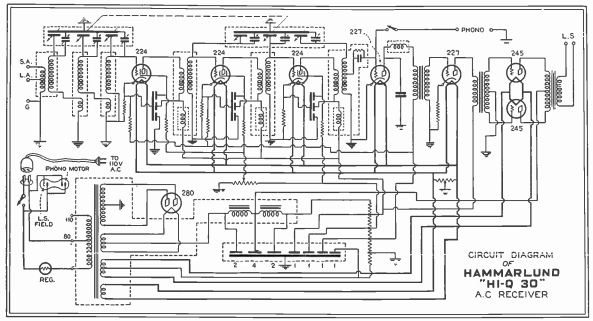
The New Hammarlund HiQ-30 Phono-Radio



The Circuit

Proven features of past and present engineering are embodied in the new "HiQ-30" receiver, the result of two years of intensive "shield grid" laboratory experimentation and a season of successful shield grid production.

The "HiQ-29" made use of standard parts, while the "HiQ-30" uses only specially designed parts throughout, resulting in a degree of efficiency otherwise unobtainable.

The "HiQ-30" A.C. Phono-Radio Receiver consists of a three stage tuned band filter or pre-selector, followed by a high gain three stage screen grid tuned radio frequency amplifier, a super-sensitive detector, a high quality intermediate audio amplifier, and a balanced push-pull power amplifier. The nine tubes include a voltage regulator, a CX-380 rectifier, three C-324 R.F. amplifiers, a C-327 detector, a C-327 first audio and two CX-345 power tubes.

Both the band filter and radio frequency amplifier circuits are tuned by a single illuminated knob control vernier dial with kilocycle graduations. Shielding has been carried out to an extent usually found only in experimental laboratory receivers. The completely shielded screen grid amplifier provides tremendous amplification at all broadcast frequencies, yet without the slightest instability or regenerative distortion. Automatic voltage regulation preserves the tube efficiency and thus aids in maintaining uniform volume level.

The HiQ band filter system preselects the desired signal before amplification. It is this new principle which provides "flat-top tuning," greatly increasing the selectivity, *without side band cutting*, and preserving the radio frequency signal characteristics required for perfect tone.

The complete set is built on a strong metal chassis with no visible wiring. The sub-panel wiring, "unit" construction, and factory assembly, wiring and testing of the filter and amplifier units make the construction a very simple operation requiring only two or three hours of time. The radio phono-switch is mounted on the front panel for convenience of operation.

The "HiQ-30" operates on either an inside or outside antenna. A copper screen tacked on to the rear of the cabinet suffices for local reception.

The "HiQ-30 Manual" which lists at 25 cents contains complete information on both the A.C. and Battery Operated Model of "HiQ-30" Receivers and Tuners.

List of Parts

1—Hammarlund	"HiQ-30" Foundation Unit (Code QFU-30)
1—Hammarlund	No. BS-3 Thee Stage Band Filter Unit
1—Hammarlund	No. RF-3 Three Stage Screen Grid Amplifier Unit
1—Hammarlund	No. SD Knob Control Drum Dial
1—Hammarlund	No. SPC Shielded Polarized R.F. Choke
1—Hammarlund	No. AF-2 First Stage Audio Transformer
1—Hammarlund	No. AF-4 Push Pull Input Transformer
1—Hammarlund	No. AFM Push Pull Output Transformer
1—Hammarlund	No. PS-45 Power Supply Unit for Push-Pull '45s
3—Hammarlund	No. TS Screen Grid Tube Shields
*1—Aerovox	No. CHQ-30 Filter Condenser Block
*3—Aerovox	No. BP-3 Triple By-Pass Condensers
1—Yaxley	No. 810-C Center Tapped 10 ohm Resistor
1 pr.—Yaxley	No. 422 Insulated Phono Tip Jacks
1—Yaxley	No. 401-S Speaker Twin Tip Jack
*1—Electrad	No. RHQ-30 Voltage Divider
*1—Electrad	No. 3 Flexible Grid Resistor, 1500 ohms
*3—Electrad	No. 3 Flexible Grid Resistors, 400 ohms
*3—Electrad	No. 3 Flexible Filter Resistors, 5000 ohms
*1—Electrad	Royalty Volume Control Potentiometer, 25,000 ohms, special taper
*1—Eby	No. 6-11 Two Prong Tube Sockets marked "Amperite"
*1—Eby	No. 6-11 Four Prong Tube Sockets marked 280
*2—Eby	No. 6-11 Four Prong Tube Sockets marked 245
*2—Eby	No. 6-11 Five Prong Tube Sockets marked 227
*3—Eby	No. 6-11 Five Prong Tube Sockets marked 224
*1—Eby	Triple Binding Post Strip
*1—Hart & Hegeman	No. 20510 Phono Toggle Switch
*1—Hart & Hegeman	No. 20595 Line Toggle Switch
*1—Hart & Hegeman	Mica Fixed Condenser, .001 mfds.
*1—Beaver-Arrow	Handle Cap, Cord Connector and Silk Cord
1—Beaver	No. L-14 Duplex Receptacle
1—Arrow	No. 8339 Plug Type Midget Receptacle

* Specially designed for the "HiQ-30". Not stocked by radio distributors and available only on special order.

The Complete 1929-1930 Catalog of Aerovox Products May Be Had Free on Request to
Aerovox Wireless Corporation, 70 Washington Street, Brooklyn, N. Y.

The Aerovox Research Worker

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Loudspeaker Coupling Systems

Part 2*

By the Engineering Department, Aerovox Wireless Corp.

IT is not possible in this article to take up a detailed method of designing this type of matching transformer but the general principle involved is as follows:

The primary winding impedance of the transformer with open secondary is designed to greatly exceed the A.C. plate resistance of the tube at the lowest frequency at which a good response is desired.

The primary to secondary turns ratio of the transformer required is obtained by taking the square root of the number obtained by dividing the impedance of the loudspeaker at the lowest frequency at which a good response is desired into twice the A.C. plate resistance of the output tube.

To take a concrete example we will assume that we are using an amplifier with a CX-371A tube in the output stage. The A.C. plate resistance of the tube at 180 volts plate voltage and 40.5 volts grid bias is 2,000 ohms.

The impedance of the given loudspeaker which it is desired to use in connection with the amplifier is 1,500 ohms at 60 cycles. The coupling transformer should be designed so that its primary winding impedance, with its secondary winding open is at least 10 times the plate resistance of the tube. The ratio of primary to secondary turns is obtained by taking the square root of (4,000 divided by 1,500) which equals 1.6 to 1.

When an output transformer is used as shown in Fig. 4 (see November Research Worker), it is necessary to use a bypass condenser "C2" of at least 2 mfds. to act as a bypass for the signal current across the resistance of the voltage divider system so as to prevent coupling in the power supply unit. The voltage rating of this condenser must be somewhat higher than that of condenser "C2" in Fig. 3, due to the fact that in Fig. 3 the voltage drop through the choke reduces the voltage applied across the condenser.

* NOTE—Readers who are beginning their subscription with this issue and have therefore not received Part 1 of this article, may obtain Part 1 by writing to the Aerovox Wireless Corporation and asking for the November issue of the Research Worker. There is no charge or obligation.

When using high impedance speakers, properly matched to the output tube, the choke and condenser coupling gives greater efficiency than the output transformer coupling.

In the last few years, the method of using more than one tube in the output stage has become very popular, as affording a means of obtaining greater power output and less distortion.

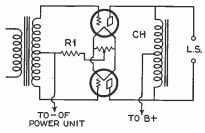


Fig. 5.

In one system of using more than one tube in the output stage, two or more tubes are simply connected in parallel, that is the grids of all the tubes are connected together, the plates are connected together and the filaments are connected together. One of the effects produced by connecting two or more tubes together in this way is to lower the A.C. plate resistance of the output stage, because such parallel connection of the tubes amounts to connecting the plate resistances of the tubes in parallel. This system of connection (resistance in parallel) naturally results in a plate resistance that is equal to 1/2, 1/3 or 1/4 of the plate resistance of a single tube when 2, 3 or 4 tubes respectively are used, provided that the plate resistance characteristics of all the tubes are the same.

The use of several tubes in parallel in the output stage therefore results in a combination of much lower plate resistance and provides

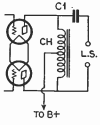


Fig. 5A.

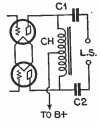


Fig. 5B.

a system which is better matched to speakers of the electromagnetic types, because with this lowered plate resistance, the output stage and the loudspeaker are better matched at the lower frequencies, resulting in better loudspeaker response at those frequencies.

It is necessary however, in order to get good results, to either match the tubes carefully or to provide some means of equalizing the differences between the tubes, by providing separate and adjustable grid bias or plate voltage controls.

In a push-pull circuit, the tube and plate circuits are connected in series, so that the plate resistance of this type of circuit for two tubes, is equal to twice that of a single tube, provided of course that the tubes are well matched or are provided with adjusting means in the plate or grid circuits to equalize the differences in the characteristics of the two tubes.

Since the push-pull type of circuit increases the plate resistance of the output stage, and provides a further discrepancy in the matching of the electromagnetic type of speaker to the output stage, this type of circuit does not increase but actually decreases the low frequency response of an electromagnetic loudspeaker of the usual type, UNLESS a proper output transformer is used to couple the speaker to the output stage.

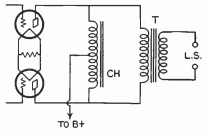
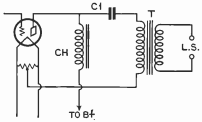


Fig. 6.

Ordinarily therefore, direct coupling of an electromagnetic type of speaker to the output of a push-pull stage, as shown in Figs. 5, 5A and 5B is not desirable since all of these systems provide an improper impedance match between the loudspeaker and the plate resistance of the output stage, for most efficient transfer of energy at the lower frequencies.

A third system of connecting tubes in the output stage is a combination of the parallel and push-pull systems. In this system two or more tubes in parallel are used in each half of the push-pull stage. If four tubes, each having a plate resistance of 2,000 ohms were used in such a combination, using two tubes in parallel in each half of the push-pull stage, the plate resistance of each pair of tubes in parallel would be 1,000 ohms and the push-pull, or series combination of the two pairs of tubes would result in a total plate resistance of 2,000 ohms. In other words, four tubes connected as described, in what might be termed a series-parallel arrangement, would have a total plate resistance of a single tube but with greater undistorted power output.

The circuits shown in Figs. 5, 5A and 5B are practically equivalent to each other as far as operation is concerned. If the choke "CH" in



all three circuits is made to provide a high inductance of the order of 30 to 40 henries so that its impedance is approximately 30 to 40 times that of the loudspeaker circuit, the greater part of the signal current will flow in the external circuit consisting of the loudspeaker which is shunted across the choke coil in Fig. 5; the condenser "C1" and speaker as shown in Fig. 5A or the two condensers "C1" and "C2" and the speaker as shown in Fig. 5B.

The use of condensers in the speaker circuit does not add to the efficiency of the push-pull system in that the use of capacity in the circuit will have a tendency to produce resonance peaks which may be harmful, unless the capacities are large, at least two to four mfds. total in the circuit. This tuning effect of condensers in the speaker circuit is sometimes used to boost the response of a speaker at certain frequencies by producing resonance at those frequencies.

The disadvantage of Fig. 5 lies

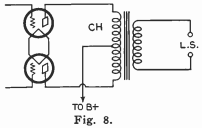


Fig. 8.

in the fact that the speaker terminals are at fairly high potential and in the case of high voltage units may be dangerous because of possible shock, if the speaker terminals are touched while the unit is in operation.

The use of a single condenser at "C1" in Fig. 5A, protects one of the terminals but not the other. To fully protect the speaker terminals, two condensers should be used as shown at Fig. 5B. In this case however, the two condensers are in series and the total capacity in the circuit is naturally reduced. If both condensers are of equal capacity, the capacity of the two condensers in series will be half that of either one of the condensers. To obtain a total capacity of 4 mfds. in the circuit would require a capacity of 8 mfds. in each condenser or a total of 16 mfds.

If the tubes shown in Fig. 5 are well-matched and if the two sections of the choke coil "CH" are equal, there will be no D.C. voltage measurable across the two plates or across the terminals of the speaker. The reason for this is naturally that both points are equally distant, electrically, from the "B+" terminal to which the centerpoint of the choke is connected.

Under normal conditions of operation, the condensers in the loudspeaker circuits are not subjected to any voltage except the very small voltage that may exist due to slight inequalities in the system.

If either of the speaker terminals should accidentally be connected to the filament lead or any other low potential lead of the receiver however, even through the comparatively high resistance of the hand of the operator touching both a loudspeaker lead and a low potential lead at the same time, a comparatively high voltage may be placed across the condenser, and it is therefore advisable to use condensers which will withstand the highest voltage used in the output circuit.

Since the total impedance of the plate circuit of a push-pull amplifier, such as is shown in Fig. 6 is equal to the sum of the impedances of the tubes in each half of the circuit, the total impedance in the circuit shown in Fig 6, using tubes of the CX-371A type, which have an impedance of 2,000 ohms each, would be 4,000 ohms. To obtain the primary to secondary turns ratio of the transformer required to couple such a circuit with an electro-magnetic type of speaker having an impedance of 1,500 ohms at 60 cycles, it would be necessary to divide twice the plate impedance of the tubes, or 8,000 by the impedance of the speaker or 1,500 which would give an answer of 5.33, and take the square root which gives the primary to secondary turns ratio as 2.3 to 1.

An ideal coupling system, combining the advantages of separating the D.C. and signal components of the plate circuit which is possible

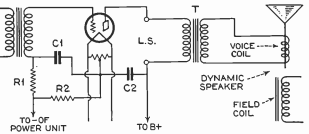


Fig. 9.

with the choke coil and condenser combination, and the impedance matching characteristics of the impedance adjusting transformer can be obtained by using the circuits shown in Figs. 7 and 8. The circuit shown in Fig. 7 can be used with an output stage employing a single tube or with two or more tubes connected in parallel. The one shown in Fig. 8 can be used with a push-pull output stage employing two tubes as shown or with a push-pull stage employing combinations of parallel tubes in each half of the push-pull stage.

In this type of circuit, it is necessary to make the primary winding of the impedance adjusting transformer "T" high so as to prevent losses in signal strength. The impedance of the choke "CH" must

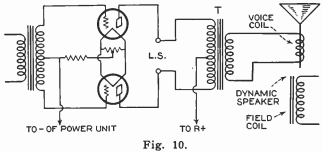


Fig. 10.

therefore be made correspondingly higher than that of the primary winding of the transformer so as to pass most of the signal current through the primary of the transformer, "T".

The essential difference between the electromagnetic speaker and the electrodynamic speaker has already been mentioned in Part 1 of this article, which appeared in last month's Research Worker.

From the standpoint of matching the speaker to the output stage, this difference consists mainly in the wide difference between the impedance characteristics of the two types of speakers over the audio frequency response range.

Whereas the impedance of the electromagnetic speaker is very high to start with, being of the order of 1,000 ohms and more at zero frequency (direct current) and increasing rapidly up to a value as high as 40,000 ohms and more at 5,000 cycles, the impedance of the electrodynamic speaker voice coil is only a few ohms and in some cases only a small fraction of an ohm at zero frequency and is seldom more than 25 ohms at 5,000 cycles.

This means that the load imposed by the electrodynamic speaker is more nearly constant over the audio frequency range and is therefore more suitable for use with the practically constant plate resistance of the output tube.

The very low value of impedance of this type of speaker however, makes it absolutely necessary to use an impedance matching transformer, between the output tube and the voice coil of the speaker.

The usual connections used to couple this type of speaker to the output stage of an amplifier are shown in Figs. 9 and 10. Fig. 9 shows the coupling of the speaker to an output stage consisting of a single tube or a number of tubes in parallel.

Fig. 10 shows the coupling of the speaker to a push-pull stage consisting of two tubes in push-pull arrangement or a push-pull stage with each half of the output stage consisting of two or more tubes in parallel.

The combination choke, condenser and transformer type of coupling may be used to advantage in dynamic speaker output circuits by introducing a choke and condenser between the output tube and the coupling transformer, as shown in Figs. 7 and 8.

The use of this system allows only the signal current to flow through the primary winding of the coupling transformer and keeps the flow of the heavy direct current in the plate circuit out of the primary winding of the transformer where it would tend to saturate the core and prevent faithful reproduction.