10.5 Power-Stage

The power-stage is the last amplification stage in the signal chain; it delivers the power required to drive the loudspeaker. In most cases, it operates with rather pathetic efficiency because normally less than half of the power produced by the power stage is actually fed to the loudspeaker – the remainder is converted into heat within the power-tube(s). In order to be able to sufficiently dissipate this power loss, the tube(s) deployed in the power-stage is (are) larger than typical preamplifier tubes. The thermal load capacity of power tubes typically amounts to 12 – 45 W with their physical volume up to 10 times that of a preamp-tube. Since power-tubes can deal with high voltages but not with high currents, they are almost never directly connected to the loudspeaker. Rather, the plate-currents of the power-tubes are fed to the output transformer that takes care of an impedance matching towards the speaker.

A good overview is provided by the **family of output characteristics** of the power-tube (**Fig. 10.5.1**) showing the relation between plate-voltage and plate-current. Multiplying these two quantities yields the **power-dissipation at the plate** P_a, i.e. the power heating up the plate of the tube (in addition to the heating done by the tube filament). If the specified maximum dissipation at the plate is exceeded for long periods of time, the tube begins to glow and may be destroyed. The so-called **power-hyperbola** is given in Fig. 10.5.1 as the dashed line, indicating the largest permissible plate-current for the respective plate-voltage. To the right, the characteristic finds it limitation in the largest allowable plate-voltage; larger values will cause sparking and damage. Towards the top, the maximum specifications of plate-current and/or grid-drive provide a ceiling; the lower limits are given by the blocking behavior of the tube. Normally, tubes are rather good-natured regarding overload situations (much more so than transistors) because the associated thermal time constants are much longer. However, this behavior must not be interpreted as general "indolence": continuous overload will reduce the lifetime (Chapter 10.5.9).

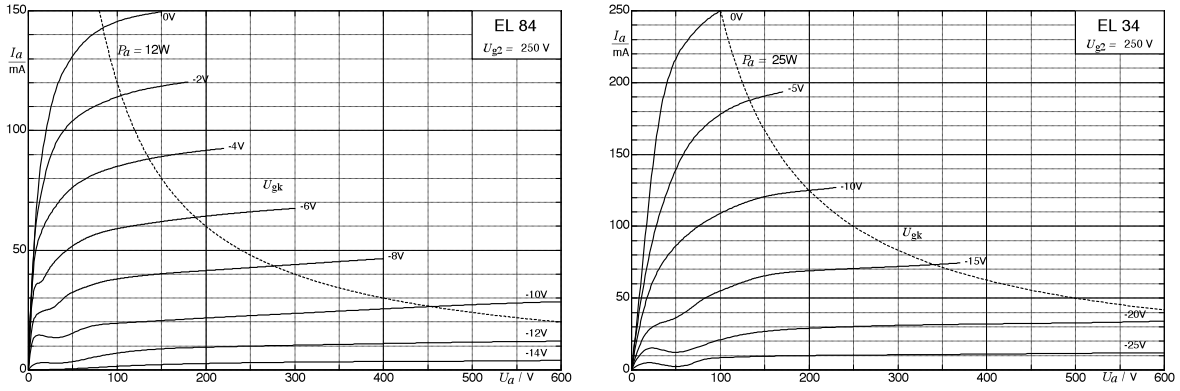

Fig. 10.5.1: Family of output characteristics of two typical power-pentodes. Screen-grid-voltage U_{g2} = 250V.

It should be noted that the characteristics given in Fig. 10.5.1 are sourced from datasheets (as is the case for all tube characteristics); to a degree, the individual tube-specimen will look different. In addition, it needs to be considered that power-tubes are almost always tetrodes or pentodes, and consequently their behavior is defined by both control-grid *and* screen grid. For data-sheet specifications, the screen-grid-voltage is assumed to be constant – however, reality shows that it depends on the drive-levels, after all. On the one hand, this is due to the fact that the supply-voltage drops somewhat as the drive-levels increase ("sagging"), and on the other hand, it is because there is a voltage-drop across the grid-resistor.

