Da: Audio Handbook, Normann H. Crowhurst, 1951

Elliptical Load Lines—Reactive Load

Those cases deal with wrong bias or wrong load, always supposing the load in the valve anode circuit behaves as a pure resistance. In practice, especially at the ends of the frequency range, it is seldom like a pure resistance. Inductances and capacitances in the circuit make the load line "elliptical." This is not so difficult to understand as is often supposed. The property of a pure reactance, *i.e.*, a capacitor or high Q inductance by itself, is that the peaks of current coincide with zeros of voltage and vice versa.

A load line due to pure reactance takes the form shown in Figure 14. The arrowheads shown represent the direction taken by the operating voltage and current for a high Q inductance. When voltage is a maximum positive, at A, current is zero; quarter of a cycle later current is at maximum, and voltage is zero, at B; another quarter cycle, and voltage is at maximum negative, current is zero, at C; after the third quarter cycle, current is maximum negative, and voltage is zero at D; finally after the fourth quarter cycle the position is back at A. Current reaches any position in its cycle, quarter of a cycle after voltage has passed the same position. For a capacitance, the direction of the arrowheads would be reversed.

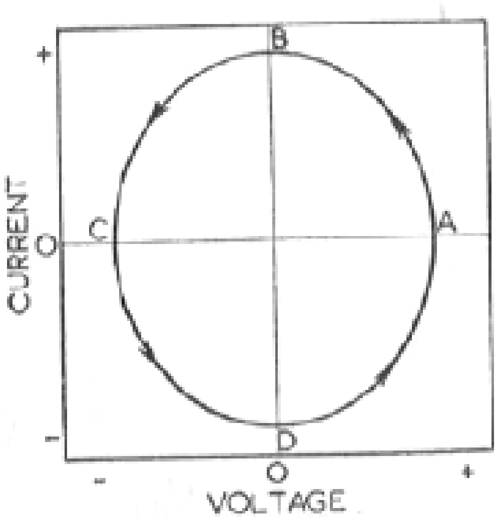

FIG. 14. ELLIPTICAL LOAD LINE DUE TO PURE INDUCTANCE.

In valve circuits pure reactance loads can never occur, because there must be coupling resistances, etc., and the voltage and current never become actually negative, but fluctuate, always in a positive direction. The reactance component appears either in shunt or in series with the known resistance load.

The effect of parallel addition of reactance to a resistance load, AB, across "ideal" valve characteristics (*i.e.*, in which the grid voltage "curves" are all straight, parallel, and equally spaced), working at the operating point C, is shown in Figure 15 (a), while (b) represents the effect of reactance added in series with a resistance load. It is not easy to show elliptical load lines on practical valve characteristics where the effect of reactance causes distortion, because the ellipse goes out of shape, the current waveform being distorted differently from the voltage waveform. But from the ideal ellipses, applied in imagination to actual valve characteristics, it is easily understood that shunt reactance, in the case of triodes and series reactance, in the case of tetrodes or pentodes, cause distortion.

Practical Cases of Elliptical Load Line

In tetrodes or pentodes, series reactance causes distortion very like that caused by too high value of resistance load. One kind of series

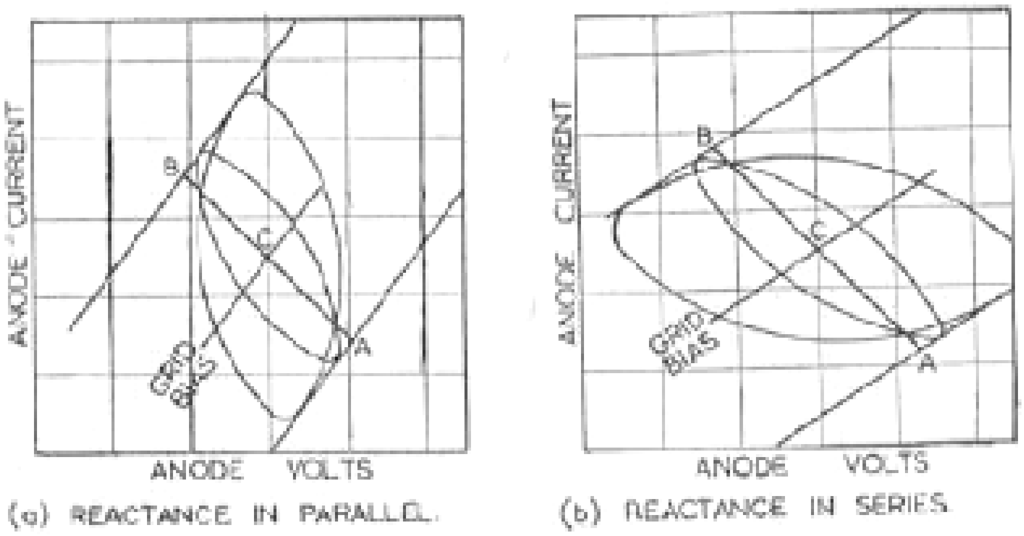

FIG. 15. "IDEAL" LOAD LINES FOR REACTANCE ADDED TO FIXED RESISTANCE, AB.

reactance normally met in these circuits is the coupling capacitor, so this distortion can arise at low frequencies if the coupling capacitor following a tetrode or pentode stage is too small. A commoner cause is the speech coil reactance of a loudspeaker, used as a load for a tetrode or pentode output. This is partly why tetrodes or pentodes need correction capacitors connected, either from anode to earth, or across the secondary of the output transformer.

In triodes, the kind of shunt reactances that may cause trouble are the grid input capacitance of the following stage, which is unlikely, and the inductance of a coupling choke or coupling transformer primary. The latter will cause distortion particularly at low frequencies, if the inductance is not high enough for the purpose. Notice that this distortion is quite different from that produced by saturation of the core of the choke or transformer, due to too high a level at too low a frequency. The latter is quite another source of distortion, and one usually less often met in modern practice.

The kind of waveform produced is rather different from anode bend distortion, although it does not sound very different. Figure 11 (c) shows the waveform produced by a coupling choke of too low an inductance value.