How to Improve the Amplifier

A Comprehensive Treatment of an Important Subject

(By "MEGOHM")

BECAUSE the audio amplifier is common to every valve receiver, and also assists in obtaining the best type of gramophone reproduction, it has, in company with the loudspeaker, become a subject of supreme importance. It is the constant desire of every constructor to alter and improve with the aim of ultimately possessing a push-pull amplifier working completely off the electric mains supply.

Those who have already arrived at this stage know the extreme satisfaction to be derived from an amplifier capable of handling heavy volume with remarkable clarity and an absence of noticeable distortion. Such reproduction, of course, assumes the provision of a loudspeaker worthy of the amplifier. Although a power amplifier may be capable of giving enormous volume without distortion, such volume need not necessarily be used, but forms an amount of "reserve" that ensures the very highest quality of reproduction when normal volume is used. This is a very different condition to that obtaining when a small amplifier is used, and every part of the circuit is "pushed" to give far more volume than the outfit should be expected to give. The result of this latter method is the production of plenty of noise, accompanied by very little quality.

Apart from the bad effects of amplifying the output of an overloaded detector valve, there may be inefficient transformers or other components, and valves incapable of carrying satisfac tory volume.

Of course, as many are aware, the valve in the last stage is the main factor, so long as it is backed up by other necessary improvements in the circuit, and when it comes to placing two valves in "push-pull" in the last stage, some rather drastic changes may be necessary. But these changes are all worth while, and have to be faced sooner or later by the progressive constructor.

Power Valves.

POWER-VALVES may be used in the last stage of any receiver, and may be classed as "small," "medium" and "larger" or "super," the latter class including the 245, 210 and 250 types.

A power-valve has a low impedance, which allows a large "B" current to pass, and has a thick and long filament in order to increase the emission of electrons. The plate is large, and its high applied ("B") voltage increases the electron flow, which in turn is varied by the action of the grid becoming alternately positive and negative.

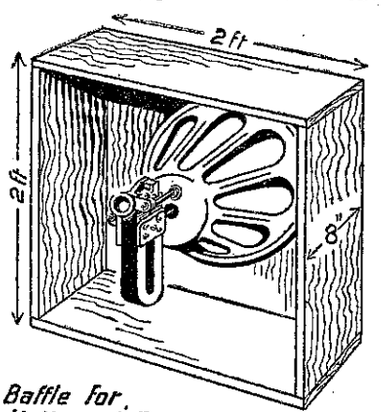
The relative positions of the three electrodes with regard to one another, and the spacing of the grid wires determine the amplification factor of a valve, and in a power-valve the electrodes are placed to give a low impedance, and this, with open-spaced grid wires, gives a low amplification factor. The ability to handle greater volume compensates for the lessened amplification. In receivers with a large overall amplification, and consequently capable of passing heavy volume to the first audio stage, it may be necessary to place in that stage a suitable power-valve, usually a small one, so that fair amplification is retained, but where two large valves are employed in push-pull in the last stage, the first audio may have two smaller valves in push-pull also. This is the most satisfactory arrangement of all, but complete operation from the mains is practically a necessity.

For the battery-operated set with an output valve that does not handle the required volume very efficiently, it may be desired to place a larger valve in the last stage. Probably such a change must be accompanied by several other changes, because the fact of the larger valve passing more "B" current, possibly at a higher voltage, introduces other matters for consideration. In order to obtain the full advantages of the larger valve, the plate voltage should be near the maximum recommended by the manufacturer, and the actual current in milliamperes taken from the "B" battery will be greater than previously. Where a "B" eliminator is in use the required voltage will probably be forthcoming, and probably the milliamps. as well, because if the eliminator maximum is 150 to 180 volts, it will not be used on a valve requiring more than 20 milliamps., such as the UX171. For dry "B" batteries to last a reasonable time, the total drain should not exceed about 15 mills., so that a 112 type valve is economical, and where dry "A" batteries are used also, the UX120 is about the limit.

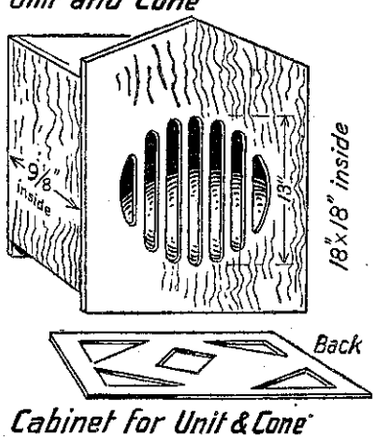
Grid bias has usually to be increased when a larger valve is installed, but is easily provided by a 22½ volt or other suitable dry "B" battery, if not provided by an eliminator.

The Loud Speaker.

THE next consideration concerns the output to the loudspeaker. In sets with a small output valve the "B" current usually traverses the speaker windings, but as it will probably be only about 6 mills., no harm is done to the speaker magnets if correct polarity is observed in connecting the leads. Where the current passed is more than 10 mills. it is advisable to employ a choke-condenser output filter to protect the speaker windings from saturation by the "B" current. Quality is assisted thereby, and the lower impedance of the output valve will not then affect the speaker output.



Baffle for Unit and Cone



Cabinet for Unit & Cone

A valve delivers its maximum undistorted volume when working into an external resistance equal to twice that of the plate resistance or impedance. This means that the impedance of the speaker should be about double the impedance of the valve impedance, though actually there is nothing critical about the matter, especially so long as the speaker resistance is not less than that of the valve.

An output transformer may be used to compensate for the difference, especially if a dynamic speaker is used.

In the case of an ordinary speaker, an output choke usually renders further matching of impedances unnecessary. It also prevents serious loss of plate voltage, prevents heating of the speaker windings, prevents the placing of a mechanical bias on the speaker armature, and prevents feed-back from the last valve. The inductance of the choke should not be less than 20 to 25 henries, and the condenser 2 to 4 microfarads. The combination can be purchased as a complete unit.

The adoption of large valves means the provision of a power-pack to supply up to 450 volts, and comparatively large current. A pair of 210's in push-pull will require 36 mills., and a pair of 250's will take 110 mills. at the highest plate voltage of 450. The 245 is a new valve giving output about equal to the 210, but with only 250 volts on the plate. The filaments of such valves are run from low-voltage raw alternating-current supplied by the power-pack, the voltage of the 245 being 2.5, and of the 210 and 250, 7½ volts.

The average loudspeaker requires about 100 milliwatts (0.1 watt) to give good volume for a small room, but to obtain consistent quality there should be considerable reserve of power beyond this. The less reserve of power, the greater the liability to blasting or distortion on occasional notes. At the highest plate voltage of 150, the UX 112A gives nearly .2 watt, and with 180 volts the UX171A gives .7 watt output.

It will, of course, be understood that these notes are chiefly for the benefit of owners of the numerous battery-operated sets, many of them home-built, that will continue in use for a considerable time to come. Many of the hints, however, apply equally well to home-built a.c. sets, especially as the last stage in any a.c. set invariably contains an ordinary power-valve, the filament being heated with raw a.c. The average factory-built a.c. receiver has a more liberal audio equipment than its battery prototype, owing to the availability of greater power, and for the same reason the inclusion of a dynamic speaker is usual.

Audio Transformers.

ONE of the easiest ways of improving an amplifier is by introducing better transformers than those already installed. Indifferent transformers may introduce a considerable amount of both frequency distortion and harmonic distortion. Frequency distortion is the difference in the amount of amplification at various audio frequencies. A poor transformer will give considerable amplification on high notes, and may give objectionable emphasis known as a "peak" around a particular frequency; whilst at the same time the amplification of low notes is so slight that below, perhaps, say, 150 cycles, they are practically lost.

A well-designed modern transformer is provided with a primary winding of high impedance, so that the low notes are sufficiently amplified, whilst high note loss is prevented by sectional wind-