



Figure 3.4. Theoretical negative-compliance characteristics. The forces plotted are the electric forces exerted on the diaphragm by the negative-compliance mechanism. For the curve, the vertical quantity is that within the curly brackets of equation (3.34).

'factor of safety' must be allowed, and the criterion adopted by Quad is that the diaphragm tension should be such that the capacitance at the fixed-plate terminals, measured at a very low frequency, e.g. 5 Hz, well below the resonance frequencies, shall increase by a factor of approximately 1.4 when the polarizing supply is switched on. From Fig. 3.2, in which all impedances to the right of $C_m d \alpha^2$ may be neglected at the low measuring frequency, it is easily deduced that this criterion corresponds to $C_m d \alpha^2 = 0.286 C_0$, the diaphragm stretching stiffness then being 3.50 times the negative stiffness.

If the diaphragm is moved away from the middle very slowly, say by a sustained strong draught, its voltage will remain equal to V_{pol} , in all positions, Q varying appropriately. The negative-compliance force on it then varies non-linearly with position, as shown in Fig. 3.4. The equation for this curve is easily derived, as follows.

Referring to Fig. 3.1(b), and bearing in mind that the diaphragm voltage is now equal to V_{pol} for all values of x , equation (3.1) can be applied to C_1 and C_2 to give the forces of attraction on the diaphragm with $V_{\text{sig}} = 0$. Thus

$$\text{Force towards right} = -\epsilon_0 A V_{\text{pol}}^2 / (d - x)^2$$

$$\text{Force towards left} = \epsilon_0 A V_{\text{pol}}^2 / (d + x)^2 \quad (3.32)$$

Hence F , the total negative-compliance force towards the right, is given by

$$F = \frac{1}{2} \epsilon_0 A V_{\text{pol}}^2 [(d - x)^{-2} - (d + x)^{-2}] \quad (3.33)$$

and a little algebraic manipulation shows that this may be more conveniently expressed in the form:

$$F = \frac{2\epsilon_0 A V_{\text{pol}}^2}{d^2} \left\{ \frac{x/d}{[1 - (x/d)^2]^2} \right\} \quad (3.34)$$

This is the equation from which the Fig. 3.4 curve was plotted.

When x is very small compared with d , the denominator becomes very nearly unity and the equation then approximates to

$$F = 2\epsilon_0 A V_{\text{pol}}^2 x / d^3 \quad (\text{for } x/d \ll 1) \quad (3.35)$$