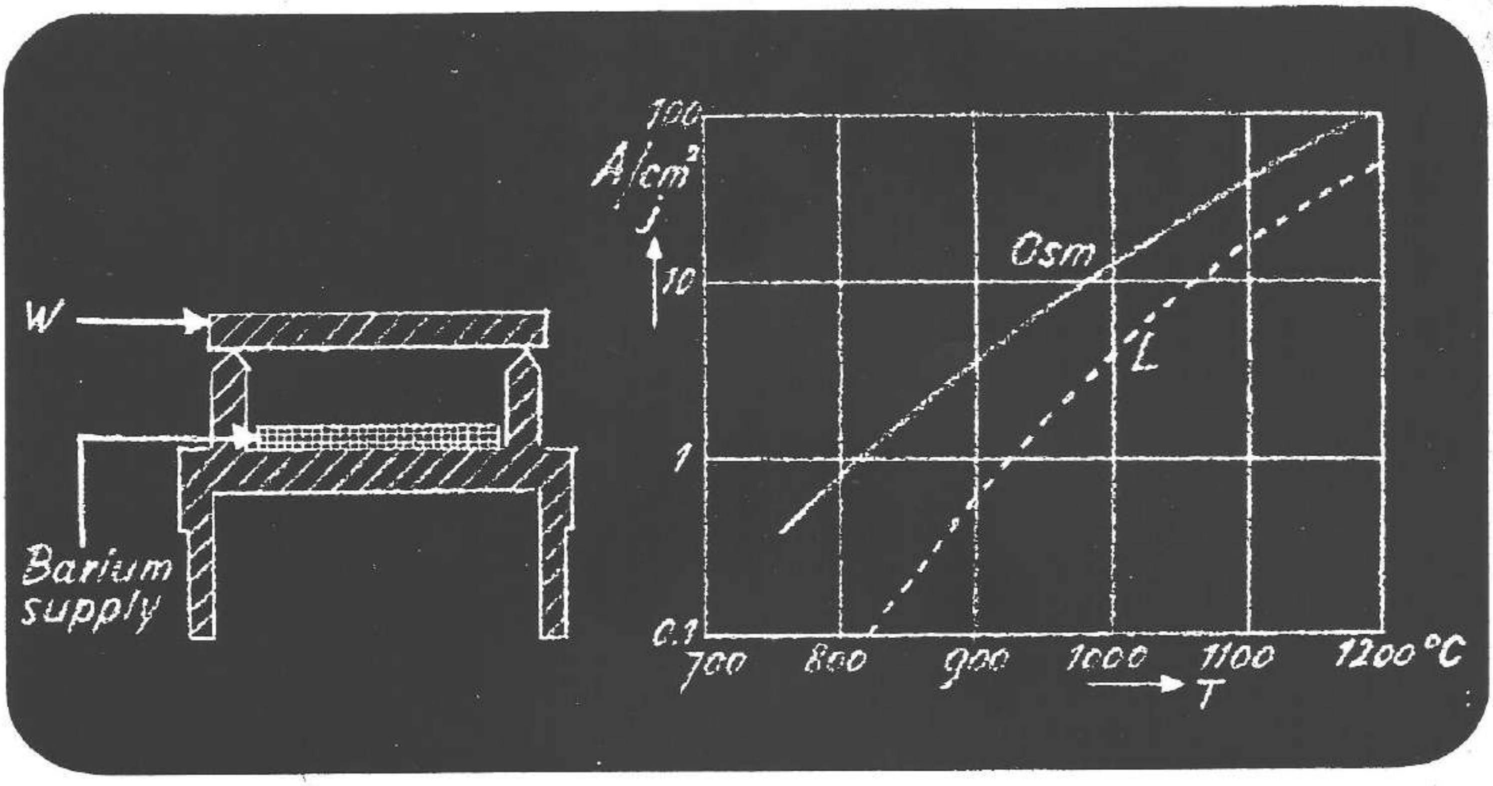

Electrons available from stock; evolution in cathodes

Condensed from a paper by dr. P. Zalm

The development of electron tubes for higher frequencies and energy output creates an ever increasing demand for better cathodes. Today's magnetrons and other microwave tubes could never have been developed, had not the spectacular evolution of thermionic cathodes led to impressive possibilities. Of particular importance in this connection are the dispenser-type cathodes, on the subject of which we here set down a few stray thoughts.

It is to the credit of the late H. J. Lemmens, of the Philips Research Laboratories, a creative investigator with exceptional intuition, that he proceeded from a fundamental separation of functions in cathodes. Whereas for a long time the functions of "heating" and "emission" in oxide-coated cathodes had been separated, he applied separation of the "electron-emission" and "barium-supply" functions as well. He thus indicated ways of solving the problem of the limited current density of oxide-coated cathodes. In the normal oxide-coated cathode the average current density must not exceed 0.5 to 1 A per cm^2, since otherwise, owing to the layer's resistance, so much heat would be generated in it that damage would occur. One of the factors determining the resistance in the layer and with which the life of the cathode is also linked, is its thickness (approx. 80 microns). If the layer is made very thin (say 5 to 20 microns), then, for the same current density the cathode's life will be short.

In the case of normal barium-strontium oxide-cathodes the emitting layer consists of small (Ba, Sr)O crystals. These owe their low work function (and thus good emission at not too high temperatures) to the adsorption of barium. Barium evaporates, however, and has to be replenished. This occurs through reaction of the BaO with the reducing agent added to the nickel of the cathode: Al, Mg or Si etc. In L-cathodes (L for Lemmens) and other dispenser-type cathodes the necessary barium is replenished not from the layer, but from a separate, small supply chamber shut off by a "lid" of porous tungsten; this results in a good separation of functions between emitting layer and barium supply. Hence the emitting surface consists of the porous tungsten on which a film of barium of atomic thickness has been adsorbed; the series resistance is then extremely low. A pleasing aspect of this development is that the substratum (the metal "lid" on the supply chamber) can be varied at will. Frequent use is now made of this degree of freedom.

More recent developments in these cathodes disclosed an interesting paradox. When a study is made of the question as to how the work function of metals is influenced by adsorption of electropositive elements such as barium, it is found that at tungsten-barium interface a change in potential occurs, due to formation of a dipole layer as a result of polarisation of barium atoms. This dipole layer reduces the work function. It is possible to calculate that for a higher work function of the base material the number of barium atoms which can be adsorbed in such a state of polarisation is greater. This increase is so sharp that the paradoxical effect is obtained that the higher work function of the base metal is more than compensated.

This calculation has been confirmed in practice. So we looked for the base material among metals with high work functions. These are to be found especially in the platinum group. For a number of applications osmium was chosen from this group. The Os-cathode, as every other normal dispenser-type cathode, can withstand temperatures of up to 1,100 °C.

For professional purposes, particularly in communications engineering, it excels on account of high current densities (up to 40 A/cm^2) and long life (10^5 hours at 1 A/cm^2).

Therefore it can truly be said that here many electrons are available from stock, and will be for a very long time.

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