly with no appreciable wear.

Contributed by H. A. MacDonald.



The lowly collar button has at last been applied to radio. They make efficient jacks for phone tips.

FIVE-CENT EMERGENCY JACKS

Many constructors of experimental radio sets take great pride in seeing just how much of the apparatus that goes into a receiver can be made from spare parts in the junk box. Although the "parts" needed for these jacks are not generally in the radio junk box, they are bound to be somewhere around the house. These parts are nothing more than two collar buttons.

As almost all collar buttons have holes in them, it is only necessary to see whether the tips of the phone cord will fit snugly. If the holes are too large, with a pair of pliers pinch the shaft in order to reduce the size of the opening, and if the hole is too small, it can be easily enlarged by spreading the soft metal with a nail and hammer. Holes having a slightly larger diameter than that of the smallest end of the button are then drilled in the panel. These holes are then countersunk on the front of the panel so that the buttons will be flush with it. Place the buttons in their holes and twist the connecting leads to the part projecting through the rear of the panel. Then, with a good hot soldering iron, place a ball of solder around the shaft of the button, as shown in the accompanying illustration. This will not only hold the jack in place but will provide an excellent contact.

Contributed by J. V. Moran.

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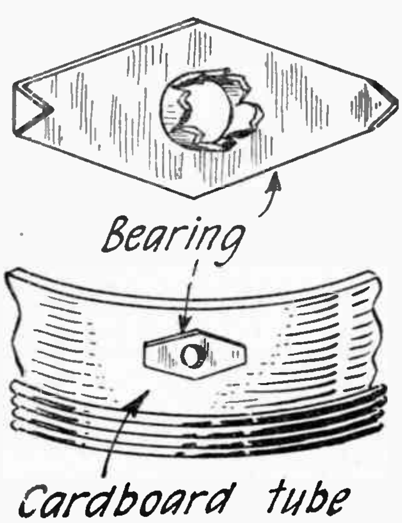
ROTOR SHAFT BEARINGS FOR CARDBOARD TUBES.

Since paper tubes are both common and admittedly good from the electrical standpoint, it is desirable to have suitable bearings in them for the rotor shaft. The paper



A rotor shaft bearing made from a piece of sheet brass. The hole for the shaft is made with a center punch.

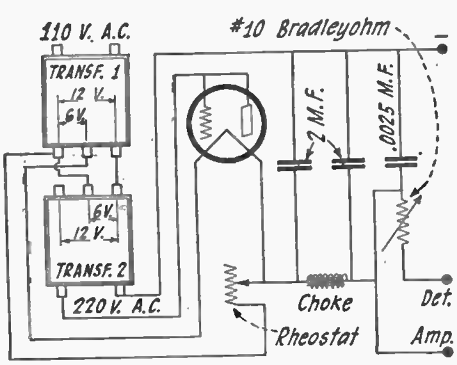
tube is not sufficiently rugged in itself to have a hole through it remain a permanently good bearing and though the tube can be reinforced with leather-board or other material, and the whole treated with shellac, it is better to provide metal bearings. My first were made with pairs of sheet brass strips, one piece each side of the tube wall—a laborious and unsatisfactory method, but later good bearings were quickly and easily made by cutting diamond shaped pieces of sheet brass or aluminum, say 1¼ inches long, with enough of each end bent to a right angle to reach through the paper tube and clinch, making good and substantial bearing.

The hole for the shaft should be made with a small punch and then spun out to the required size by revolving a smooth tapering spindle in it; this is better than a drilled hole, as it leaves the bearing with considerable wearing surface and the burr tends to hold the shaft snugly and without play.

Contributed by Frank N. Blake.

A SIMPLE "B" BATTERY ELIMINATOR.

The radio fan desiring to build a rectifier



Posts "Det." and "Amp." are the B+ output. Special high resistance meter required for voltage tests. Low output is due to high resistance choke or poor rectifier tube. Special rectifier tubes are recommended.

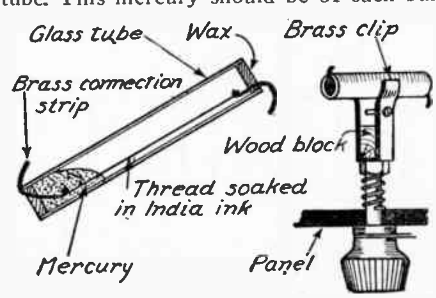
which will take the place of "B" batteries is often puzzled as to how to secure a transformer to step up the A. C. voltage before rectification. Fig. 1 shows how bell ringing transformers can be used for this purpose. This half wave rectifier will supply both detector and amplifier plate current and give excellent results on sets using up to four tubes.

Transformer No. 1 steps the 110-volt A.C. down to 6 volts to light the filament of the tube, and also supplies 12 volts to transformer No. 2, which is used as a step up transformer. By applying 12 volts from No. 1 to the 6-volt winding of No. 2, 220 volts A. C. is obtained from No. 2, which is supplied to the grid and plate of the tube. The secondary of an audio transformer can be used for a choke coil, but it is better to rewind it with 5,000 turns of either No. 32 or No. 34 B. & S., S. S. C. wire which will give sufficient choking effect with a minimum of D. C. resistance so that the drop in voltage is small. The Bradleyohm is used to cut down the voltage to 22½ volts for use on the detector.

Contributed by J. R. Benge.

A MERCURY VARIABLE GRID LEAK.

An excellent variable grid leak may be made with a piece of glass tube about 2 inches long. A heavy thread is soaked in India ink and run through the glass tube close to the inside wall. This thread is held at one end by a short piece of brass or copper strip. The other end is embedded in a piece of sealing wax which entirely closes one end of the tube. Another brass strip is also inserted in this end of the tube so that it will make contact with a quantity of mercury which is placed in the tube. This mercury should be of such bulk



Details of a mercury variable grid leak.

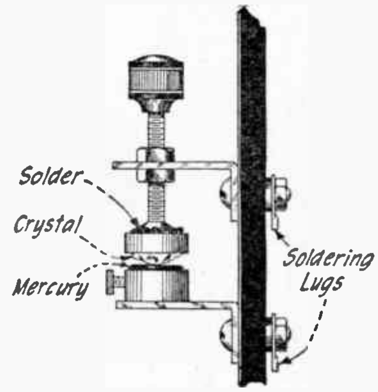
that it will almost completely cover the thread when the tube is placed in a horizontal position. After the right quantity of mercury has been found, the other end of the tube should also be sealed with wax. This variable leak is mounted in a brass clip, which is attached to a knob and shaft inserted through the panel. A small block of wood is bolted to one end of the shaft and the brass clip is held in place over it, as shown in the diagram. A stiff brass spring is placed over the shaft between the panel and the wooden block so that sufficient tension is always had to keep the grid leak in any position in which it may be placed. Light, flexible leads may be soldered to the two brass connection strips at either end of the tube. When the tube is in a vertical position maximum resistance is had and as it is gradually turned to the horizontal position, the mercury short circuits more of the thread, thus cutting down the resistance.

Contributed by L. W. Elliot.

A MERCURY CRYSTAL DETECTOR.

For those who are building reflex receivers and who wish a good sensitive crystal detector which will hold its adjustment under practically all conditions, the detector described in this article is recommended.

Mount a cup, see illustration, on the lower angle with the set screw projecting away from the panel. Screw one nut on the shaft to within ⅝ inch of the head and put the other end of the shaft through the hole in the upper angle and screw another nut down to fasten it securely. A binding post knob may be screwed on the end of the machine screw to act as a handle. The mounted crystal should then be soldered to the head of the machine screw. At the nearest drug store obtain ten cents worth of mercury. Unscrew the set screw on the lower cup until it is almost out and nearly fill the



A crystal detector employing mercury as the contact. Turning the thumb screw on the lower cup raises or lowers the level of the mercury.

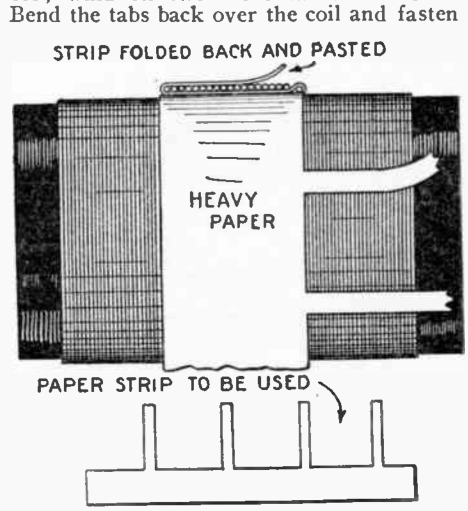
cup with mercury. The crystal should then be lowered until it almost touches the mercury. The mercury should be forced up by means of the set screw so that it barely touches the crystal.

If a crystal with a rough surface is employed, the results will usually be best. Silicon should give very good reception in this type of detector. Select a sensitive piece.

Contributed by C. Wesley Wisel.

FASTENING A PRIMARY COIL.

The fan who builds his own is often confronted with the problem of winding a small, untuned primary coil over the secondary coil and fastening the ends so that they will be permanently fixed. Cut from heavy paper a strip like that shown in the sketch. Make it as wide as the primary coil will be and leave several half-inch strips attached to one side. This is fastened to the secondary coil with collodion, the tabs extending to one side. Wind on two turns of wire before starting to wind the coil, these being the leads. After winding the first turn, bend the strips back over it and then wind on the rest of the coil *over* the strips, which should be previously coated with collodion. After finishing the coil, wind on two more turns for leads. Bend the tabs back over the coil and fasten



One of the best methods yet devised for fastening a primary coil that is wound over a secondary.

them down as shown in the sketch. In a few minutes the wires can be clipped loose at the ends and the coil will be complete, with long leads.

Contributed by Clyde D. Williams.

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QUICK CHANGE COILS

For the fan who wishes to use different coils to cover different wave bands, or for experimenting with different styles of coils, the following method of mounting will be found very convenient.

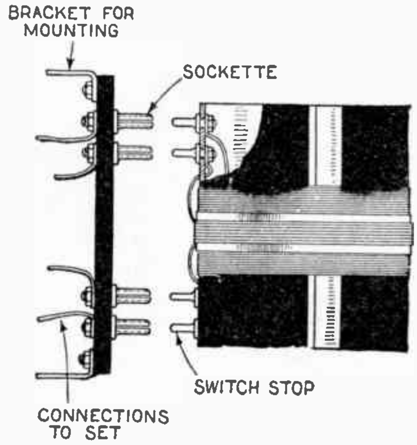


Fig. 1. Quick change method of connecting two windings on the same tube in a circuit.

About ¾ of an inch from each end of a small strip of panel—say ½ inch by 4 inches—mount one of the little "Sockettes" such as are sold in sets of four for mounting tubes. This is for coils with a single winding, but if the coil censists of two windings, mount two of the sockets at each end of the panel strip. This panel may then be mounted with small brackets or in any manner desired, and at any convenient

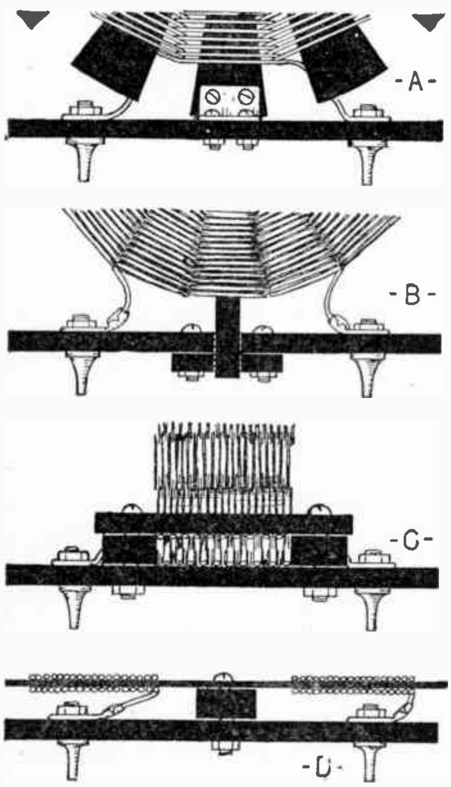
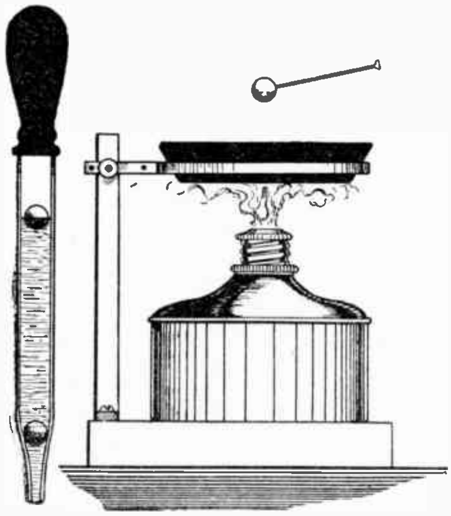


Fig. 2. How to mount four different types of coils for quick change.

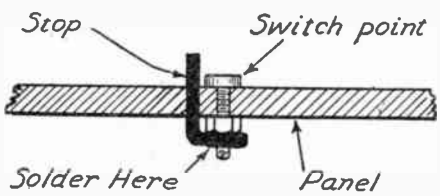
place in the set—on the baseboard, panel, or back of a variable condenser. Consider the sockets the terminals of your coil, and make the proper connections to instruments or binding posts. These connections may be soldered if desired.

For coils which are wound on either cardboard or composition tubes, an ordinary switch stop is mounted at each end of the tube for the single winding, or two at each end for the double winding, and the ends of coils connected directly to these stops. Care must be taken to space the stops exactly the right distance to correspond with the sockets as shown in Fig. 1. Also be careful to see that when the stops are inserted in the sockets the proper connections will be made. It is well to follow a set rule in making these connections. For example, let the two outside sockets and stops always be the terminals of the secondary winding, the right to connect to the stator plates of the variable condenser and the left to the rotor, while the two inside stops will be the primary connections, right to aerial and left to ground. If the same rulo is always followed, no changes will be necessary, once the connections are made.

For other styles of coils, use another strip of panel for mounting the switch stops, and attach the coil to this panel by any method desired. A, Fig. 2, shows a spider-web coil mounted with a small angle piece of brass or copper. B is one of the self-supporting flat coils, which has a small rod of wood or composition thrust into one of the openings and this rod is then inserted in a hole drilled in the panel strip, and of such a size that the rod will fit snugly. A small additional strip of the panel material used to reinforce this mounting as shown in the illustration will make it more substantial. C represents one of the basket or diamond weave coils, which is attached by means of an additional strip of the panel material, and two small squares of the same, while D shows another method of mounting a spider-web parallel with the panel strip. Honeycomb coils may be tied on with a piece of thread or twine.



Small balls made of cork and sealing wax can be used for hydrometer floats.



A neat switch stop made of a piece of heavy wire.

When once mounted in this way the coils in a set may be changed with practically as much ease as you plug your phones or loud speaker into a jack—simply by inserting the switch stops in the sockets. It is well to occasionally spring the four sections of the sockette together, so as to be sure that they make a good contact with the stops and support the coil firmly.

Contributed by M. S. Palmer

HOME-MADE BATTERY TESTER

One of the chief parts of a radio receiving equipment is the storage battery, and all too often this does not get the attention that it merits. Often it is allowed to remain in a discharged condition, which is very unwise. There are also several other difficulties which could be avoided if proper use was made of a hydrometer. Too often hydrometers are not replaced if broken, and yet there is a very simple method of repairing them and also for making new ones.

On the point of a pin place a piece of cork about the size of the head of a safety match and roll it in melted sealing wax until a generous amount is collected on the cork. When the wax has cooled, remove the pin and close the hole by holding the ball of wax over a flame. Then place the wax ball in either an old hydrometer tube or a large medicine dropper, and fill with solution from the charged battery. Sandpaper the wax ball until it just floats in the solution. Then prepare another ball of a different colored wax, but this time put the ball into a solution taken from the battery when it is in a *discharged* condition. These two balls are then placed in a hydrometer case, as mentioned above.

The method of testing with this hydrometer is to draw same of the battery solution up into the hydrometer, and if one of the balls, for instance, the red one, which can be used to indicate the discharged condition, floats and the other one sinks, the battery needs charging.

Contributed by Lyonel Goodenrath.

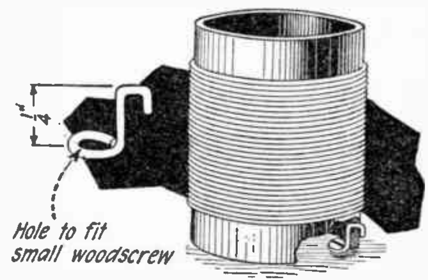
A NEAT SWITCH STOP

In building a receiver wherein a switch stop is required, it will not be necessary to purchase one, as the following scheme may be used. This stop consists of a piece of No. 14 bare copper wire or bus-bar bent into the shape of an L. A hole is drilled through the panel close to the last switch point, and the piece of bent wire is inserted from the rear, as shown. It should be securely fastened to the switch point by soldering. This very simple switch stop will admirably accomplish the purpose for which it is intended and will not detract from the appearance of any cabinet.

Contributed by Herbert Forsstrom.

COIL CLAMP

An easy and inexpensive way of fastening coils firmly to the baseboard without using brackets or bolts is illustrated in the accompanying sketch. Cut a piece of busbar or round wire (about No. 14 or 16) 1½ inches long. Bend a loop in one end of the wire to fit a small wood screw and then turn the straight part of the wire at right angles to the loop. Form a hook in the straight part, which passes through a hole drilled in the tube about ¼ inch from the bottom. The coil may then be placed on the baseboard and fastened down by passing a wood screw through the loop in the clamp.



A coil clamp easily made.

Contributed by T. J. Brant.

World Radio History

A VERNIER SCALE.

There are dozens of vernier adjusters on the market but no vernier scales although there are many selective but stable receivers and especially wavemeters for which a device for reading fractions of a scale division would be useful and convenient. The scale described here is a modification of that employed on calipers and may be applied to any large dial which runs true and is accurately engraved.

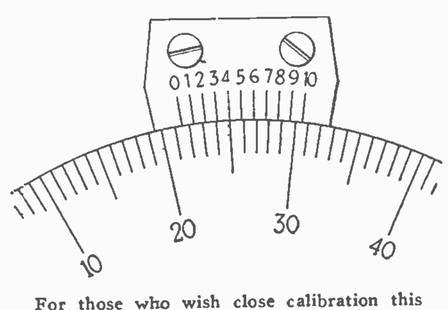
Cut a piece of bakelite as shown in the drawing. It should be as thick as the edge of the dial and fit the curve as closely as practicable. The curved edge can be shaped on a small emery wheel, and the straight edges cut with a saw and smoothed with a file. The ten divisions should be engraved with a sharp tool in the same space taken by nine on the dial and filled with white enamel. Accuracy is important in this operation.

The scale is easily read by the following method. Take the dial reading opposite the zero line of the vernier just as if the zero line were the ordinary arrow. Then note which line of the scale is opposite a line of the dial. The number above this vernier line is the number of tenths of a division. For example on the illustration the reading is 21.4. Simple, isn't it? A little study will show why this is so.

Contributed by Robert G. Garlock.

A CONTACT CLEANER FOR SOCKETS.

If your receiving set is to work at maximum efficiency, it is absolutely necessary that the tube socket contacts be clean. A dirty or corroded contact will often spoil what would otherwise be excellent reception. As a rule, these contacts are cleaned with a piece of sandpaper or emery cloth held in place on the end of a stick. This method, however, is clumsy and a good job is rarely done. If the little instrument herewith described is used for this purpose, it will be a simple matter to do this work, and clean contacts will always be assured. This contact cleaner can be used on both standard and UV-199 or C-299 sockets. It is made of a piece of round wood 1⅜ inches in diameter and 4½ inches long. One end of this piece of wood, for a length of one inch, is cut down to ¾ of an inch in diameter. The other end is also slightly cut down for a length of about ½ inch. Two round pieces of emery cloth of a diameter ½ inch larger than the ends of the contact cleaner are now forced over the ends by means of two copper rings ¼ of an inch wide. It might be advisable to cut slits about ¼ of an inch deep on the edges of the



For those who wish close calibration this vernier scale is recommended.

emery cloth disks so that when forced in place, a smooth surface will be obtained. To use this instrument it is only necessary to remove the tube, insert one end of the contact cleaner in the socket and while applying pressure, twist it from side to side. It will be found that the contacts can be cleaned in this manner very easily. The time and labor expended on this contact cleaner will be amply repaid by the knowledge that the efficiency of the receiver will not be lowered by imperfect tube contacts.

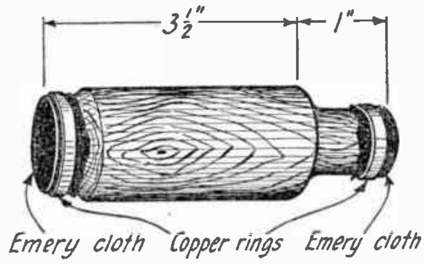
Contributed by John A. Dengler.

NON-CORROSIVE BATTERY LEADS.

The fumes that arise from a lead plate storage battery when it is charging or discharging have a very troublesome property of corroding certain metals. One of the metals so affected is copper. Usually leads made of this material are used for connecting the storage "A" battery to the set. In such a case the wires soon start to corrode, especially at the point where they are fastened to the battery terminals. This corrosion takes the form of a soft pasty, bluish mass, being most prominent at one terminal.

After this formation starts to build up, the connection betwen the wire and the battery terminal becomes bad and gives trouble. Usually it is necessary to entirely remove the wire and thoroughly clean the terminal.

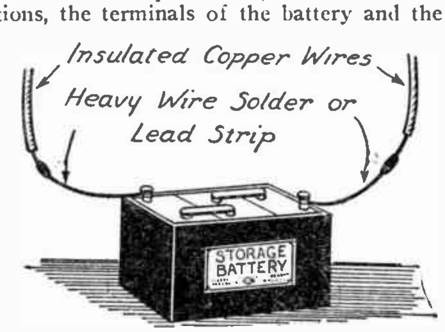
All of this trouble can be remedied once and for all by soldering or clamping a piece of heavy, hard wire solder about a foot long to each of the terminals. The copper leads may then be soldered to the ends of the lead strips, as shown. Other materials than solder may be used for this purpose.



A socket contact cleaner cut to shape from a piece of round wood.

Strips of lead, or in fact any lead that can be readily found and can be soldered or clamped tightly to the terminals will fill the bill. The most important point is to keep the copper leads away from the battery, using the non-corrosive metal where it will be exposed to the fumes arising from the battery.

As an added precaution, coat the connections, the terminals of the battery and the



Wire solder may be used to prevent corrosion on battery connections.

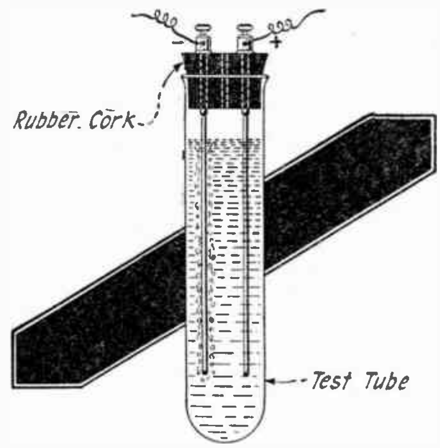
connection strips with a thin film of vaseline or lubricating grease. This will prevent any possible corrosion of any impurities that happen to be present in the metals, and will tend to preserve the appearance of the battery.

Contributed by A. P. Peck.

A SIMPLE POLARITY INDICATOR.

The materials needed for this polarity indicator are a test-tube, rubber cork, two binding posts, about 12 inches of No. 26 wire and a weak acid solution.

Drill two holes in the rubber cork the size of the screws that fit on the binding posts. Drill a small hole through the center of the cork to allow any gases that might form, to escape. To the under side of the binding post screws, solder enough



Test tube polarity indicator.

of the copper wire to reach two-thirds of the way down the test-tube, when the cork is in tight. Fill the tube three-quarters full of a weak sulphuric acid solution, or water to which has been added a little vinegar.

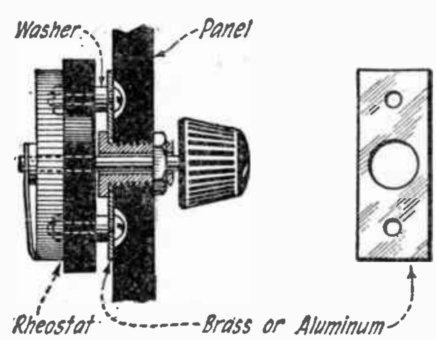
To test the polarity of a circuit, place to the terminals of the indicator the two wire from the circuit under test. The largest quantity of bubbles will form around the wire immersed in the solution to which the negative wire is attached.

Contributed by L. Kelley.

ONE HOLE MOUNTING FOR RHEOSTATS.

The majority of the rheostats are made today with two mounting screws, and in very few instances are these screw heads covered by a dial on the front of the panel. The idea here presented is to eliminate these screw heads and so improve the appearance of the panel.

A piece of either a 1/32-inch sheet brass or an aluminum plate from an old condenser, about 2 x ½ inch is drilled as follows: A hole ⅜ inch in diameter in the



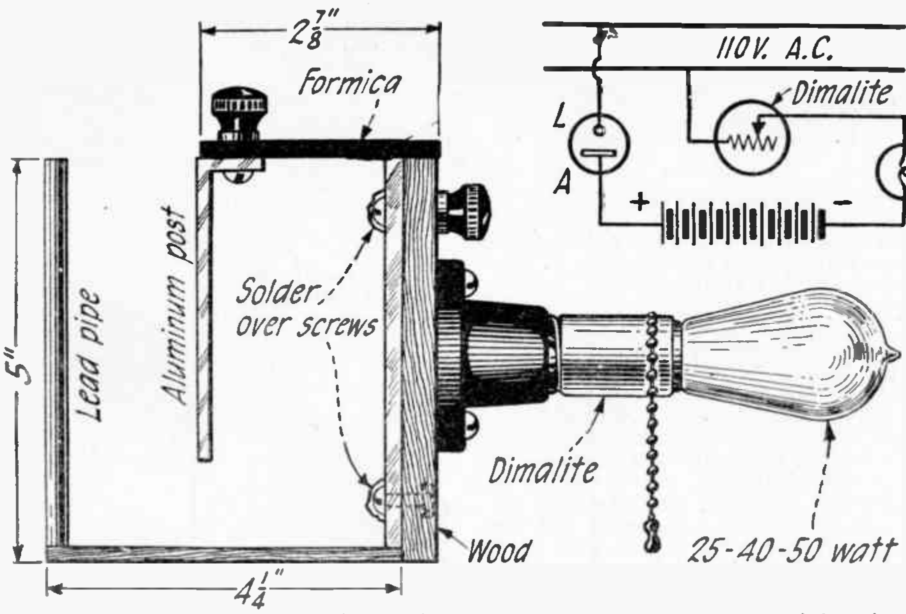
A simple way of mounting a rheostat without having to drill holes in the panel for the screws.

middle and two holes large enough to take the screws provided for fastening the rheostat to the panel are drilled in their relative positions to the rheostat. Two 6/32 round head screws are used to fasten the rheostat to the strip. Countersink two holes in the panel to fit the screw heads so that the strip will lie flat on the panel.

A bushing is prepared to fasten this strip to the panel by drilling a piece of ⅜-inch threaded brass rod, so that the shaft of the rheostat will turn easily in it.

Contributed by W. B. Scofield, Jr.

World Radio History



Details and circuit connections of the "B" battery charger. Note the compactness of the unit.

A "B" BATTERY CHARGER

Herein is described a new idea in electrolytic rectifiers for charging storage "B" batteries. This rectifier uses the container, a lead pipe five inches long and about 4¼ inches in diameter, as the lead element. On one side of this pipe, extending along its whole length, is a piece of wood, ¾ of an inch in thickness, which has been well shellacked or dipped in hot paraffin. The important feature of this rectifier is the use of a "Dimalite" socket in connection with the usual light bulb, to regulate the flow of current. The Dimalite is screwed into an electric light socket which is fastened to the piece of wood. With this arrangement, five different values of current may be obtained without changing bulbs. The aluminum electrode is fastened to a piece of formica or hard rubber 2⅞ inches long, which is, in turn, suspended over the edge of the pipe, as shown in the sketch. A round piece of lead of the same diameter as the pipe is, of course, soldered at the lower end to make the bottom of the container. Before soldering, the bottom edges of the pipe should be scraped bright and candle grease applied. The sheet of lead is also scraped and candled and then soldered to the bottom of the pipe. The electrolyte employed is a saturated solution of borax with a few drops of ammonia added. This charger will be found extremely useful in charging "B" batteries, as a number of batteries may be charged in parallel by simply regulating the current flow by means of the Dimalite.

Contributed by W. F. Hanes, Jr.

A REAL LOUD SPEAKER FOR THE MAN WHO MAKES HIS OWN

The loud speaker, herein described, was designed and perfected by a man long experienced in the construction of sound producing instruments. The volume and quality do not depend on a megaphonic action but rather upon the vibrations set up by the speaker itself.

The secret of the excellent quality of this speaker is the bridges, similar in action to the sound posts of the violin, which attach the inner horn to the outer shell of the speaker.

The choice of construction material is vital to the success of the finished product. The loud speaker in possession of the writer is constructed of clear, straight grained spruce. While it is true that some of the veneer panels will give fair results, the wood of the spruce or pine will prove best.

The first step is to lay out a full scale plan of the parts of the speaker, then cut the material to be used, exactly to size. The parts should then be assembled, coating each joint with good strong glue and making them fast with small brads.

When the complete instrument has been assembled, let it dry for a day and then give the interior two or three coats of good shellac.

The speaker can then be placed in an appropriate cabinet and a fancy grill for the front cut out with a jig saw.

Any type of speaker unit can be used and the builder will have to construct the inner horn to suit the type of unit he intends to use.

This speaker surpasses in quality any that has been put on the market to date and the volume depends upon the unit employed.

Contributed by Jesse J. Hipple.

SPREADING DIAL READINGS

To most of the fans experienced in tuning the old-style condensers with most of the station wave-lengths jammed in the first quarter of the dial, the arrival of the straight-line frequency condensers is a great relief. However, many set owners have two things to consider; there may be some of the old-style condensers on hand that are too good to throw away and the outlay of money for new condensers, even though they will facilitate tuning, may not always be possible. While the resulting condensers described below are not absolutely the straight-line frequency type, they will do the work in a most satisfactory manner and do not involve a great deal of labor in their construction.

To make an 11-plate condenser, that size being needed in a special circuit built by the writer, a 17-plate condenser was cut down. As will be seen later on, the extra number of plates are necessary, in order to give the desired capacity, to compensate for the material that is removed from the rotor plates. The rotor plates of the condenser were removed and taken off the shaft. Then, with a small pair of shears, a file and emery paper to finish off, pieces were trimmed in sizes as follows:

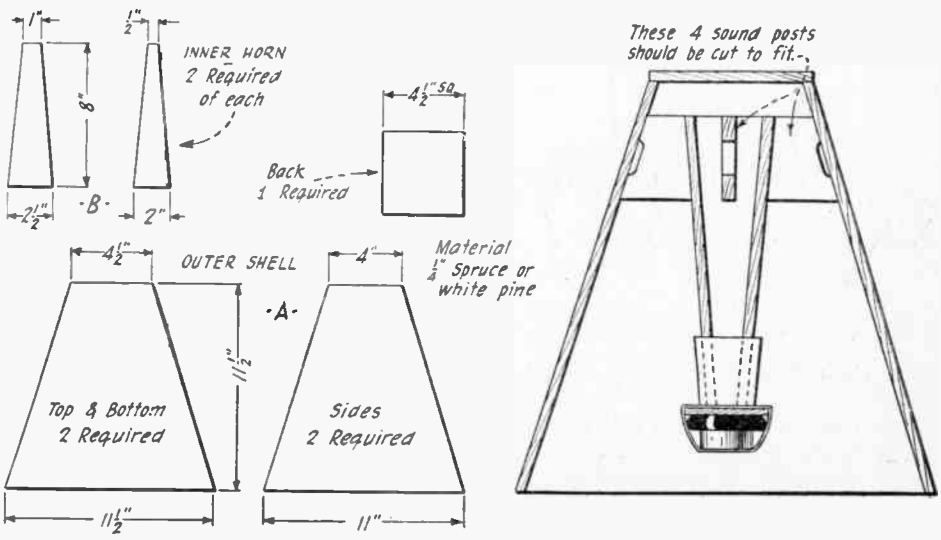
1st plate was left full size.
2nd plate sector removed equal to 15 dial divisions.
3rd plate sector removed equal to 27 dial divisions.
4th plate sector removed equal to 37 dial divisions.
5th plate sector removed equal to 45 dial divisions.
6th plate sector removed equal to 52 dial divisions.
7th plate sector removed equal to 58 dial divisions.
8th plate sector removed equal to 63 dial divisions.

It might be said here that more time and closer calculations might produce a truer curve, but the idea is the same and can be worked out for any size condenser for any curve.

The rotor is then assembled and the unit replaced. The edges of the high-wave side will be even, while on the low side the edges will fan out and mesh in the sequences of the above table. This gives an eccentric rotor in which the smallest capacities are on the low waves and load up progressively in inverse proportion to the frequencies producing the straight-line effect.

In tuning: From 0 to 15 is a 3-plate vernier condenser, from 15 to 27 is equivalent to a 15-plate condenser with only an 11-plate range, thus the kilocycles are spread out on the low waves and close together on the high, with fairly equal divisions over the whole range of the condenser, which remains the same total capacity of the oldstyle 11-plate condenser. It should be noted that great care must be taken in the preparation of the plates. *Do not bend them.* Also be sure, when replacing the plates, that the same number of washers are in the same positions.

Contributed by Chas. H. Stagg.

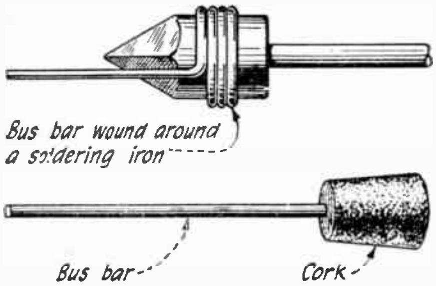


Construction details of a simple form of loud speaker built up of straight grained spruce board.

World Radio History

USES FOR BUS BAR WIRE

Have you ever, while wiring a set, found that your soldering iron was 1/16 of an inch too large to get into some corner? Instead of tearing the set apart next time, just allow the soldering iron to cool off and wrap a piece of bus bar around it. It will



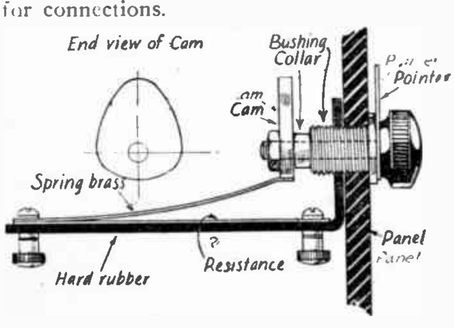
An easy way to solder out-of-the-way joints using bus-wire.

do the trick very nicely. If there are a number of such places in your set, procure a large cork and insert about three inches of bus bar in it. This will serve as a soldering iron, the only disadvantage being that it will not stay hot very long.

Contributed by A. A. Blumenfeld.

VARIABLE GRID LEAK.

Following is a description of a very efficient variable grid leak which is smooth in operation and has the added advantage of being easily mounted on the panel. It is desirable to have a grid leak which can easily be varied, as a slightly different setting will be required for DX and local stations. The grid leak resistance is made by soaking a strip of cloth in India ink and letting it dry. This resistance is then mounted on a piece of insulating material, bent at right angles as shown in the illustration. This is best constructed of a piece of hard rubber about 4½ inches long and 1 inch wide. This piece of hard rubber is easily bent at right angles 1½ inch from one end by immersing it for a couple of minutes in boiling water, to soften it. A bushing, such as that used in an ordinary jack, is obtained. This bushing serves as a bearing and also holds the insulating bracket to the panel. A hole is bored through the short end of the bracket and threaded to take the bushing. If it is not possible to thread the bracket, it may be held in place by means of a nut. The resistance is varied by means of a piece of spring brass which is bent to the shape shown. When the knob is turned a cam made of hard rubber or bakelite and fashioned as shown, gradually depresses the spring, thereby shorting more or less of the resistance. Two binding posts are fastened to the base of the instrument for connections.



Constructional details of an excellent variable grid leak employing a cam adjustment.

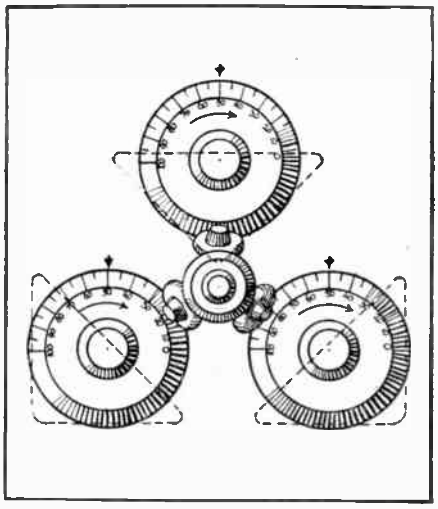
Contributed by Robert H. Watkin.

UNI-CONTROL FOR TUNED RADIO FREQUENCY SETS.

The problem of operating three dials at once on the Neutrodyne and various other tuned radio frequency sets can be easily overcome by arranging the three tuning condensers in a triangular position on the panel, as shown in Fig. 1, and by placing three brackets with soft rubber vernier rollers attached and a central operating knob exactly in the center.

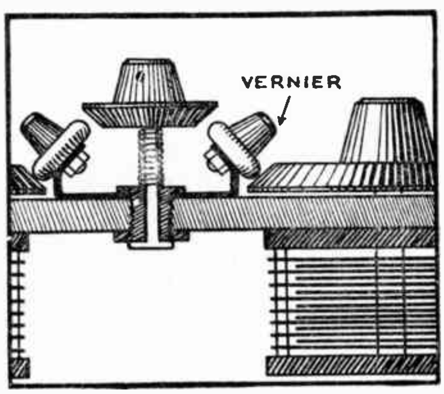
By grasping the center knob and pushing in, it will operate all three condensers simultaneously and in the same direction. For final adjustment the center knob is released and each condenser is tuned separately with the vernier knobs.

Below is shown a cross section view of the Uni-Control. The central operating



An ingenious idea for the control of a tuned radio frequency or Neutrodyne set. The three condenser knobs and dials are clustered in the manner shown and worked upon by separate verniers. By turning the center knob all three condensers are manipulated.

knob is mounted on a shaft having a collar soldered to the end, and should be free to slide in and out of the panel bushing. The spring tends to keep the knob



By pressing down on the central knob it is brought in contact with the three verniers. Turning the central knob rotates the vernier and consequently moves the condenser dials.

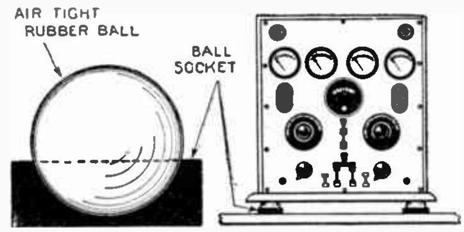
free from the verniers for separate adjustment of the condensers.

The air-core transformers do not have to be mounted on the condensers, but can be placed in a straight line at the customary six-inch spacing and at the customary angle of approximately sixty degrees.

Contributed by Robert Van Buskirk.

ELIMINATING VIBRATION FROM THE TRANSMITTER.

While installing a local transmitter, considerable annoyance was experienced from the vibrating of the transmitting panel when the motor-generator unit was set in operation. After numerous experiments with several types of cushioning, including felt, hair, soft rubber, rubber sponges, and so forth, the novel system sketched here was tried and proved to be all that could be desired. It did completely eliminate all traces of vibration from the transmitter and was less expensive than any other style used. Small motor-generator units can be cushioned in the same way, employing more balls of course, because of the added weight.



The lowly rubber ball can be used efficiently for removing vibration from a set as shown above

The turned wood sockets for the balls are much cheaper than the cast-lead or glass caster-holder type, but, for best results, one of the latter types is advised, inasmuch as they hold their form better and have no tendency to split (which is not the case with the wood sockets unless a very hard wood is used in construction). However, for the average amateur, either type will be found very serviceable. The rubber balls may be secured in any novelty store at from five to ten cents a piece, but inspect each closely for any signs of puncture or rotting cracks.

When this system is assembled and in place it will be found to be all that could be desired to eliminate vibration.

Contributed by Louis A. Cummings.

IMPORTANT IMPROVEMENT IN BALANCED INTERFLEX

(Continued from page 27)

Since publishing the Balanced Interflex circuit, the designer has found that the set can be much improved by the addition of a carbon pile rheostat, such as the Bradleystat or Filkostat, in the filament circuit of the tube to which the carborundum detector is connected.

The reason, as was found out, is that there is too great a variation in the various characteristics of the crystal detectors, as well as in the tubes, and in order to get the maximum results from the tube, it is necessary to adjust the filament voltage, which very often becomes critical.

The automatic resistance while satisfactory in most cases, cannot do two things at once on this particular tube, and for this reason the carbon type rheostat has been found better on this tube. On the other tubes, the automatic resistances are satisfactory.

Some crystal detectors are so critical that the adjustment of the rheostat becomes very important, and for that reason a wire-wound type rheostat is not sufficiently fine, hence the reason for the recommendation of the carbon type is plain.

If, after installing the rheostat, the loud speaker emits a mushy sound, it shows that the crystal detector is overloaded. By unscrewing the rheostat knob, it will be found that this mushy sound soon disappears.

If too much resistance is used—if the tube does not light up enough—the volume tends to decrease.

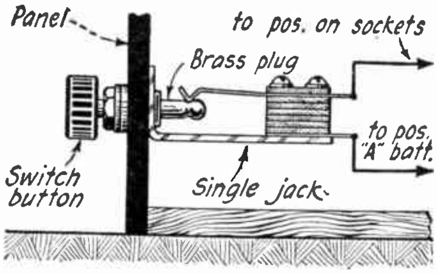
The rheostat should be mounted behind the panel, as once the crystal detector is adjusted to its tube it need never be touched again.

The same procedure was found necessary in the REGENERATIVE INTERFLEX described in this book.

World Radio History

AN IMPROVISED "A" BATTERY SWITCH

Having immediate need for an "A" battery switch, and not wanting to wait until I could get a switch from the wholesale house, I utilized a single circuit jack for this purpose. The accompanying drawing shows the method of use very clearly and



A simple "A" battery switch made from a single circuit jack, a switch knob and a brass plug.

little explanation is needed.

I used the rheostats in the negative lead in this case and carried the positive lead from the binding post of the "A" battery direct to the bottom lug of the jack, and the lead from the spring to the positive terminals of the sockets.

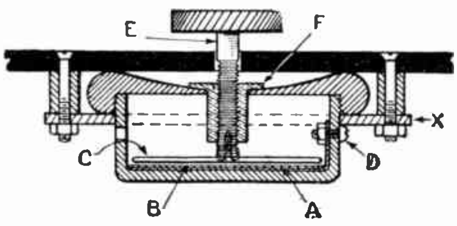
I had a short brass rod of the proper size to fit the hole for a standard plug, and I threaded this to fit a round button taken from an old snap switch. While not as good as the manufactured switches on the market, it answered the purpose and the black switch button did not detract from the appearance of the set.

Contributed by G. E. Brumbaugh.

AN EAR-PHONE CONDENSER

Procure an old receiver of the moulded type—the metal shell type will not do in this case—and remove the magnets, etc., from the interior. Insert a piece of copper A into the shell, so that it fits firmly in the back, as shown in the diagram, leaving a lug on this plate long enough for the screw D to pass through. This screw will form one terminal of the condenser.

Next obtain a piece of sheet mica B, the thickness of which will depend on the capacity which is desired in the condenser. The thinner the mica, the greater will be



A variable condenser which is made in the moulded form of an old receiver should be handy for the experimenter.

the capacity of the condenser; about .002 of an inch serves well. Cut the mica so that it entirely covers the copper sheet A, to which it should be fastened by means of a little shellac.

The movable plate C may be a piece of aluminum which is drilled and tapped to take a 1/8-inch machine screw with countersunk head, which screws into a tapped hole in the end of the adjusting screw E. Be sure that the head of the screw is countersunk a shade below the surface of the plate C, as it will otherwise bear on the mica and keep the plates further apart than is intended, thus causing the maximum capacity of the condenser to be considerably less than is desired.

By means of the machine screw, screw plate C tight against the end of screw E, which should be turned off square. Then run some solder around the joint on the upper end, so that it will not work loose.

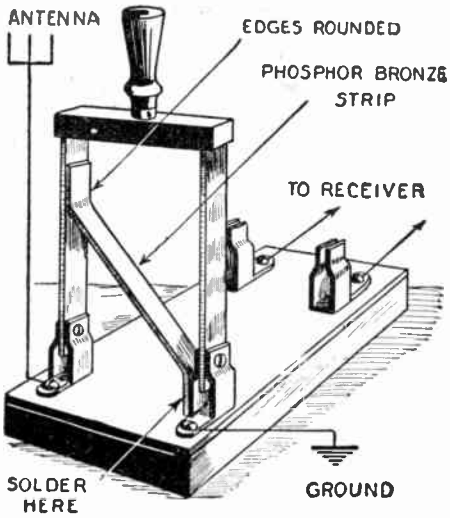
The center hole in the ear-piece of the receiver should then be enlarged, if necessary, and tapped out to take the brass bushing F, which is screwed on the outside and tapped inside to suit the thread on the adjusting screw. To obtain fine adjustments, this thread should be as fine as possible.

All the pieces should then be assembled as shown in the diagram, particular care being taken here to make sure that plate C is absolutely parallel to plate A. This is important.

The diagram shows a type of panel mounting in which X is a piece of insulating material, such as hard rubber or bakelite, with a hole cut in it, into which the phone should be a "push in" fit. This subpanel is attached to the main panel by means of four machine screws and spacing washers, as shown, one at each corner of the subpanel.

A condenser such as this, if carefully made, will be very useful about the laboratory or work bench and will well repay the trouble of constructing it. This instrument may be used in any number of experiments, and its maximum capacity may always be readily calculated for different thicknesses of dielectric that may be used.

Contributed by T. A. Vincent.



By adding a strip of copper or bronze to a D.P.S.T. switch, an efficient lightning switch can be made.

GROUNDING A LIGHTNING SWITCH

Many radio fans use an ordinary double-pole, single-throw knife-switch for connecting the antenna and ground to their receiving set. Then another switch is employd between the antenna and ground for lightning protection. Now why not let the double-pole switch serve also as a lightning switch? This would be an advantage as the lightning switch is sometimes forgotten —and the cost of a lightning switch is saved, as well.

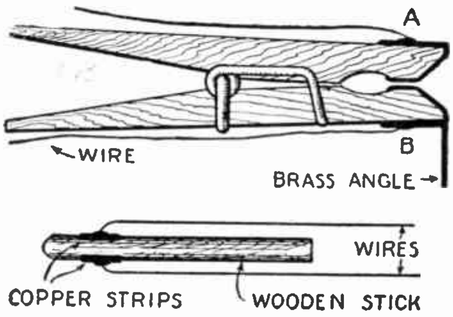
A small strip of phospher bronze or copper about ½ or ¼ inch wide and about 1/32 inch thick is bent to the shape shown in the illustration and soldered to the ground-point of the switch, so that the strip will just touch the antenna blade when the switch is in the open position. It is easily seen that this will interfere in no manner with the proper functioning of the switch. It is well to round off the edges of the strip so that the blade will make an easy sliding contact with it.

When the switch is left in the open position, which it ordinarily is, the antenna will the grounded circuit is automatically opened.

Contributed by Oliver Kirchner.

A CLOSED CIRCUIT JACK AND PLUG

Nearly every object around the house



If a jack and plug are needed for an experimental set these are easy to make.

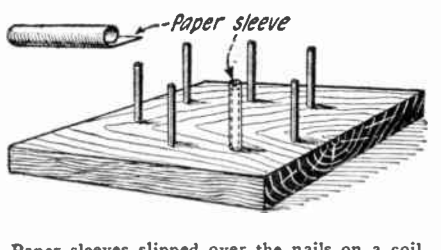
has more or less use in a radio set and here is a use for the clothes-pin. Procure a clothes-pin of the type that is illustrated in the sketch and bend around the ends A and B strips of thin copper for contacts. As the jaws of the pin are normally in a closed position, these contacts will normally be closed. Lead wires are soldered at the points A and B. The plug is made from a wooden rod that fits snugly between the jaws of the clothes-pin. On this rod are fastened two contacts to which are soldered the phone leads. This jack and plug are easy to construct and should prove of value to the experimenter.

Contributed by Ellis Elder.

PAPER SLEEVES FOR BASKET-WEAVE COILS

Doubtless many experimenters who roll their own basketweave coils have had the misfortune to scrape the insulation from the wire when removing the coil from the pegs, even though great care was exercised in the act.

This difficulty may be overcome by making paper sleeves to slip over the pegs.



Paper sleeves slipped over the nails on a coil winding form make it easy to get the coil off when completed.

When the completed coil is removed from the pegs, the paper sleeves slip off, too. As they are soft, they may be withdrawn from the coil easily, leaving the insulation intact.

The paper sleeves may be made of light wrapping paper about one inch wide and the same length as the peg. The paper is rolled smoothly around the peg and fastened along the edge with glue or shellac. The sleeves must slip off the pegs easily, so that when the coil is completed, there will be no tendency for wire to bind on the pegs.

Contributed by C. E. Multog.

World Radio History

AN INTERESTING CODE PRACTICE METHOD.

A coil of small wire is wound up the drop of an electric light to about 20 or 30 turns and a pair of phones and key are connected in series with it and the ground, as shown in Fig. 1. All then that remains is to work the key to get a clear musical note very like some C.W. whistles. More than

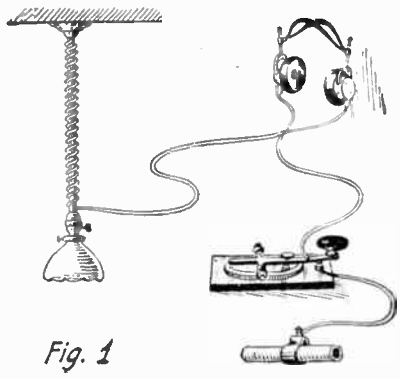


Fig. 1

Employing the A. C. hum of the lighting system for practicing the code.

one pair of phones may be used, if desired.

For use at the radio club, a two-step amplifier with a loud speaker connected as in Fig. 2 will give sufficient volume to fill any room when the key is worked.

For a novelty practice method that gives an action almost exactly like the sound of an arc transmitter with its back-wave, it is necessary to place a resistance as shown by the dotted lines in Fig. 2. The resistance R can sometimes be a pair of head phones or two pairs in series, depending on the input impedance of your amplifier. Again R can be a ½ or ¼ megohm gridleak or a

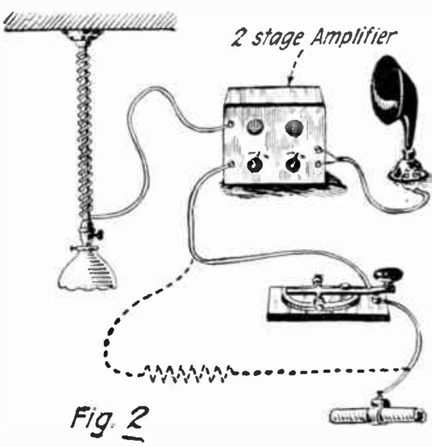


Fig. 2

By inserting a two-stage A. F. amplifier and a loud speaker, sufficient volume is had for filling a room.

couple of either in parallel as is found necessary.

Contributed by L. W. Hatry.

A LOW LOSS SPACE-WOUND COIL.

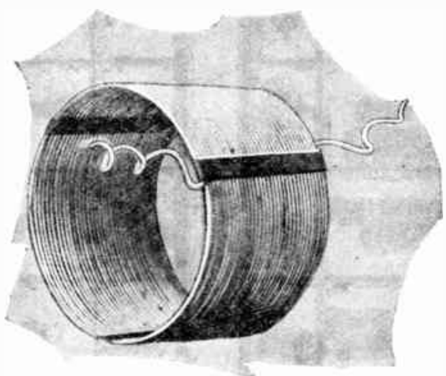
The following is a description of a coil having very low electrical losses and sufficient mechanical strength to enable it to be used under the most rigid conditions. This coil eliminates two undesirable features found in other popular low loss coils, *viz.*, the danger of short-circuiting turns as in the "basket-weave" type and the high distributed capacity as found in the "pickle-bottle" type.

Any size wire between No. 12 and 20 will be satisfactory for winding the coil. However, it is recommended that No. 16 or 18 be used if possible. Obtain a bottle whose diameter is equal to that of the coil to be constructed. From a piece of gum paper tape cut out three strips 5/16 inch wide and approximately three times as long as the finished coil is to be. Several rubber bands will come in handy here to hold the tape strips on the bottle while the wire is being wound on. The turns should be spaced by a string which is wound on along with the wire. Ordinary wrapping twine will be satisfactory for the smaller wire, but something bigger should be used for the larger sizes. When the correct number of turns has been wound on, fasten the end of the wire by another rubber band and remove the string. Apply a thick coat of collodion on the wire over the tape strip. Allow this to dry and put on a second thin coat. Moisten the tape not covered by the wire and collodion and press down while it is still sticky. When this dries, break the bottle and remove the completed coil.

Contributed by E. F. Powell.

FASTENING STRANDED WIRE

There are quite a few listeners-in who use stranded wire for their aerials, or possibly for the guy wires. Those who have



An efficient form af inductance. The coil is space wound and is self-supporting.

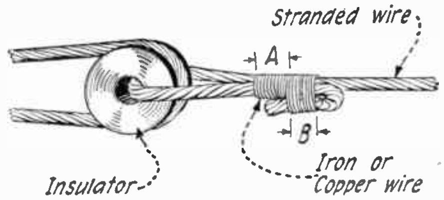
tried to fasten this kind of wire to insulators or other supports have found that it is a difficult thing to secure a satisfactory and neat job.

If the following scheme is followed out, a workmanlike fastening can be made that will not only look better, but will be stronger than usually found.

Bend the standard wire through, or around the insulator, and pull about four inches through. Secure some copper wire, or galvanized iron wire, and begin winding, as shown at "A" very tightly and securely for about one-half to three-quarters of an inch. Then, bend the remaining end over, and continue the winding as shown at "B"; cut the extra binding wire off.

If desired, this joint may be soldered. A fastening will be obtained that will easily stand pull equal to the breaking point value of the stranded wire itself.

Contributed by Floyd French.



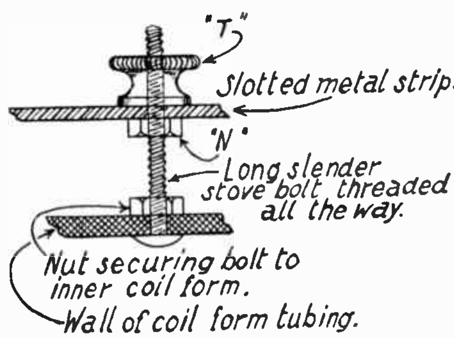
An excellent splice.

SEMI-FIXED THREE-CIRCUIT TUNER

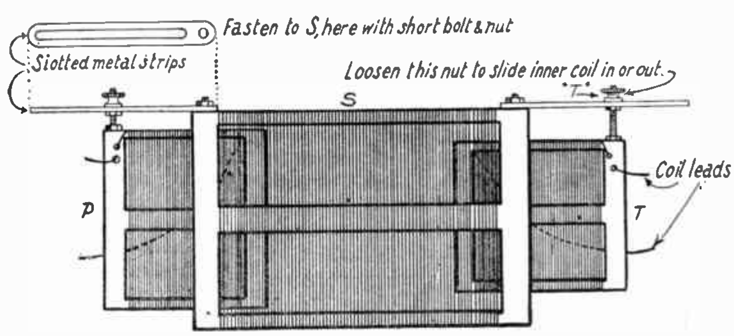
One serious objection to the ordinary tickler coil method of regeneration control is the mechanical, not electrical, difficulties and inconveniences encountered. Many of these difficulties may be overcome and the control of the regeneration actually made smoother, by using a fixed tickler coil with a series variable condenser.

The accompanying sketch clearly shows a simple system of this type of regeneration control. S, the secondary, is wound in a manner and style to suit the fan's own requirements. P, the primary, should have from 10 to 15 turns and be of such a diameter that it fits fairly snugly inside the secondary. T, the tickler, should have a smaller diameter than P, for two reasons: to keep its field from spreading too much and also to reduce to a minimum its effect on the tuning of the secondary. The number of turns of T should be between 25 and 30. The metal strips, should be of material stiff enough to support the coil without appreciably sagging when the movable coil is near the outer end. The nuts should be adjusted to such a position that the inner coil centers properly with the secondary. This adjustment having been determined, solder the nut to the bolt, or use a lock-nut to keep it in position. To adjust the coupling simply loosen the thumb nut, T, and slide the coil in or out to the proper position and then tighten the nut.

Contributed by F. C. Ruehl.



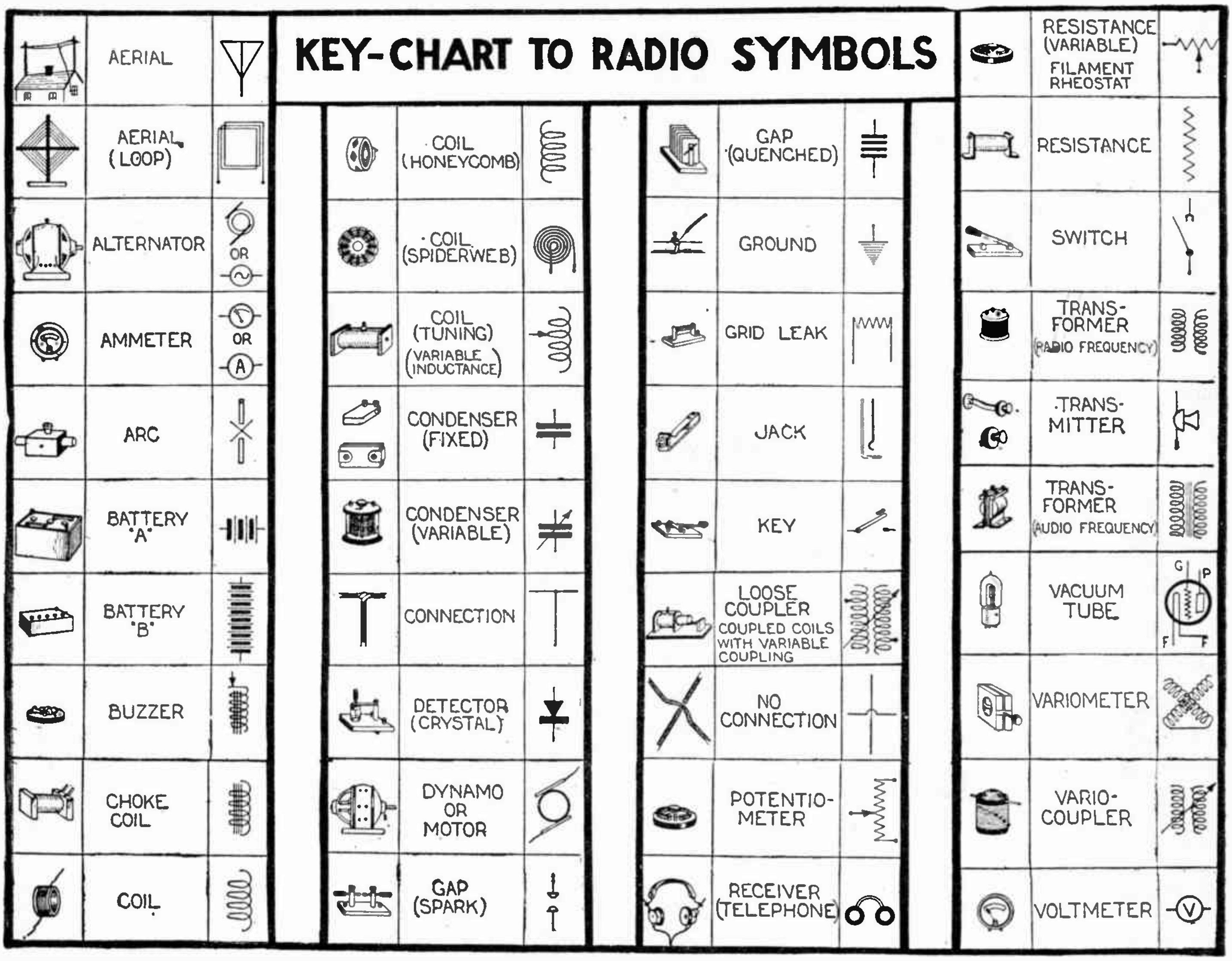
Constructional details of the method of attaching the adjustable coils to the frame are shown above.



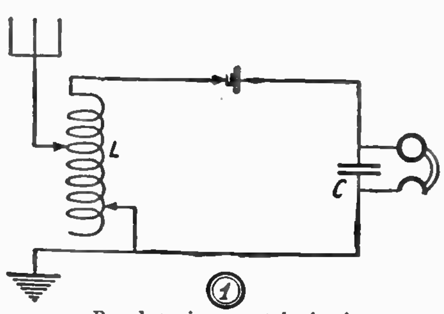
By suspending the primary and tickler coils in this way very fine adjustments can be made which will be semi-permanent

118 Standard Hook-Ups Illustrated and Described

ONE of the greatest fascinations of radio reception is the experimenting with various new and unusual circuits. Many an interesting evening can be spent with a few odds and ends of radio apparatus if the experimenter tries out different circuits or those in which he has incorporated some new kink of his own. Of course, it must be remembered that circuits are quite well standardized today and it is well to have a basic foundation before experimental work is started. Therefore we present herewith a series of 118 standard hook-ups with which you can experiment to your heart's content. Every one of them has been tested out and has been found to give the results described. In order to be able to read the diagrams, you must know what the various symbols mean. Directly below will be found a list of the various instruments with pictures of them and also with the symbolic representation used in the diagrams. Study this list and become familiar with the symbols.

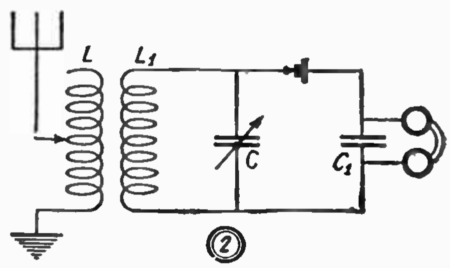


Circuit No. 1 shows a crystal detector circuit using a two slide tuning coil as the tuning element. The antenna is connected to one of the sliders and the ground to the other so that the inductance between them may be varied. This arrangement permits the antenna circuit to be tuned and also the coupling between the primary and secondary circuits to be changed to increase the selectivity. The secondary circuit is composed of the section of the coil comprised between the top of the coil and the slider connected to the ground. The condenser C is a by-pass condenser of about .001 M.F. capacity. With the sliders as shown, the coupling tight.



Broad tuning crystal circuit.

Circuit No. 2 is that of a crystal receiving set using a vario-coupler or loose coupler for tuning. The two circuits are separate and the secondary coil may turn or slide inside of the primary, which may be varied either by means of a sliding contact or switch and switch points connected to taps on coil L. The secondary L 1 is fixed and has the proper number of turns to receive over the desired wave bands when tuned by means of the variable condenser C. C1 is the by-pass condenser of .001 MF. capacity. To tune this circuit, couple coils tightly, set condenser C at zero and vary the primary for signal. Then vary C until signal is loudest.



Sharp tuning crystal circuit.

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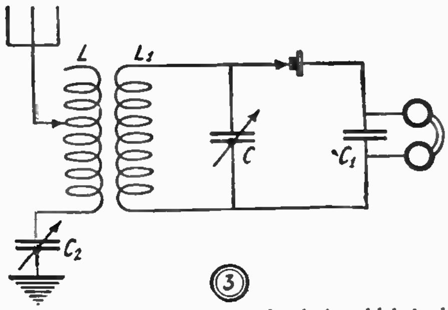
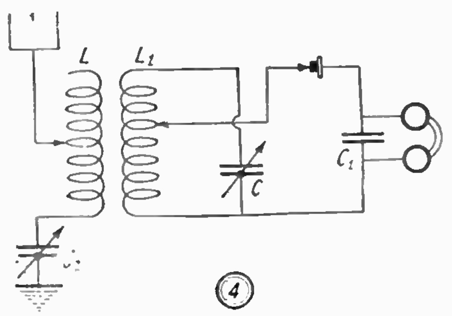
Circuit No. 3 is similar to the circuit No. 2 except for the addition of the variable condenser in the antenna circuit. This condenser permits finer tuning and also allows wave-lengths shorter than the natural wave-length of the antenna to be received. The variable condenser C 2 shown between the primary coil and the ground permits extremely sharp tuning and has the effect of shortening the natural wave-length of the antenna exactly as if some wire were cut out of the antenna itself. With such a receiver there are four tuning controls, the



A standard crystal detector circuit in which both the antenna and the secondary circuits are tuned.

primary tuning switch, the primary condenser, the coupling between coils L and L 1, and the secondary condenser C. The tuning of such a receiver is the same as that of the circuit No. 2 and the antenna variable condenser should be set at maximum while tuning. When the desired signal is tuned in the primary condenser is readjusted to obtain selectivity and finer tuning. Needless to say the crystal detector should be adjusted before tuning. This may be done with a buzzer or by listening on some local station which is easily tuned in.

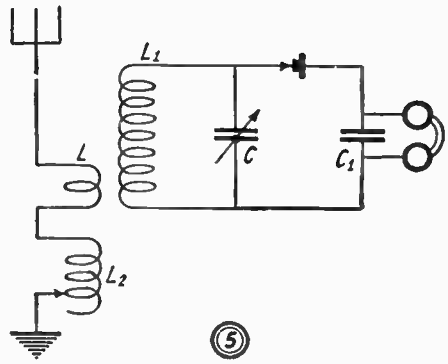
Circuit No. 4 is the same as No. 3 with another additional improvement consisting in the tuning of the detector circuit by means of a switch or slider on the secondary coil. This arrangement provides an extra circuit for the detector and telephones which increases the signal strength and selectivity. Since this control is not critical the tuning is the same as that of the circuit No. 3, the inductance of coil L 1 being adjusted after the desired signal is tuned in.



Another variation of circuit No. 3. Both signal strength and selectivity are increased.

The two coils L and L 1 may be wound on tubing or spider web fashion, with taps every 10 or 15 turns to vary the amount of inductance in the circuit. The number of turns on each coil varies, of course, with the wave-length to be tuned in. If only the broadcast range is to be received, about 50 or 60 turns of No. 20 D. C. C. wire should prove suitable. The coupling between the two coils should be variable so as to increase the selectivity of the receiving system whenever necessary. The two coils may be mounted on a rod so as to slide along the same axis, or they may be mounted on a hinge to vary the angle between them.

Circuit No. 5 is a simplification of the other circuits in that the number of controls is reduced without sacrificing much of the selectivity. In this arrangement coil L1 composing, with the condenser, the secondary circuit, is tightly coupled directly over coil L 1. In order to tune the primary circuit a separate coil L 2 mounted at right angles or at a distance from L1 and variable, is used to tune the primary or antenna circuit. In this arrangement there are only two controls, that is, the switch or slider on coil L 2 and the variable con-



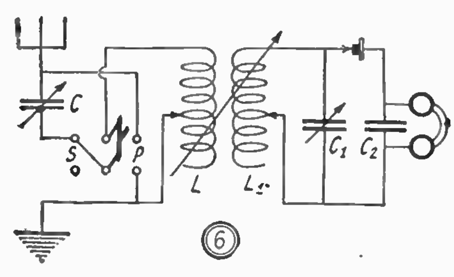
Another selective crystal detector circuit in which the secondary is very loosely coupled to the primary.

denser C.

This circuit, on account of its simplicity, is recommended to the beginners who do not know how to tune the more complicated receivers. It may be constructed as follows: Coil L 1 should consist of 60 turns of No. 20 D. C. C. wire wound in a single layer on bakelite or hard rubber. Directly over this winding should be wound 6 turns of the same wire composing coil L. Coil L 2 is similar to L 1 but with a tap every 5 turns. Use 3" diameter tubing.

Circuit No. 6. When it is desired to receive long and short wave-lengths, the use of a series parallel switch is useful to control the primary condenser in series or in parallel with the primary coil. In such an arrangement the two coils L and L1 should be variable in steps or should be honeycomb or duo-lateral coils of various sizes which may be plugged in a special mounting. With such inductances any desired wave-length may be tuned in.

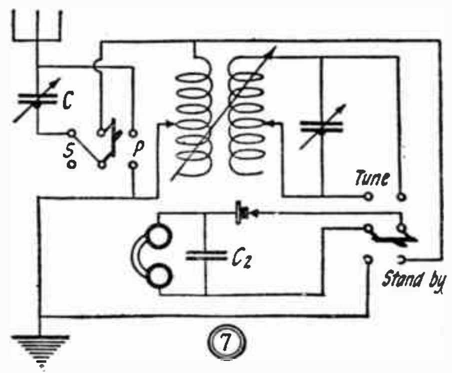
If one contemplates the improvement of the receiver at a later date, it would be best



A crystal detector circuit in which a switch is used for changing from a long wave to a short wave tuner.

to buy a 3-coil mounting, the third mounting being used for the plate coils of the vacuum tube detector when one is used. The two variable condensers C and C 1 should be of the 43 plate type having a capacity of .001 mfd., preferably equipped with a vernier. The telephone condenser C 2 is an ordinary .001 mfd. fixed condenser. In this circuit the antenna variable condenser C is used in series to receive the short wave-lengths; in parallel with the primary coil to tune in the long ones. The series parallel switch in this circuit enables the set to tune over a much wider range of wave-lengths than would otherwise be possible. In this circuit, as in the ones above, it is best to tune the primary circuit first and then adjust the secondary for loudest signals.

Circuit No. 7 is similar to No. 6 but with an extra double pole double throw switch connecting the detector and telephones either across the primary or the secondary. This system simplifies the tuning considerably, especially when the wave-length of a station to be received is not exactly known. When in the stand-by position the switch connecting the detector and telephones across the primary transforms the

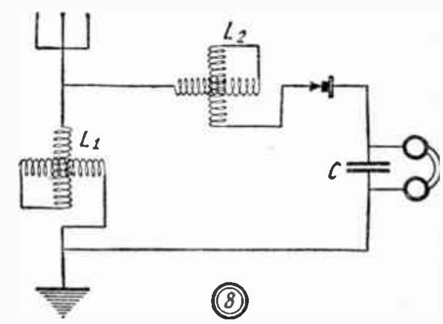


Another and more flexible long and short wave crystal receiving set.

receiver into a single circuit set and permits the operator to easily tune in a station by merely varying the variable condenser C which may be placed in series or parallel with the primary coil to receive short or long wave-lengths, since the single circuit arrangement is not very selective. Then the operator throws the secondary switch to the tune position and adjusts the secondary circuit and coupling for greater selectivity. This method is used in the majority of commercial receivers.

For the reception of short wave-lengths the two coils may be composed of a standard variocoupler or loose coupler having about 60 turns 3 inches in diameter on each coil, or the equivalent.

For experimental purposes, or when great selectivity is not necessary, *Circuit No.* 8 may be employed. In this circuit two variometers are used for tuning instead of variable condensers or tapped coils. The first one, L 1, tunes the antenna circuit, and the other L 2, the secondary circuit. This circuit is merely shown as a possible applica-



Two variometers comprise the tuning arrangement for this simple receiver.

tion of two variometers for tuning, but is not recommended unless the receiver is located at a certain distance from any transmitting station, since this set is not very selective.

The best circuits recommended to be used with a crystal detector are the Nos. 3, 4, 6 and 7, which, although slightly more complicated, are much more efficient than the others.

The importance of using standard apparatus cannot be over-estimated. Especially is this the case with the beginner. Results are dependable only when such instruments are used.

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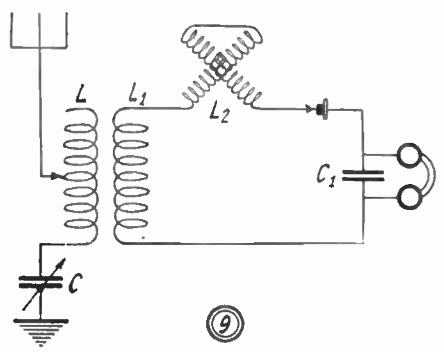
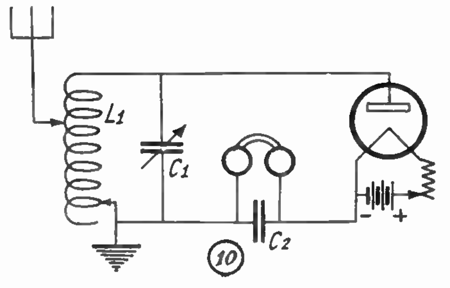
Circuit No. 9 is similar to No. 8 which appeared on page 85, but employs a variocoupler for tuning instead of a variometer. A variometer is used in the secondary circuit and such an arrangement will prove much more selective than No. 8. If interference is experienced, the secondary can be rotated so that it is at an angle to the primary and the set retuned. In this way it will not be difficult to tune out most interfering stations. The variable condenser shown at C may have a capacity of .0005 or .001 mfd. The variometer L2 is a standard instrument and should be of good construction for best results. It will be found that most of the tuning will be done with the variometer, and the primary after once being adjusted, will be varied very little except for large changes in wave-length.



Double circuit receiver with variometer tuned secondary.

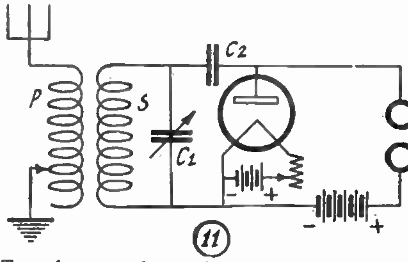
Circuit No. 10 shows a single circuit receiver using a two electrode tube instead of a crystal. Although it is only a little more sensitive than a crystal receiver, it does not have to be adjusted and is always ready for operation. The inductance L1 may consist of the primary of a standard variocoupler or it may be made by winding 60 turns of No. 22 S.C.C. wire on a 3½-inch tube. The winding should be tapped about every six turns and two switch points are connected to each tap. This will give an inductance that can be varied over the same winding by two switches. A two-slide tuning coil



Single circuit receiver with two element tube

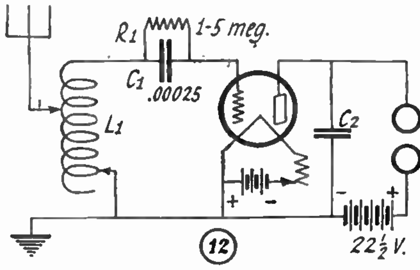
may also be employed as the tuner, instead of the tapped inductance. The variable condenser C1 has a capacity of .0005 mfd. A condenser of this size usually consists of 23 plates. The by-pass condenser C2 is fixed and has a capacity of .001 mfd.

Circuit No. 11 also uses a two-element tube, but in this case a variocoupler is employed for the tuner. The primary of this variocoupler will consist of the same number of tunrs as the turner in *Circuit No.* 10. Only one switch and one set of taps are used to vary the inductance. This primary may be tapped every six turns, which will give 10 switch points. The secondary of this coupler is made so that it will rotate inside of the primary and is wound with about 45 turns of No. 24 S.C.C. wire. The variable condenser C1 should be about .0005 mfd. and the fixed condenser, C2, is of the same capacity. A "B" battery of 22½ volts is used in this circuit and greater signal strength will be had with this arrangement than can be expected with *Circuit No.* 10. If interference is experienced, the secondary may be turned so that it is at quite an angle to the primary and the set retuned until the station again comes in strong.



Two element tube receiver using "B" battery.

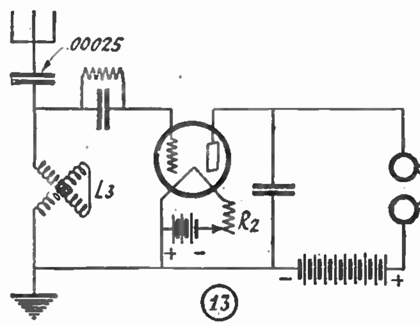
Circuit No. 12 is the simplest of all circuits using a three-element tube and, as in the case of all preceding circuits, is non-regenerative. A fixed condenser of .00025 mfd. capacity is placed in the grid circuit between the grid of the tube and the tuner and is known as a grid condenser. A grid leak (R1) is shunted across the grid condenser and will usually be from one to five megohms in resistance. The usual by-pass condenser C2, is .001 mfd. and is connected across the phones and the "B" battery. A "B" battery is always used in a circuit employing a three-element tube. The voltage of this battery will depend upon the type of tube used. If a soft tube, such as a UV-200 is employed, the "B" battery will vary



Single circuit receiver using three element tube.

between 16½ and 22½ volts. With such a tube, when the rheostat—which in this case will have a resistance of six ohms—is turned up to a certain point, a slight hiss will be heard in the phones. For best results the tube should always be operated just under this hiss.

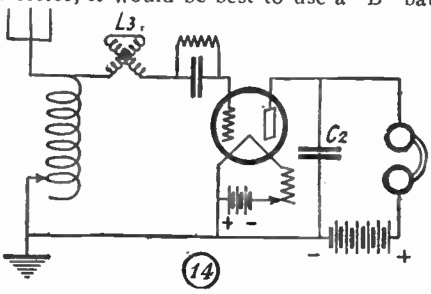
Circuit No. 13. This circuit is similar to No. 12, but employs a variometer L3, for tuning. The wave-length of the average variometer, when used in series with the antenna, is too high to respond to the lower broadcast wave-lengths and a fixed con-



Simple receiver employing a variometer as tuner.

denser of .00025 mfd. capacity should be placed in series with the antenna to reduce it. The grid condenser in this receiver is a .00025 mfd. one, which is standard for most circuits. The tuning is very simple, the variometer being varied until the station is picked up. The resistance of the rheostat R2 will depend upon the kind of tube used. The voltage of the "B" battery will also depend upon the tube, but it will usually be not higher than 45 volts. A circuit such as this, which does not use regeneration, will have a receiving range of about 100 miles.

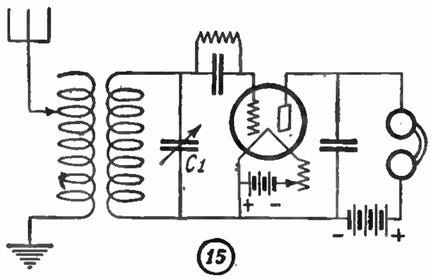
Circuit No. 14 is a circuit that will prove fairly selective. The antenna system is tuned by means of a tuning coil which may consist of 60 turns of No. 22 S.C.C. wire on a 3½-inch tube tapped every six turns. The secondary, or grid circuit is tuned by a standard variometer L3. The switch on the antenna coil is varied until the desired signal is picked up and then the fine tuning is done by means of the variometer. If a UV-200 tube is employed as the detector, it would be best to use a "B" bat-



Single circuit receiver with variometer tuned grid circuit.

tery that is tapped from 16½ to 22½ volts, so that different voltages may be tried to determine which gives best results. Care should be taken that the positive of the "B" battery is always connected to the plate through the phones. The by-pass condenser C2 is not always necessary and the receiver should be tried both with and without it, to determine which gives better results. This condenser will be of about .001 mfd. and is not critical.

Circuit No. 15. In this circuit a variocoupler is used in place of the tuning coil shown in Circuit No. 14. Also, the secondary circuit is tuned by means of a variable



Double circuit receiver with secondary condenser for tuning.

condenser of .0005 mfd. capacity, instead of the variometer. Much greater selectivity will be had in a two-circuit receiver of this kind, as it is possible to vary the coupling between the primary and the secondary coils of the variocoupler. When tuning, the primary switch lever is placed on the second or third tap and the variable condenser varied until a station is picked up. If no station is heard, the switch lever is changed to another tap and the condenser again varied. Sometimes certain taps on the primary will give better results than others for certain stations, but this can only be determined by experiment. As a rule, however, one certain tap on the primary of the variocoupler will bring in most stations in the broadcast wavelength range and it will not be necessary to change to another tap unless a great variation of wave-length is required. This circuit will give very good results, although as it is not regenerative, stations further than 100 or 200 miles distant will not be picked up except under exceptional conditions.

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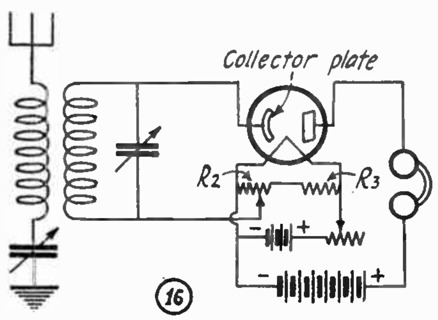
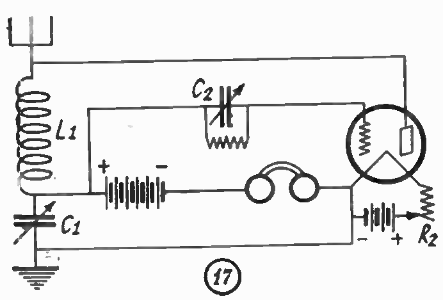
Circuit No. 16. Here is a circuit that will prove far more sensitive than any of the others thus far described. In this receiver the Sodion tube is employed as the detector. A special form of loose coupler must be used with this tube, as very loose coupling is required for best operation. This tube does not have a grid, as is the case in a three-element tube, but instead it has a curved metal plate known as the collector. The circuit for this tube is similar to a standard vacuum tube circuit, but it requires a potentiometer of about 50 ohms (R2) in series with a fixed resistance of 150 ohms (R3) connected across the filament battery and rheostat as shown. The primary of the coupler may be tapped as usual, or it may consist of a fixed inductance with a variable condenser of .001 mfd. capacity in series. The secondary of the



Receiver using the sodion Tube.

coupler is tuned by a variable condenser of .0005 mfd. capacity. This circuit is very sensitive, especially on weak signals, which makes it excellent for long distance reception. A receiver using this tube cannot oscillate, is non-regenerative, and will not interfere with other receiving sets.

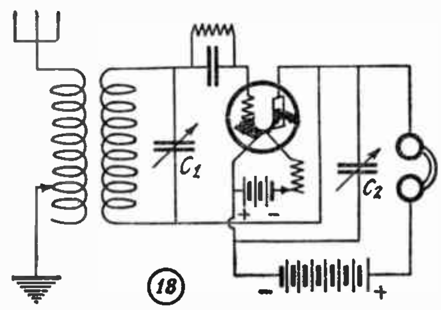
Circuit No. 17 shows the simplest form of regenerative receiver using a standard three-element tube. This receiver is of the ultra-audion type, and regeneration is obtained and controlled by means of the rheostat R2 and the variable grid condenser C2. A fixed grid condenser of .00025 mfd. capacity may be used, but if a variable one of .0005 mfd. is employed, greater control over the regeneration may be had. The tuning coil in this circuit is a fixed inductance and may take the form of honeycomb or spider-



Ultra audion circuit with a single coil.

web coil of 25 or 35 turns. This is shown as L1. The tuning is accomplished by means of a variable condenser C1, which is in series with the coil and ground and which has a capacity of .001 mfd. If desired, the inductance L1 may consist of a tapped coil such as the primary of a variocoupler. This type of coil is not absolutely necessary, but will prove of advantage where the antenna is too long or too short for a fixed inductance. A receiver of this type will prove fairly selective and should have a receiving range of at least 500 miles. As this is a regenerative receiver, it will cause great interference to other receiving sets if operated incorrectly.

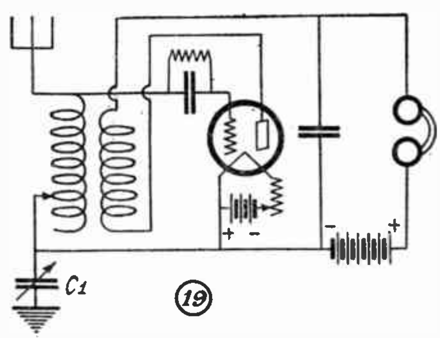
Circuit No. 18 shows another form of ultra-audion receiver using a variocoupler in place of a single coil. Tuning is accomplished by means of the switch on the primary and the variable condenser C1 in shunt with the secondary. Regeneration in this case is controlled by means of the .0005 mfd. variable condenser shown as C2. It will be seen that the phones and "B" battery in this receiver are removed from the oscillatory circuit and the lower terminal of the secondary, instead of being connected to the "A" battery, is run directly to the plate of the tube. The grid condenser may be variable if desired, and will help to control regeneration, but this is not necessary for good operation. In tuning a receiver of this kind, the primary of the coupler is varied by means of the switch and the secondary circuit is tuned by means



Ultra audion receiver with variocoupler for tuning.

of the variable condenser C1. If the variable condenser C2 has all of its plates intermeshed, the tube will go into a state of oscillation which will distort signals and create interference in nearby receiving sets. The remedy for this is to furnish less capacity by moving the rotary plates of the condenser until the signals are clear and not distorted. If the signal is not very loud, more regeneration can be obtained by increasing the capacity of the condenser.

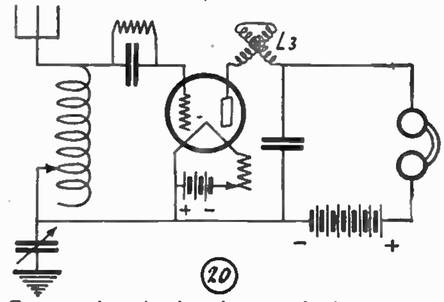
Circuit No. 19 is of the single circuit type and tuning is accomplished by means of the switch on the primary and the variable condenser C1 of .001 mfd. capacity in the ground circuit. Any wave-length may be reached to the limit of the tuner by varying the switch and tuning between the taps with the variable condenser. The second-



Single circuit regenerative receiver with tickler.

ary of the coupler is connected in the plate circuit of the tube in series with the phones and "B" battery and regeneration is obtained by varying the coupling between the two coils. When assembling this circuit, and the primary and secondary coils are parallel with each other the plate and grid leads should always be connected to opposite ends of their respective coils. When these two coils are parallel, greatest coupling is had and the tube will be in a constant state of oscillation. When a station is tuned in, the secondary should be placed at such an angle to the primary that the signal is loudest without being distorted, which will usually be just before the tube goes into oscillation. This oscillation point is indicated by a click in the phones and at this point a squeal will be heard and signals will become mushy and distorted. As stated before, *never operate a regenerative set with the tube in an oscillating condition.*

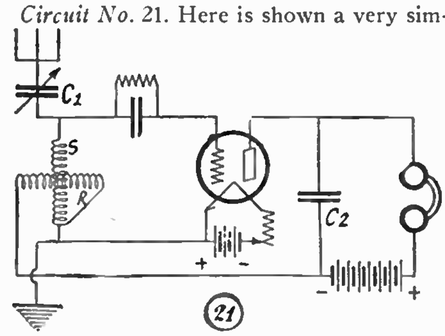
In *circuit No.* 20 we have another regenerative receiver which uses the same tuning system as Circuit 19, but in this case regeneration is obtained by means of a variometer L3, in the plate circuit instead of the tickler coil. This variometer tunes the plate circuit to the same wave-length as that of the grid circuit and when these two circuits are exactly in tune, or in resonance, the tube will go into oscillation. When a station is tuned in by means of the switch and series condenser, the variometer is vari-



Regenerative circuit using tuned plate system.

ed and as it approaches the resonance point, regeneration will take place and the signals will increase greatly in strength. It will be found easier if the grid and plate circuits are both tuned at the same time, as in this way, if any weak station is in the range of this receiver, it will then be picked up. This receiver, or, in fact, any receiver shown in these pages with the exception of diagrams 10, 11 and 16, can be used with any of the three element tubes on the market. Great care should always be taken that the right voltage is used for the filament, as otherwise the tube might easily be burned out. This receiver is also of the single-circuit type and consequently will not give very sharp tuning, although it is capable of long distance reception if no interference is experienced.

Circuit No. 21. Here is shown a very sim-



Simple single circuit regenerative receiver.

ple single circuit regenerative receiver using a single variometer for tuning and regeneration. This variometer should invariably be of small size, having no more than 40 or 45 turns on the stator, and the same number on the rotor. In this receiver the stator of the variometer acts as the tuner and is connected in the antenna circuit in series with a variable condenser C1, of .001 mfd. capacity. The ground is taken off at the intersection of the stator and rotor, as shown. The other end of the rotor is connected to the plate of the tube through the "B" battery and phones. A small variometer should be used because if one of standard size is employed in this circuit there will be too much wire on the stator to tune to the lower wave-lengths. The by-pass condenser shown at C2, may not be necessary and the receiver should be tried with and without it to determine which connection gives the better results.

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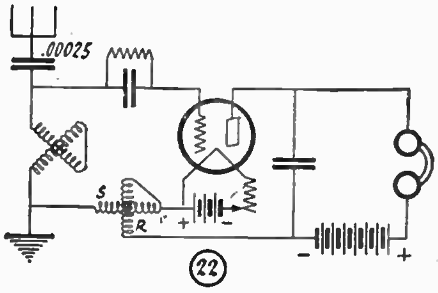
Circuit No. 22 is a regenerative receiving set using two variometers, one of which is placed in the antenna circuit for tuning and the other in the grid-filament-plate circuit for regeneration. As will be seen, the filament connection is made at the junction of the rotor and stator of the second variometer. The stator of this variometer is connected between the filament and the ground side of the tuning variometer. The rotor is connected between the filament and the plate of the tube in series with the phones and the "B" battery. This variometer should be of small size having no more than 40 or 45 turns on the stator and the same number of turns on the rotor. As this receiver

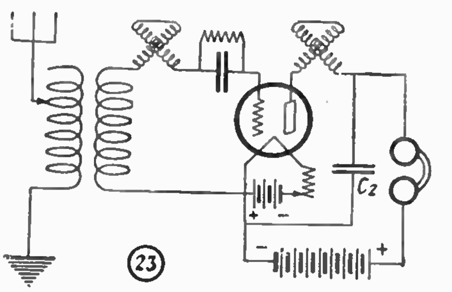


Two-variometer regenerative circuit.

will cause great interference under certain conditions, care should be taken that it is operated correctly.

Circuit No. 23 shows a receiver which will prove very selective, and for a one-tube receiver is very hard to excel. A standard variocoupler is used for tuning. A variometer is inserted in the grid, or secondary circuit which will give very close tuning. Another variometer of the same size is used in plate circuit for regeneration. A by-pass condenser C2, of .001 mfd. capacity, usually will be found necessary in this circuit. Contrary to the general opinion, the tuning of this receiver is not difficult. The primary switch is set on a switch point, usually the third or fourth, where broadcast stations will be received. Both variometers should be varied simultaneously, keeping just under the oscillation point. In this way, as the tuning of the secondary circuit is changed, the receiver is always at its most efficient point and weak stations can readily be heard.

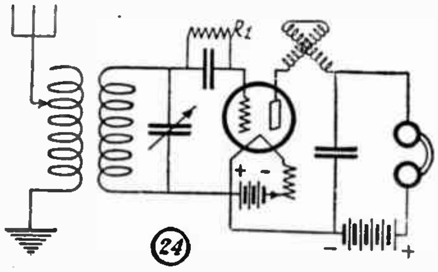
Circuit No. 24 is the same circuit as No. 23 with the exception that a variable condenser is used to tune the secondary circuit instead of a variometer. By using this variable condenser the tuning will be slightly



Standard three-circuit regenerative receiver.

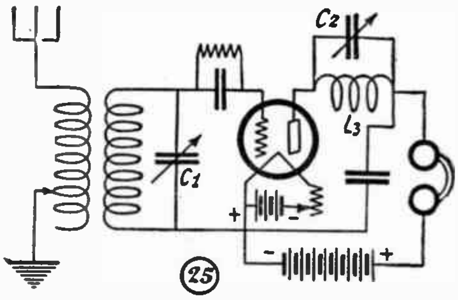
sharper and a wider band of wave-lengths will be covered. The grid leak R1 will have as resistance from one to five megohms depending upon the type of tube used. The tuning of this receiver is identical with that of diagram No. 23. If interference is experienced, the coupling between the rotor and stator coils may be loosened and the set slightly retuned. As the rotor is turned at a greater angle to the stator, sharper tuning will be had. If the angle is very great, the signal strength will be lessened, but this is sometimes advisable to eliminate heavy interference. Under good conditions a receiver of this type should have a receiving range of 800 to 1,200 miles, if conditions are very favorable.

Circuit No. 25 is also a three circuit regenerative receiver, but in this case instead of a variometer in the plate circuit for regeneration, a fixed inductance L3, shunted by a variable condenser C2, is used. This



Three-circuit receiver with condenser tuned secondary.

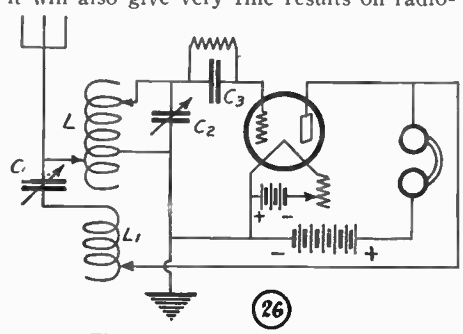
inductance should be approximately the same value as the secondary of the variocoupler. A honeycomb coil of 50 turns will give very good results in this position. The variable condenser C2, has a capacity of .0005 mfd. The condenser C1, also has a capacity of .0005 mfd. and is used to tune the secondary circuit. The tuning of this receiver follows the same method as employed in diagrams 23 and 24, both condensers being varied at the same time. The variocoupler used in this circuit should be of good manufacture and should contain



Regenerative circuit with condenser tuned plate coil.

from 45 to 50 turns on the secondary. The primary is tapped at every 8 or 10 turns and is varied by means of a switch. It is not necessary that this primary be finely tuned. Try reversing the "A" battery leads as one connection will work better with certain tubes.

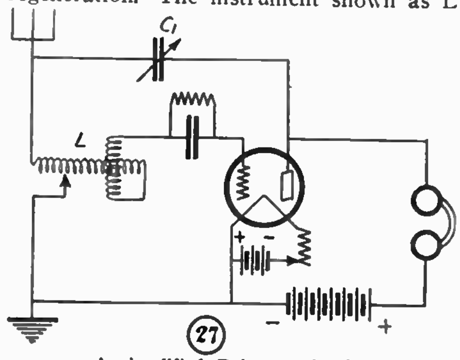
In *circuit No.* 26 we have the well known Reinartz circuit. This receiver will give very selective tuning and is quite a favorite with the amateurs. This circuit was originally designed for C.W. reception, but it will also give very fine results on radio-



The selective Reinartz circuit.

phone work. Coils L and L1 are wound in spider-web fashion on the same form. These coils have been described many times in various radio publications and they may be procured from any radio supply dealer. L1 in this circuit acts as a tickler coil, but regeneration is mostly obtained by capacity feed back through the variable condenser C1. This condenser has a capacity of .001 mfd. The variable condenser C2, with which most of the tuning is done, may have 17 or 23 plates. The grid condenser C3 has a capacity of .00025 mfd. and should be of good make. The "B" battery voltage will depend upon the type of tube used.

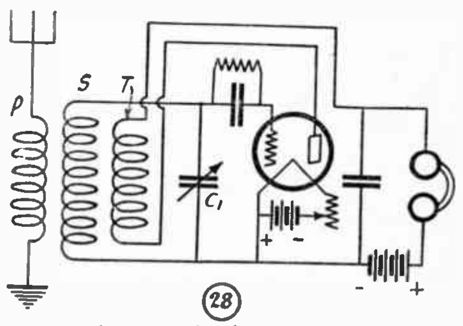
In *circuit No.* 27 is shown what is known as the modified Reinartz receiver. At first glance this circuit appears to be new, but it is nothing more than an untuned primary circuit having capacity feed-back for regeneration. The instrument shown as L



A simplified Reinartz circuit.

is a standard variocoupler of the old type, where the secondary may be revolved through 180 degrees. The secondary winding is connected to the end of the primary winding as shown. The lower end of the primary winding should be tapped every turn for 10 turns and is controlled by a switch. By using more or less turns by means of this switch, great selectivity is obtained. The variable condenser C1 has a capacity of .001 mfd. and is used to produce regeneration. When tuning this receiver the switch may be set on any point and the rotor of the variocoupler turned until a station is picked up. Greater volume is then obtained by increasing the capacity of the variable condenser C1. It is best practice to make both of these operations at the same time, as in this way the receiver can always be kept at the maximum point of regeneration and very weak signals picked up.

In *Circuit No.* 28 we have a simple regenerative receiver which combines selectivity with long distance reception. The tuner of this receiver consists of a rewound variocoupler. A coupler of the 180-degree type having a secondary winding of 35 to 40 turns is recommended. The primary winding should be removed and a new winding consisting of 42 turns of No. 20 S.C.C. wire



An untuned primary receiver.

wound on in its place. This winding will be the secondary of the instrument. The primary consists of 10 turns of No. 18 or No. 20 S.C.C. wire wound directly over the lower end of the primary and separated from it by two or three layers of cardboard or other insulating material. The variable condenser C1 has a capacity of .0005 mfd. and should preferably be of a vernier type. A non-vernier condenser may be used, but in this case a vernier dial is recommended. When connecting the tickler coil, the plate of the tube should be connected to the lower

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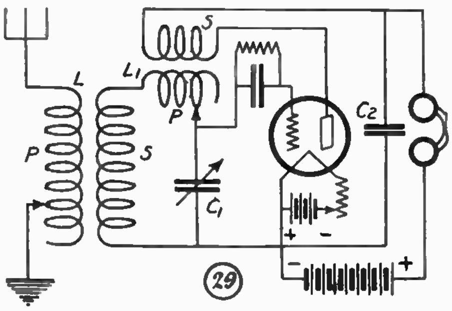
terminal if, when the tickler is horizontal in respect to the secondary, the grid is connected to the top terminal of this secondary coil. If these connections are correctly made, there will be no need to reverse the tickler connections afterward.

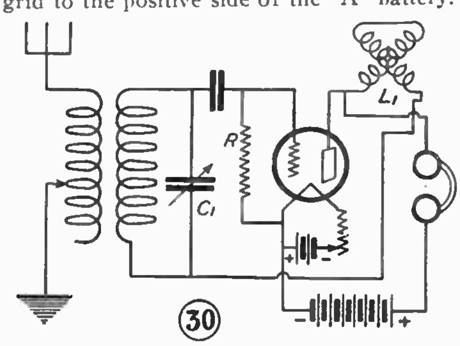
Circuit No. 29 shows a circuit with which a fairly wide band of wave-lengths may be covered with efficiency. In this circuit two vario-couplers are employed and are shown as L and L1. Regeneration is obtained by means of the secondary of the second variocoupler acting as a tickler in the plate circuit of the tube. To obtain regeneration, part of the winding of the primary of L1



Two-variocoupler receiver.

must always be used, and for this reason it is advisable that the variocoupler L have a secondary of about 30 turns. The variable condenser C1, with which the secondary tuning is accomplished, has a capacity of .0005 mfd. It will be found that for practically all broadcast stations only one or two taps on the primary of L1 will be used. Experiment will determine which taps to use on the primary of L for certain stations. As the secondary of this first variocoupler can be varied in its inductive relation to the primary, very sharp and selective tuning wil be had. If the primaries have sufficient turns, a wave-length of 3,000 meters may be reached. The by-pass condenser C2 will have a capacity of .001 mfd.

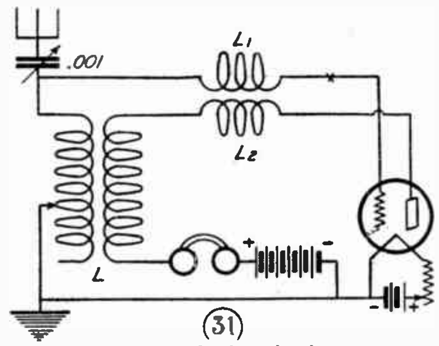
Circuit No. 30 also shows a three circuit regenerative receiver, but in this case the phones and the "B" battery are removed from the oscillatory circuit. It will be noted that the grid return of the tube does not connect to the filament but goes to the plate through the plate variometer. In this circuit the grid leak R must be connected from the grid to the positive side of the "A" battery.



Three-circuit regenerative receiver.

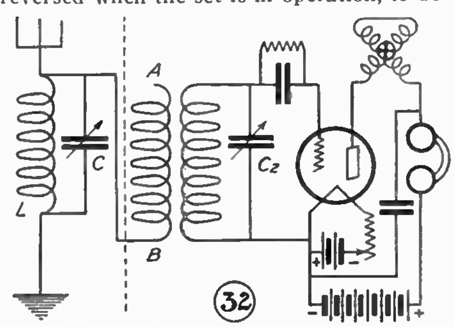
The values of the various instruments in this circuit are the same as in preceding diagrams. The tuning of this circuit is no different than the other three circuit regenerative receivers shown, the variable condenser C1 and the plate variometer L1 being varied at the same time. As the phones and "B" battery are removed from the oscillatory circuits, no by-pass condenser will be found necessary. This circuit will be found extremely sensitive, fairly easy to tune and under favorable conditions will bring in long distance stations.

Circuit No. 31 shows a simple regenerative receiver that is slightly different from the standard circuits. A standard variocoupler L is employed with a secondary winding consisting of not more than 40 turns. The primary should consist of about 80 turns tapped every 10 turns and is employed with a variable condenser of .001 mfd. in series with the antenna. The two



Super selective circuit.

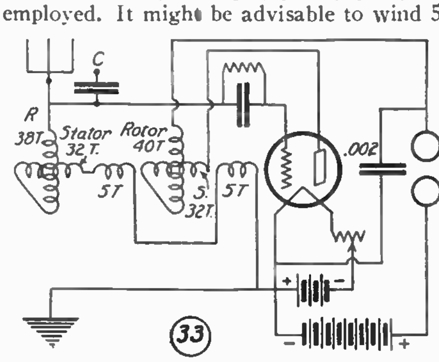
inductances, L1 and L2, are spider-web coils of about 20 turns each. These two coils are mounted stationary, in inductive relation to each other and about three inches apart. One coil goes to the grid of the tube and the other is connected to the plate in series with the secondary of the tuner, the phones and the "B" battery. The tuning is accomplished by means of the primary switch and the variable condenser. Regeneration is obtained by varying the inductive relation of the secondary to the primary. The leads on one of the spider-web coils should be reversed when the set is in operation, to de-



Method for increasing selectivity.

termine which gives best results. As a rule no grid condenser is required in this circuit, but one may be tried in the position shown at X.

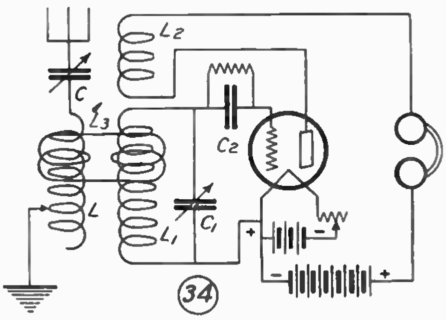
In *Circuit No.* 32 is shown a circuit that is very little known, but which will prove very effective in eliminating interference. As will be seen, any type of two or three circuit tuner may be used in conjunction with this system to good advantage. In this case it is shown with a standard three circuit regenerative receiver. The inductance L will consist of about 35 turns of wire wound on a three inch tube. The size of this coil is only approximate as it will vary in accordance with the size of the antenna employed. It might be advisable to wind 50



Compact regenerative receiver.

turns on a three-inch tube tapped every 10 turns so that the size of the coil may be varied for any size of antenna. The variable condenser C may be .0005 or .001 mfd. capacity. It will be noticed that only one connection is made from the coil L to the primary of the tuner. This connection should be tried at both A and B, as one connection will work very much better than the other. The inductance L should *not* be in inductive relation to the tuner of the receiver. When tuning this receiver it will be found necessary to vary the condenser C and the condenser C2 at the same time, as both must be in resonance.

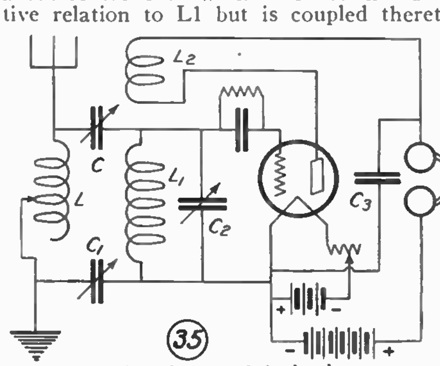
In *Circuit No.* 33 is shown a diagram which will prove very efficient being selective and sensitive and at the same time very compact. This type of receiver may readily be used as a portable set. It really con-



A sharp tuning circuit.

sists of two variometers, the stators of which are both wound upon the same form separated from each other 1¾ inches. The stator winding of the plate variometer is continued for five turns on each side of the stator winding of the plate variometer as shown. This gives a combination of tuned plate and tickler feed-back. The proper number of turns for both variometers is shown on the diagram. It will be advisable to place a fixed condenser (C) of .0005 mfd. in the antenna circuit and provide two binding posts so that the antenna may be connected directly to the variometer or through the condenser as desired.

In *Circuit No.* 34 we have a receiver which will prove very selective, especially in a district where many broadcast stations are located. The condenser C may be of .00025 mfd. capacity, but may be left out if desired, as it is not absolutely necessary. L may be a coil of 80 turns tapped at every 10 turns, L1 and L2 are the primary and secondary of a variocoupler. In this case, the primary of the coupler should consist of about 35 turns of wire. L is not in inductive relation to L1 but is coupled thereto



Capacity coupled circuit.

by means of a continuous loop of wire shown at L3. This loop should be wound three turns around each coil, as shown in the diagram. Most tuning will be done with the condenser C1, which in this case may be of .0005 mfd. The grid condenser C2 is of standard size (.00025 mfd.).

Circuit No. 35. In this diagram we have a circuit using capacity coupling. This coupling is accomplished by means of condensers C and C1, which are of .0005 mfd. capacity. The main tuning inductance L is, as usual, of about 80 turns, which may be tapped at every 10 or 12 turns. Coils L1

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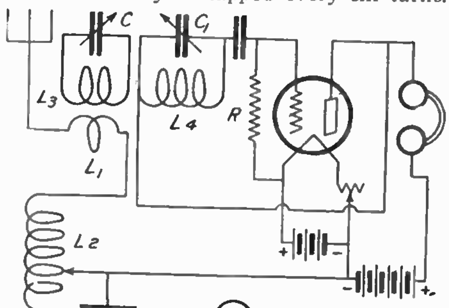
and L2 may be the primary and secondary of a standard variocoupler. It will not be necessary to use taps on the primary of this coupler, as a fixed number of turns (approximately 35) will be sufficient when tuned by the .0005 mfd. variable condenser C2. The coil L2 is inserted in the plate circuit of the detector for regeneration. The by-pass condenser C3 is of .001 mfd.

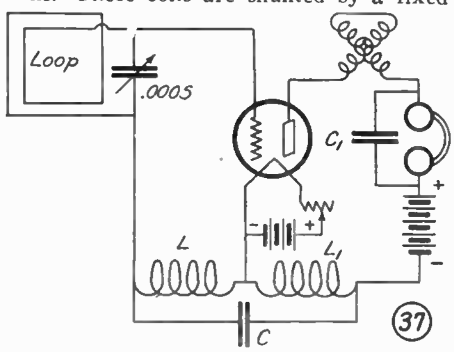
Circuit No. 36 shows the well-known Cockaday circuit, which has proven very popular. The antenna system is comprised of coils L1 and L2. L1 is a single turn of bus-bar wire around coil L3. L2 consists of 43 turns of No. 18 S.C.C. wire on a 3-inch tube. This coil is double bank wound and may be tapped every six turns.



36
Cockaday four-circuit receiver.

It is in non-inductive relation to the other coils. L3 consists of 34 turns of No. 18 S.C.C. wire and is also wound on a 3-inch tube. L4 consists of 65 turns of the same size wire and is wound on the same tube, with L3, separated from it by about ⅛ inch. Variable condensers C and C1 have a capacity of approximately .0003 mfd. and are of the 17-plate variety.

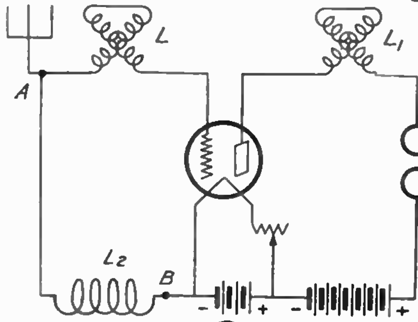
Circuit No. 37 shows a super-regenerative receiver which, if correctly constructed and operated, will give remarkable results on all stations received. A loop is used for this type of receiver and is tuned by a variable condenser of .0005 mfd. capacity. Coil L is a honeycomb or duo-lateral coil of 1,500 turns and coil L1 is one of 1,250 turns. These coils are shunted by a fixed



37
Simple Super-regenerative circuit.

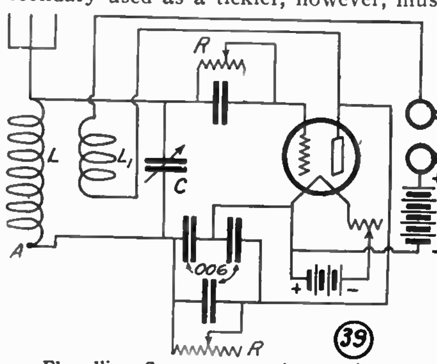
condenser C of .004 mfd. capacity. A standard variometer is inserted in the plate circuit, which will control the regeneration. A fixed condenser C1 is also shown connected across the phones, but it may sometimes be dispensed with, with no loss in efficiency. When receiving, there will always be in evidence a high pitched whistle known as the variation frequency. If this whistle is too bothersome it may be reduced by decreasing the size of the condenser C.

Circuit No. 38 shows a simplified and improved super-regenerative circuit known as the Autoplex. In this circuit two variometers shown as L and L1 are employed to tune the grid and plate circuits. These variometers must be of good manufacture and should have a large value of inductance. Only one honeycomb coil of 1,250 turns shown at L2 is used in this receiver. This receiver will give very good results with an antenna or ground alone, connected to point A. If a ground is to be used with the antenna, it should be connected to point B. As a rule best results are obtained with an antenna of about 50 feet in length.



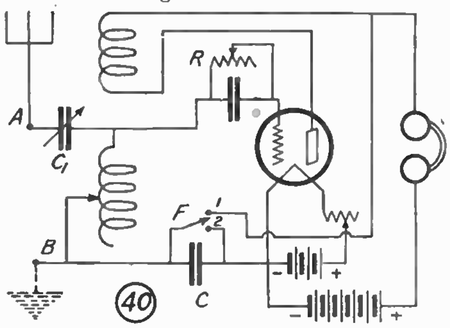
38
The Autoplex circuit.

A unique form of super-regenerative receiver known as the Flewelling circuit is shown in *circuit No.* 39. This circuit does not employ large size honeycomb coils as do most "supers," but instead, uses three condensers of .006 mfd. capacity each. The inductances L and LI may be the primary and secondary of an ordinary variocoupler. It might prove of advantage to have the primary of this coupler tapped every 10 turns in the usual way. The secondary used as a tickler, however, must be wound with at least 100 turns of wire for the best results. Two grid leaks shown as R are employed and must be variable. The resistance of these leaks will vary from 1 to 10 megohms. The variable condenser C which is used for tuning, has a capacity of .0005 mfd. (23 plates). The "B" battery in this receiver must be fairly large and can be of any voltage from 90 to 150. A hard or amplifying tube must be used in this receiver if best results are to be obtained. A ground is not shown in the diagram, as it is usually not necessary, but one may be tried at the point shown as A.

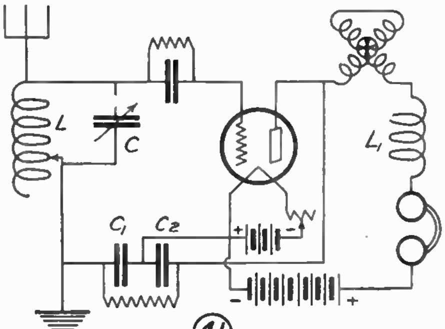


39
Flewelling Super-regenerative receiver.

In *circuit No.* 40 is shown a modified and greatly simplified Flewelling circuit. The same tuning system is used in this receiver as was shown in circuit No. 39. In any Flewelling receiver the tickler coil in the plate circuit must be wound with at least 100 or 120 turns of wire. Only one fixed condenser of .006 mfd. is used in this receiver. This condenser may be shorted by the switch F, so that the receiver can be used as an ordinary single circuit regenerative set. When used as a "super" the switch is thrown to point 1 and an antenna only is required. When used as a simple regenerative receiver the switch is thrown to point 2 and a ground is connected to point B, as shown by the dotted lines. The variable condenser C1 may have 17 or 23 plates, but the smaller size is recommended. The grid leak R is variable and has a resistance of from 1 to 10 megohms. When this receiver is operating correctly as a super-regenerative set, local stations will be strong enough to operate a loud speaker.

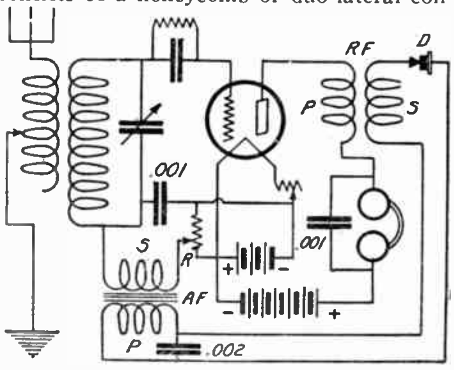


40
Simplified Flewelling circuit.



41
The Bishop Ultra-regenerator.

Another type of super regenerative circuit is shown in *circuit No.* 41 and is known as the Bishop Ultra-regenerator. In this receiver two fixed condensers C1 and C2 of .002 mfd, capacity are employed. A fixed resistance of 12,000 ohms is shunted across these condensers. The tuning inductance L may consist of 80 turns of wire tapped every 10 turns and the tuning is done by means of the variable condenser C, which has a capacity of .0005 mfd. Regeneration is obtained by means of the tuned plate method and a variometer of standard size is employed for this purpose. A radio frequency choke coil, shown as L1 is also inserted in the plate circuit between the variometer and the phones and consists of a honeycomb or duo-lateral coil



42
One tube Reflex circuit.

of 400 turns. A fixed grid leak is shown in the circuit, but it is always advisable to use a variable grid leak of from 1 to about 10 megohms.

In *circuit No.* 42 we have a simple one-tube reflex receiver. This receiver incorporates one stage of radio and one stage of audio frequency amplification. The same tube is used to amplify at radio frequency and after detection by the crystal shown as D, it again amplifies at audio frequency. An ordinary variocoupler may be used for tuning and the secondary is shunted by a variable condenser of .0005 mfd. capacity. A potentiometer shown as R is used so that the tube may be kept from oscillating. This instrument should be of rather high resistance; in the neighborhood of 400 ohms.

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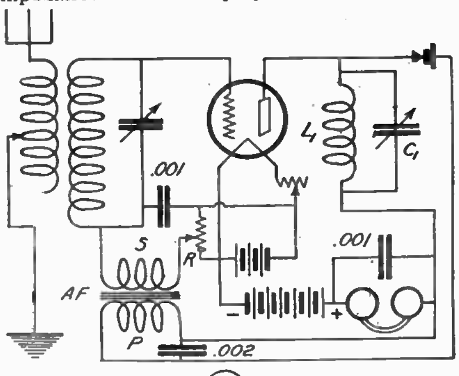
It will be noticed that fixed condensers are connected across the phones and the primary and secondary of the audio frequency transformers. These condensers are known as by-pass condensers and are employed to allow the radio frequency currents to pass the high resistance of the phones and the coils of the audio frequency transformers.

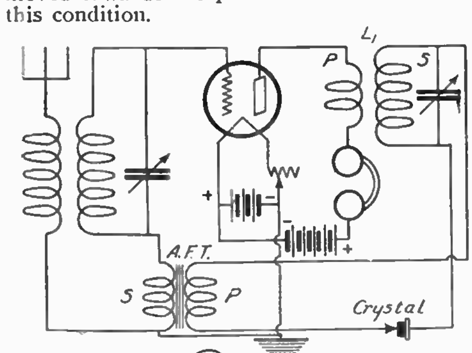
Another reflex circuit is shown in *Circuit No.* 43. In this circuit, instead of a radio frequency transformer, a tuned impedance coil is employed. This coil is



43

Reflex receiver using tuned impedance R.F. amplification.

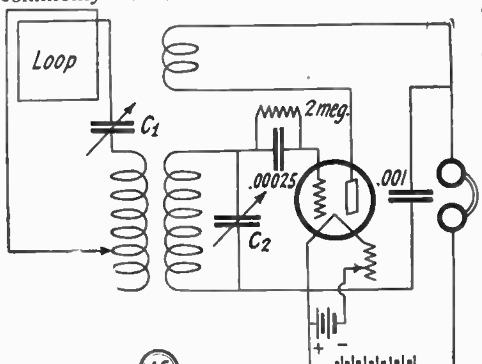
shown as L1 and may be made by winding 45 turns of No. 24 S.C.C. wire on a 3-inch tube. A variable condenser C1 of .0005 mfd. capacity is shunted across this impedance coil for tuning. Any type of tuner may be used, although in this case a standard variocoupler is shown, the secondary of which is tuned by a 23-plate variable condenser. A 400-ohm potentiometer shown as R is employed to keep the tube in a stable operating condition. This type of reflex receiver will be found much more selective than that shown in diagram No. 42. The tuning condenser across the secondary of the coupler and the variable condenser across the tuned impedance coil must both be tuned to exactly the same wave-length before any station can be received. If the tube tends to oscillate, the potentiometer lever should be moved towards the positive side to correct this condition.



44

The Harkness one-tube reflex.

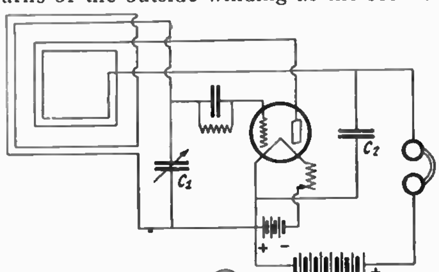
A reflex circuit that is very simple to build and will prove quite selective is shown in *circuit No.* 44. This is known as the Harkness single tube reflex and uses a special tuner and radio frequency transformer. The secondary of the tuner is constructed by winding 55 turns of No. 24 S.C.C. wire on a 3-inch tube. The primary is of 15 turns, wound directly over the secondary and separated from it by a piece of insulating paper. The secondary of this coupler is shunted by a variable condenser of 17 plates. The special radio frequency transformer shown as L1 is made in a similar fashion. The secondary is wound the same as the special coupler but the primary consists of 20 turns of wire. The secondary of this transformer is also shunted by a 17-plate condenser. A fixed crystal detector is ordinarily used in this receiver, although any good crystal detector may be employed. This receiver operates very satisfactorily without the use of any by-pass condensers that are commonly needed in other reflex circuits.



45

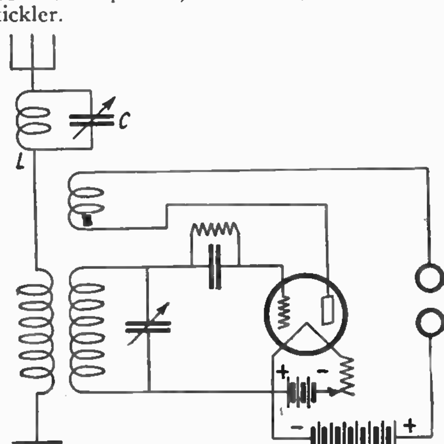
A single tube regenerative set employing a loop aerial.

Where an outside antenna is undesirable and only one tube is to be employed, it is sometimes possible to use a loop when quite near a broadcast station. The circuit for this arrangement is shomn in *circuit* 45. The tuner and tickler may be of any standard form such as a variocoupler, honeycomb or spider-web coils. If a variocoupler is employed, it will be necessary to use 35 turns of the outside winding as the secondary. A separate primary winding may then be wound directly over the secondary and should consist of 25 turns tapped every five turns. The condenser C1 may be of .0005 or .001 mfd. capacity. The condenser C2 which tunes the secondary circuit should be .0005 mfd. capacity. The rotor of the coupler is, of course, used as the tickler.



46

A novel one tube receiver.

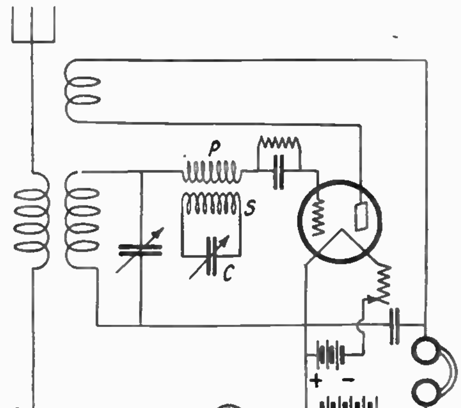


47

A circuit employing a wave trap.

In *circuit No.* 46 is shown another one-tube loop receiver. Two loops are used in this circuit, one as the tuner and the other for regeneration, in the plate circuit. The tuner is the larger loop consisting of 12 turns of wire on a 2-foot frame. As shown in the diagram, the plate loop is placed in the center of the larger loop and is so arranged that it can be rotated similar to an ordinary tickler coil. The number of turns in this loop is not critical, being in the neighborhood of 15. If desired, this loop may be of the same size as the other and arranged so that the distance between it and the other one may be varied. Tuning is accomplished in this circuit by means of the condenser C1, which is of .0005 mfd. capacity. A by-pass condenser will usually be found necessary in this circuit and is shown as C2.

In *circuit* 47 is shown a standard regenerative receiver with the addition of a

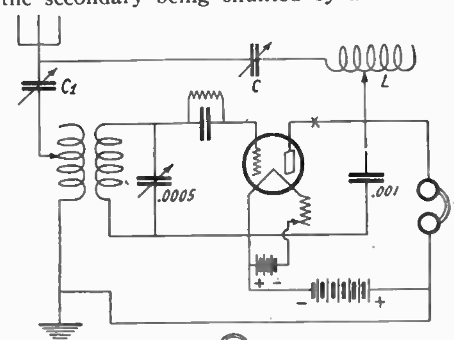


48

A circuit using a coupled wave trap.

wave trap in the antenna circuit. This wave trap is composed of a fixed inductance L, shunted by a variable condenser C. The fixed inductance may be a honeycomb coil of 50 or 75 turns or, if desired, it may be constructed by winding 45 turns of No. 24 S. C. C. wire on a three-inch tube. The variable condenser is of the 23 plate variety and has a capacity of .0005 mfd. When it is desired to eliminate the interfering station the variable condenser should be adjusted until its signal strength is at a minimum or until entirely wiped out.

Another type of wave trap which will prove extremely efficient and which can be incorporated directly in the receiver is shown in *circuit No.* 48. This wave trap consists of a primary and a secondary coil, the secondary being shunted by a variable



49

Circuit system for eliminating interference.

condenser. The secondary consists of 45 turns of No. 22 S.C.C. wire wound on a tube three inches in diameter. The primary consists of 10 turns of the same size wound directly over the secondary and separated from it by a single layer of cardboard. The variable condenser C is of .0005 mfd. capacity.

In *circuit No.* 49 is shown another method of eliminating interference. This consists of a variable inductance, L, in series with a variable condenser, C, connected from the antenna to the plate of the tube. In this case it will be necessary to employ a variable condenser, C1, in the antenna circuit. This condenser may be of

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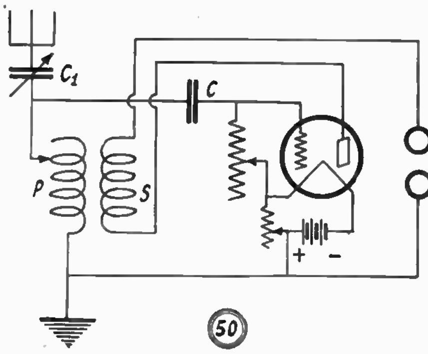
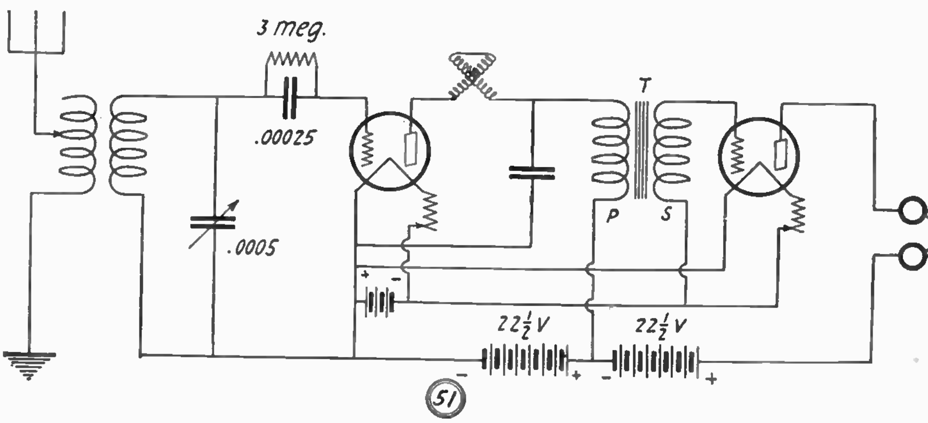


A "B" battery-less circuit.

.0005 or .001 mfd. capacity. The inductance, L, may consist of 50 turns of No. 22 S.C.C. wire wound on a tube three inches in diameter and tapped every 10 turns. The variable condenser may be of .0005 mfd. capacity. If desired, regeneration may be obtained by inserting a variometer of standard size in the plate circuit of the vacuum tube at the point marked X.

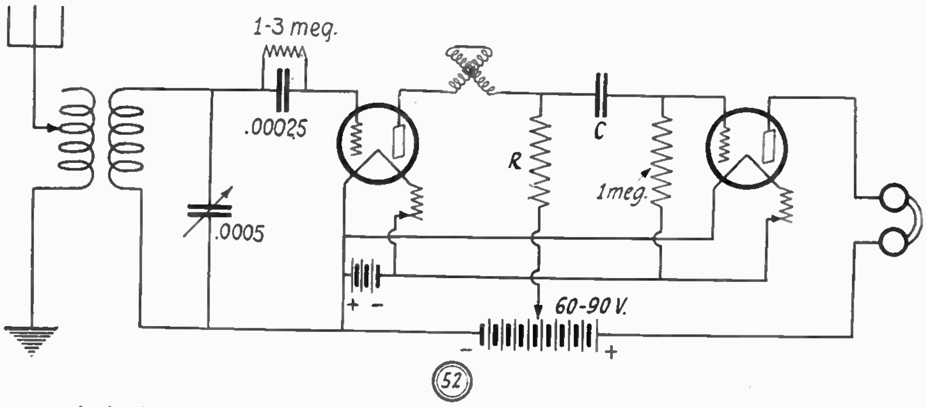
In *circuit No.* 50 we have a receiver which operates fairly well without a "B" battery. This receiver is of the single circuit type using a variocoupler for tuning. The condenser C1, may be either .0005 or .001 mfd. capacity. The secondary of the variocoupler is in the plate circuit of the detector tube for regeneration and should contain at least 80 turns of wire. As no "B" battery is used the phones are connected directly to the positive lead of the "A" battery. A variable grid leak of from one to five megohms resistance will be found advisable and should be connected directly from the grid to the positive terminal of the "A" battery. The grid condenser, C_1 may be of .00025 or .0005 mfd. capacity.



A circuit incorporating one stage of audio frequency amplification, for volume.

Where greater volume is desired, one stage of audio frequency amplification may be added to practically any detector circuit, and a diagram through which this is accomplished is shown in *No.* 51. It will be noticed that this one stage of audio frequency amplification is used in conjunction with a standard three-circuit regenerative receiver. An audio-frequency transformer must be employed as shown at T. The primary of this transformer is connected in the plate circuit of the detector tube in place of the phones. It is recommended that a transformer with a ratio of not higher than 5 to 1 be employed as otherwise distortion is liable to occur. A hard or amplifying tube such as a UV-201A or a C-301A must be employed as the amplifier. For best results it would also be necessary to use a higher plate voltage on this tube. As a rule 45 volts will be sufficient for one stage of amplification and this is obtained by connecting two 22¼-volt "B" batteries in series.

It is almost impossible to obtain an audio-frequency transformer that will not distort to some extent and for this reason a resistance coupled amplifier is sometimes made use of. However, since a resistance coupled amplifier will only give about 2/3 the amplification delivered by a transformer, it is not generally used for one stage. A circuit using resistance coupling is given in *circuit No.* 52. It is shown in conjunction with a three circuit regenerative receiver, although any type of receiver may be employed. The resistance shown at R should be of the non-inductive type and of a value of 50,000 ohms. It will usually be found necessary to use a higher "B" battery voltage with resistance coupling than with transformers. A grid condenser will also be required in the grid circuit of the amplifying tube as shown at C so that the "B" battery voltage will not be

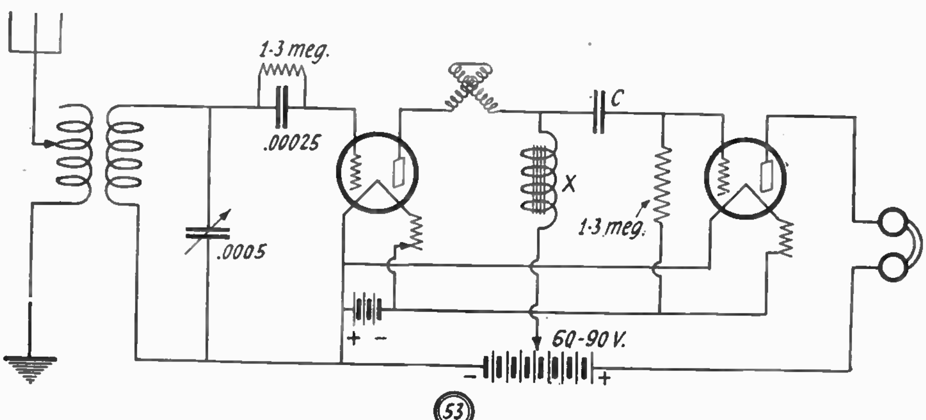


A circuit incorporating one stage of resistance coupled audio frequency amplification.

impressed upon the grid. The capacity of this condenser is not critical and may be from .006 to 1 mfd. As an amplifying tube must be operated with a negative potential upon the grid a grid leak of one meghom is connected from the grid of the tube to the negative of the "A" battery.

In *circuit No.* 53 is shown another system of providing distortionless amplification. Instead of a resistance a choke coil is employed and is shown at X. If desired, this choke coil may be constructed by winding 5,460 turns of No. 34 S.S.C. wire in 14 layers on an iron wire core 3½ inches long and 3/8 inch in diameter. In winding it will prove best to separate every two or three layers of wire with a piece of waxed paper. If an old audio frequency transformer the primary of which is burned out happens to be laying about, the secondary will function very well as this choke coil. The grid condenser shown in this diagram at C should be of approximately .01 mfd. capacity. The grid leak connected from the grid to the negative filament should be from 1 to 3 megohms, best determined by experiment. A hard or amplifying tube must, of course, be used in this circuit and a "B" battery voltage from 60 to 90 is recommended. This type of amplification has been shown with a standard three circuit regenerative receiver, but it may be used with practically any circuit. Although it will not produce the same volume of sound as an amplifier using an audio-frequency transformer, it will, nevertheless, give sufficient volume to operate a loud speaker when fairly close to a broadcast station.

Choke coil coupled amplification has recently received another impetus for broadcast reception due to its faithful reproduction of voice and music and the usual lack of distortion found in a circuit employing it. It is quite possible to purchase choke coils especially designed for this purpose on the market today and in some cases a complete unit incorporating not only the choke coil but also the blocking condenser and the grid leak for the audio frequency amplifying tube may be had. Using this unit, the construction of an impedance or choke coupled amplifier is greatly simplified, as the only accessory necessary for connecting up an additional stage of amplification is the amplifying tube and a socket.



A choke coil audio frequency amplifier connected to the usual form of receiving circuit.

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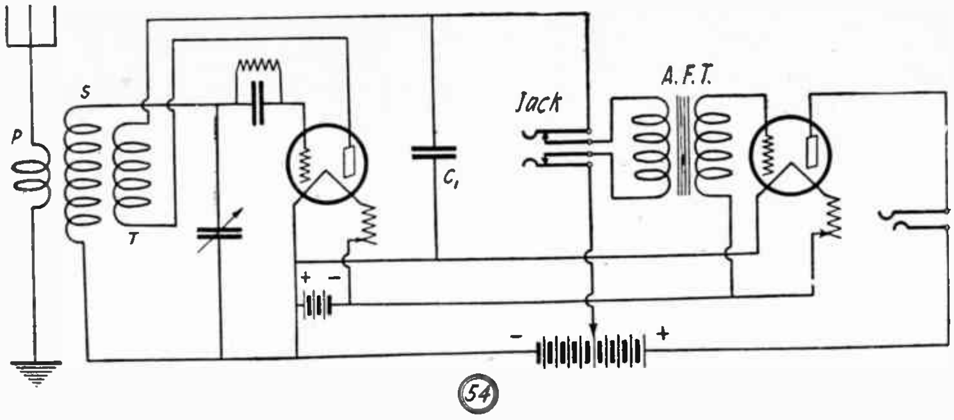
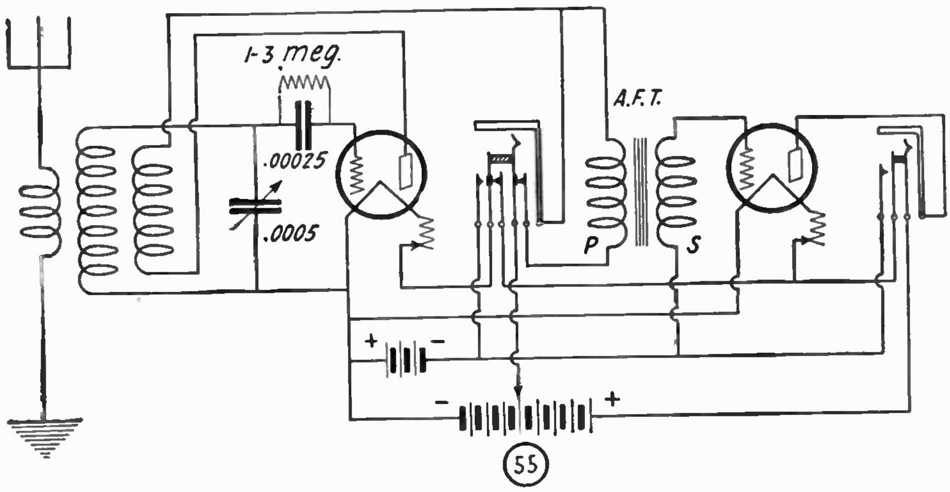


A detector and single stage audio frequency amplifier circuit employing phone jacks.

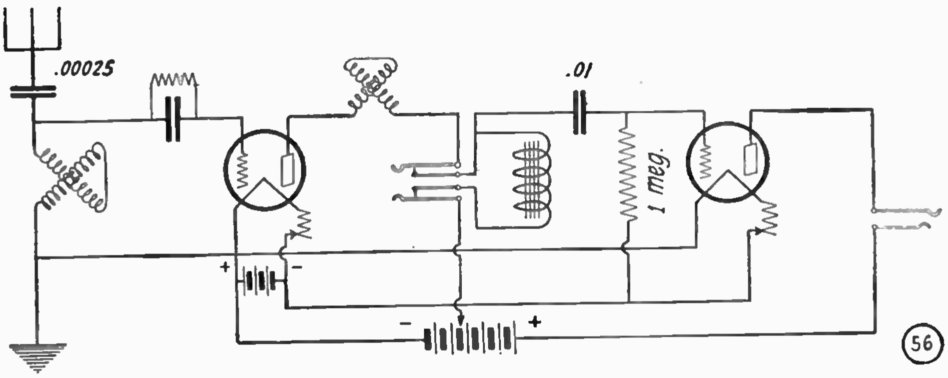
It is sometimes undesirable to use a stage of audio frequency amplification when the ear phones are employed and some means must be used so that the phones may be plugged in on the detector alone and the amplifier disconnected from the circuit. In *circuit* 54 is shown how this is accomplished by means of a double circuit jack. This type of jack has two outside and two inside springs which normally make contact with each other. However, when a phone plug is inserted the two outside springs disconnect from the two on the inside, thereby breaking this part of the circuit and allowing the current to flow through the phones instead of the primary of the audio-frequency transformer. A single circuit jack is connected in the plate circuit of the amplifying tube so that the phones may be connected at this point when desired. In this circuit the audio stage is shown in conjunction with the untuned primary receiver described in *No.* 28. It may be necessary to connect a by-pass condenser of .0005 mfd. or .001 mfd. capacity in the position shown at C1.



One stage of audio frequency using filament control jacks.

In *circuit No.* 55 is shown a regenerative circuit in conjunction with one stage of audio frequency amplification using filament control jacks. These jacks are very convenient, since with their use it is unnecessary to turn off the filament current to the tubes not in use. A little study of this circuit will show that when the phones are plugged into the first jack, the detector tube alone lights up and when the phones are plugged in the second jack, both tubes are lighted. When the set is not in use it is only necessary to remove the plug and the filament current is automatically cut off. An untuned primary coupler is shown as the tuner in this circuit, although any type of tuner may be employed. A condenser of .0005 mfd. capacity is shunted across the secondary for tuning. Any type of receiving tube may be employed providing the correct "A" battery voltage is used.

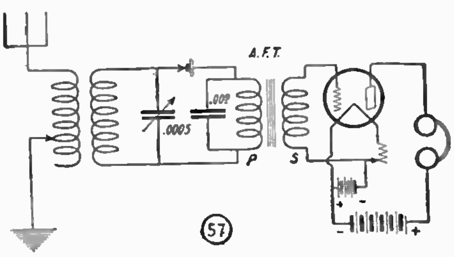
It sometimes happens that the primary of the audio frequency transformer burns out. In such cases the secondary may be used as a choke coil amplifier and when used in this connection will function extremely well. The volume obtained may not be as great as when a transformer is used, but the quality of reproduction will be excellent. A diagram showing a circuit employing such use of a transformer is given in *circuit No.* 56. A double circuit jack is also incorporated so that the detector alone may be used when desired. A grid condenser must, of course, be employed in the grid circuit of the amplifying tube and has a capacity of .01 mfd. A grid leak of one megohm is connected from the grid of the tube directly to the negative of the "A" battery. In this circuit a variometer is shown as the tuner, and a .00025 mfd. condenser is placed in series with the antenna to lower the wave-length.



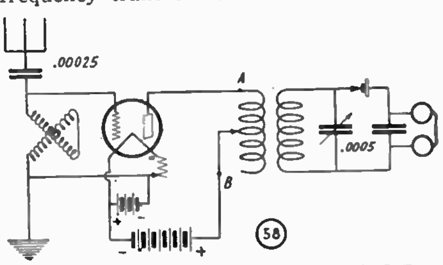
A regenerative circuit with one stage of choke coil audio frequency amplification.

When local stations only are desired, and pure reproduction is wanted, a crystal receiver in conjunction with one stage of audio frequency amplification will give excellent results. Such a circuit is shown in *circuit No.* 57. A good audio frequency transformer with a ratio of not higher than 4½ :1 should be employed. An amplifying tube such as the UV-201A or C-301A with a 6-volt "A" battery and a rheostat of 15 ohms will prove satisfactory. If desired, however, a UV-199 or a C-299 may be employed with three dry cells for the filament in series with a rheostat of 30 or 35 ohms. The "B" battery will be of 45 or 72 volts.

When reception over greater distance is desired with a crystal receiver, a stage of radio frequency amplification may be placed directly before the receiver without altering the wiring in any way, providing a variocoupler is used in the crystal receiver. A diagram of this circuit is shown in *circuit No.* 58. The radio frequency amplifier consists of an amplifying tube and a tuner. The tuner in this case is an ordinary variometer with a .00025 mfd. condenser in the antenna circuit. The plate of the radio frequency tube is connected directly to the antenna binding post of the crystal set and the ground binding post is connected to the positive terminal of the "B" battery. No radio frequency transformer is employed, the variocoupler serving as a tuned radio frequency transformer.



A crystal detector with one stage of A.F. amplification.



Crystal detector with one stage of R.F. amplification.

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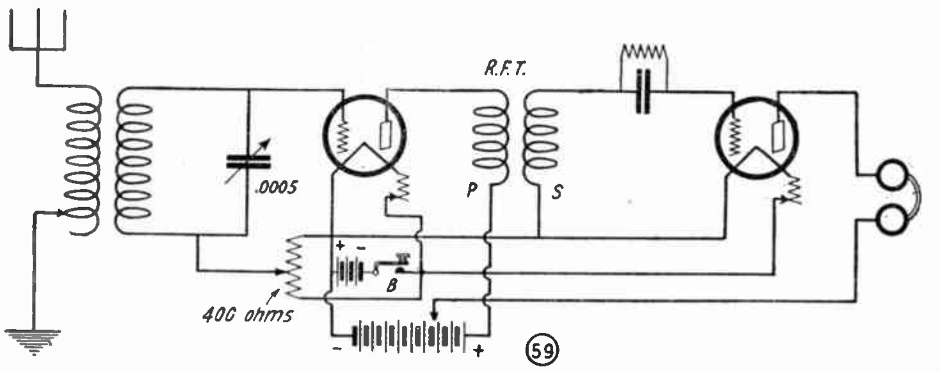
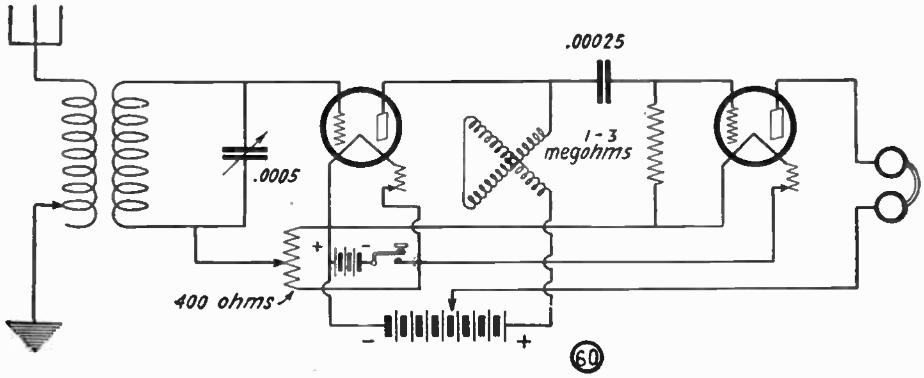


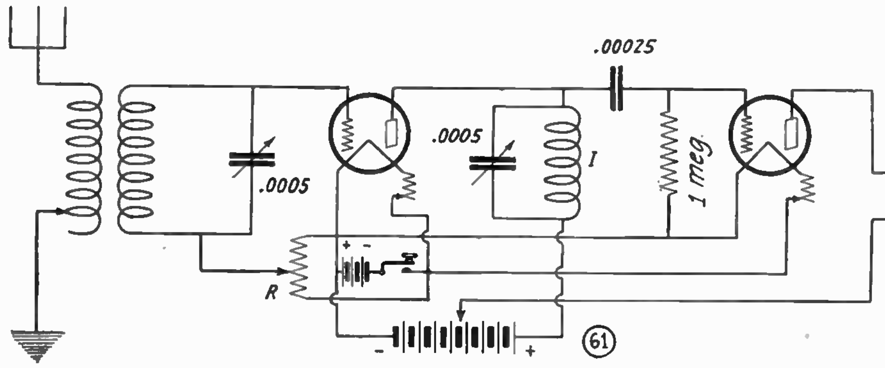
A detector and one stage of transformer coupled radio frequency amplification.

In *circuit No.* 59 is shown a 2-tube receiver consisting of detector and one stage of radio frequency amplification. In this circuit a radio frequency transformer is employed. The tuner consists of a standard variocoupler with the secondary tuned by a .0005 mfd. variable condenser. As regeneration is not had in this circuit the tuning will be rather broad unless the coupling between the primary and secondary of the variocoupler is kept comparatively loose at all times. A potentiometer of 400 ohms is connected across the "A" battery leads and the grid return of the amplifier tube is connected to the movable arm. If the radio frequency tube oscillates, the potentiometer lever should be moved towards the positive side until the oscillation ceases. If this lever can be moved all the way to the negative side without the tube oscillating at any wave-length, the potentiometer may be omitted and the grid return connected directly to the negative "A" battery. A filament switch shown at B is employed so tubes may be switched on or off and so the potentiometer will be disconnected when the set is not in use.



A selective radio frequency circuit using the tuned impedance method of amplification.

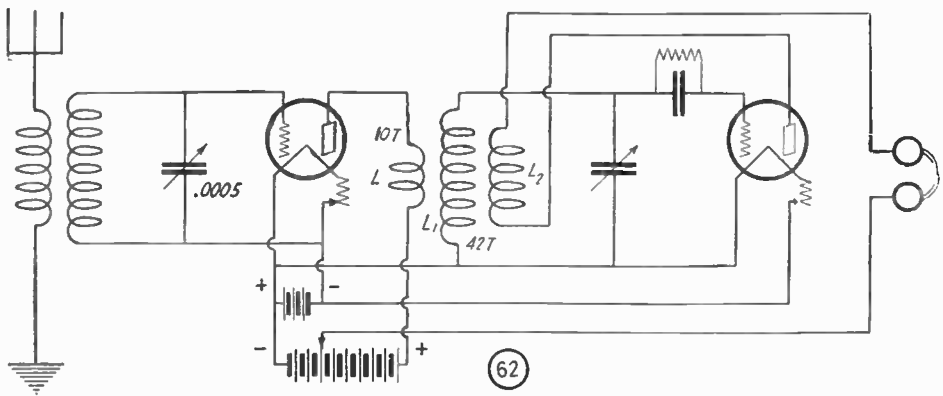
In *circuit No.* 60 is shown a radio frequency amplifier using the tuned impedance system of amplification. In this case the tuned impedance coil consists of a standard variometer connected in the plate circuit of the amplifying tube. A standard grid condenser of .00025 mfd, capacity is employed in the detector grid circuit, and the grid leak is connected from the grid directly to the positive lead of the "A" battery, as shown. In this circuit it is essential that a potentiometer be employed, as otherwise the radio frequency tube would be in a constant state of oscillation. This potentiometer should have a resistance of approximately 400 ohms. A filament switch is also connected in the negative "A" battery lead. The tuning of this receiver will be found fairly sharp. The secondary variable condenser of the tuner and the plate variometer must both be tuned to the same wavelength for any given station. It will be noticed that on the lower wave-lengths the potentiometer lever must be moved closer to the positive side to keep the tube from oscillating.



A tuned impedance radio frequency circuit using an inductance and variable condenser.

Circuit No. 61 shows another type of tuned impedance radio frequency amplification. In this case, instead of the variometer, a coil of wire shunted by a variable condenser is employed in the plate circuit of the amplifier. This coil shown at 1, may consist of 40 turns of No. 22 S.C.C. wire wound on a tube 3½ inches in diameter. The variable condenser should have a capacity of .0005 mfd. This type of tuned impedance coupling will give slightly better results as regards sharpness of tuning than that described in diagram 60. The grid condenser has a capacity of .00025 mfd. and the grid leak has a resistance of one megohm. The potentiometer shown at R must be employed and should have a resistance of at least 400 ohms. A variocoupler is employed in this circuit, the secondary of which is shunted by a variable condenser of .0005 mfd. capacity. As a radio frequency tube in this type of circuit will oscillate very readily great care should be taken that it is handled correctly so interference is not created in nearby receiving sets.

In *circuit No.* 62 is shown a radio frequency receiver which if correctly built and operated will give exceptional results. This receiver consists of one stage of tuned transformer coupled radio frequency amplification with regeneration in the detector circuit. The coils L, L1 and L2 are the primary, secondary and tickler of an untuned primary coupler. This untuned primary coupler was described in diagram 28 in this book. It will be noticed that this is circuit No. 28 with one stage of radio frequency amplification connected directly ahead of the detector. The tuner used in the antenna system consists of a primary and secondary which is identical with the primary and secondary of coils L and L1. The secondary of this tuner is shunted by a variable condenser of .0005 mfd. capacity. The untuned primary coupler secondary must also be tuned with a condenser of the same capacity. Both condensers must be tuned to the same wave-length to receive any station. As the regeneration obtained in the detector circuit is equal to an extra stage of radio frequency amplification, this receiver will duplicate the results of most three-tube R.F. sets. No potentiometer is required in this receiver.



A tuned radio frequency transformer is employed here and regeneration is obtained in the detector circuit. Oscillation of first tube circuit may be due to too many turns in "L".

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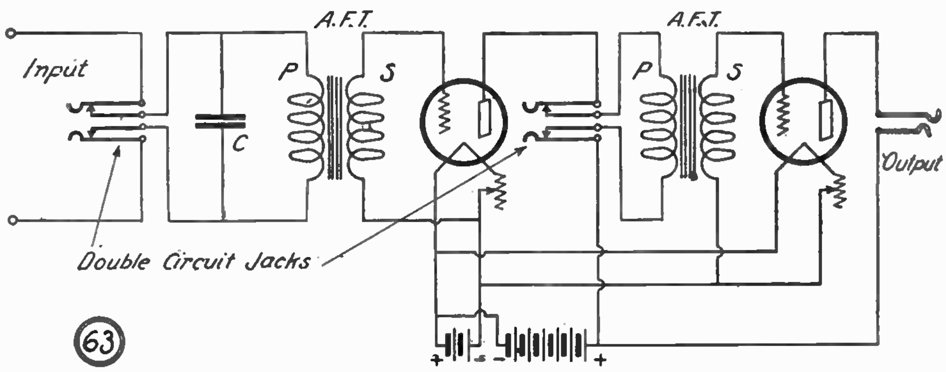


Circuit diagram of a two-stage audio frequency amplifier with telephone jacks.

Circuit No. 63. In this diagram we have a circuit of a 2-stage audio frequency amplifier which may be added any standard one tube receiver. Audio frequency transformers are used and a ratio of not higher than five to one is advised. One single circuit and two double circuit jacks are employed, thus allowing either detector, first or second stage of audio frequency to be used. The output of the detector tube is connected directly to the two input binding posts on the amplifier. A fixed condenser C is shown shunted across the primary of the first transformer. This condenser is of low capacity, approximately .00025 mfd. and is employed to compensate for the capacity of the phone cords when the phones are removed from the detector circuit. If this condenser is of the right size there will be no need of returning when the change is made from the detector to the first stage. The same "A" and "B" batteries are employed for both detector and amplifier.

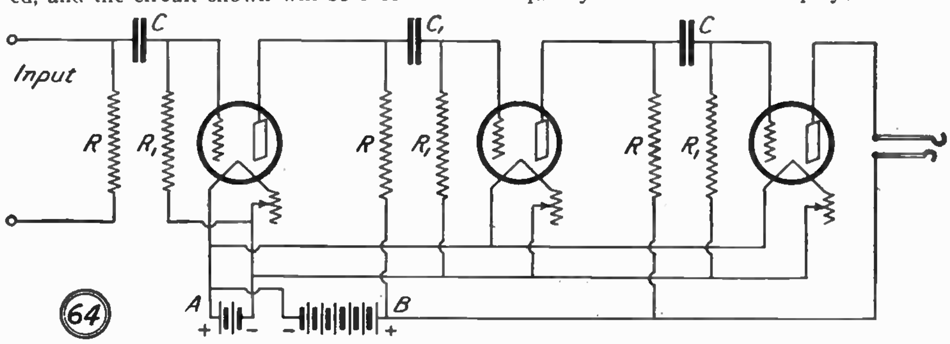
All that is necessary is to connect the positive and the negative filament binding posts of the detector to the respective terminals of the "A" battery and take a tap off at 22½ or 45 volts on the "B" battery and connect it to the plus "B" battery post of the detector on the receiver. No wire need be connected to the minus "B" battery binding post on the receiver as the negative circuit of the "B" battery is completed to the "A" battery in the audio frequency amplifier.

The type of tube to be employed in this audio frequency amplifier circuit is a matter of preference. If WD-11, WD-12 or UV-199 tubes are used, employ a 1½ volt "A" battery for the first two types and a 4½ volt "A" battery and 25 to 30 ohm rheostats for the last mentioned type. "B" voltages from 45 to 60 can be safely utilized. If UV-201A or Western Electric E tubes are used, a six volt "A" battery will be required, and 25 ohm rheostats if those of the first mentioned types of tubes are employed. "B" voltages from 45 to 100 may be used.

Circuit No. 64. Where an audio frequency amplifier is desired, which will give very little distortion, three stages of resistance coupled amplification are recommended. Distortion is always present when audio frequency transformers are employed, and the circuit shown will be free from this trouble. As a resistance coupled amplifier does not give as much volume as one using transformers, three stages will be required instead of two. The resistances R should be approximately 50,000 to 70,000 ohms. Grid condensers C are employed in the grid circuits and should be of fairly high capacity, approximately ½ mfd. These condensers must be employed so that the plate voltage is not applied to the grid of the tubes. The resistances shown as R1 are ordinary grid leaks of approximately ½ megohm resistance. Best results will be obtained with a rather high "B" battery voltage and 120 to 150 volts are recommended.

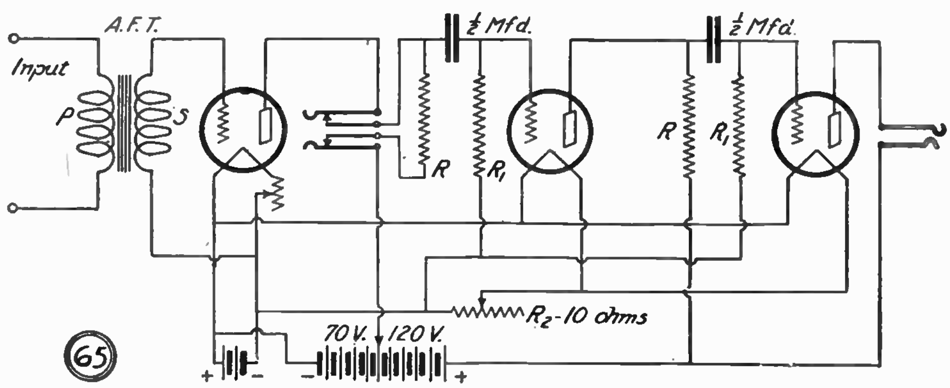
It is necessary, no matter the type of tube employed, that a high "B" voltage be employed, as there is a considerable drop of potential across the resistances, thus making the effective plate voltage a good deal lower than the actual voltage of the "B" battery.

This circuit is shown to be used in conjunction with any standard receiving circuit and is arranged so that the "A" and "B" batteries are common to both. The return circuit to the filament of the first resistance R is completed through the receiver in use.



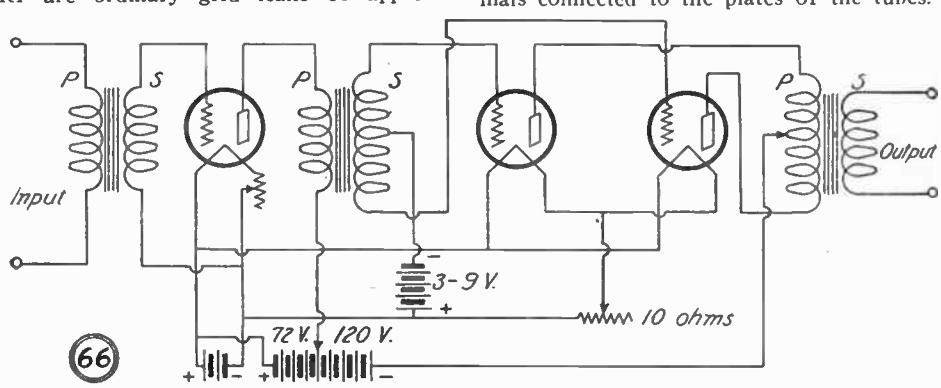
A three stage resistance coupled audio frequency amplifier circuit.

Circuit No. 65. Here is a three stage audio frequency amplifier combining an audio frequency transformer and resistance coupled amplification. The audio frequency transformer is employed in the first stage and a double circuit jack is also used after the first amplifying tube so that the phones may be plugged in at this position. The grid condensers in the grid circuits of the last two tubes are of ½ mfd. capacity and the resistances R are approximately 50,000 ohms. The grid leaks shown as R1 are of ½ megohm resistance and are connected directly to the negative of the "A" battery. One rheostat of 10 ohms, shown as R2, is employed to light the filaments of the last two tubes. The same "B" battery voltage may be employed for all three stages, but it is recommended that the last two tubes have a much higher voltage than the first. This amplifier may be employed with any standard one tube circuit and will give exceptionally good results.



A single stage transformer coupled and two stage resistance coupled audio frequency amplifier circuit.

Circuit No. 66. Here we have a two stage audio frequency amplifier using the push-pull method of amplification. In a circuit of this kind three tubes are employed for two stages of amplification. It will be seen that special transformers are employed for the last two tubes. The secondary of the first transformer has its two opposite terminals connected to the grids of the tubes and the primary of the last transformer has its two end terminals connected to the plates of the tubes.



A two-stage A. F. amplifier, the last stage being push-pull. "B+" connects to output transformer primary.

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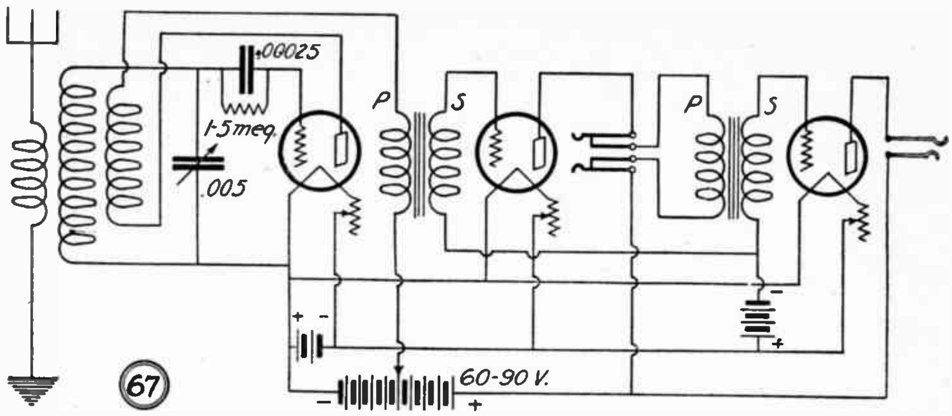
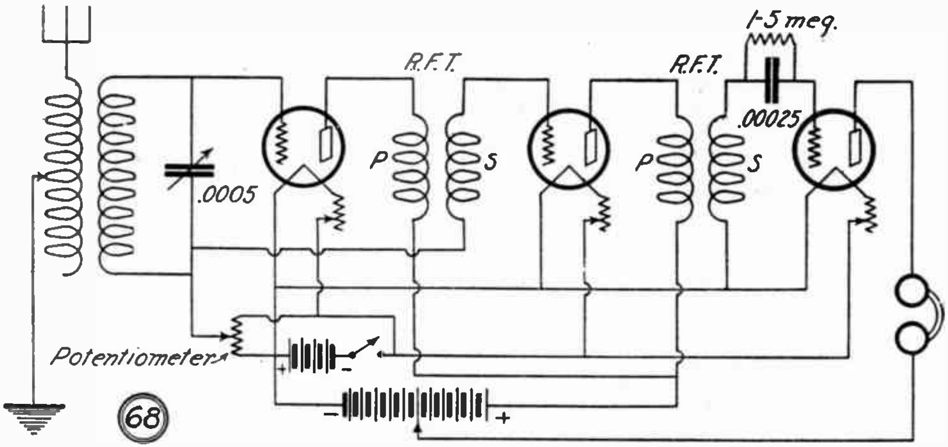
Circuit No. 67. Here is shown a regenerative receiver in conjunction with two stages of audio frequency amplification. The tuner in this receiver is an untuned primary coupler and was described in circuit No. 28. Audio frequency transformers are used in the amplifier and should not have a ratio higher than 5:1. A double circuit jack is inserted after the first stage so that the phones may be plugged in at this point. When the loud speaker is used, it is plugged into the single circuit jack after the last stage. If a good antenna is used with this receiver, fair volume will be obtained on the loud speaker on the first stage when local stations are received. The grid returns of the two amplifying tubes are connected together and run to the negative terminal of a "C" battery which will have a voltage of from three to nine volts, depending upon the voltage of the "B" battery. This "C" battery has its positive terminal connected to the negative of the "A" battery. A "C" battery is necessary when a high voltage is used on the plates, as it cuts down the current consumption and helps toward the elimination of distortion.



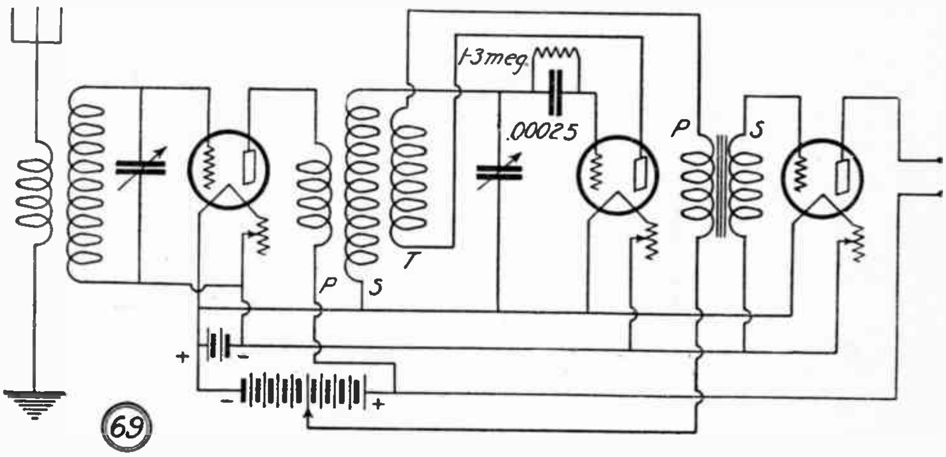
A regenerative receiving circuit and two stage audio frequency amplifier.



Receiving circuit employing two stages of untuned transformer radio frequency amplification.

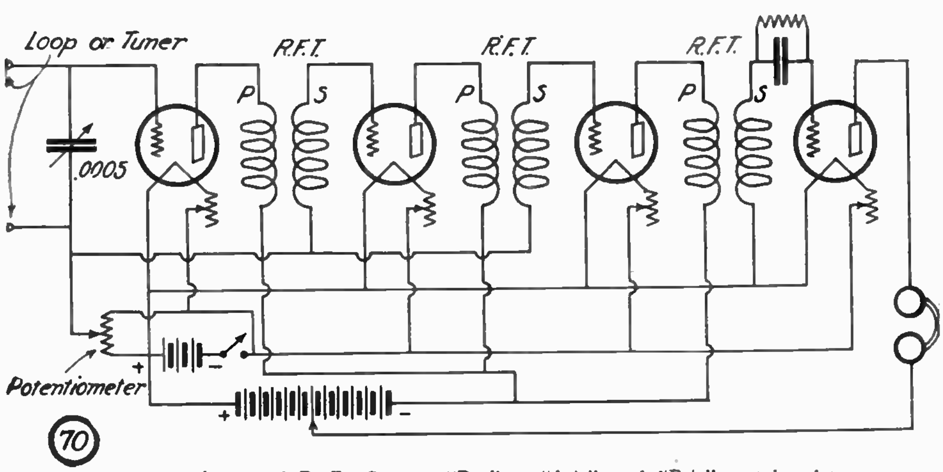
Circuit No. 68. Where long distance reception is desired, together with simplicity of tuning, the circuit shown here may be used. This consists of a tuner employing two stages of radio frequency amplification. As regeneration is not employed in this circuit, a coupler should be used which is capable of very loose coupling between the primary and secondary, otherwise the tuning will be broad. A variable condenser of .0005 mfd. capacity is employed across the secondary of the coupler for tuning. To avoid capacity effects, this condenser must be connected with the rotary plates to the filament. If a good make of radio frequency transformer is used, the tubes will oscillate and consequently a potentiometer must be employed so that this oscillation can be controlled.

Circuit No. 69. Here we have a circuit combining one stage of radio frequency with regeneration in the detector circuit. As one stage of audio frequency is also used, a loud speaker may be employed on practically all stations received. The antenna tuner consists of an untuned primary coupler without the rotor. The radio frequency transformer is an ordinary untuned primary coupler, like that described in circuit No. 28. The primary of this coupler must be wound with large wire, of not more than 10 turns. The secondaries of both couplers are shunted by variable condensers of .0005 mfd. capacity for tuning. Both condensers must be varied at the same time, as both secondary circuits must be in resonance before any station can be picked up. No potentiometer is necessary in this receiver, the grid return of the first tube being connected directly to the negative of the "A" battery. Properly handled, a circuit of this kind will be equivalent to one having two stages of radio frequency amplification.

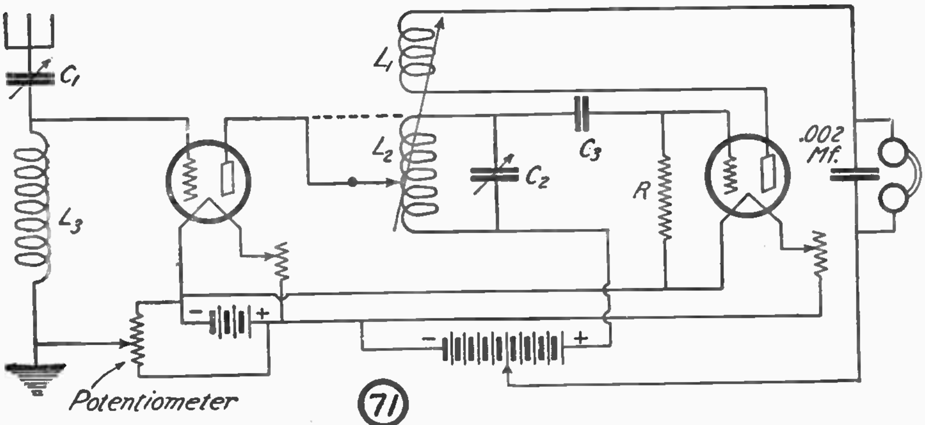


One stage of R.F., one stage of A.F. and regeneration in the detector circuit.

Circuit No. 70. A long distance receiver employing three stages of radio frequency amplification is shown in diagram No. 70. This type of circuit may be used with a loop with excellent results, but if desired, a tuner may be employed with an antenna and ground. A variable condenser of .0005 mfd. capacity is employed for tuning and may be used to tune a standard coupler or a loop. A potentiometer of 400 ohms is connected across the "A" battery leads to control the oscillations of the tubes. Where a potentiometer is used, a filament switch should always be employed so that this part of the circuit is always disconnected when the receiver is not in use.

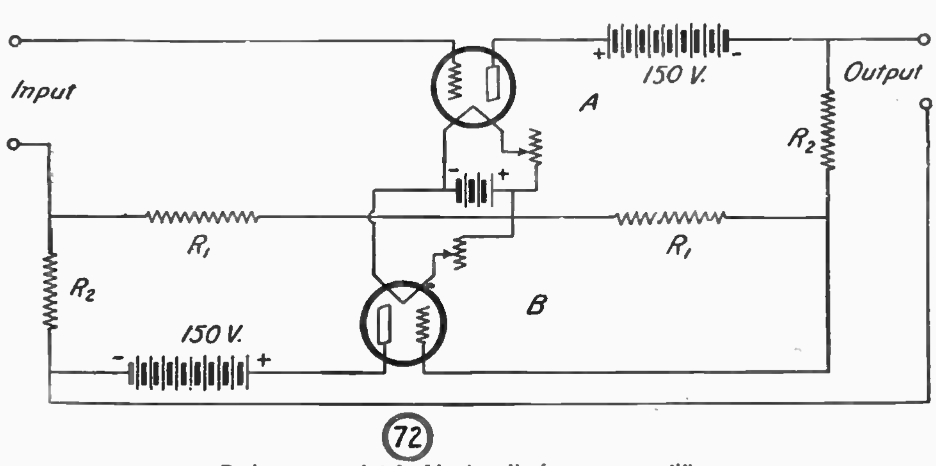


Three stages of untuned R. F. Connect "B—" to "A+", and "B+" to tube plates.



Single circuit regenerative receiver with one stage tuned R.F. amplification.

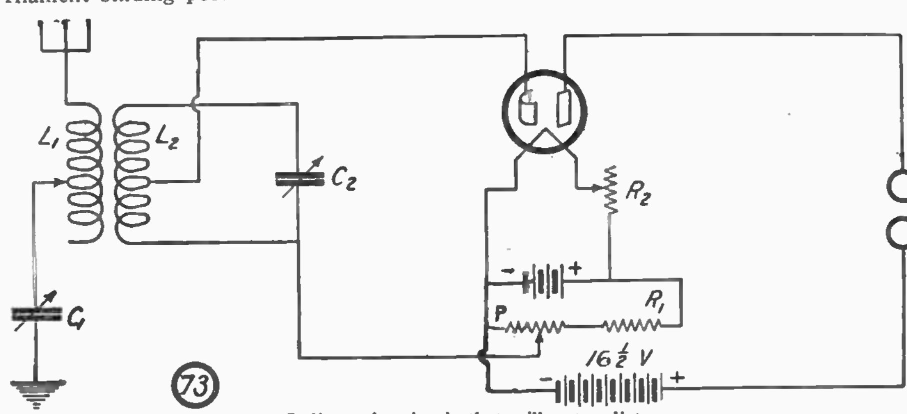
Circuit No. 71. The above diagram shows a simple single circuit regenerative receiver, having a stage of tuned impedance coupled radio frequency amplification. A variable condenser C_1 of .001 mfd. capacity, and a honeycomb coil, L_3, having 35, 50 or 75 turns, form the antenna tuning circuit. Coils L^1 and L^2 may be those of a variocoupler, across the primary of which is shunted a variable condenser, having a capacity of .0005 mfd. L^1 acts as a tickler coil, and supplies regeneration in the detector circuit. A potentiometer is required to supply the proper grid bias to the radio frequency tube, and should have a resistance of between 200 and 400 ohms. Two 35-turn honeycomb coils may be used instead of the variocoupler, in which case the lead from the plate of the first tube is connected as indicated by the dotted line in the diagram. The grid leak R of 1 megohm is connected between the grid and the negative filament binding post of the detector tube.



Resistance coupled feed-back radio frequency amplifier.

Circuit No. 72. This circuit is a radio frequency feed-back amplifying unit that uses two tubes and is resistance coupled. Resistances R^1 are 10,000 ohms and R^2 are 50,000 ohms. The terminals marked "input" are connected to the tuning unit and those marked "output" go directly to the detector tube. The output from the tube A is fed into the tube B, which in turn is fed into the tube A again through the tuner. As this action is continuous, the resulting input to the detector tube is larger than with the usual type of resistance coupled R. F. amplifier.

It is best to use either the UV-201A type tube with this radio frequency amplifier, or the Western Electric "E" tubes, as with these it is possible to use high plate voltages. It is necessary to have separate "B" batteries having a voltage between 100 and 150 volts, as the voltage drop across the resistance is very high. The resistances R^1 and R^2 may be of the Lavite type.

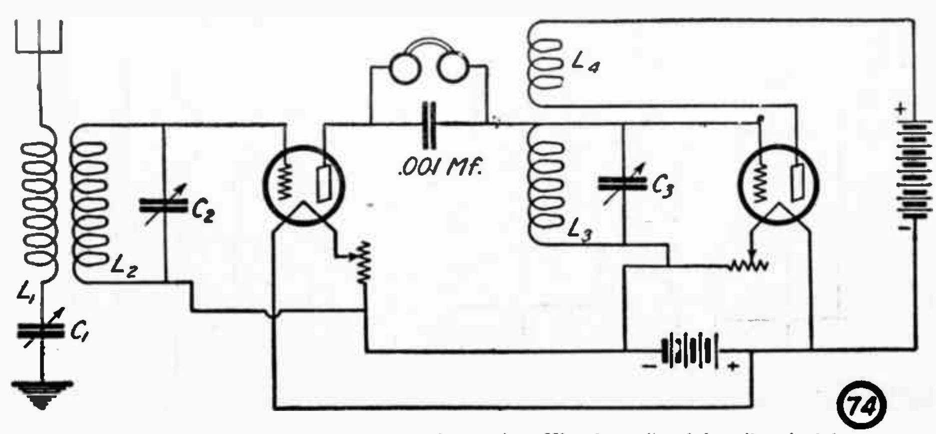


Sodion tube circuit that will not radiate.

Circuit No. 73. This circuit has as its detector the Sodion tube introduced by Mr. H. P. Donle. The condenser C^1 of .001 mfd. capacity, is in series with the primary of the variocoupler L^1. The secondary of the coupler L^2 is tapped about 10 turns from the bottom and connected to the collector terminal of the tube. L^2 is shunted by the variable condenser, C^2, of .0005 mfd. capacity. P is a 200-ohm potentiometer and the resistance, R^1, has a value of 100 ohms. The rheostat, R^2, used with the tube, is of 30 ohms. The Sodion tube can be used only as a detector and is an excellent one to use in crowded city sections, as it will not oscillate and, therefore, the set can not radiate and create interference. The tube has many advantages over the crystal detector and the diode tube and avoids some of the disadvantages of these devices for detection.

Circuit No. 74. This circuit is an excellent one for the reception of C.W. signals. The four inductances shown are honeycomb coils, their size depending on the wave-length band to be covered. The variable condensers C_1 and C_2 have a capacity of .0005 mfd. and C_3 is .001 mfd. The plate voltage on the oscillator tube is not critical and may be 45 volts. The first tube, called the modulator, is connected across the oscillating circuit of the oscillator tube. The space between the filament and the plate acts as a resistance, the value of which is varied by the incoming signals impressed upon the grid. No "B" battery is necessary for the modulator tube, as its plate is supplied by high frequency current from the oscillating circuit.

This circuit may also be employed for the reception of broadcast programs by the use of the proper size inductances. Coils L_1 and L_2 may be a variocoupler and inductances L_3 and L_4 may be 50 and 25 turns duo-lateral coils respectively. This rather unique circuit should prove of great interest.



An excellent hook-up for G.W. reception, using Ultradyne "modulator" principle.

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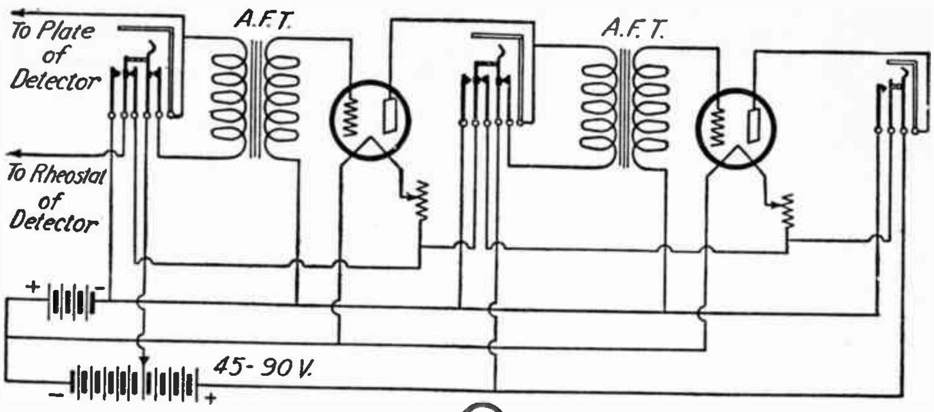
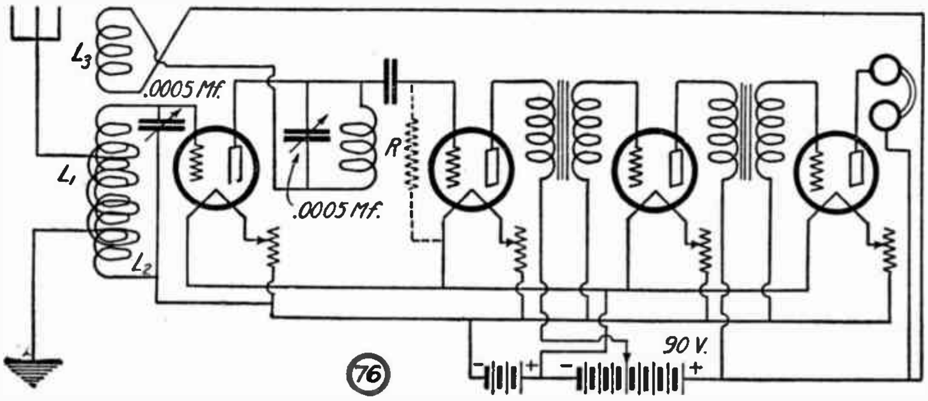
Circuit No. 75. In this circuit are shown two stages of audio frequency amplification, having filament control jacks. The use of these jacks will mean in the long run a saving to the builder, as only the filaments of the tubes that are being used are lit. This amplifying unit can be built as an integral part of a set, or can be built in a separate cabinet for the experimenter's work bench. If built as a separate unit, binding posts are used to connect it with the tuner. Four binding posts are needed for the "A" and "B" battery terminals and two for the input. A precaution to be observed is to place the transformers at right angles to each other to reduce, as far as possible, any losses that may occur.



75

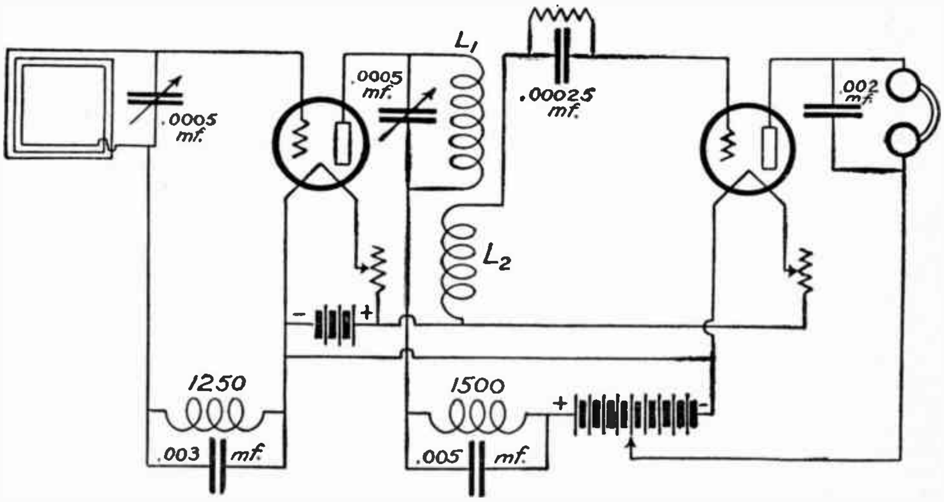
Two stages of transformer coupled A. F. amplification with filament control jacks.

Circuit No. 76. In this diagram is shown the Superdyne receiver, with two stages of audio frequency amplification. L_1 is four turns of No. 22 D. C. wire wound directly over the 42 turns of L_2. These windings are on a tube four inches in diameter. L_3 is 36 turns of the same wire on a rotor, which is 3⅝ inches in diameter. This rotor is inserted half way into one end of the four inch tube and is arranged with bearings for rotation. The plate inductance coil is 45 turns of the same wire, wound on a four-inch tube. The variable condensers, which should be of the vernier type, have a capacity of .0005 mfd. When constructing the set, it is important that the plate coil be at right angles to the coupler to prevent any inductive effects. This set will give excellent results also with a short indoor antenna connected to the grid side of L_2, the negative side of the "A" battery being grounded. This eliminates L_1, which is used for an outdoor antenna. A grid leak is sometimes necessary, depending upon the type of detector tube used and is placed in the position shown by the dotted resistance R.



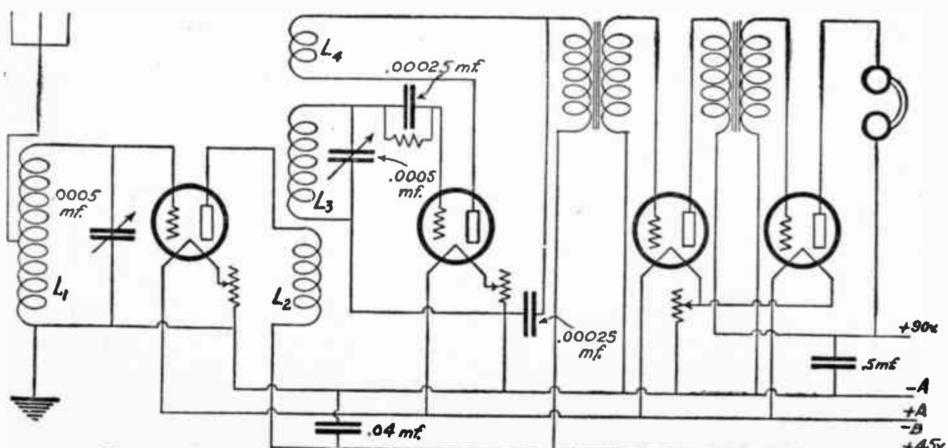
Superdyne receiver using the negative feed-back principle.

Circuit No. 77. Although the Super-Regenerative type of set is a more or less difficult one to master, when the experimenter does get it adjusted properly the results obtained are gratifying. In Fig. 77 is shown a two tube "Super" that presents no great difficulties of construction. The inductance L_1 consists of 16 turns and L_2 of 40 turns of No. 26 D.C.C. wire, both coils being wound on the same 3½-inch tube, with ½ inch between windings. The inductances of 1,250 and 1,500 turns should be of the honeycomb coil type and should be in inductive relationship with each other. The loop should be about three feet square and have 10 turns, which are spaced ¼ inch apart. To operate at maximum efficiency, a UV-201A type of tube should be used and at least 90 volts on the plate of the first tube, the oscillator and 45 volts on the plate of the second, which is the detector, although this latter figure may be varied, depending on the individual tube.



No. 77. Two-tube Super-Regenerative circuit with two condensers for tuning.

Circuit No. 78. The Teledyne circuit is one which has stood the test of time and is famous for its extreme selectivity and the fact that it will not radiate. This set has a wave-length range of 200 to 550 meters and has the same dial settings at all times for a given station. The variocoupler is a 3-inch length of 3-inch tubing for the stator and a ¾-inch length of 2⅛-inch tubing for the tickler coil. The tickler L_4 has 28 turns of No. 26 S.S.C. wire and the stator L_3 has 39 turns of No. 24 S.S.C. wire. The inductance L_2 consists of four turns of No. 24 S.S.C. wire, wound directly over L_3, but separated by a strip of varnished cambric cloth. A standard variocoupler may be used instead of L_3 and L_4. For L_1 wind 68 turns of No. 26 S.S.C. wire, tapped at the fifteenth turn, on a 3-inch tube.



No. 78. The four-tube Teledyne circuit, which has a wide wave-length range.

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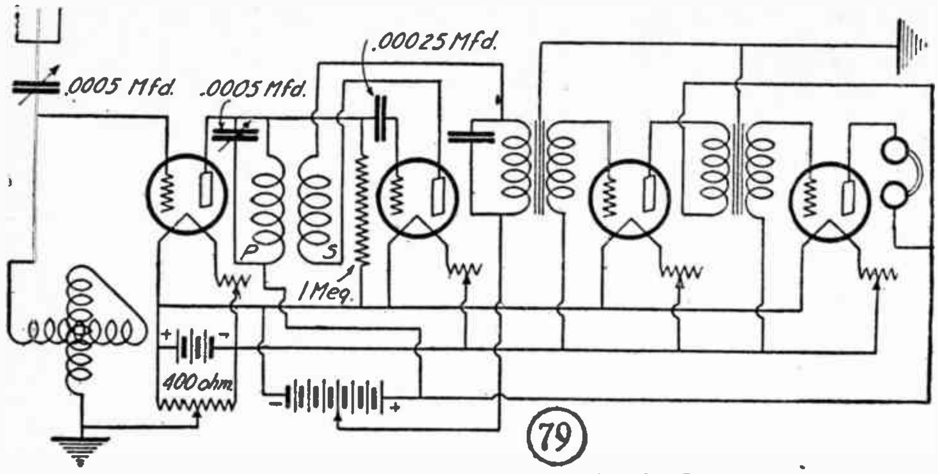
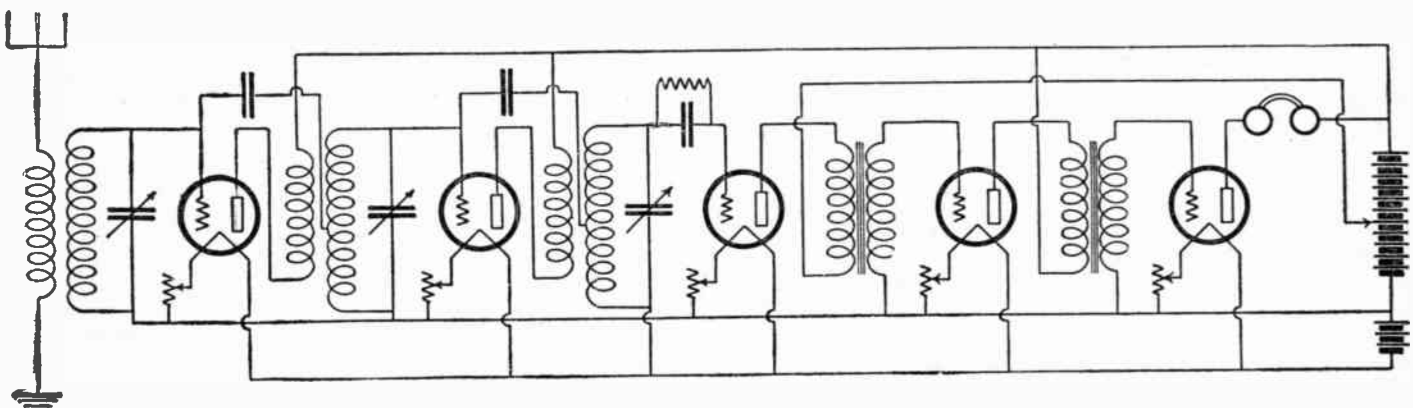


No. 79. An English four-tube set that is excellent for DX work. Connect the 1 meg. leak to grid side of grid condenser.

Circuit No. 79. For the fan who wishes a set that is stable and excellent for DX work, we can recommend the one shown in Fig. 79. It is an English circuit and built entirely of standard parts. The variometer in the antenna circuit and the variocoupler that is used as a radio frequency transformer should be of a high grade, for the proper functioning of the circuit is dependent upon their quality. The 400-ohm potentiometer is used to place the correct grid bias on the radio frequency tube. The cores of the audio frequency transformers are shown connected to ground, but this is optional. Connect the stationary plates of the variable condenser in the antenna circuit to the antenna binding post and those of the variable condenser across the stator of the variocoupler to the plate binding post of the tube. UV-199 tubes will work very well in this set, but it is recommended that UV-201A tubes be used for the best results. The audio frequency transformers should have a ratio of 5 or 5½ to 1. At least 90 volts "B" battery should be connected to the plates of all the tubes with the exception of the detector,

Do not try to force loud signals by using too much "B" battery; 67½ volts is usually sufficient and no more than 90 should ever be used. The condensers shunted across the secondaries of the "neutroformers" have 17 plates and by careful adjustments when placing the dials on them, stations can be tuned in at approximately the same readings for all three. UV-201A type of tubes will be best in the four amplifier stages and the UV-200 type should be used as a detector, although a 201A may be used.



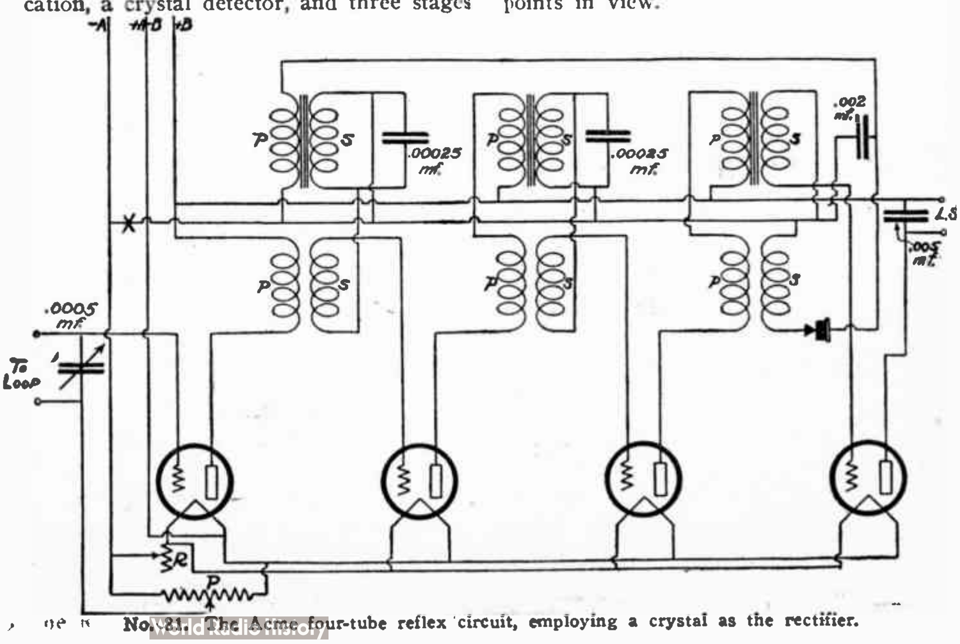
No. 80. A five-tube Neutrodyne circuit with two stages of audio frequency amplification.

Circuit No. 80. To dwell at length upon the wonders of the Neutrodyne receiver would be rehearsing an oft told tale. However, no series of circuits would be complete without one. The hook-up shown in Fig. 80 is the standard one that was invented by Prof. Hazeltine, except that there has been added two stages of audio frequency amplification. A variometer may be used for obtaining regeneration. This is placed in the lead from the plate terminal of the third tube to the primary of the next transformer. This will considerably improve the reception of weak signals and give a more uniform action over the entire range of broadcast wave-lengths.

Circuit No. 81. In the accompanying diagram is the Acme reflex circuit, which has three stages of radio frequency amplification, a crystal detector, and three stages of audio frequency amplification. There are but four tubes used, however, which should be of the UV-201A type. The crystal should be a fixed detector. If the set has a tendency to oscillate or howl, try reversing the leads of the transformers one pair at a time until the noise has stopped. The use of a "C" battery is good practice in this, as in any circuit that has more than three tubes, because it not only reduces "B" battery consumption, but also greatly improves the quality of reception. This battery is placed at X with the positive terminal of the "C" battery connected to the negative "A" lead and the negative terminal to the secondaries of the transformers. The loop antenna is of special design. It has 15 turns of No. 22 Litz. wire spaced 3/8 inch apart wound in a spiral on sticks three feet long.

Use manufactured R.F. transformers and in the audio amplifier do not use transformers with a higher ratio than 5 to 1.

A good many reflex circuits are hard to get into correct operation as they are critical and erratic. This one particular set, however might almost be classed as an exception to the rule inasmuch as possibly thousands of them have been built and practically all of them have worked perfectly without the least bit of trouble. This is one of the simplest and most powerful reflex circuits that has ever been designed and if good apparatus is used in it, the results should be all that can be expected from four vacuum tubes and possibly even a little bit more. Use a good stable crystal detector as this is an important part of the set. A permanent one is to be desired, if simplicity is one of the points in view.



No. 81. The Acme four-tube reflex circuit, employing a crystal as the rectifier.

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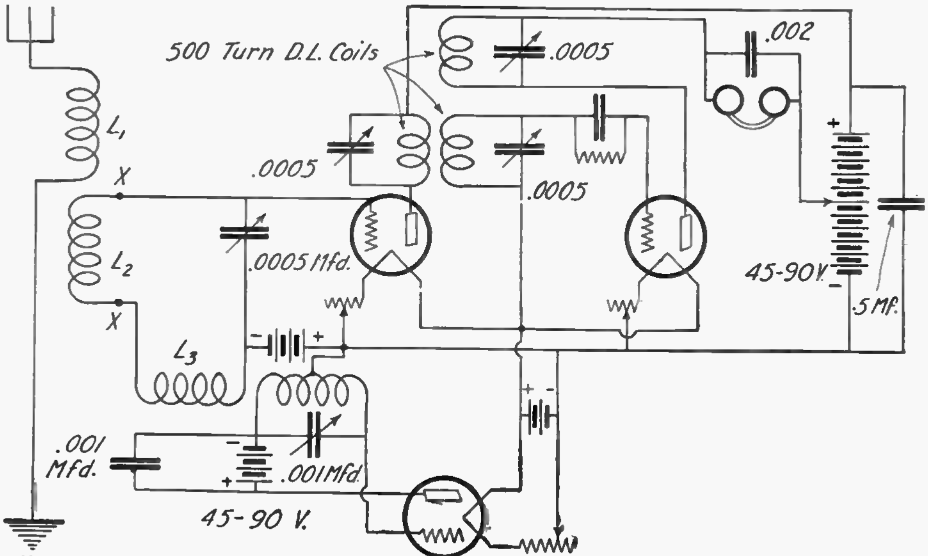
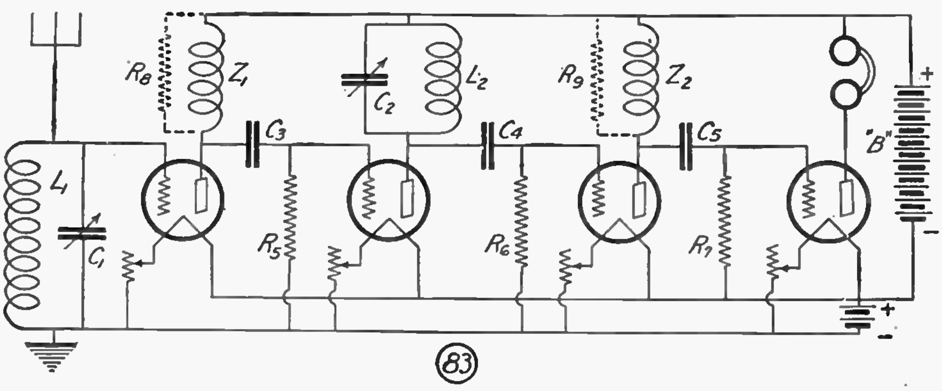


No. 82. A three-tube Super-Heterodyne circuit with one tube functioning as first detector, one as second detector and one as oscillator.

Circuit No. 82. Many fans are anxious to experiment with the Super-Heterodyne circuit, but the expense of the equipment has prevented them. In Fig. 82 is shown a circuit that has for its principle the Super-Heterodyne method and the parts are relatively inexpensive. The constants of the coils are as follows: No. 20 D.C.C. wire is used for winding all the coils. L^1 is five turns on a 4-inch tube and L^2 is 35 turns on the same tube, starting ¼ inch from L^1. L^3 is four to eight turns on a 3-inch tube and L^4 is 27 turns on the same tube, the latter winding being tapped at the 13th turn. The three honeycomb coils in the plate circuit of the two tubes should be placed in a regulation mounting, so that their inductive relationship may be varied. If a loop is used with this circuit it is connected in the places marked X, thereby eliminating the primary and secondary windings, L^1 and L^2. The set is tuned by the .0005 mfd. condenser across the secondary and the .001 mfd. condenser in the oscillator circuit. The three .0005 mfd. condensers shunted across the honeycomb coils need very little adjustment after once being set.

The tuning of this circuit is not very difficult. Place the .0005 mfd. variable condenser in the L^2 L^3 circuit at a low scale reading and slowly turn the .001 mfd. variable condenser, which controls the oscillator circuit, until a hissing noise is heard. If no signals come in at this point increase the .0005 mfd. condenser reading one or two degrees and retune the oscillator circuit condenser until the hissing is again heard. This is continued until signals are heard.

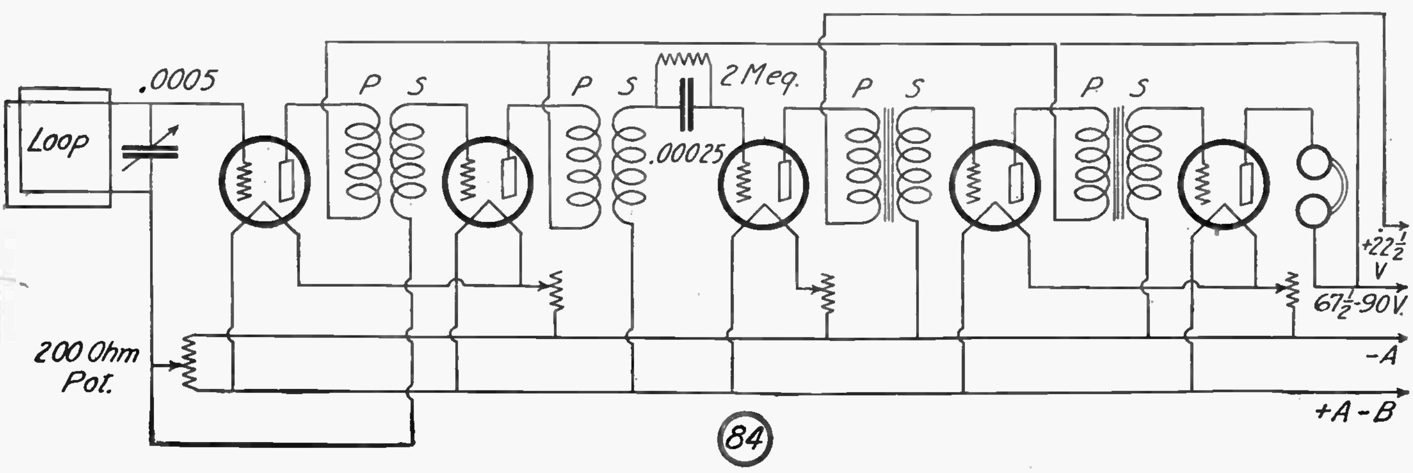
Circuit No. 83. In Fig. 83 is shown an English circuit comprising three stages of radio frequency amplification and a detector. Z1 and Z2 are choke coils and are wound on a tube 2 inches in diameter, using 350 turns of No. 30 B. & S. gauge D.C.C. wire. L1 and L2 are made of 54 turns of No. 20 B. & S. gauge D.C.C. wire wound on a 3-inch tube. The variable condensers, C1 and C2, have a capacity of .0005 mfd. The three condensers in the plate circuits of the tubes, C3 and C4, have a capacity of .0005 mfd. and C5, a capacity of .00025 mfd. The resistances, R5, R6 and R7, have a value of 70,000 ohms. There are shown two resistances, R8 and R9, of a resistance between 50,000 and 100,000 ohms, that may be used instead of the choke coils. UV-199 tubes may be used in this set, but UV-201 A tubes will give better volume. In this circuit although three stages of radio frequency amplification are used, there is but one condenser to tune, controlling these three stages. With the other condenser in the grid circuit of the first tube, this makes the set as easy to tune as one with but one stage of radio frequency amplification and detector.



Three stages of radio frequency amplification and detector employing the T. A. T. system.

Circuit No. 84. For the fan who is looking for a set that brings in the stations consistently we can recommend the circuit shown in Fig. 84. It has two stages of transformer coupled radio frequency amplification, detector, and two stages of audio frequency amplification. One of the greatest advantages of the set is that there are but two controls—the .0005 mfd. condenser shunted across the loop antenna and the potentiometer that adjusts the grid bias on the first two tubes. Any good make of radio frequency transformer may be used. However, proper precautions should be taken to prevent any inductive coupling between them. The condenser should be of the low loss type and a vernier adjustment is essential. UV-201A tubes are recommended for use in this circuit.

Above it was mentioned that any good make of radio frequency transformer would suffice in the plate circuits of the first two tubes; it should also be stated that the transformers should be built around laminated iron cores. When purchasing radio frequency transformers, the buyer should ascertain the wave-length band that the transformer is designed to cover. If the receiver is designed for broadcast reception the transformers should be designed to cover a wave-length band from 200 to 600 meters. The selection of the radio frequency transformers should be carefully made, as the receiver will not function at maximum efficiency unless there are excellent transformers in the circuit.



Five-tube receiver employing two stages of transformer coupled radio frequency amplification, detector, and two stages of audio frequency amplification.

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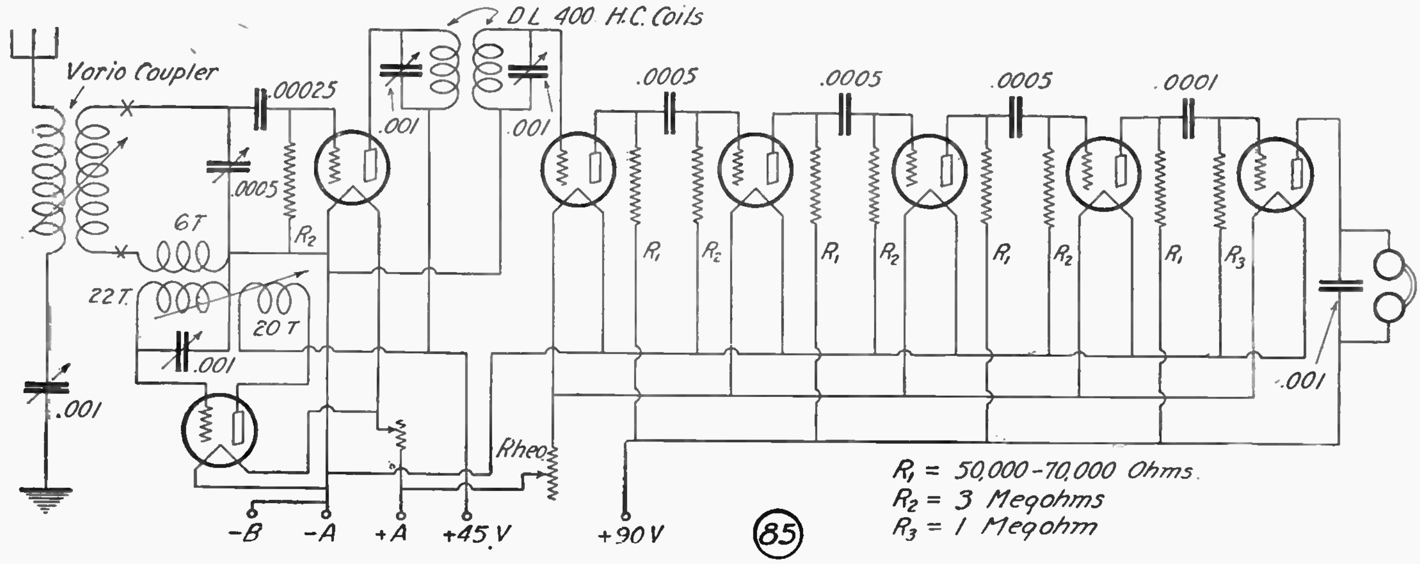
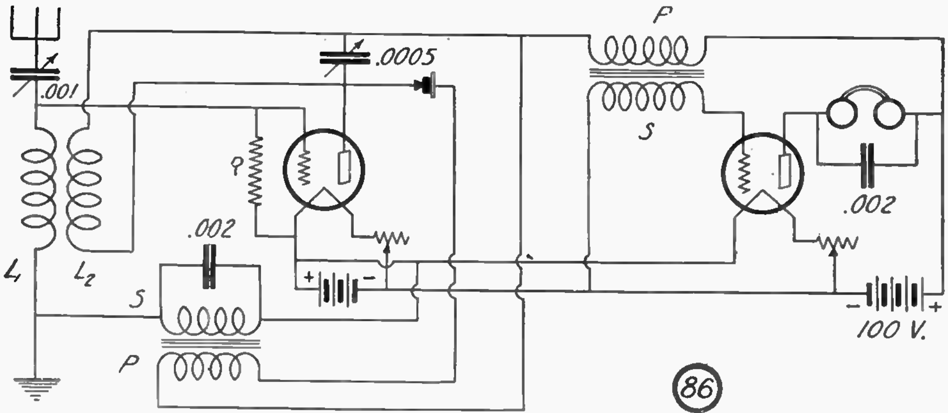


Standard super-heterodyne seven-tube circuit.

Circuit No. 85. The Super-Heterodyne needs very little introduction to radio fans in general. However, as is true with every fundamental circuit, there are many variations of it. In Fig. 85 is a standard Super-Heterodyne, the only variation being the use of resistances and condensers instead of the intermediate radio frequency transformers. Almost all the values of the apparatus are shown in the diagram. At the points marked X in the connections from the secondary of the variocoupler, a loop antenna may be substituted for a coupler. The two .001 mfd. variable condensers shunted across the honeycomb coils, after once being set, need very little adjusting, the set being tuned with the other three variable condensers. However, if a loop antenna is used instead of the variocoupler, this will reduce the tuning controls to two. The leads from the resistances and condensers should be kept as short as possible. The 6- and 22-turn coils may be wound on the same 3-inch tube, the 20-turn coil being wound on a tube that will rotate freely inside the 3-inch tube. The use of UV-201A tubes is recommended for this circuit.

Circuit No. 86. The S.T.-100 circuit is a stage of radio frequency amplification, crystal detector, and two stages of audio frequency amplification. The S.T.-100 is one of the easiest reflex circuits to build, there being nothing tricky about it. The usual precautions in wiring a set should be observed, as short leads from and to transformers, etc. The antenna inductance L1 should be a 35- or 50-turn honeycomb and the tickler coil should be a 75-turn honeycomb. The resistance between the grid of the first tube and the positive filament should be about 100,000 ohms. This is an essential part of the circuit and if unsatisfactory results are obtained with 100,000 ohms, lower values should be tried. The "B" battery of 100 volts may be shunted by a 1 mfd. condenser. Because there is but one stage of radio frequency amplification, the S.T.-100 is not very effective on long distance signals. Its chief use seems to be in obtaining very loud signals within a 50-mile range. Also the reception on a loud speaker is much better than when phones are used. By applying 4.5 to 9 volts on the grids of both tubes, the quality of speech and amplification is materially improved.

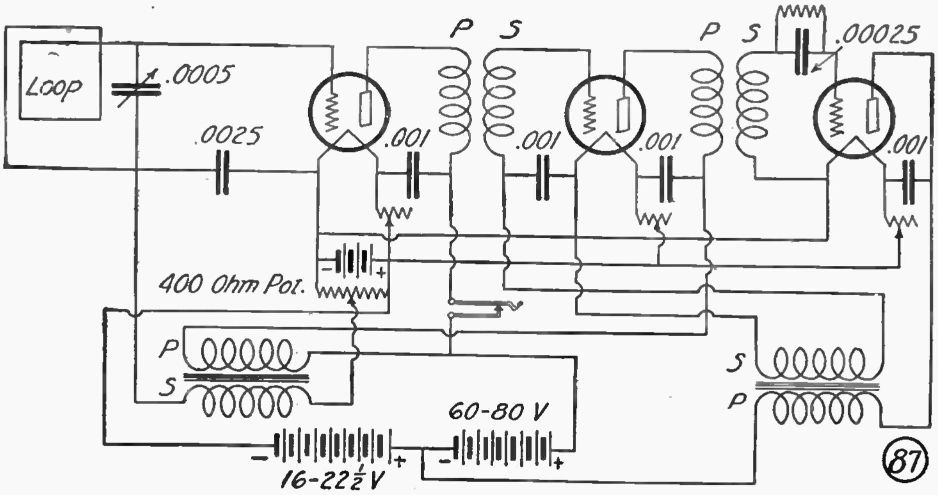


English reflex circuit using one stage of radio frequency, crystal detector and two stages of audio frequency amplification.

Circuit No. 87. The Inverse-Duplex circuit shown in Fig. 87 is so arranged that each tube does the work of two. In many reflex circuits some tubes do more work than others and an unbalanced circuit results with correspondingly poor reception. The Inverse-Duplex is so designed that all parts of the circuit are balanced. Before the audio frequency stages of amplification are added, the radio frequency stages and detector should be tested. Also before connecting any condensers in the set, they should be tested for short circuit. If the first part of the circuit functions satisfactorily, the two audio frequency transformers may be added. This set is rather a difficult one in which to eliminate howls, but by reversing the leads to the transformers this trouble may be overcome. A loop antenna is the proper type to use. Wind 8 to 12 turns of No. 18 wire spaced ¼ inch apart on an 18-inch frame. UV-201A tubes or those of similar type should be used, as the set is designed to operate with storage battery tubes.

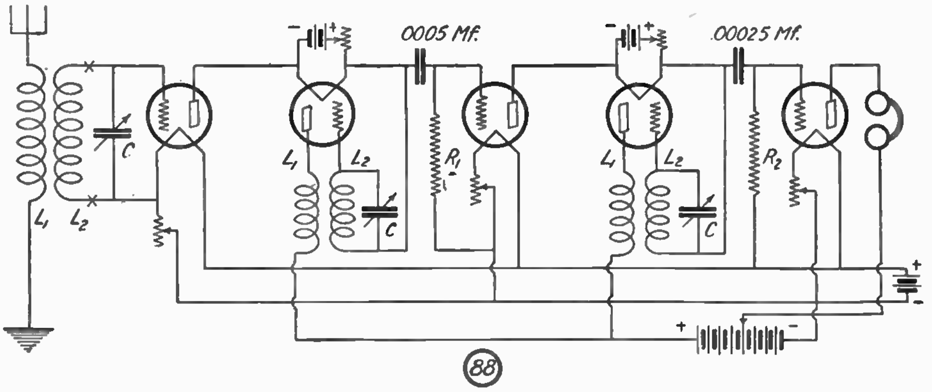
The 400-ohm potentiometer that is connected across the filament battery is used in order to give the proper grid bias to the first tube. As in every receiver employing radio frequency amplification, the grid bias is an important factor in the stabilizing of the set, as it allows the tube to operate at the proper point on the grid voltage-plate current characteristic curve.

The one big feature of this particular reflex circuit is that the tubes are not in any case overloaded. This is the trouble with the usual reflex circuit but by the Inverse Duplex method, the tube that acts as the first stage of R. F. is the second A. F., while the second R. F. acts as the first A. F. Thus the loads are balanced.



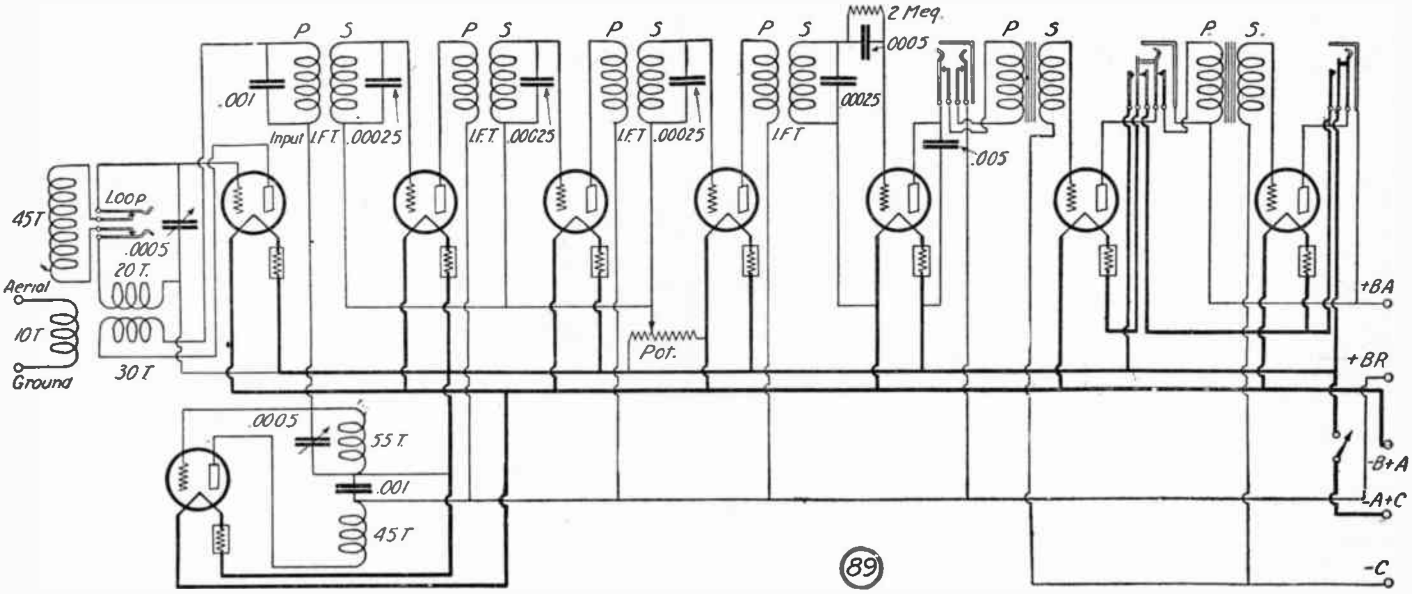
The three-tube Inverse-Duplex circuit.

Circuit No. 88. A new and ingenious system of resistance coupled radio frequency amplification is shown in the accompanying sketch. Not only are the vacuum tubes used as amplifiers, but they are also employed as resistances. The chief feature of the circuit is the minimization, if not the complete elimination of foreign noises and distortion. The inductances L1 and L2 are wound on a three-inch tube. The secondary of 60 turns is wound on the tube first, over which is placed a strip of varnished cambric for insulation. On this cambric is wound the primary of 15 turns. The condensers C have a value of .0003 mfd. The resistance R1 is 1 megohm and R2 is 2 megohms. The second and fourth tubes are of the WD-11 type because a separate filament battery must be used for each. The other three tubes should be of the UV-201A type for best results. If it is desired to use a loop antenna, the first coupler may be eliminated and the loop may be connected at the points marked X. As in all resistance coupled amplifiers, the voltage of the "B" battery must be higher than in the ordinary tuned plate or other style circuits. The exact plate potential required will vary with the type of tube used. The high degree of amplification and clarity of signal obtained with this circuit is truly remarkable. The construction is well within the scope of the average experimenter.



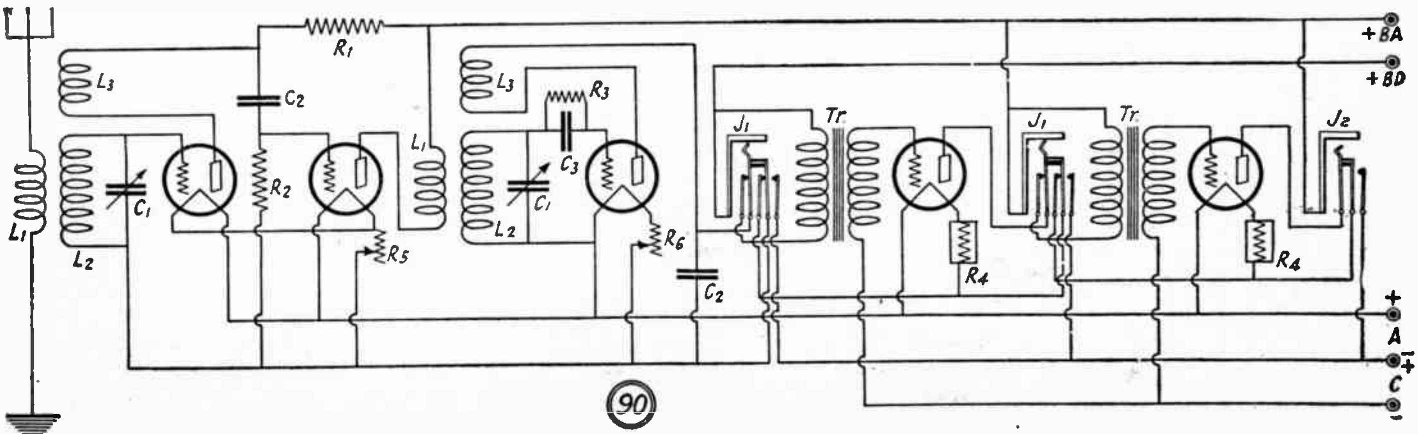
Circuit employing a unique method of radio frequency amplification. The use of two WD-11 tubes with separate "A" batteries is a new point. Extreme selectivity as well as high amplification is given by this circuit.

Circuit No. 89. In the circuit shown in Fig. 89 there is incorporated a different system of producing beat notes than is employed in any other Super-Heterodyne receiver. Amperites instead of rheostats are used throughout. The 200 to 400-ohm potentiometer shown is used to give the proper grid bias to the intermediate frequency tubes. It is hardly necessary to say that the apparatus should be so placed that leads may be as short as possible.



The Ultradyne Super-Heterodyne circuit, using the modulation system. Note the difference in the connection at the first tube and the form used in the absorption circuit. This hook-up gives the complete wiring diagram for the Ultradyne including two stages of audio frequency amplification.

Circuit No. 90. The secret of this set's success lies in the blocking tube used between the first and second regenerative circuits. Oscillations are controlled entirely by the two ticklers, there being no potentiometer, which adds greatly to the simplicity of control. The couplers are alike as to size and windings. They may be made with any 180-degree variocoupler form. First wind on the stationary form 40 turns of No. 24 D.S.C. wire. Directly over this winding, a strip of cambric should be placed, over which are wound seven turns of the same wire. The tickler coil should have 40 turns of the same size wire. These three windings should be wound in the same direction. The variable condensers C1 are .0005 mfd. and C2 have a value of .0005 mfd,. C3, the grid condenser, is .00025 mfd. R2 and R3 are resistances having a value of 2 megohms and the resistances R4 are amperites. Results may be obtained using either a loop or an outside antenna. If a loop antenna is used, the primary of the first variocoupler is eliminated from the circuit, the loop being connected in series with the secondary.



Five-tube cascade regenerative circuit including two stages of audio frequency amplification with filament control jacks. The 3-coil units must be in non-inductive relation. R1 is a 10,000 to 100,000 ohm variable resistance.

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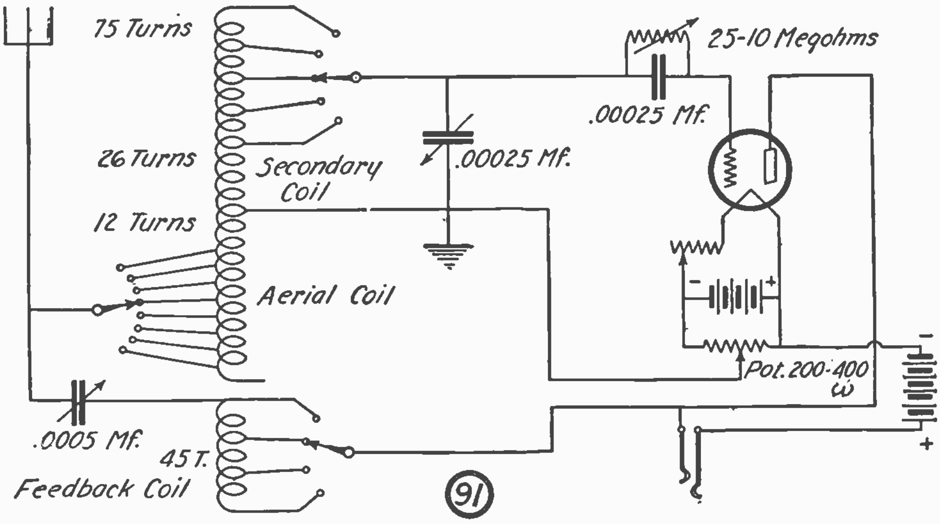
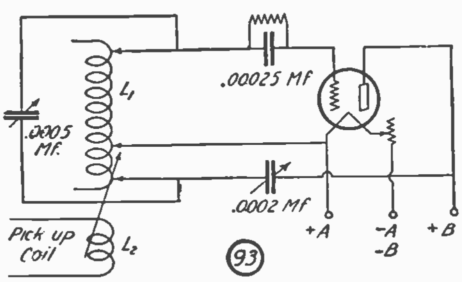


The selective and efficient Reinartz hook-up having in the circuit a potentiometer for controlling the grid bias.

Circuit No. 91. The hook-up shown in the accompanying sketch is the well-known Reinartz circuit. The efficiency of this circuit is due largely to the fact that all the inductances are brought together and concentrated in one small space. The coils forming the aerial-secondary and feed-back inductances may be wound on a 2½-inch tube with No. 22 D.C.C. wire. The feed-back coil may be spaced about ¼ inch from the other. If a spider-web coil is used the all around efficiency will be increased. The coils then are wound on a form that is 1¾ inches in diameter. The aerial-secondary coil is tapped at every turn for the first 10, the 12th turn is tapped and connected to ground and the movable contact of the potentiometer, and from the 26th to the 75th turn the coil is tapped every seven turns. The feed-back coil of 45 turns is tapped at every 15th turn. The movable plates of the .0005 mfd. condenser should be connected to the antenna and those of the 11-plate condenser which should be of the vernier type, should be connected to the ground. The inductance should be mounted at least three inches back of the panel so that the leads from the inductance will extend directly to the switch points without crossing. The dry cell type of tube may be used, but the UV-201A type is recommended. With a potentiometer in the circuit, as illustrated, this set, if properly constructed, should be an excellent DX getter.

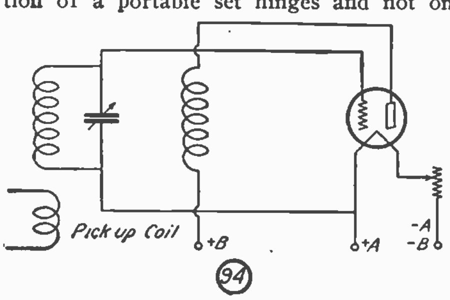


The Hartley oscillator circuit employing one tapped coil and a pick-up coil.

It is interesting to note that this circuit was designed primarily for C.W. reception, but it is one of the most selective broadcast receivers known today. The circuit shown in Fig. 91 has only one tube, but audio frequency amplification may be added very easily.

Circuit No. 92. The accompanying diagram shows a circuit that is extremely sensitive; so much so that it will operate very satisfactorily on a ground alone without any antenna whatsoever. It is also selective and easy to control, as there are but two adjustments. The selectivity of this set is due to the fact that it oscillates continually, and unless the incoming signal has exactly the same period of oscillation as that generated by the set itself, it is very effectually blocked out, since the grid circuit cannot oscillate at any period except the one determined by the plate variometer setting. This causes most of the tuning to be done by the plate variometer. This means that tuning out the nearby stations and picking up a weak distant station operating at nearly the same wave-length is always possible. The ground tap is taken from the center of one coil of the variometer. One end of this coil must go to the aerial binding post. When using a ground with no antenna, the ground is connected directly to the antenna binding post. Because of this, this set is especially adapted to being made into a portable outfit. A dry cell tube is recommended if this is to be a portable set, although better results will be found if a large tube is used.

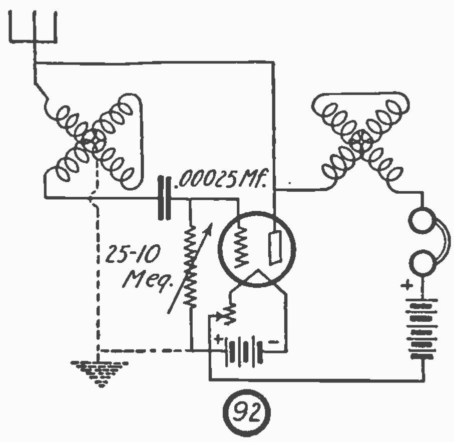
It may not be amiss here to say a few words in regard to circuits that are adaptable to use in portable sets. Editors of radio question and answer departments often receive inquiries asking whether or not this or that type of set can be used in a portable receiver. This question is one that can be answered by anyone knowing anything at all about radio if he will only stop to consider the situation from a few different angles. The first important one is whether or not batteries of large size can be carried. Then again, is more than one tube to be used? Is a loop to be employed or can a regular aerial and ground be used? It is upon these points that the construction of a portable set hinges and not on



The three-coil oscillator circuit.

the actual circuit to be employed. Practically any circuit from a crystal detector to a Super-Heterodyne can be made into some type of portable receiving set. The only thing that it is necessary for the constructor to do is to exercise a little ingenuity in the placement and arrangement of parts. For instance, grid and plate inductances in multi-tube sets should not be in inductive relation to each other. They should be placed so that the windings run at right angles to each other or should be far enough apart so that there can be no interaction between them. Another good example of this work is the angle at which the coils in a Neutrodyne are placed. This arrangement also reduces the inductive effect found between parallel coils. Then again, audio frequency amplifying transformers should be accorded the same treatment. Place the cores at right angles and distortion and noise will be reduced. And so we can see that the answer to the question propounded above is that practically any circuit can be used in a portable receiver if the instruments used are small enough and if judgment is employed in arranging them.

Circuit No. 93. In the accompanying diagram is shown the fundamental circuit for the Hartley oscillator and a pick-up coil for the Super-Heterodyne receiver. The inductance L1 is composed of 50 turns of No. 22 D.C.C. wire wound on a 3-inch tube. The pick-up coil, L2, has 10 turns of the same size wire wound on the same tube spaced about ½ inch from the first mentioned winding.



A two-variometer circuit that is excellent for a portable outfit as it may be used with or without a ground connection.

The oscillations are controlled by the variable condenser of 23 plates and also the amount of inductance that is in the grid and plate circuits. The amount of plate voltage necessary for oscillation depends upon the type of tube that is used. It is advised that a 201A or 301A type of tube be in the circuit, as a higher plate voltage may be applied to this tube, though other types of tubes will operate satisfactorily.

Circuit No. 94. Another type of oscillatory circuit is shown in Fig. 94. In principle it is the same as that of Circuit No. 93. Three honeycombed coils are employed to form the inductances, and the 23-plate condenser is connected across the grid coil for controlling oscillations. The same data for tubes that was indicated in the former oscillator applies to this circuit, too.

Both of these hook-ups are given in these columns because every Super-Heterodyne circuit has as its fundamental, some such circuit for changing the incoming frequency to the wave-length that the intermediate transformers are designed for, by heterodyning. Also the principle of oscillations and how they are produced in a circuit should be thoroughly understood by every experimenter.

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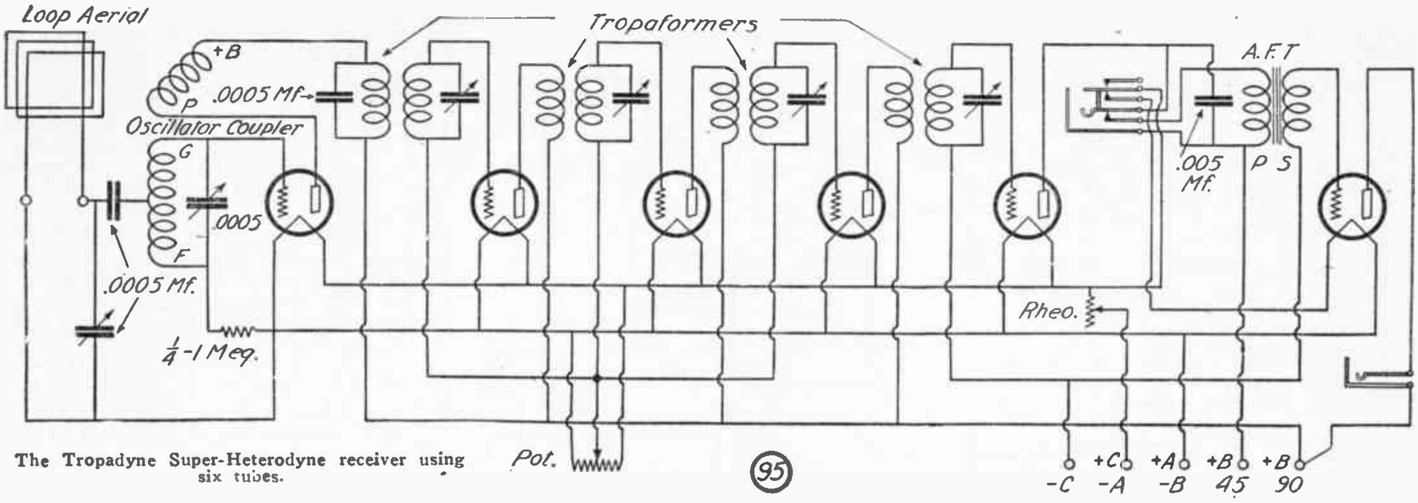


The Tropadyne Super-Heterodyne receiver using six tubes.

Circuit No. 95. The value of the Tropadyne need not be told to readers of *Radio News,* as the merits of the circuit have been told in the August and November, 1924, issues and in this book. In the first place there are but six tubes used, giving as much volume as the average set using more tubes. The selectivity of this set is excellent. Two lengths of three-inch tubing, one three inches and the other four inches long, are required to wind the coupler and the oscillator coils on. The primary and secondary coils are wound on the 3-inch tube and are designated as AG and GF, respectively. The primary coil AG consists of 8 turns of No. 24 S.S.C. wire and the secondary GF is 50 turns of the same wire, both coils being wound in the same direction. On the 3-inch tube that is 4 inches in length, wind on 12 turns of No. 20 S.S.C. wire and then wind on 55 turns of the same wire. On these two tubes the two windings are spaced ½ inch apart. The two variable condensers have a capacity of .0005 mf., *i. e.,* 23-plate condensers. The remaining apparatus has the values indicated in the diagram. The frequency changer tube, which is the first one at the left in the diagram, is placed in the layout of the apparatus between the two condensers. This is done in order to make the connections as short as possible to this tube and condensers. The size of the panel necessary for this receiver is one 7 by 30 inches, which size allows sufficient space for wiring.

Above are given the constants for a coil that is used as a coupler when an outside antenna is used. The coil is shown in the circuit diagram published on page 49 of this book, and is designated by the same letters. Although this circuit functions very satisfactorily on an outside antenna, it performs excellently on a loop antenna, and if this is used the coupler need not be constructed.

The connections of the Tropadyne are similar to the standard Super-Heterodyne, except for the first tube. It will be noticed, however, that there are no grid condenser and grid leak in the circuit of the second detector. These two pieces of apparatus were eliminated because it was found that distortion was decreased to a minimum by operating the tube on the lower bend of the tube's characteristic curve. This is accomplished by connecting the grid return lead to the negative terminal of the "C" battery, which acts as a grid bias for the audio frequency amplifier tube. This applies a negative potential to the grid of the detector, and heretofore very little or no current is absorbed by the detector, and the selectivity of the intermediate amplifier is considerably improved. With a "C" battery of 9 volts and a plate voltage of 45, the selectivity is so great that powerful local stations otherwise broad in tuning are tuned in and out with the vernier alone. This battery does not decrease the volume and the quality of reproduction is remarkable. The data for the construction of the intermediate transformers will be found in this volume as referred to above. These transformers are tuned by variable condensers across the secondaries, so that each transformer is operating on the same wave-length.

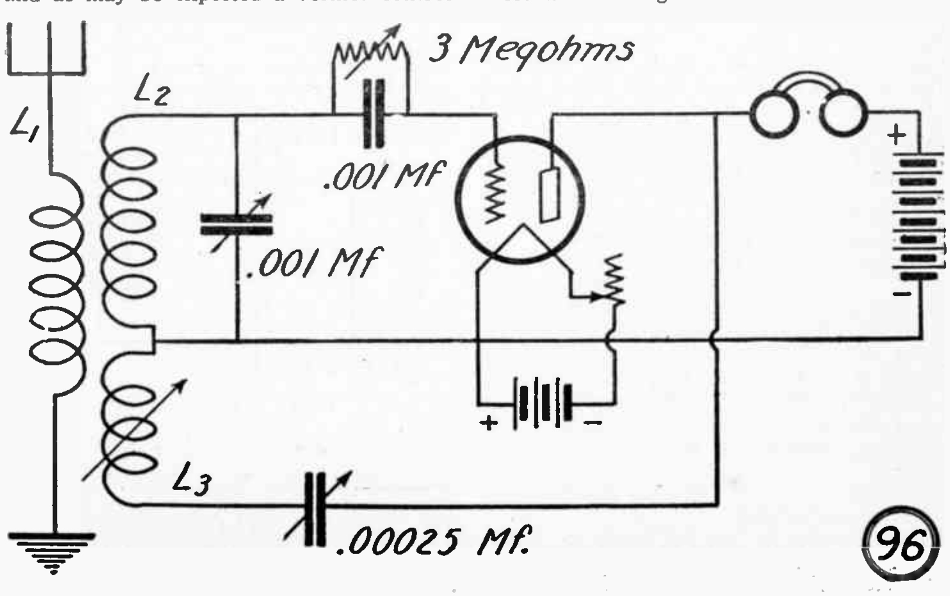
Circuit No. 96. One of the most interesting circuits for the experimenter is the hook-up shown in Fig. 96. It is an adaption of the famous Hartley oscillator circuit. The apparatus required for this circuit can be easily made by the average experimenter. The inductance L2 is wound on a bakelite or hard rubber tube 3½ inches in diameter and consists of 35 turns of No. 18 D.C.C. wire. Directly over this winding is placed L1 which is 10 turns of the same size wire. The movable part of the coil, L3 is wound with 20 turns of No. 20 D.C.C. wire on a bakelite tube 2¾ inches in diameter. The tube on which are wound L1 and L2 is placed with its axis parallel to the panel. In the end opposite that which has the inductance L1 on it, drill two holes diametrically opposite to take the bearings of the rotor, L3. These bearings are made of small machine screws. The rotor does not have to be controlled from the front of the panel, as it remains in the same position after once being set. The two variable condensers are placed at the left-hand side of the panel with the inductances directly in their rear. With this arrangement very short leads are the result.

The tuning of the set is extremely sharp, and as may be expected a vernier control must be used on the .001 mfd. condenser. The close approach to the point of oscillation is evidenced by the fact that the circuit does not "spill over" into oscillations suddenly as is the case with nearly all regenerators. As the regeneration control condenser is increased, the amplification increases continuously, gradually working into the condition for oscillation. The approach is so close that both the incoming signals and the regenerative whistle can be heard at the same time when the tuning is very close.

The adjustment of the movable part of the coil is made as follows: The set is tuned for the longest wave-length it is desired to receive, with the movable coil at right angles to the main coil. This is the condition for least amplification or feedback. The movable coil is rotated until the set just begins to oscillate. It need not be adjusted after this, and it will be found that the controlling may be done entirely by the .00025 mfd. condenser.

This circuit will function on any size antenna, but it is advised that the total length be limited to 120 feet. This includes the lead in. The different sizes of antenna are compensated by the tuning condenser; that is, if the set has been calibrated and a different antenna is used then the readings will be different also.

When constructing this set, be sure that the rotor plates of the .001 mf. variable condenser used for tuning are connected to the filament circuit. It is sometimes advisable to connect this point, that is, the filament circuit, to the ground. Making the connections in this way reduces any body capacity effect that might otherwise be noticed when tuning.



A one-tube regenerative set that gives excellent results and is easy to construct.

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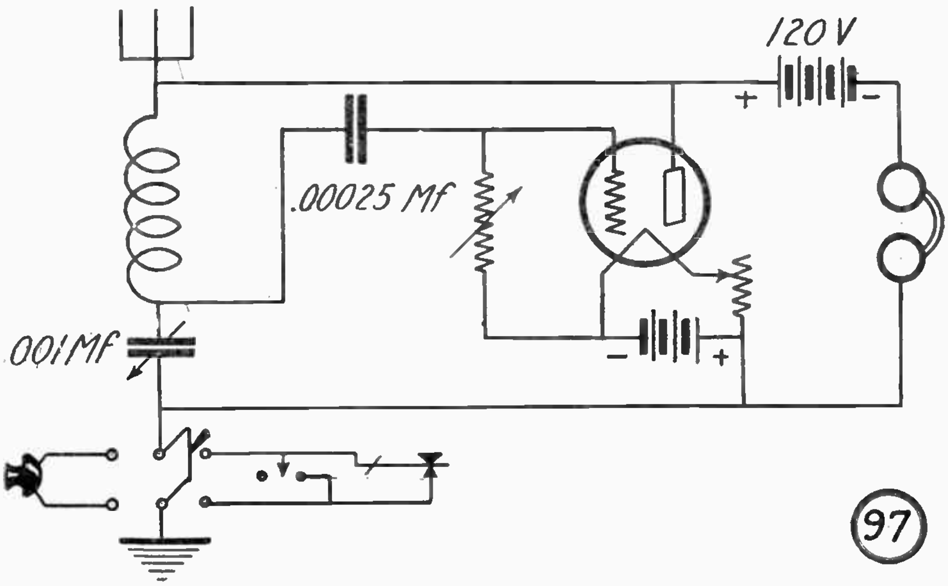


A combination transmitting and receiving set which may be built by the experimenter and which should give excellent operating results.

Circuit No. 97. Have you ever wanted to do some experimenting along the lines of combining a transmitting and receiving set? If so, doubtless visions of motor generator sets, 500-watt tubes and such things have crossed your mind and so discouraged you. Yet here is a circuit that requires none of these expensive things and will illustrate very well the principle involved.

The inductance consists of 30 turns of No. 14 D.C.C. wire wound on a 3-inch bakelite or hard rubber tube. As the variable condenser of .001 mfd. capacity (43 plates) is the only tuning instrument in the circuit a verner attachment of some sort is necessary.

Circuit No. 98. Very few experimenters are aware that audio frequency transformers may be used as shown in Fig. 98. This hook-up is one which will make the set operate on a wave-length in the neighborhood of 6,000 to 10,000 meters and up. As may be seen in the diagram two variable condensers are employed, having a capacity of .001 mfd. (43 plates).

If the experimenter has several types of transformers on the bench, it would be an interesting thing to determine what sort of reception would result with several stages of this sort of amplification. There is no reason to believe that it would not be possible to pick up the long wave stations using a circuit of this type, because the longer the wave-length, *i. e.*, the lower the frequency, the more efficiently will the set operate. If the input transformer of a pair of push-pull transformers is available, the tapped winding would be used to change the wave-length, as tapping in one, either part of or the whole winding would act as a different amount of inductance in the circuit. This transformer would of course be used in the antenna and ground circuit, as primary and secondary.

Circuit No. 99. The circuit numbered 99 is one to delight the heart of the experimenter. It requires six tubes, but every stage of amplification is coupled to the preceding one in a different manner. The experimenter may vary these coupling placements in any way he wishes.

The constants are as follows: One is a standard two-coil type of coupler with an untuned, fixed coupling, primary. Primary "P" may consist of about 10 turns of No. 24 D.C.C. wire wound at the end of secondary "S." This secondary consists of about 50 turns of the same size wire wound on a three-inch tube, but spaced about ¼ to ½ inch from the primary.

Unit two is a standard radio frequency transformer. It will probably be best to use a high-grade iron core radio frequency transformer, as shown, rather than an air core type.

Unit three incorporates resistance coupling with a plate resistor "R," variable between 25,000 and 250,000 ohms. The working value of this resistance will be close to 100,000 ohms.

Unit four shows how a variometer is used for the tuned impedance type of coupling.

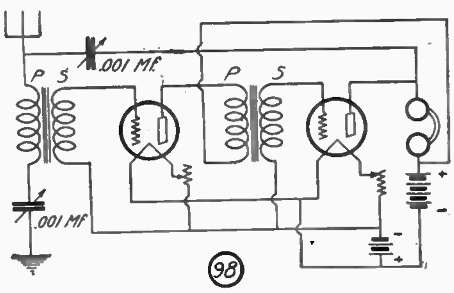
Unit five shows a choke coil type of coupling known as the "T. A. T." system. The natural period, or wave-length, of this coil is outside of the operating range of the set and functions mainly as an inductive resistance. It comprises about 250 turns of No. 30 D.C.C. wire wound on a 2½-inch tube.

Unit six employs tuned impedance, but instead of using a variometer, as in unit four, a coil is shown tuned by a variable condenser. This coil may consist of about 50 turns of No. 24 D.C.C. wire on a three-inch tube.

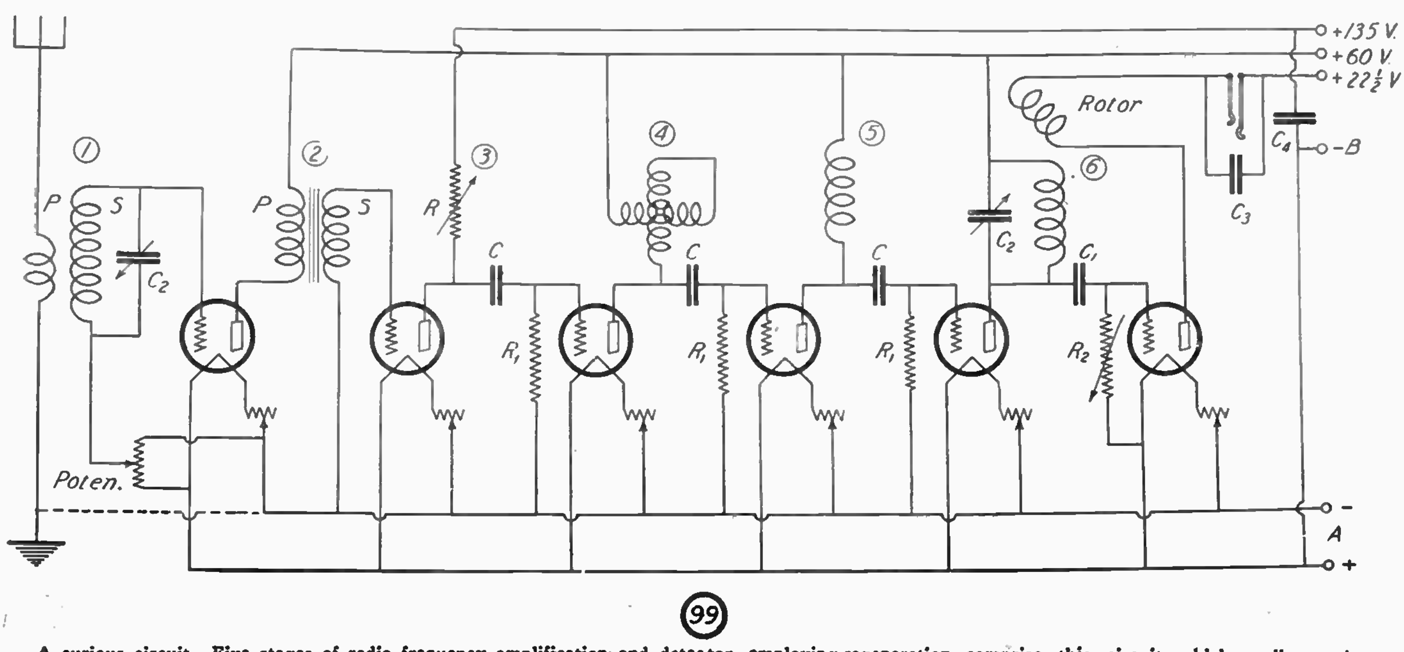
Condensers "C" are blocking condensers used to prevent the plate current being applied to the grids of the tubes. They may be of about .0005 mfd. capacity. The detector condenser, C1, is of .00025 mfd. capacity. Variable condensers C2 are of .0005 mfd. capacity, C3 is about .001 mfd., C4 about .05 mfd.

Resistances R1 are one megohm grid leaks.

The potentiometer has a resistance of 200 to 400 ohms.



A long-wave receiving set using audio frequency transformers for coupling.



A curious circuit. Five stages of radio frequency amplification and detector employing regeneration comprise this circuit which really works. Tuned transformer, untuned transformer, resistance, impedance, choke and another form of tuned impedance coupling are used in the sucessive stages.

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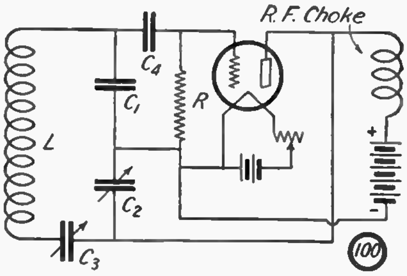


The Colpitts oscillator is shown above. As will be noticed, the "B" battery is not in the oscillatory circuit and the interposition of the R. F. choke keeps the radio frequency currents from leaking off.

Circuit No. 100. Another efficient form of oscillator other than the Hartley described before is the Colpitts circuit. In this circuit, the coupling between input and output is capacitative and can be varied by changing the value of the capacity C_2. In effecting this change, the oscillatory period of the circuit $LC_2C_3C_1$ is changed, and it thus becomes necessary to change the capacity C_3 an amount necessary to obtain the desired period of oscillation.

It might be well to recall that in the case of the Hartley oscillator, the coupling between the input circuit (grid), and the output circuit (radio frequency), was obtained by conductive coupling. As noted above, the double adjustment is somewhat of a slight disadvantage when using the Colpitts oscillator in practice. The capacity C_2 has the high potential applied to it and in order not to affect the oscillatory circuit $LC_2C_3C_1$, a radio frequency choke coil must be interposed between the plate supply, as is shown. C_4 is a grid condenser while R is a grid leak. Due to the multiplicity of condensers it is best to check the frequency with a standard wavemeter, because the matter of calculating the frequency would resolve itself into a rather difficult job.

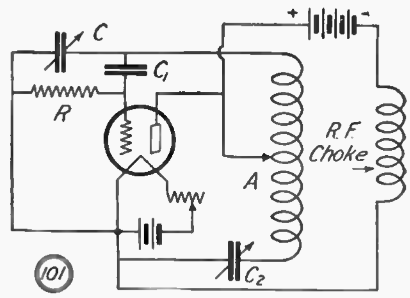
Circuit No. 101. One of the simplest oscillators is that devised by Heising. The circuit has a number of desirable features, which are evident upon reference to the diagram. By changing the position of the clip A, it is possible to vary the coupling between input and output. This form of oscillator has found wide appreciation and is being used by many amateurs and experimenters. Here again, as in the Colpitts oscillator, the capacity-grid leak resistance method of obtaining the required negative potential on the grid of the tube, is used.

There are different modifications of oscillators, but all are adaptations of the circuits described.

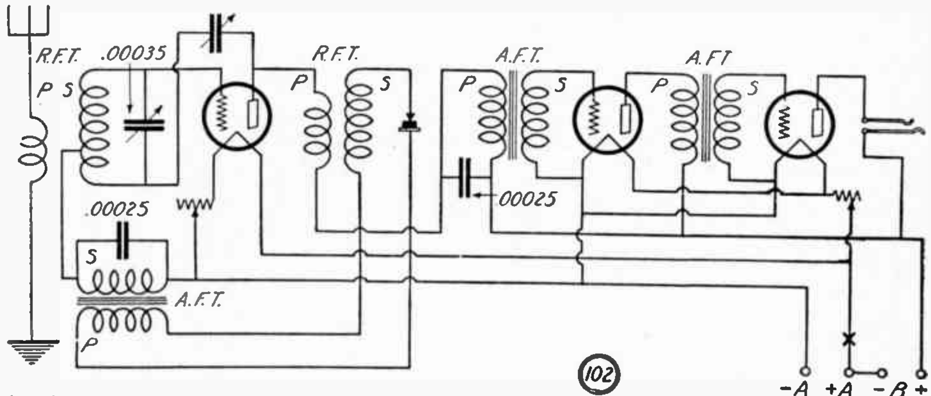
Circuit No. 102. So much has been said about the popularity, low cost, and faithful reproduction of the reflex circuit, that many people are beginning to realize its importance and are turning toward it. However, as there are so many reflex circuits, it is often confusing to the layman as to just what circuit he should use. The Rasla reflex circuit, as shown in the accompanying diagram, is one of the simplest and most efficient receivers of this type it is possible to build.

By reference to the diagram, it will be noted that the antenna system is untuned, of a semi-aperiodic nature. The secondary is tuned by .00035 mfd. condenser of the low loss type, but as will be noted, only a part of the secondary coil is included in the grid circuit. A small balancing condenser tends to obviate the undesirable creation of oscillations, and also serves somewhat as a volume control. Analyzing the circuit we see that it consists of one stage of tnned radio frequency amplification, crystal detector, a reflexed stage of audio frequency and two stages of straight audio frequency amplification.

The radio frequency transformer is one that is designed so that its impedance matches that of the fixed detector, thus giving maximum transfer of energy and efficient coupling. A .00025 mfd. fixed condenser is shunted across the secondary of the audio transformer which is used for reflexing. A 30 ohm rheostat is necessary for the careful adjustment of the detector tube, while a 6 ohm rheostat will handle the audio frequency amplifier tubes very nicely.



Heising's oscillator is depicted above. The condensers C and C2 tune the grid and plate circuits respectively. Heising is famed for his method of modulation.



An efficient reflex circuit. It consists of one stage of tuned radio frequency amplification, crystal detector, reflexed audio amplifier and two stages of additional audio frequency amplification. This circuit can be successfully operated with a loop antenna, if the loop is directly connected to the tuning condenser. It can also be employed successfully in a portable set, if dry cell tubes are used.

Circuit No. 103. It is a safe bet that one out of every five receivers now on the market is a regenerative set employing 3 or more tubes. The owners of such a set experience interference which often cannot be eliminated readily and many of them resort to a wave trap as a remedy.

By the addition of one tube more, it becomes possible to increase greatly the range and selectivity of the set. The extra tube is used in the capacity of a radio frequency amplifier, which through the use of a small variable condenser known as a neutralizing condenser, affords protection against radiation and serves as an aid to distance-getting.

The antenna is connected to a six turn primary winding on a form 3½ inches in diameter. This winding is placed in the center and above a secondary consisting of 60 turns of No. 22 D.C.C., the same size wire being used for the primary. A .0005 mfd. variable condenser is shunted around the secondary and will be found to give excellent selectivity. The regenerative qualities of the three-circuit tuner will still more enhance the receptive ability of the receiver as a whole.

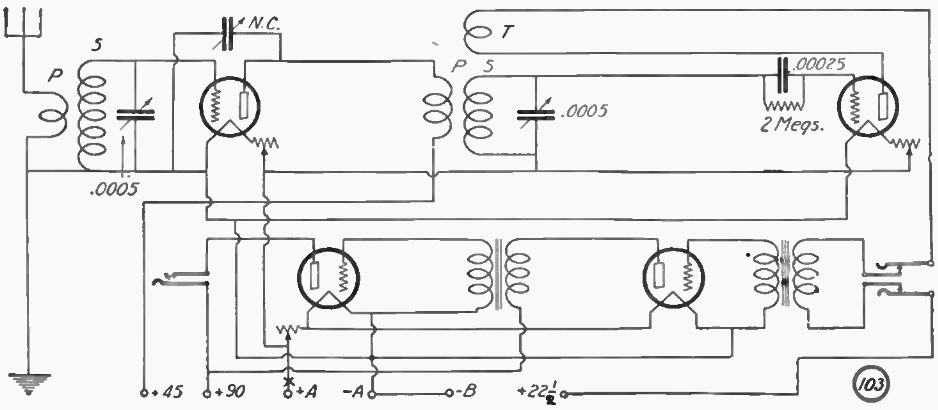
Whether two stages of transformer-coupled audio, three stages of resistance-coupled or one stage of push-pull amplification are used, the circuit will give unexcelled results when properly wired.

For the beginner who desires to build the tuner himself, the following information may be helpful. The primary consists of twelve turns of No. 12 D.C.C. wire on a tube three inches in diameter. The secondary can be wound on the same tube about one-half inch away and consists of 55 turns of No. 16 D.C.C. The tickler coil is wound with No. 22 D.C.C. on a smaller size diameter tube and contains 34 turns. It should be mounted in close inductive relation to the secondary and should be variable in coupling to it.

If it is desired, a standard three circuit coupler of the ordinary type available on the market today may be used for the tuning coil indicated by P, S and T in the diagram.

A word about the auxiliary equipment. The antenna should be a single wire about 100 feet long and well insulated. The ground connection should go to a cold water pipe and a good clamp employed which will insure a permanent connection.

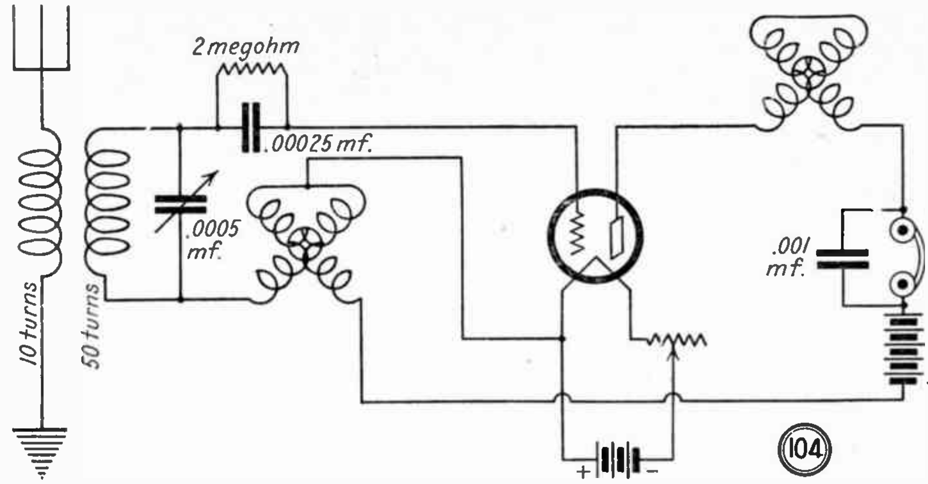
The small neutralizing condenser will have to be adjusted occasionally and should have a value of 15 mmfd. maximum capacity.



Combining tuned neutralized radio frequency amplification with regeneration and two stages of audio amplification gives a splendid hook-up. Neutroformers are employed, the second one being augmented with a rotor upon which is wound the tickler coil. This circuit is considered to be very selective.

World Radio History

Circuit No. 104. This is an interesting circuit for the experimenter, as it uses a split variometer as well as a regulation variometer. The primary and secondary coils are wound on a 3-inch bakelite or hard rubber tube, the primary being wound over the secondary. The primary, which is aperiodic, consists of 10 turns of No. 24 D.C.C. wire and the secondary is 50 turns of the same size wire. The variable condenser, which has a capacity of .0005 mfd., is shunted across the secondary and should be of a low resistance type. The variometers are of standard design in order to cover the wave-length band.

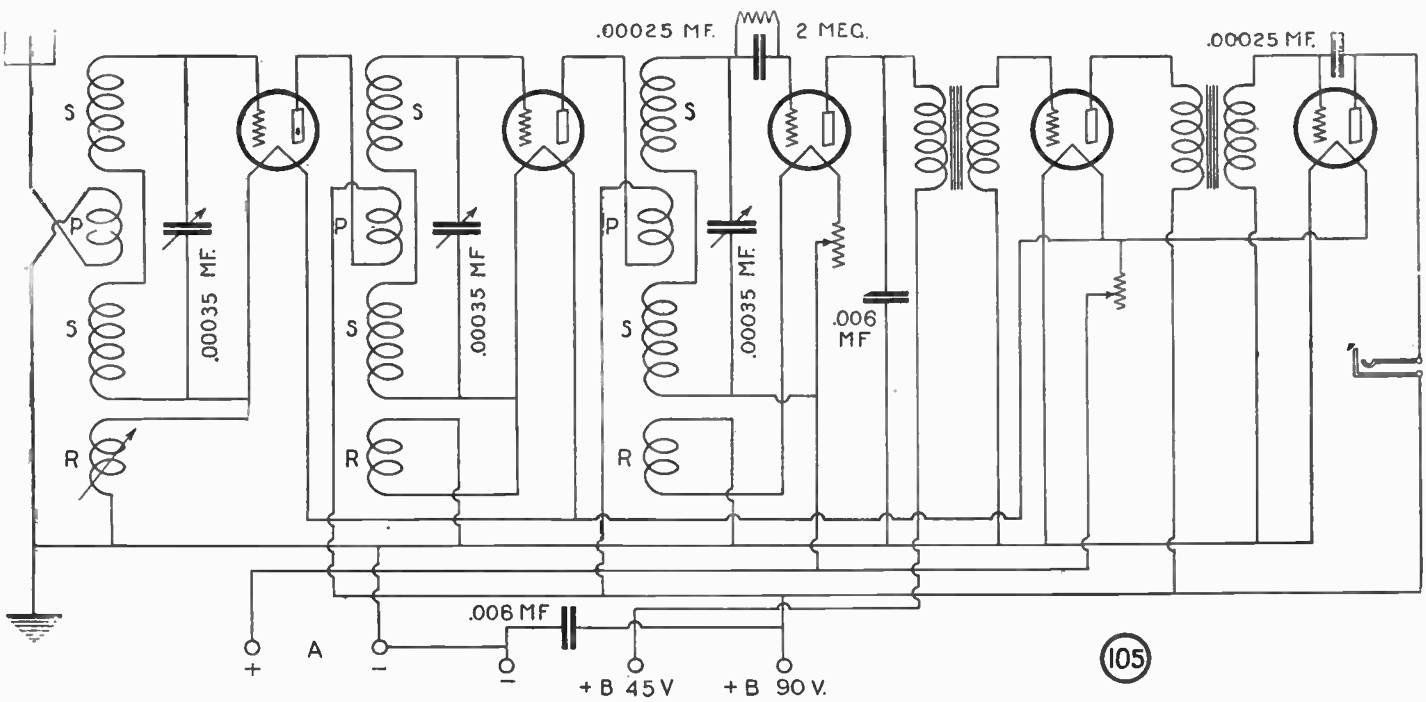


Regenerative circuit using two variometers, one having split windings. Circuit good for DX work.

Circuit No. 105. The receiver that is shown in the accompanying diagram is one that is non-radiating if properly adjusted, and extremely selective. However, a word of precaution should be inserted here: if the set is improperly adjusted it becomes a powerful squealer.

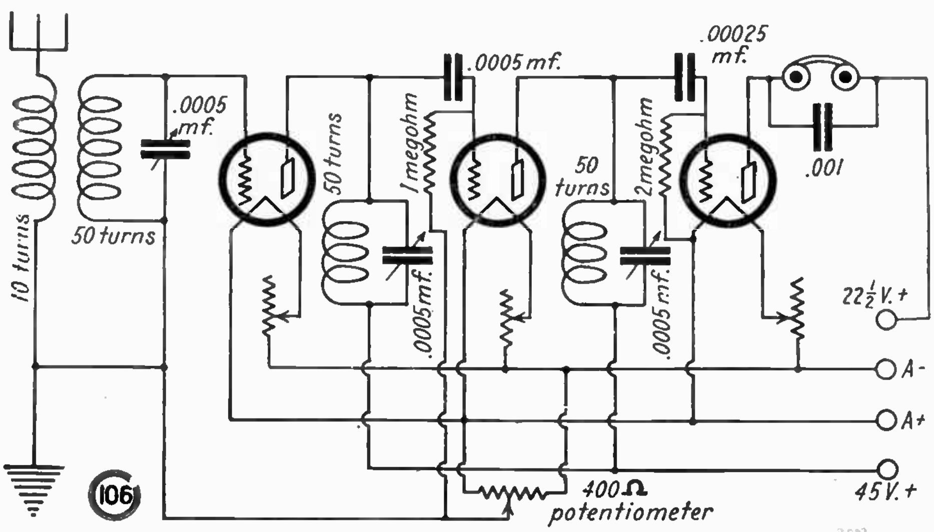
Three bakelite or hard rubber tubes 2½ inches in diameter and 6 inches in length are required. First there is wound on 45 turns of No. 22 D.C.C. wire and ⅛ of an inch away from this winding is wound 6 turns of the same size wire, which is the primary coil. The secondary winding is then continued for another 45 turns, thus making two 45-turn coils in series on the same tube. Then the compensating winding of 6 turns is wound on, in the *opposite* direction from that of the other coils on same tube.

The above description applies to two of the transformers, the third being slightly different in that the compensating coil is wound on a small rotor which is placed at one end of the tube. This rotor is a piece of bakelite tubing 2 inches in diameter and one inch long, at one end of which is placed the 6-turn winding. Here it is unnecessary that the winding be in the opposite direction, as the coil itself may be rotated through 180 degrees and thus change its polarity. This last coil described is used in the grid circuit of the first tube, the other two transformers being used in the second and third tube circuits.

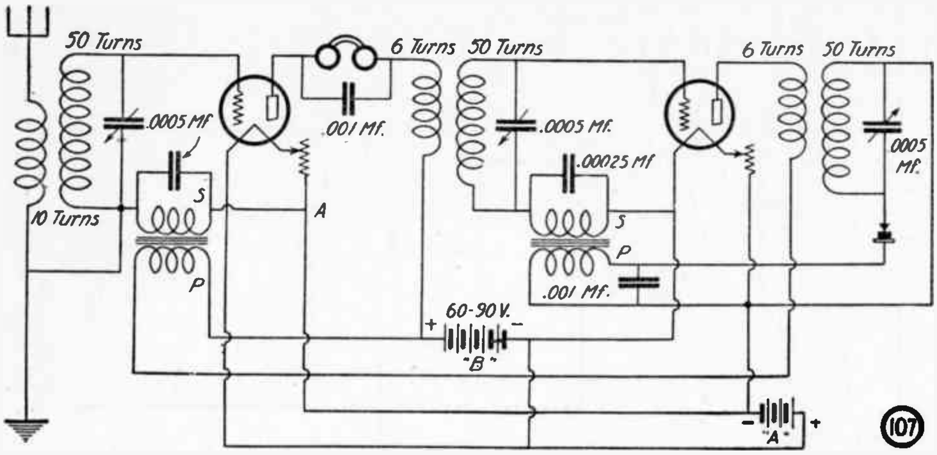


The five-tube non-radiating Monophase circuit, having two stages of radio frequency and audio frequency amplification with detector.

Circuit No. 106. The three-tube circuit that is shown in Fig. 106 is not difficult of construction and, if properly made, should give excellent results. The primary and secondary coils, which are wound on the same 3-inch bakelite or hard rubber tube, consists of No. 24 D.C.C. wire. The aperiodic primary has 10 turns and the secondary, over which the primary is wound, has 50 turns. The two coils in the plate circuits of the radio frequency amplifier tubes are 50 turns of No. 24 D.C.C. wire, wound on a 3-inch tube. The grid leak across the second tube is 1 megohm and that across the detector has a resistance of 2 megohms.



A three-tube set which may be employed for any band of wave-lengths, by the use of honeycomb coils.



In the Inverse-Duplex circuit each tube does double duty. The crystal detector insures clarity.

Circuit No. 107. The circuit of the Inverse Duplex receiver is so made that each tube performs its duty as a radio frequency amplifier as well as an audio frequency amplifier. This circuit is so designed that all parts of it are balanced, which is not always the case in reflex circuits. This unbalancing of reflex circuits is one of the chief causes of trouble in this type of receiver. It is an excellent plan to thoroughly test the radio frequency stages of amplification before adding on the audio frequency stages. In the accompanying diagram the circuit is shown with a crystal detector instead of the electron tube that has formerly been used. This type of detector should give exceptionally clear signals and the difference in volume will be hardly noticeable.

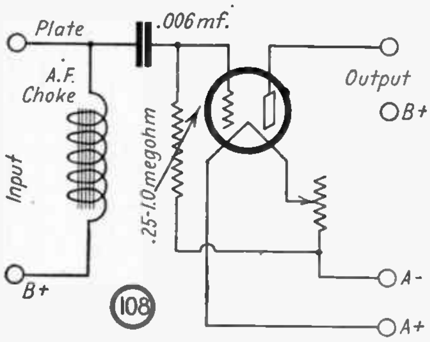
The primary and secondary coils are wound on the same 3-inch bakelite or hard rubber tube and are wound with No. 24 D.C.C. wire. The secondary has 50 turns and the primary that is wound over the secondary separated only by the insulation of the wire, has 10 turns. The radio frequency transformers are also wound on 3-inch tubes with the same size wire as that mentioned above. The secondary has 50 turns and directly over this is wound the primary of 6 turns. Instead of running the grid return wire of the first tube to the point marked A, it may be connected to the movable arm of a 400-ohm potentiometer, which should be connected across the filament battery in the usual manner. This is for getting the proper bias on the grid of the first tube.

In case the experimenter wishes to try an indoor antenna with this circuit instead of the outdoor antenna for which it is designed, the loop is connected directly across the first .0005 mfd. variable condenser. This will eliminate the aperiodic primary and the secondary coils of 10 and 50 turns respectively. Excellent reception has been accomplished on a loop antenna with this circuit, but the outdoor antenna is recommended for all around good reception.

The types of tubes that are best adapted for use in this receiver are the UV201-A and C301-A. Although the smaller tubes of the 199 type may be used, they will not give the volume that the larger ones will produce. The crystal should be of the fixed type in order that there is no trouble from adjusting it during reception.

Circuit No. 108. Very few radio experimenters pay much attention to audio frequency amplification because the detecting part of the circuit seems to hold a much greater interest. However, the study of audio amplification is a most interesting one, the ultimate goal being volume without the sacrifice of purity of tone.

Audio frequency transformers have many advantages, which need not be mentioned here as they are so well known. In Fig. 108 is shown a type of amplifier that may prove to be a most interesting study and, at the same time, quite inexpensive to construct. The only materials necessary are an audio frequency choke coil which may be the secondary of an audio frequency transformer, a fixed condenser having a capacity of .006 mfd. and a variable grid leak having a resistance that may be varied from .25



A system of audio frequency amplification which gives excellent volume without distortion.

to 1.0 megohm. The electron tube should be a UV201-A or C301-A, in order that the plate voltage necessary for the functioning of the stage of amplification may be applied with safety. The rheostat is placed in the negative lead of the filament and the grid return, *i. e.*, the lead from the grid leak, is connected to the negative lead, but between the rheostat and the "A" battery. The plate voltage applied to the input side of the amplifier should be about 45 to 60 volts and that applied to the output should be between 60 and 90 volts.

Circuit No. 109. Resistance coupled R.F. amplifiers at wave-lengths below 600 meters give rather mediocre results, but if a tuned circuit is used instead of the usual grid leaks, much better results are obtained. Such a circuit is shown in Fig. 109. The resistances should be variable so that they may be adjusted to prevent oscillation of the circuit at any wave-length.

The antenna and secondary coils are wound on a 3-inch bakelite or hard rubber tube. The secondary of 50 turns of No. 24 D.C.C. wire is first wound on the tube and over this is wound the 15 turns that form the primary. The two coils that are in the plate circuits of the radio frequency amplifier tubes are 50 turns of the same size wire wound also on 3-inch tubes. The blocking condensers of .0005 mfd. and .00025 mfd. in the plate circuits of the first two tubes should be tested before being installed, for, if they are shorted, the plate voltage will be introduced into the filament circuit, and the tubes blown out.

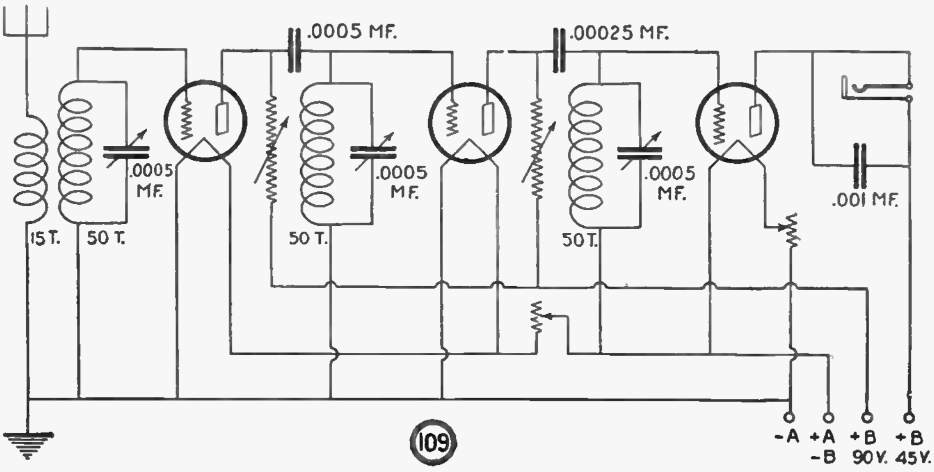
There is not shown in the diagram any form of audio frequency amplification, but this is placed after the detector in the conventional manner. Type UV201-A or C301-A tubes should be employed.

The field of experimenting in radio is very large. One fundamental circuit can be used in many variations which will still further resolve themselves into others of more or less complexity. Thus, radio frequency amplification can take place in types of tuned and untuned circuits, both of which may be neutralized and may be effected by means of resistance, impedance and choke coupling, up to several stages of amplification.

The same applies to audio frequency amplification in the measure that several types of coupling may be employed: resistance, choke, transformer and push-pull. The detector tube can be regenerative, non-regenerative, superdyned or heterodyned. These different methods are adaptable to other variable factors, so that the number of combinations possible becomes indeed great.

The general tendency in circuit design is the use of no more than three stages of radio frequency amplification, though most commercial receivers incorporate two steps. Again, two stages of transformer coupled audio frequency amplification are used to a greater extent than other types.

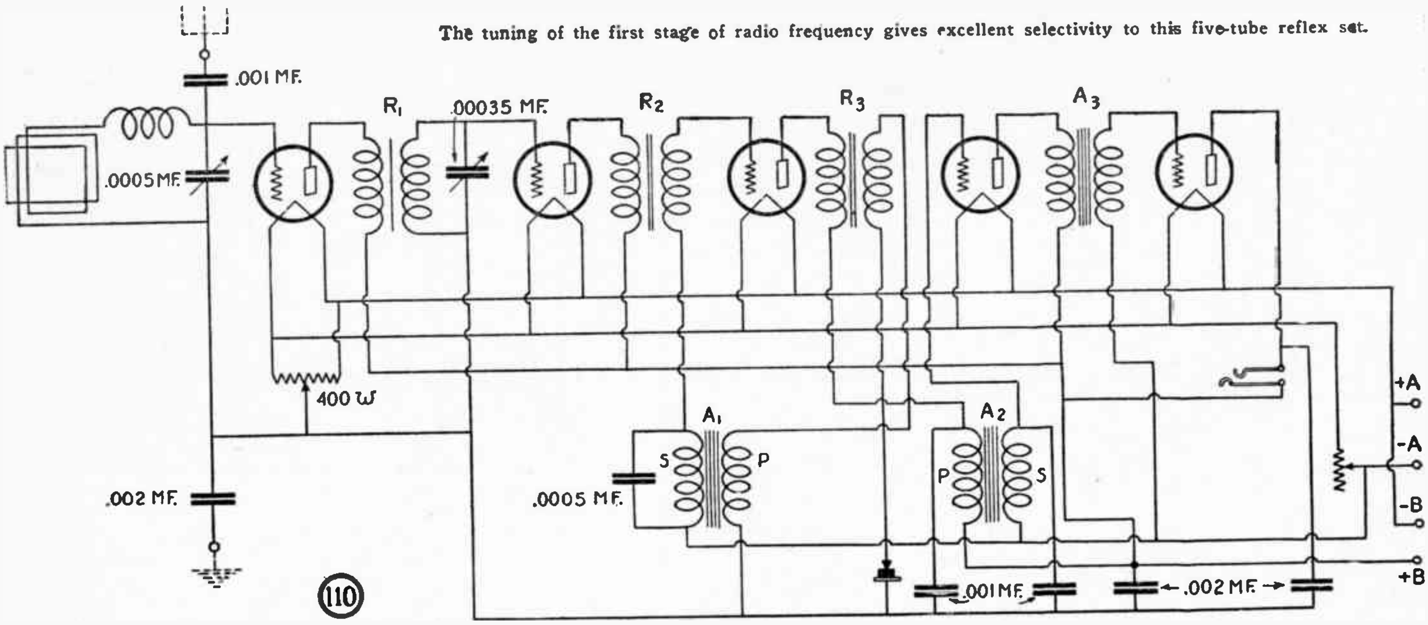
Experiment! There is a vast field for improvement in circuit design and, last but not least, record the results of your work. Such records may become of great value in the future.



Three-tube receiver using 10,000 to 100,000 ohm variable resistances to prevent oscillations.

World Radio History

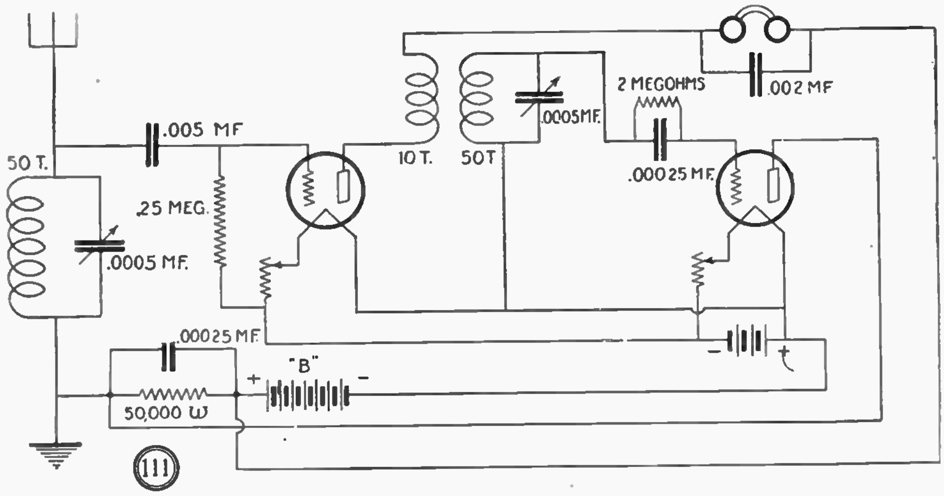
The tuning of the first stage of radio frequency gives excellent selectivity to this five-tube reflex set.



Circuit No. 110. This reflex receiver has a sensitivity determined by the utilization of three stages of radio frequency amplification, one of which is tuned in order to give a high degree of selectivity. This selectivity is increased by the use of a loop antenna.

The radio frequency transformers can be home-made if desired, and the specifications are given below, but it is recommended that a standard type of transformer is installed, as transformers are more or less difficult to construct. The first R. F. transformer, R1, has a primary winding of 33 turns and the secondary has 105 turns, wound with No. 26 wire. The windings are of the "pie" type and the mean diameter is 1¼ inches. Two of the pie windings are in the primary and three in the secondary, and there is also a little iron used in the core. R2 has 75 turns on the primary and 400 turns in the secondary, wound with No. 34 wire, the mean diameter of the coils being about ¾ inches. R3 is also wound with No. 34 wire and has the same diameter. There are 225 turns on the primary and 330 turns on the secondary. Each of these transformers has a little more iron in the core than the preceeding one. The audio frequency transformers A1 and A3 have a ratio of 4 to 1 and A2 has a ratio of 5 to 1. The panel may be about 15 inches long and the depth of the cabinet about 8 inches. There is a crystal employed for rectification instead of a tube, because of its many well-known advantages.

The three stages of audio frequency amplification are used to get enough volume; it is possible to use as many as three stages because of the staggered characteristics and the balancing and opposing of the stray fields of the transformer systems. In the commercial receiver there is a grounded metal panel used; the lowest connection line in the accompanying diagram represents this grounded panel.



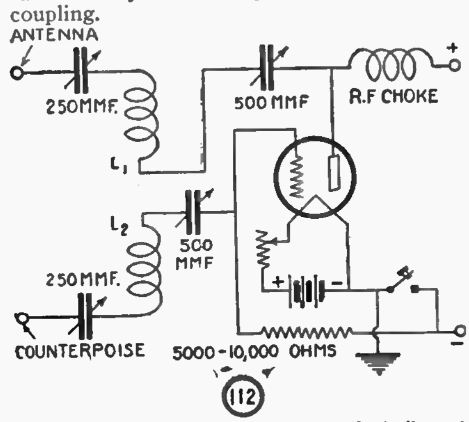
A popular English reflex receiver using resistance instead of transformer coupling in the audio stage.

Circuit No. 111. This is an English circuit that has found great favor among British radio fans. In differs from the ordinary form of reflex circuits in that the audio frequency amplifier has resistance coupling instead of transformer coupling. As a resistance has no natural period of vibration it will not cause the howling which is so common in transformer coupled reflex circuits. In Fig. 111 the first tube acts as both radio and audio frequency amplifier and the second tube is the detector. In the plate circuit of the detector is a resistance of 50,000 ohms, shunted by the condenser.

The grid condenser in the first tube circuit is used for blocking the plate voltage from the grid of the tube. The phones or loud speaker are connected in the plate circuit of the amplifier tube in series with the primary of the radio frequency transformer, which is preferably of the tuned type and should be so adjusted that the circuit will not oscillate at any setting of the condensers. A plate voltage in the neighborhood of 100 volts, depending, of course, upon the type of tubes employed, will be necessary for good reception.

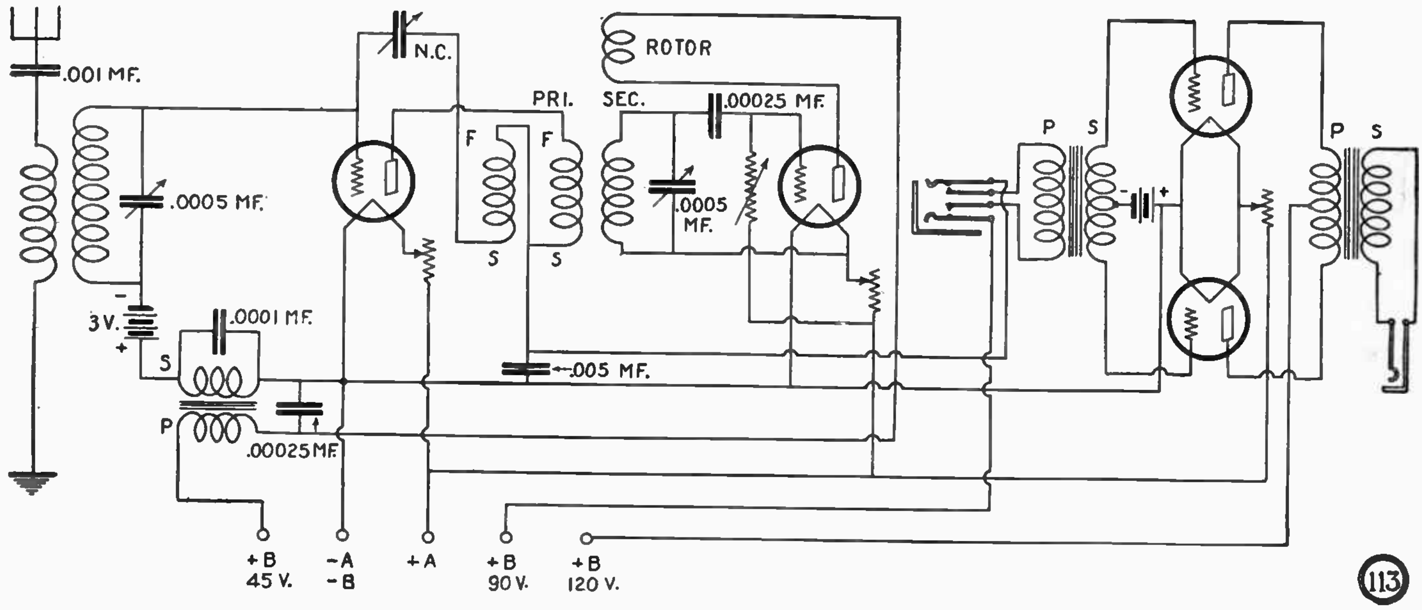
Circuit No. 112. In the accompanying diagram is shown the circuit of a transmitter that should prove of interest to the transmitting experimenter. It is the circuit that was developed by John L. Reinartz and has been operated successfully on wave-lengths as low as 5 or 6 meters. There are four variable condensers employed, two having twenty-three plates and the other two having eleven plates. The inductances L1 and L2 are wound with copper ribbon and have about five turns each, the number of turns depending on the type of vacuum tube used. The resistance in the grid circuit of the tube also depends upon the type of tube used and is between 5,000 and 10,000 ohms. This value is dependent upon the type of tube because of the amount of plate voltage that may be used, the value of the resistance varying directly as the plate voltage. The radio frequency choke coil may be either a 300-turn honeycomb coil or 200 turns of No. 24 wire on a tube approximately 1½ inches in diameter. The type of vacuum tube may be a 5-watt, an "E" tube or a 201-A.

It will be seen that, in this circuit, the grid and plate are so connected that their potential is but little more than zero, the circuit being so proportioned that sufficient voltage is procured for the proper operation of the tube. The size of the antenna has very little to do with the operation of the circuit, other than that there must be not more than one-half wave-length spacing between the far ends of the radiation system for proper electrostatic coupling.



A short-wave transmitter that is easily built and interesting to work.

World Radio History

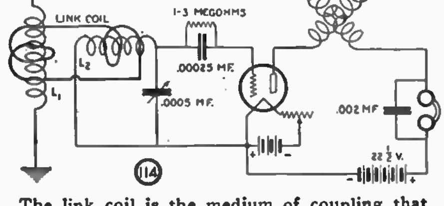


The Roberts reflex receiver is an excellent one if the coils are wound according to instructions.

Circuit No. 113. This type of reflex receiver is sensitive, selective and gives signals of excellent volume and clarity. The quality of reproduction depends greatly upon the inductive relations of the various coils, as will be seen by experimenting with the circuit.

The primary and secondary coils are wound on a 3-inch tube of bakelite or hard rubber. The primary has 10 turns and is wound over the secondary of 50 turns, No. 20 D.C.C. wire being used. There are two ways of making the four-coil unit. One is to wind the coils in cylindrical form and the other is to employ spider-web forms. S and F indicate the start and finish of a two-wire coil made by winding two wires, side by side, on the form at the same time the wire being no larger than No. 26 D.C.C. It is also advisable for one wire to have colored insulation so that there will be no danger of confusing the windings. It has been found that the R.F. tube can be more easily neutralized if these two wires are twisted together before winding them on the form. Twenty turns of this twisted wire are wound on a spider-web form or on a 3-inch tube. This leaves four connecting ends, two at the start, S, and two at the finish, F. The S of one coil and the F of other coil are connected. On a second spider-web form placed about ½ inch from the first, are wound 45 turns of No. 22 D.C.C. wire. If the 3-inch tube is being used, the same number of turns may be wound on, starting ¼ inch from the starting end of the 20-turn coil. At the finishing end of the 20-turn coil is placed the tickler, which has 22 turns of the same size wire. If spider-web forms are used, the tickler may be about the same number of turns, placed on one of these forms and variably coupled to the secondary. It should be noticed that the antenna and secondary coils must *not* be in inductive relationship to the four coils just described.

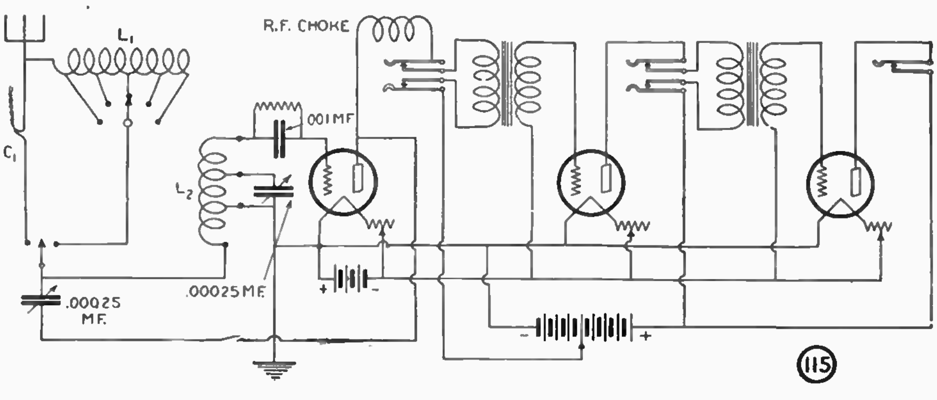
Circuit No. 114. For experimenters who wish a circuit that is very selective, the one



The link coil is the medium of coupling that makes this set very selective.

in the accompanying diagram is recommended. The inductances, L1 and L2, are wound of No. 22 D.C.C. wire on 3-inch tubing and each coil has 50 turns. These two coils should be mounted at right angles, and there should be at least 12 inches between centers. For extreme selectivity a separate unit might be built consisting of L1 and the .001 mf. condenser. These two coils are linked together by the coils indicated by the heavy line in the diagram. This connecting link is a rubber-covered wire, having as low a resistance as possible. There is one turn of this link coil around each inductance. If a separate unit is built, as mentioned above, it might be placed two feet away from the rest of the circuit. The variometer in the plate circuit of the tube is for regeneration.

The type of vacuum tube that may be used is a UV-201A or C-301A. The length of antenna should be about 125 feet, although this is not very important.



This set can be built to cover any wave range, by varying the amounts of inductance in the circuits.

Circuit No. 115. Those experimenters who are familiar with the Reinartz circuit will notice in the accompanying diagram several changes, *viz.*, the absence of the plate coil and the addition of a coil in the antenna circuit, which is for the purpose of detuning this circuit so that the effect on the tuning will be zero. Through this means the tuner can be calibrated before being connected to the antenna, and its calibration will remain constant, regardless of the size and type of antenna to which it may be connected. The great advantage of this detuning coil is the fact that it cuts receiver radiation to zero.

For the R.F. choke coil, wind on an ordinary size drinking glass about 2½ inches in diameter, 75 turns of No. 24 D.C.C. wire in jumble fashion. Slip off the tumbler and wind a few turns of thread around the coil so that it will be self-supporting. The coil should be mounted as near the plate of the tube as is consistent with good wiring practice and should not be placed near any of the other coils.

Around the same drinking glass wind 50 turns of the same size wire, making a loop for tapping at every tenth turn. This coil L1 is mounted on the tuner panel near the antenna connection. Connect one end of a 2-foot length of lampcord to the switch-point and the other to the antenna, leaving the other ends open. See C1. Two pieces of magnet wire twisted together may be used if desired. If selectivity is too great, add to length of wire.

If the wave-length is to be 150 to 220 meters, the coil L2 is made as follows: On the same tumbler wind in jumble fashion, as before, 5 turns of No. 16 D.C.C. wire, making a 3-inch loop for tapping; then continue for 15 turns with another tap loop and then 5 more turns. Bind, as before, with thread. It will be noticed that there is a 4-to-1 turn ratio of antenna to ground and grid to ground. Maintain this ratio in any other coil that is made. Also notice that the tuning range is 150 to 220 meters, and that if a cipher is added to the 15 turns that are shunted by the condenser, you will have 150, and if a cipher is added to the total number of secondary turns, which is 20, you will have 200, meaning that the approximate range of any coil made with the turn ratio, as above, may be determined beforehand.

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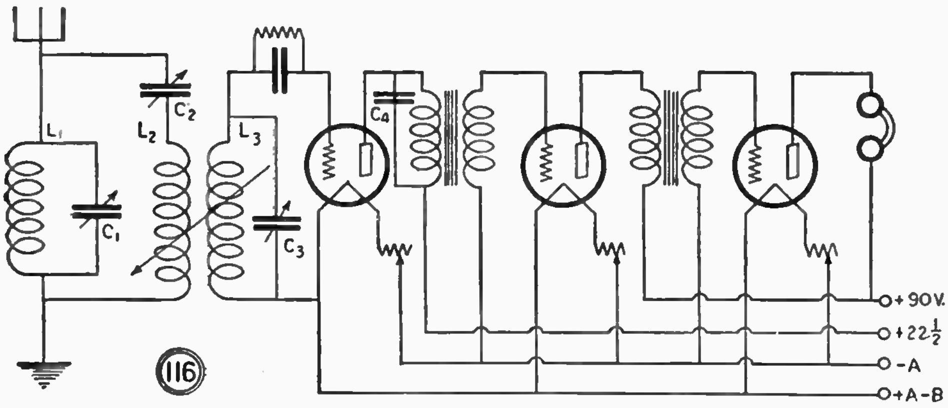


By the use of the wave trap principle this circuit becomes one of the most selective known.

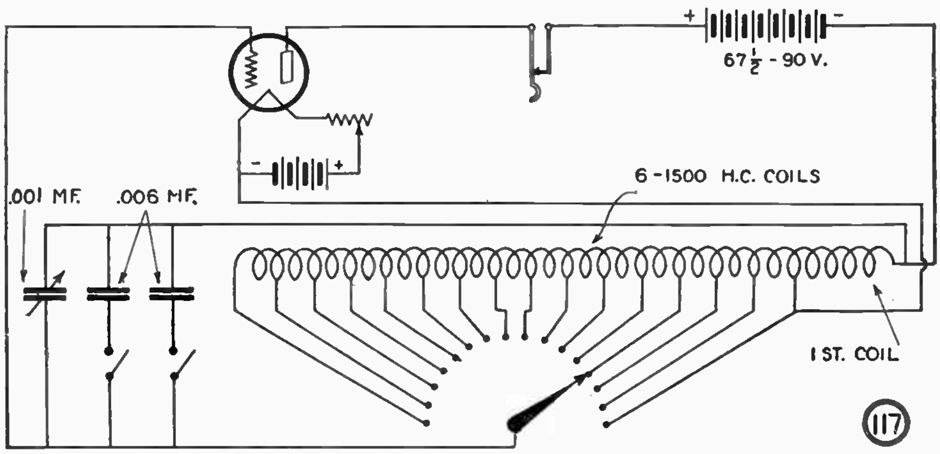
Circuit No. 116. For the fan who lives in a district congested with many broadcast stations which are difficult to separate, the receiver circuit shown in Fig. 116 should prove of great interest. Nearly every fan who has built a set has given some thought to wave traps, and it is this principle which is used in this circuit.

The coils used in the receiver may be wound in basket-weave style or may be the single-layer inductances. In either case, however, they should be wound with No. 14 D.C.C. wire in order to reduce the resistance of the circuit as much as possible. The inductance L1 has 20 turns and is shunted by the variable condenser C1 which has a capacity of .001 mf. The coils, L2 and L3, which are in inductive relationship to one another, have 50 and 15 turns, respectively. If the coils are single-layer wound, the diameter of the tube should be 3 inches. It should also be noticed that the inductance L1 should not be near the other two inductances, L2 and L3. The condenser C2 has a capacity of .0005 mf.

Circuit No. 117. The audio frequency oscillator circuit, shown in the accompanying sketch, should recommend itself to the experimenter who is interested in making tests on loud speakers or any instrument that needs a source of audio frequency current. By employing sufficient inductance and capacity in the circuit and using a tap switch for varying the inductance, different tones may be obtained.

The inductance is made by connecting six 1500-turn honeycomb coils in series and bringing out to the switch-points twelve taps. These coils may be placed side by side and clamped in position by some suitable means. Care should be taken that the fields of the coils assist one another, *i. e.*, that the winding is all in the same direction. If the outside end of one coil is connected to the inside end of the next, the circuit should operate correctly. It will be noted that the negative side of the "B" battery is connected to one of the end coils, which we will call the first coil. The filament of the tube is connected to the other lead of the first coil, where it is attached to the second coil.

It will perhaps be difficult to procure two condensers having a capacity of .06 mf., so if the experimenter will build up ten condensers of .006 mf. capacity each and connect them in parallel, he will have the equivalent of a .06 mf. condenser. The variable condenser shown will act as a vernier adjustment to the frequency. If a greater variation is desired, taps may be made on the two condenser piles, in addition to the taps on the inductance.



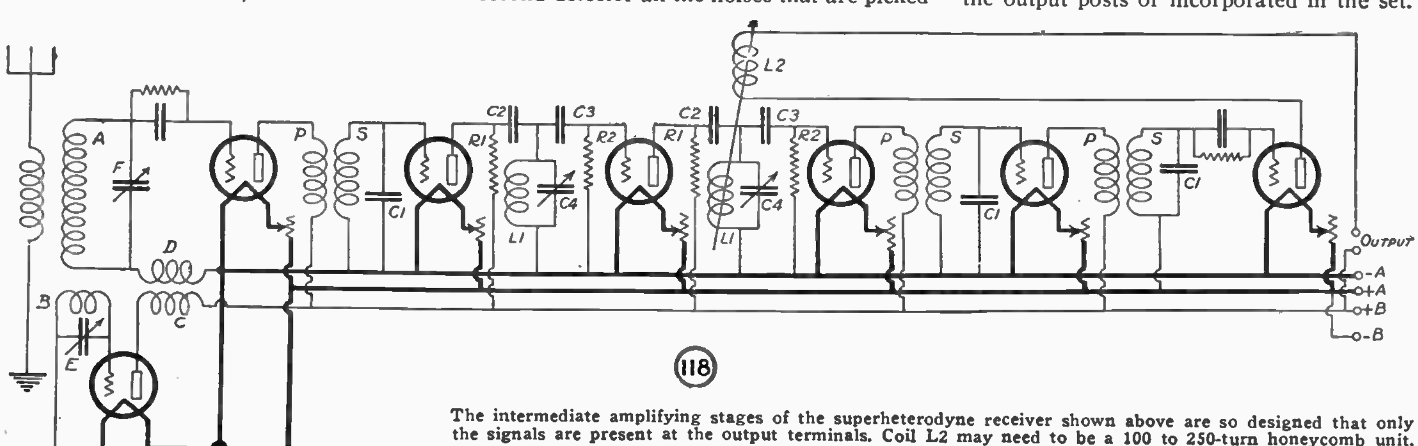
The audio frequency oscillator circuit will be valuable for testing loud speakers and apparatus needing audible tones.

Circuit No. 118. One of the complaints sometimes heard from users of super-heterodyne receivers is that the intermediate stages are wont to pass through to the second detector all the noises that are picked up, as static and the like. Through the process embodied in the receiver shown in Fig. 118, the majority of these unwelcome noises are eliminated. No deviation from standard super-heterodyne practice will be noticed in the circuit up to the plate circuit of the third tube. Instead of the intermediate frequency transformer here, there is a resistance, a tuned circuit and a grid leak.

The condensers C2 and C3 are of small capacity, .00025 mf. or less. Experience will show that the static and tube noises are of audio frequency and are usually loud in ratio to the signal intensity. Therefore, the size of C2 effectually prevents their passage into the grid of the next tube. The only possibility left to them is to take the alternative path through the resistance R¹ which is approximately 25,000 ohms. Here they are dissipated in the form of heat, leaving only the higher frequencies to pass on.

The detector and oscillator are of the standard type. The tuning coil A may be made by winding 64 turns of No. 18 S.C.C. wire on a 3-inch tube. The condensers E and F have a capacity of .0005 mf. The pick-up coil D may be 10 turns of No. 18 wire wound at the end of the oscillator inductance tube, which is also 3 inches in diameter. The plate and grid coils, B and C, for the oscillator may consist of 40 turns for the former and 64 for the latter, separated about one-half an inch from each other on the tube. The resistances R2 have a value of about three megohms. L1 is a 400-turn honeycomb coil and C4 has a value of .001 mf. capacity. L2, the tickler coil for obtaining regeneration, has between 8 and 15 turns of No. 18 wire wound on a 3-inch tube. The definite number of turns cannot be given as they will vary in different sets.

In the hook-up no audio frequency is shown. Any type amplifier may be added at the output posts or incorporated in the set.



The intermediate amplifying stages of the superheterodyne receiver shown above are so designed that only the signals are present at the output terminals. Coil L2 may need to be a 100 to 250-turn honeycomb unit.

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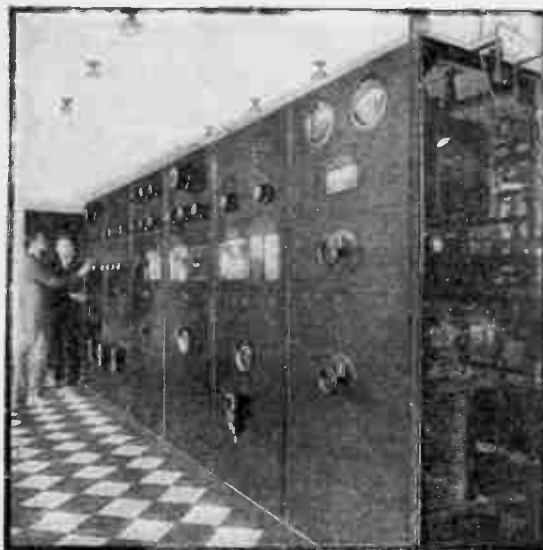

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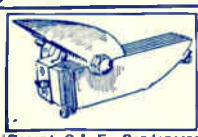
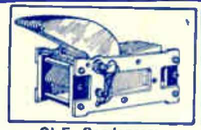
Dial Marker
The big little thing you have been waiting for. Just drill a hole in the panel and mount the marker above the dial. Nickel plated and polished
F7788 Dial Marker, three for ....$.10



Pacent S.L.F. Condensers
The famous Pacent SLF Condenser. The latest word in condensers. Sturdy, compact, take up less room than most others. Minimum insulation used.
F4432 .00035 mf. 17-plate $2.95
F4433 .0005 mf. 23-plate 3.95



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Lowest prices ever offered. Despite this low price, these condensers are made with precision aluminum stampings, hard rubber insulation. Money back if not satisfactory.
F3513 .00025 13 pl..$1.06
F3517 .00035 17 pl.. 1.20
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"Guaranteed" Vacuum Tubes
We consider the "Guaranteed" tube one of the best on the market. Any tube replaced if defective, providing filament lights. **Calibrated curve goes with each tube.**
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Audio Transformer
This is the famous Pacent Audioformer. Nickel case is grounded to base. Extra high degree of amplification. Minimum distortion and reaction. Binding posts and solder lugs. Ratio 3½ to 1.
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Audio Frequency Transformer
No better Transformer made. Highest class materials. Impregnated coils. Silicon steel stampings used. Save 50 per cent by assembling it yourself.
F1100 Ratio 4½-1..$1.40
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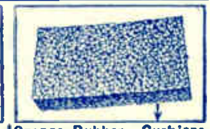
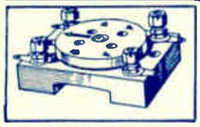
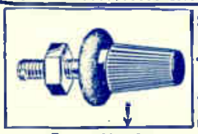


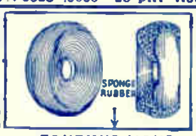
Sponge-Rubber Cushions
Get rid of tube noises due to vibration. Softest sponge rubber made. Size 2½"x3", ⅜" thick.
F8989 Sponge-rubber cushions, each $0.12
Six for 0.60



Universal Socket
Takes new "X" type tubes as well as old standard "CV" and "C" types. Made entirely of Isolantite. No capacity effect between plate and grid. New phosphor bronze wiping contacts. Standard mounting type.
F6514 ....$0.49



Rasco Vernier
Why use a vernier dial when a vernier attachment will do anything and everything a vernier dial accomplishes? Clevcrest vernier made. Can be used with any dial. Soft rubber ring engages dial. Nothing to come apart.
F1450 Vernier......$0.12

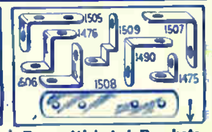


FONEKUSHIONS
Made of sponge rubber. Make wearing your receivers a pleasure. Positively exclude all noises and make reception a pleasure. Sponge rubber will last for years. Light as a feather. Sanitary.
F3550 Fonekushions, set of two $0.35

Dial Button
Made in blue enamel and gold, to be worn in button hole. Every radio fan wants one. ⅜" diameter, best gold plate. Perfect reproduction of radio dial.
F7799 Dial Button, Each $0.25

Vacuum Tube Shell
Nickel plated shell for the man who builds his own. 4 holes to attach to subbase. Each shell comes complete with 4 phosphor bronze socket contacts. See illus. 4748.
F4747 Vacuum Tube Shell and Contacts $0.16

Cord Tip Jack
Takes place of binding posts. Cord tip firmly gripped by jack. Made of brass, nickel plated. Screw to attach lead wire. **No soldering necessary.**
F1500 Cord tip jack, Each $0.15



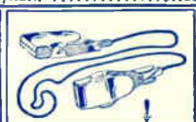
Brass Nickeled Brackets
All illustrations ¼ size.
F1505 Bracket, each $.03
F1507 Bracket, each .05
F1509 Bracket, each .04
F1476 Bracket, each .05
F1506 Bracket, each .05
F1490 Bracket, each .04
F1475 Bracket, each .03
F1508 Bracket, each .05

Microvern
THE vernier dial for extra sharp tuning. No backlash. Special finish permits logging of stations on dial. Beautiful appearance. Comes in gold or silver finish. State which wanted.
F3066 Microvern, any finish $1.76

Rasco 180° Variocoupler
Silk wire wound on bakelite tubes. Six taps. Wave length, 150 to 600 meters. For panel mounting. ¼" shaft. Your money refunded if it is not all we claim.
F3100 Variocoupler prepaid $1.05

Copper Ribbon
.0005" thick.
F700 ⅜" wide; F701 ¼" wide; F702 3-16" wide.
All sizes per foot...$0.01

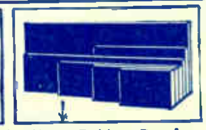
Copper Foil
.001" thick. 4" wide.
F5025 Copper Foil, per foot $0.10
10-foot length 0.80



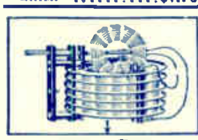
Rasco Clip Leads
Invaluable for experimental work. Clip lead hooks in a jiffy onto any wire, binding post or conductor. Safest experimental connection. Brass clips, 1 foot silk wire, green or red.
F7887 Clip Leads, ea.$0.12
Dozen lot 1.35

Adapter
Pacent Improved Adapter. Takes 199-type tubes. Fits standard 201A sockets. Phosphor bronze springs, short circuits impossible. Bakelite molded.
F6521 Adapter $0.36

PUSH-PULL
Push Pull Transformer for many new circuits. See any radio magazine. Made of best materials. Coils impregnated. Silicon steel laminations. Save 50 per cent by assembling yourself. Simple instructions furnished.
F1159 Push-Pull Transformer,ratio 6½ to 1 $2.95

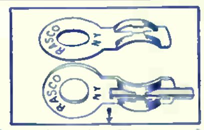


Hard Rubber Panels
Highest dielectric strength as per Bureau of Standards. Beautiful high finish.
F7100 7x10x3-16" .$0.65
F7120 7x12x3-16" . 0.79
F7140 7x14x3-16" . 0.89
F7180 7x18x3-16" ..1.15
F7210 7x21x3-16" ..1.31
F7240 7x24x3-16" ..1.46

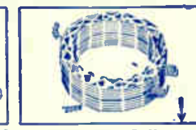


Low Loss Tuner
Same type as used in our LOLOS EXPLORER. Tunes from 200 to 600 meters. Hard rubber insulation throughout. Silver plated primary. Secondary D. C. C. Tickler silk insulated wire.
F2690 Tuner $5.00

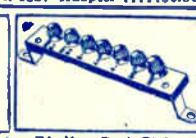
"T" Wire Connectors
This big little article solves all troubles when making "T" wire connections. Made to take 1-16" square or round bus-bar wire. Can be attached with a pair of pliers.
F2975 "T" Wire Connectors. 12 for.....$0.10



Nosolder Lugs
Finally, a real solderless lug is here. Soldering positively done away with. Takes square or round bus bar, which it holds with a vise-like grip. Perfect connection. Just slide bus bar into slip-grip.
F3727 Lug. 25 for $0.20

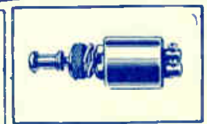


Low Loss Coil
Same type as used in Freshman and other Tuned Radio Frequency sets. D.C.C. wire. 200-550 wave-length. 3" diameter. 1" wide, 5-16" thick 4 connections, 2 primary, 2 secondary.
F2629 Low Loss Coil $0.43

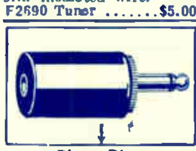


Binding Post Strip
Made of hard rubber, gold engraved lettering. Two nickel brackets for mounting. 7 hard rubber binding posts. "ANT"; "GND"; "A—"; "A+"; "B—"; "DET B+"; "AMP B+".
F870 Binding Posts $0.35

Tinned Nickel Lugs
All our lugs are tinned.
F310 Brass Lugs for No. 8 screw. doz........$0.10
F311 Copper Lugs for Nos. 6 and 8 screws, doz.0.10
F309 Copper Lugs for Nos. 4, 6 and 8 screws. doz.0.10
F308 Copper Lugs for 6-32 screw, doz. 0.10



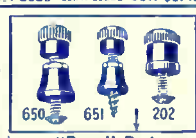
Battery Snap Switch
This Switch is produced under high standards of workmanship. Action is positive. Solderless contact screws used. One hole mounting. Nickel-plated all over. Most serviceable switch made.
F7986 ....$0.36



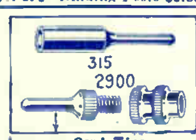
Phone Plugs
Sold from 50c to 65c everywhere. Hard rubber composition shell and patented cord tip holder. Finest workmanship throughout.
F1030 Rasco Telephone Plug. Each $0.23

Bakelite Socket
Octagon shape. Four nickel binding posts, phosphor bronze contact springs. Best brown bakelite.
F6510 Bakelite socket $0.40
F6500 Tube Socket. Made entirely of composition. Best made. Each..$0.35

Binding Post Name Plates
Dia. ⅜". These styles: Phones, Ground, —, Output, "A" Bat. —, "B" Bat. —, Loud Speaker, "C" Bat. —, Aerial, +, Input, "A" Bat. +, "B" Bat. +, Loop, "C" Bat. +, **New!** "A" Bat. + "B" Bat. —.
F6000 Name Plates, Dozen $0.15

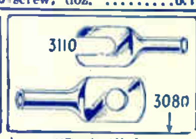


"Rasco" Posts
Made of hard rubber composition.
F650-51 Each $0.06
F202 Has nickel plated bottom, each $0.06
Dozen, each style...$0.70
F122 Initialed Binding Posts. Set of 8. Per Set $0.25

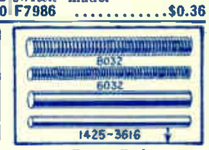


Cord Tips
Standard phone cord tips, nickeled.
F315 Each $0.03

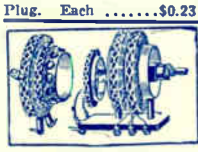
Separable Cord Tips
No solder required. Wire goes in ferrule. Shank holds it tight. Nickel plated.
F2900 Each........$0.06



"Perfect" Lugs
These new and improved lugs are brass, nickel plated, flattened on top as shown. Made of a single piece of metal. Lead wire goes into tube.
F3110, F3080 "Perfect" Lugs. Each $0.02
Dozen lots 0.20



Brass Rods
Sold in 6 lengths only.
F8032 Rod 8-32" thread length $0.08
F6032 Rod. 6-32" thread length $0.06
F1425 Rod. plain. ¼" round. length $0.10
F3616 Rod, plain 3-16" round. length $0.06



Roberts Coils
Diamond weave coils, used in standard Roberts Circuit. Tunes 200 to 550 meters. Used in 2, 3, or 4 tube circuits. These are genuine Sickles Coils, not imitations. Set comprises two units, as illustrated.
F-8112, Roberts Coils $5.95

100-Ampere Storage Batteries
Guaranteed for two years. Only new material used. Genuine hard rubber case. Acid-proof terminals. Hard rubber vents. Strong carrying handle. Written guarantee goes with each.
F-9100, 6-volt 100-ampere hour battery ...$9.50
Shipped express collect.

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All Armstrong Circuits are explained clearly, all values having been given, leaving out nothing that could puzzle you.

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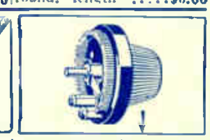
FREE

A POSTAL CARD BRINGS IT

NEW Battery Lead Tags
Latest wrinkle, made in metal, nickel-plated, polished. Clamp tag on battery wire, and it won't come off. These five styles: "B +", "B + Det.", "B —", "A +", and "A —".
F8030 Tags, set of 10$0.15



Rheostats and Potentiometers
High heat bakelite base. Come with tapered, knurled knob. 2½" dia. Complete with pointer.
F4310 6 ohm $0.38
F4311 30 ohm 0.44
F4312 Potentiometer 200 ohms 0.50

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