A model of the arc

When discussing in the previous chapter the dependence of spectral-line intensity on temperature and electron pressure we tacitly assumed the source to be homogeneous. In fact, as we mentioned in § 3.8 and found in §§ 6.12 to 6.16, we must consider radial distributions in an arc. In this chapter we shall attempt to incorporate the radial decline of temperature \( T \) and electron pressure \( p_e \) into our picture of line intensities. We shall resort to a model that approximates the actual conditions well enough to permit conclusions which have general validity. Interestingly, our calculations, which were made for instruction purposes, yield some remarkable results which enable us to define the scope of the effective values of temperature and electron pressure. We shall demonstrate in subsequent sections that a slice of plasma through the arc can be approximated, with respect to the emission of spectral lines, by a circular disk of effective temperature \( \bar{T} \), of effective electron pressure \( \bar{p}_e \), and of effective radius \( \bar{R} \). This holds for all ion lines and for most atom lines except the low-level lines of elements with a low ionization potential.  

We shall adopt the following model of the arc. The parabolic function

\[
T = T_0 - a(b - T_0)r^2
\]

(8.1)
depicts the radial temperature profile, where \( T_0 \) is the temperature at the axis, \( a \) and \( b \) are constants, and \( r \) is the radial coordinate. By the proper choice of the constants \( a \) and \( b \) the function can be made to describe the widening of the high temperature region as \( T_0 \) increases. Obviously, the function cannot hold true for large \( r \), but this causes no difficulty; the emission is negligible when \( r \) is large, so that calculations never extend to the very outskirts of the arc, where the temperature falls less steeply with \( r \) than is predicted by (8.1).

To fix numerical values for the constants we considered the temperature profile calculated by Roes for a 7-amp d.c. arc in air (see Fig. 6.36). Accordingly we adopted the following condition: \( T_0 = 6600^\circ \text{K} \), while \( T = 5000^\circ \text{K} \) at \( r = 4 \text{ mm} \). As a second condition we introduced \( T_0 = 5000^\circ \text{K} \), while \( T \approx 4000^\circ \text{K} \) at

*Some arc model calculations similar to those mentioned here have been reported by Hefferlin and Gearhart (1964).
From these conditions we determined the constants \( a \) and \( b \) to be \( 10^{-2}\, \text{mm}^{-2} \) and \( 16600\, \text{K} \) respectively. Temperature profiles computed from these values are shown in Fig. 8.1 for different values of \( T_0 \). Note that the curves of the actual