

**LESSON
31 R**

**AUDIO
AMPLIFIER PROBLEMS**



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SPEAKER PROTECTIVE DEVICES

The use of power tubes in the last stage of audio frequency amplifiers has made it necessary to provide special protection for the loud speaker and to devise suitable ways and means of connecting it into the output circuits of receiving sets. For most efficient operation such last stage power tubes require plate pressures ranging from 135 to 450 volts. It is evident that the loud speaker windings are consequently subjected to large increases in plate voltages and current as well as large-amplitude signal potentials if the speaker is connected directly into the tube plate circuit. Under such conditions the speakers operate under heavy overloads and severe electrical strains.

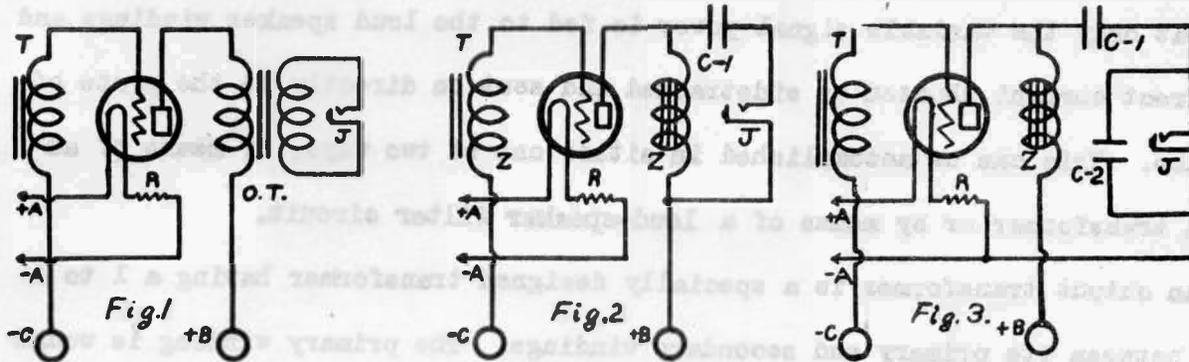
The total current flowing in the plate circuit of the last audio tube can be considered as consisting of two components, the steady direct current component from the B-battery which is fed to the plate of the tube, and the impressed signal power or voltage oscillations, which really are the only part that are finally reproduced as music or speech. The high direct current component in flowing through the speaker may cause a breakdown of the delicate windings or may cause rattling when loud signals are coming in due to the magnetizing effect in drawing the diaphragm towards one of the magnet poles. This latter condition may become especially serious if the current is sent through the windings in the wrong direction, for then the current demagnetizes the magnets and the speaker loses its effectiveness. If the cords of a speaker are marked, that is, one is black and the other has a red line or tracer through it, the cord with this red line should always be connected to the positive side of the B-battery or (B+) and the black cord to the plate side of the circuit.

Since only the variable signal power is effective in operating the loud speaker, and the direct current from the B-battery acts only to serve the plate of the tube,

it can be seen that the problem is to separate these two components in such a way that only the variable signal power is fed to the loud speaker windings and the direct current shunted or sidetracked and sent on directly to the plate of the tube. This can be accomplished in either one of two ways, by means of an output transformer or by means of a loud-speaker filter circuit.

An output transformer is a specially designed transformer having a 1 to 1 ratio between its primary and secondary windings. The primary winding is wound so that it can safely carry the heavy currents that flow in the plate circuit of the power tubes. The method of connecting this transformer into the receiving circuit is illustrated in Fig. 1, in which is shown only the last audio or output tube with the transformer primary connected into the plate circuit. As the total plate current flows through the primary, the variable signal pulsations induce similar alternating voltages in the secondary winding, and these A.C. voltages then in turn operate the speaker. The steady direct current flow has no influence on the secondary winding, for the transformer action depends upon the variable magnetic flux set up by the signal power oscillations. The two components of the plate current are thus separated, the steady direct current being sent to the plate of the tube and the signal oscillations being transmitted on to the speaker windings, and the desired result is accomplished.

In case an older receiving set has been equipped with a power tube in the last audio stage and it is desired to employ an output transformer but there is no room for it within the cabinet, the transformer can be placed in a convenient position to the side or behind the cabinet. The transformer is connected into the receiver output by means of flexible cords, and the speaker is connected to the secondary of the transformer. An ordinary audio transformer, however, cannot be used as an output transformer, for it is not of the proper design and construction. With the aid of a good output transformer any of the new type speakers can be operated from any make of radio receiver.



SPEAKER OUTPUT FILTERS

Another excellent yet rather simple method of separating the pulsating A.C. signal component from the steady direct current in the plate circuit of the output tube of a receiver is by means of a filter circuit consisting of a choke coil and a fixed condenser of rather large capacity (2 to 4 Mfds.). Two methods of connecting such a filter into the output circuit are illustrated in Fig. 2 and 3. Upon examining these circuits it can be seen that the iron core choke "Z" freely passes the direct B-battery current to the plate of the tube, but because of the choking action of the coil (its impedance) the A.C. signal component cannot get through. This signal must then pass through the fixed condenser C-1 and into the loud speaker windings. Although a 2-Mfd. condenser can be used for C-1, a 4-Mfd. is much more satisfactory in every respect, in that it offers far less opposition to the A.C. signal impulses. In other words, the lower pitched base notes will get through much more easily. This blocking condenser C-1 also prevents the direct current from passing through the speaker windings. Again the desired result is accomplished, the two components of the plate current are separated and the speaker windings are suitably protected against the excess plate potentials and current flow.

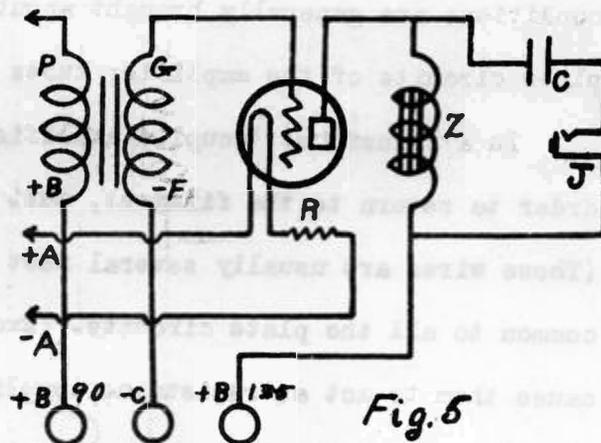
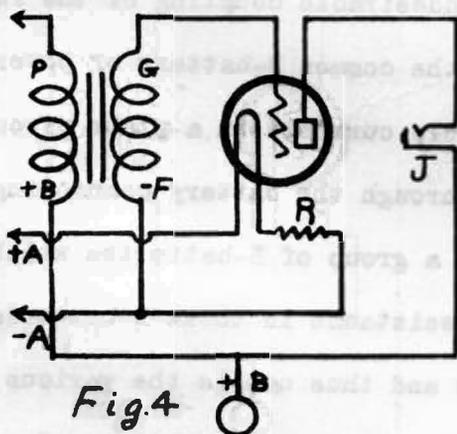
The condenser C-2 is the customary by-pass condenser connected across the speaker terminals. By experimenting with different capacities for C-2, the pitch

of the speaker can be raised or lowered to the desired pitch. Recently a small compact variable condenser has been placed on the market that ranges in capacity from 0 to .032 Mfd. This condenser has been especially designed for this purpose, and when used in connection with a good choke coil and blocking condenser, forms an excellent and flexible speaker output filter.

There are also a number of units on the market which have the choke coil and blocking condenser combined and housed in a compact and neat case. Such an output unit is connected into the receiver just like an output transformer is, as was explained in the preceding section.

TO CONVERT SECOND STAGE INTO POWER AMPLIFIER

It is a simple matter to rearrange the second stage of an audio frequency amplifier into a power tube stage. The general circuit arrangement from the old to the new is illustrated in Fig. 4 and 5.



The -F terminal of the second audio transformer is disconnected from the rest of the circuit and brought out to a special -C terminal post so that the proper bias can be placed on the grid of the tube. Into the plate circuit of the tube is connected a choke coil "Z" and a 4-Mfd. blocking condenser "C". As was explained

previously, this arrangement blocks the direct current from the B-battery from flowing through the speaker windings. Since only the signal voltage pulsations are impressed on the windings, the life of the speaker is greatly prolonged and all danger of demagnetizing the magnets due to the current flowing through them in the wrong direction, is removed.

The amount of plate pressure and C-battery voltage to use depends upon the type of tube employed. This information will always be found on the instruction slip packed with the tube. Only the best audio transformers should be employed if good tone quality output is desired. Old transformer windings should not be used as chokes, for they do not give satisfactory results.

OSCILLATIONS IN AUDIO AMPLIFIERS

Occasionally difficulty will be experienced with an audio amplifier in the form of unstable operation accompanied with a howling or throbbing noise. Such conditions are generally brought about by an undesirable coupling of the respective plate circuits of the amplifier tubes through the common B-battery or power supply.

In a transformer coupled amplifier the audio currents in a plate circuit in order to return to the filament, must travel through the battery connecting wires, (These wires are usually several feet long) to a group of B-batteries which are common to all the plate circuits. Excessive resistance in these B-batteries will cause them to act as resistance coupling units and thus couple the various plate circuits together. The result is a tendency to produce regeneration and set up audible oscillations or howls. The same is true in the grid circuits, for here the oscillations must return through the connecting wires and the C-battery in order to reach the filament. Of course, the resistance coupling effects become prominent only when the batteries become dry and partially exhausted.

If A.C. operated power supply devices are used, the previously described effects are likely to become very pronounced, for in such apparatus the various plate voltages are generally obtained by causing voltage drops across a number of resistance elements which again are common to all the plate circuits. Tendencies toward regeneration are thus inevitable, and audible oscillations or howls should be expected.

A COMPLETELY FILTERED AUDIO AMPLIFIER

Unstable operation and oscillations in audio amplifiers due to the resistance coupling effects of B-batteries or power supply, can easily be corrected by the use of suitable filters and by-pass condensers. A completely filtered audio amplifier is illustrated in Fig. 6. In this arrangement a system of audio frequency chokes and condensers are used to impede the flow of the audio currents to the B-batteries and to form suitable return paths to the filaments.

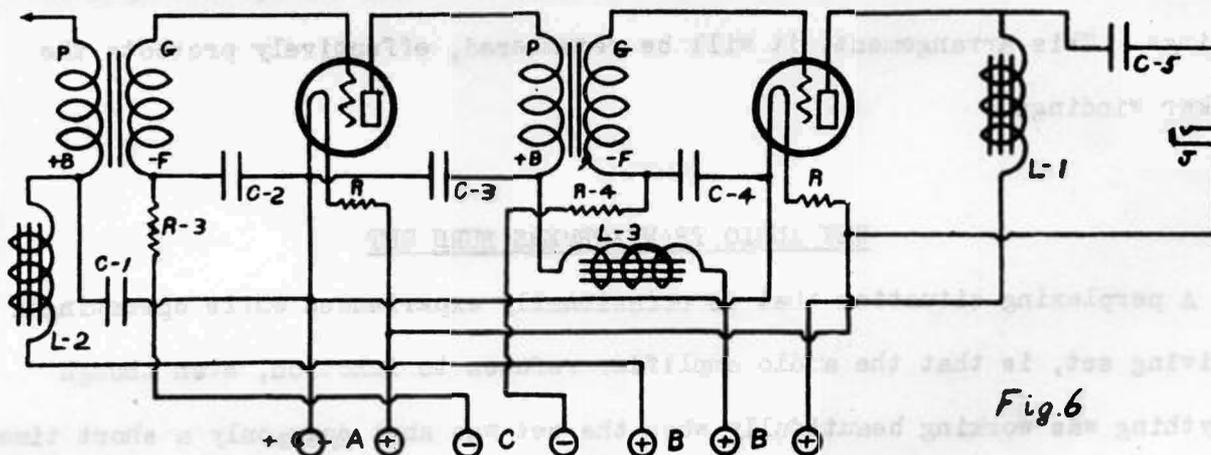


Fig. 6

In the illustrative diagram it can be seen that the two audio choke coils L-2 and L-3 are connected directly into the plate circuits. They will not hinder the normal flow of direct current, but will effectively obstruct the audio fre-

quency oscillations from passing on to the B-battery. In order to provide suitable return paths, the condensers C-1 and C-3 are used. These condensers, which should have a capacity of at least 2 Mfds., lead directly to the negative side of the filament and thus form a convenient return for the oscillations which cannot get through to the batteries.

In the grid circuits the blocking resistors R-3 and R-4 (each having a resistance of 1/4 megohm) obstruct the oscillations from reaching the C-batteries, while the condensers C-2 and C-4 provide the return paths to the filament. In reviewing the entire operation it can be seen that in each case first a choking or obstructing element is used to impede the flow of the audio currents through the B-battery leads, and secondly a return or by-path is provided for these currents as a short return to the negative side of the tube filaments.

Into the output circuit of the last tube is connected an output filter L-1 to shunt the direct current around the speaker and to force the audio oscillations through the blocking condenser C-5 (4-Mfds.) and through the speaker windings. This arrangement, it will be remembered, effectively protects the speaker windings.

WHY AUDIO TRANSFORMERS BURN OUT

A perplexing situation that is occasionally experienced while operating a receiving set, is that the audio amplifier refuses to function, even though everything was working beautifully when the set was shut down only a short time ago. Examination will reveal that one of the audio transformers is burnt out or blown out; that is, at some point the winding was overheated and melted. The circuit is thus broken at that point, and no current can flow. This condition invariably occurs in the primary winding at the transformer. What causes this to burn out is easily explained.

The coils of an audio frequency transformer are wound with very fine wire, just large enough to carry the 10 or 12 milliamperes of plate current that flows through them. No. 39 or 40 wire is generally used.

As long as the receiver and amplifier are in steady operation, this value of plate current is seldom exceeded and no trouble is experienced with the transformers. But at the instant the set is shut down, a totally different condition exists.

The current in flowing through the transformer windings, stores up a great deal of energy in the form of magnetism or magnetic field in the iron core. When the current is turned off, this magnetism collapses or dies out, and in doing so it induces a voltage in the windings which tends to keep the current flowing. This phenomenon is known as self-induction, and is merely a form of electric inertia. If the current is turned off very abruptly, as with a snap or push and pull switch, this voltage of self-induction is very great. The result is that a large current surge or rush takes place, and the fine wire is overheated and melted at some weak spot.

Observation has proven that a transformer seldom burns out while the amplifier is in operation; but that it invariably occurs at the instant the receiver is shut down. This condition could be avoided by turning down the tube rheostats gradually, but this is not always desirable nor is it as convenient as merely pulling the switch button.

HOW TO TEST A TRANSFORMER

As was previously explained, an audio transformer consists of two windings, a primary and a secondary, wound on an iron core. The current in flowing through the primary sets up a pulsating magnetic flux in the iron core, and this in turn induces a current in the secondary winding, this secondary current being fed into

the input circuit of the next tube. Now in order that a transformer can operate at all, it is necessary that both windings be continuous and uninterrupted, for otherwise no current can flow through them.

In order to test a transformer to determine if one or both windings are open, the simplest apparatus to use is a $1\frac{1}{2}$ -volt dry cell or 3-volt C-battery and a pair of telephone receivers. One of the phone cords is connected directly to the positive terminal of the battery while a piece of flexible insulated wire is connected to the negative terminal. As soon as the free end of this wire and the other cord tip are touched together, current flows through the phone receivers and a click is heard, caused by the diaphragm being attracted to the magnets.

To use this apparatus for testing a transformer, all wires leading to the transformer are first disconnected. The free end of the wire from the testing cell and the loose phone cord tip are then touched to the primary terminals of the transformer. If a clear distinct click is heard in the phones, it shows that current can flow through the primary winding and that it is intact. However, if no click is heard, no current can flow through the winding, and it is consequently broken at some point. The same test should then be applied to the secondary winding.

If a transformer is found with one of its windings open, it should be discarded and replaced with a new one, for an audio transformer cannot easily be repaired. Some manufacturers, however, will make adjustments on defective transformers.

EXAM QUESTIONS ON FOLLOWING PAGE