PROCEEDINGS
of the
RADIO CLUB *of* AMERICA

Vol. 2 No. 11 September, 1923

RADIO CLUB OF AMERICA
SPECIAL NOTICES

TO THE MEMBERSHIP:

The first meeting of the Fall Session of the Radio Club was held on Friday evening, September 28th with a very timely paper on Loud Speakers by Mr. Nyman. The tremendous interest in this paper and the very lively discussion which followed gave promise of an active season for our meetings.

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The papers this year are of such general interest that we feel sure many club members who have been unable to attend the meetings themselves would like to present their opinions on the subject. For this purpose, we will reserve in the future PROCEEDINGS a few pages for the discussion of any paper published in a previous issue.

Kindly address these discussions to the attention of the Editor and mail them as promptly as possible.

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W. S. Lemmon, Editor, 342 Madison Ave., N. Y. C.

P. Boucheron
E. V. Amy

RADIO CLUB OF AMERICA PERSONAL NOTES

At the last meeting, we were very glad to welcome back Mr. Robert Marriott, of Seattle, Washington, who is spending a few weeks in the East before returning to his duties as Radio Inspector of the Northwest District. Mr. Marriott is one of the real pioneers of radio and presented a few interesting side lights on Western loud speaker construction at the meeting.

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Mr. Harry Sadenwater, who is now in charge of the engineering of all of the General Electric Broadcasting Stations, is busy re-designing the outfit at WGY. Harry expects a flood of postal cards from Honolulu and China just as soon as he starts to heat up the big antenna at Schenectady.

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We believe that every member of the Radio Club is interested in what the other fellow is doing. You can help to satisfy this interest by letting the Editor know just as soon as you finish any startling new inventions or happen to make an addition to either your radio set or your family.

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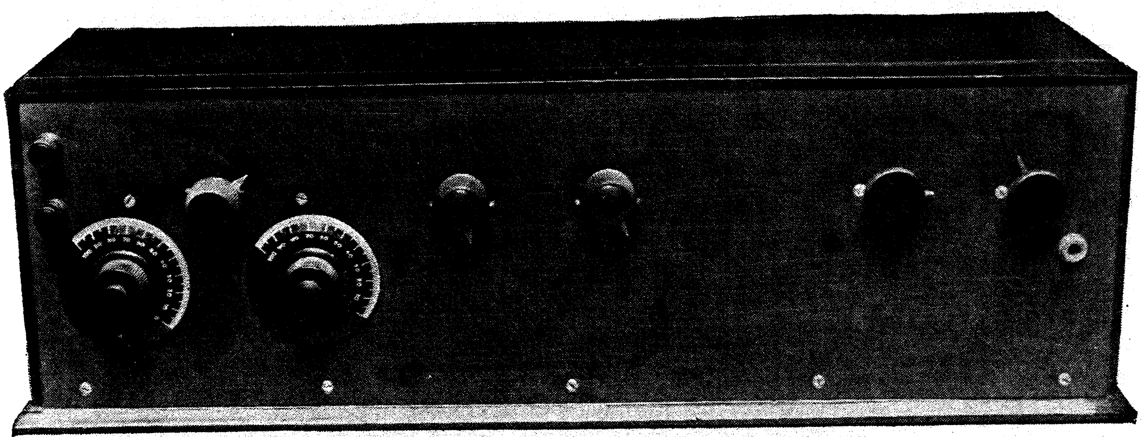


MR. ELTZ'S SEVEN-TUBE SUPER-HETERODYNE
It has but two tuning controls. The simplicity of operation of a set of this type is sure to make it increasingly popular

How to Build a Super-Heterodyne Receiver*

By GEORGE J. ELTZ, Jr.

The value of the super-heterodyne receiver has been better appreciated by the Radio Club of America than in most other circles. One reason for this may be that Edwin H. Armstrong, inventor of the super-heterodyne, is a member of the Club. Mr. Eltz has been an enthusiastic supporter of this wonder circuit since Armstrong introduced it, and in this paper he describes a receiver incorporating several recent improvements.—THE EDITOR.

THE super-heterodyne, or double-detector receiver, is now a practical piece of apparatus for use by the radio amateur and broadcast listener. To date there has been developed no other circuit which is either as selective or as sensitive. The chief drawback in the operation of this circuit has been that vacuum tubes as manufactured in the past required filament currents of about one ampere each. This high filament current necessitated the use of large batteries, making the operation of the super-heterodyne too expensive a luxury for many fans. But the new vacuum tubes, with low filament consumption, bring this type of receiver within the reach of many more of us.

A super-heterodyne may be constructed with practically any type of vacuum tube on the market to-day. Best results can probably be obtained by using the UV-201-A (C-301-A). Good results, however, can be had with the UV-199, WD-11 and WD-12 tubes.

Before going into the actual construction of the super-heterodyne, it will, perhaps, be well to consider just what happens in the circuit. It was developed by Major E. H. Armstrong, at a time when high-frequency, radio-frequency transformers were unknown. Practically the only method of radio-frequency amplification in successful use at that time was amplification by means of resistance coupling between the stages. The amplification obtained per tube by this method at high frequencies was extremely low, a voltage amplification of three or four per tube being exceptionally good. At low frequencies, however, that is, in the order of 50,000 cycles or a wavelength of 6,000 meters, amplification of a considerably higher value, perhaps as high as 6 or 7, could be obtained.

In brief, its action is as follows: the fre-

*For other articles dealing with the super-heterodyne, see "A Super-Sensitive Long-Range Receiver," by Paul F. Godley in RADIO BROADCAST for February, 1923, and "A Practical Super-Heterodyne with 199's," by Walter Van B. Roberts in RADIO BROADCAST for August, 1923.

quency which enters the loop or antenna as the case may be, is, we will say, of the order of 1,000,000 cycles, equivalent to 300 meters. This frequency is modulated by the radio transmitting station, whether telephone or telegraph, and is detected at the receiving station by the tube called the first detector tube. As part of the receiving set, a vacuum-tube oscillator is set up capable of producing frequencies of the same order as those which are to be received. The loop or antenna circuit is tuned to the incoming frequency. The oscillator in the receiving set is adjusted to a point 50,000 cycles above or below the incoming frequency. The result is a beat-note, between the incoming frequency and the frequency in the set, of 50,000 cycles. This beat-note is modulated in exact accordance with the incoming frequencies. All this action occurs in the first detector tube.

The output of the plate circuit of the first detector tube is then fed into the primary of a radio-frequency transformer designed for best operation at frequencies of about 50,000 cycles or 6,000 meters. The voltage amplification obtained at this frequency by means of transformers is high, perhaps as high as 12 or 14. After running through a number of radio-frequency transformers of this character, and their vacuum tubes, the frequency is then impressed on a circuit tuned sharply for 50,000 cycles. In this circuit, the higher frequencies which may have passed the amplifying transformers are eliminated and a coil connected with the tuned circuit impresses on the grid of the second detector tube, nothing but the 50,000-cycle modulated beat-note. This beat-note is detected by a second detector tube, the plate circuit of which supplies the power for operating a telephone headset, loud speaker, or audio-frequency amplifier.

In Fig. 1 is shown a circuit which corresponds in action to the one described above. Here the super-heterodyne is shown in operation in connection with a loop. The loop is tuned by a small variable condenser and the output impressed on the grid of the first detector tube. The transformers used for the amplification of 50,000 cycles, or as it is commonly called the intermediate-frequency amplifier, are the familiar Radio Corporation UV-1716 transformers. They are extremely efficient at a frequency of 47,500 cycles, which is the frequency used in the circuit shown in Fig. 1. Three of these transformers are used before the second detector. The "special transformer" consists of an air-core transformer, having a primary consisting of 200 turns of No. 29 double silk-covered wire, wound on a 1″ wood or bakelite core and a secondary wound immediately on top of the primary of 1500 turns of No. 36 double silk-covered wire. The length of the core is $\frac{1}{4}''$, the outside diameter of the combination being approximately 3″. No particular care need be taken in winding this transformer. It is important, however, that approximately

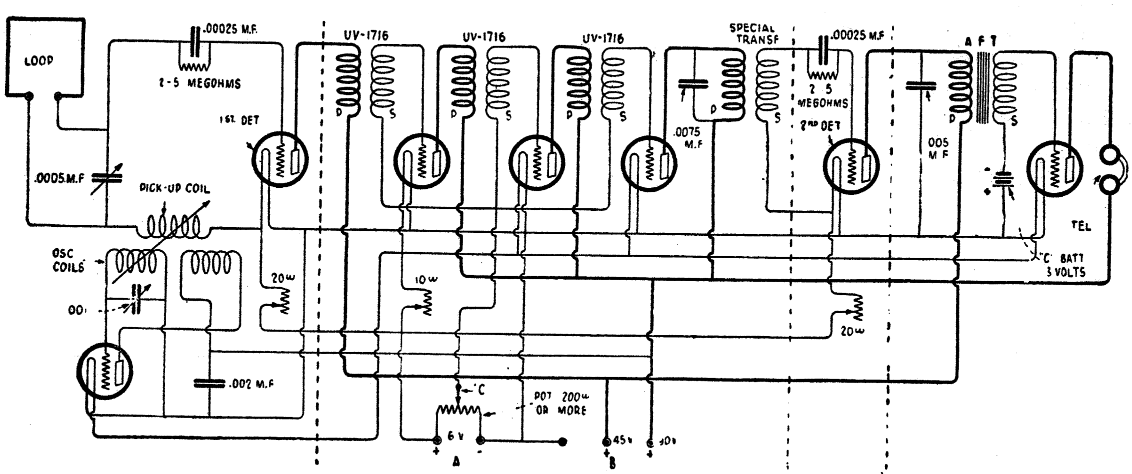


FIG. 1

The dotted lines indicate the four sections into which we may divide this super-heterodyne circuit to make it more easily understandable. In the first section (from the left) we have the wave-changing unit, then the intermediate-frequency amplifier, then the detector and finally the A. F. amplifier. For experimental purposes, it may be found advisable to arrange the super-heterodyne in separate cabinets provided with binding posts for connecting them together. By this arrangement, various combinations may be tried with very little difficulty the correct number of turns be used. Across the primary of this transformer is placed a fixed mica condenser of .0075 mfd. capacity. This condenser, in combination with the primary and secondary, fixes the frequency at 47,000 cycles, which is a particularly efficient point for amplification with the UV-1716 transformers. Between the plate of the second detector tube and the negative side of the filament, is connected a small condenser of .005 mfd. capacity, which acts as a by-pass condenser, preventing the leakage of any of the 50,000-cycle current into the audio-frequency amplifier.

BUILDING THE OSCILLATOR

THE oscillator shown at the lower left-hand corner of the diagram may be constructed of two honeycomb coils, a 35-turn coil being used in the grid circuit and a 25-turn coil in the plate circuit, or it may consist of the same number of turns wound on a Bakelite tube 3" in outside diameter. The small coil shown coupled to the grid coil of the oscillator marked "pick-up coil" should consist of 30 turns of No. 36 double silk-covered wire wound on a form 1" in diameter, $1\frac{1}{4}$" long. This coil should be capable of rotation to vary the coupling with the grid coil. Once set, this adjustment need not be changed except when vacuum tubes are changed. Only three rheostats are necessary, and if desired the number may be reduced to one, although when this is done the detector tubes cannot be operated quite as effectively. In the set shown in the photographs, four rheostats are used, one of which controls the filament current of the oscillator. This is not absolutely necessary since the amount of pick-up voltage can be readily controlled by means of the pick-up coil.

THE COMPLETED CIRCUIT

THE circuit given in Fig. 1 is one which has proved to be simple to operate, extremely selective, and very sensitive. The sensitivity of a super-heterodyne circuit of this type is far ahead of any other receiver even though the same number of tubes are used. The selectivity is not approached by any other receiver. With a receiver of this type it is possible to receive distant stations while local stations no matter of what power are operating. This high degree of selectivity is obtained due to the fact that not only is the inherent selectivity of the loop part of the super-heterodyne,

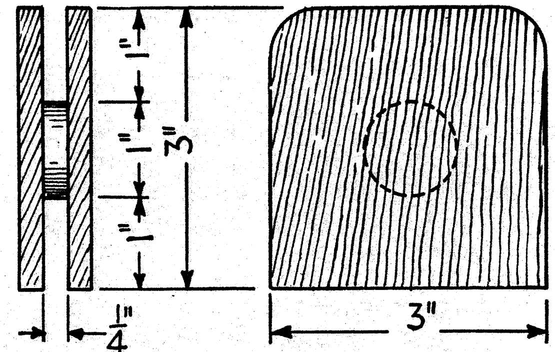
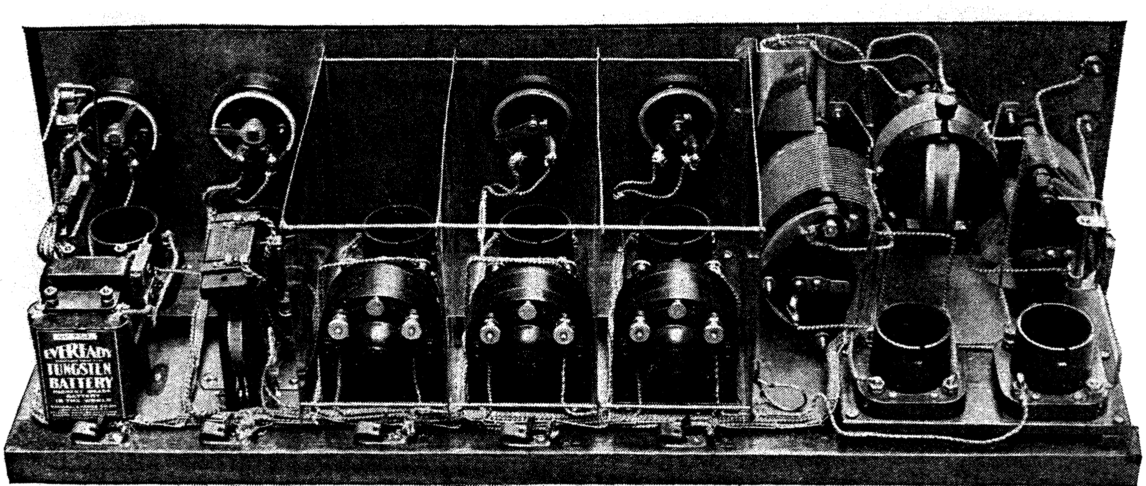


FIG. 2
This special transformer is used to couple the last R. F. tube to Detector Tube No. 2 in Fig. 1, and provides a sharp resonant point for the radio-frequency circuit. The walls of this transformer may be made of bakelite or hard rubber. The primary is wound with 200 turns of No. 29 D. S. C. and is separated from the secondary, which has 1500 turns of No. 36 D. S. C., by several layers of empire cloth

but also because the beat-note between the incoming frequency and the local oscillator must be exactly obtained or it will not pass the transformers and the tuned circuit before the second detector. In order to insure high selectivity, one precaution must be taken. Unlike other radio amplifier circuits no regeneration is obtained in the loop circuit. This being the case, the resistance of the loop circuit must be made as low as possible. Loops wound with Litzendraht wire, and condensers of very low resistance, must be used. Regeneration to a certain extent will be obtained in the intermediate circuit amplifier, although if much regeneration is present some distortion is apt to occur.

SHIELDING

FOR a set of this character to operate properly it must be carefully shielded. This precaution must particularly be taken with the intermediate-frequency amplifier, because the amplification obtained per stage is extremely high, and the intermediate-frequency amplifier is apt to oscillate unless properly shielded. If oscillation occurs, of course, no amplification is possible. If the receiver is built with the circuit of Fig. 1, it should be possible to make the grid of the intermediate-frequency amplifier tubes at least $4\frac{1}{2}$ volts negative without oscillation occurring. If this condition can be obtained, the amplifier is working properly. A small C battery should be inserted at the point marked "C", if the potentiometer does not supply sufficient negative C voltage to



REAR VIEW, SHOWING METAL SHIELDING ENCLOSING THE INTERMEDIATE-FREQUENCY STAGES

The layout may seem a bit complex, but none of the four parts which it comprises—wave-changer, I. F. amplifier, detector, A. F. amplifier—is particularly difficult to build. The circuit diagram, Fig. 1, shows clearly this division into parts

approach a point of oscillation. The values of A and B battery will, of course, depend on the vacuum tubes used. Fig. 1 gives the value for UV-201-A tubes.

WHAT THE RECEIVER WILL DO

WITH a super-heterodyne of this character it should be possible to obtain loud speaker operation on any good broadcasting station over a distance of at least 1500 miles under any condition. Under good conditions the Pacific Coast stations have been heard in New York City on a loop 21 inches square. Signals were of sufficient intensity to operate a loud speaker with enough volume to be heard over a room of moderate size. If desired, another UV-1716 transformer may be added to the intermediate-frequency amplifier. If this is done, additional care should be taken to see that the intermediate-frequency amplifier is most carefully shielded, otherwise the added amplification will be lost due to the feed-back through the wires of the set.

METHOD OF WIRING

IN THE photograph above, the wires used for connecting the filaments and the wires bringing the B battery voltage to the transformers, detectors, oscillator, etc., are shown combined in a single cable laced together and shellacked. This method of wiring is simple, neat, and introduces no losses into the circuit. It is particularly convenient when shielding is used as it eliminates a great deal of the cutting and drilling of the shields which would be necessary if bus-bar wiring were used. The wires leading from the grid and plate of the vacuum tubes to the transformers should not be placed in the cable. These wires must be run separately, or a considerable loss will result. The UV-1716 transformers should be connected with the terminals marked 3 on both the primary and secondary to the plate and grid circuits of the tubes in question. The terminal marked 1 is nearest the core. The terminal marked 3 is the outside terminal of both the primary and secondary winding and has the highest induced voltage. The wires leading to and from the grid and plate of the oscillator and oscillating coils should not be cabled. The small .002 mfd. condenser used in connection with the oscillator is for the purpose of grounding any oscillator frequency which may tend to go back through the cabled wires.

The tuning of the super-heterodyne is at first more or less difficult, particularly when it is desired to pick up stations whose wavelengths are not exactly known. Both condensers should be operated at the same time, with the dial readings approximately the same, the object being to keep a uniform space of 50,000 cycles between the two condensers. With a little care and experience this can be readily learned and the great advantage of selectivity obtained.