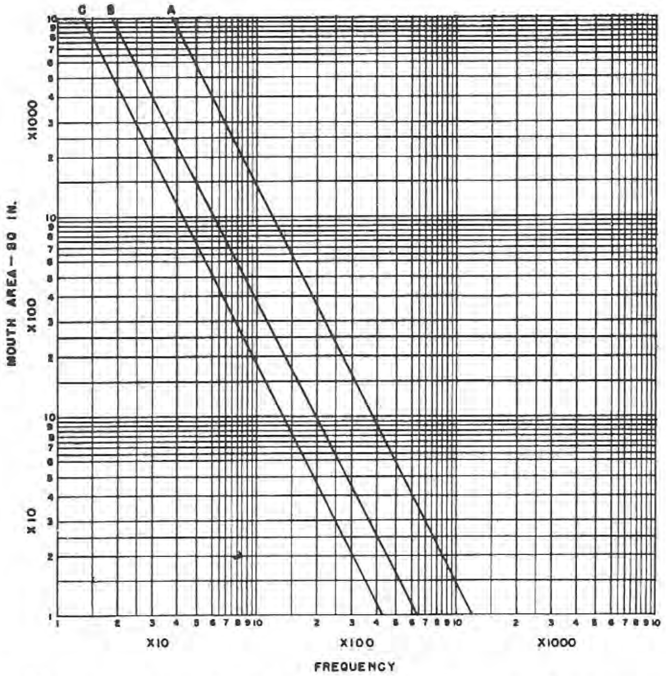

FIG. 4. Minimum horn mouth size as a function of frequency: A, operation in free space; B, intersection of two planes; C, operation in a corner.

the resistive components are equal and the reactive components are equal but of opposite sign and therefore cancel out. In the direct radiator type of speaker the moving system impedance is normally much higher than that of the air load, and this ideal condition of a conjugate match is approached only at resonance. This mismatch accounts for the relatively low efficiency of the direct radiator type of speaker.

The driver can be considered as a generator having an internal impedance:

$$Z_d = \frac{(Bl)^2}{R_g + R_c} + j\left(\omega M_d - \frac{S_d}{\omega}\right)$$

The mechanical impedance of a driver is resistive only at its resonant frequency and is highly reactive at any other frequency. If the cutoff frequency of the horn is placed below the unloaded resonance of a driver, the horn reactance is positive and increasing with decreasing frequency while the driver reactance is negative and also increasing with decreasing frequency. Thus it is possible to make the net mechanical reactance between horn cutoff and driver resonance close to zero. The cutoff frequency is generally chosen as the point where the net mechanical reactance is zero, since in the finite horn the mechanical resistance at and below cutoff is not zero but has a finite value which is a small fraction of the asymptotic value. This expedient leads to a large efficiency improvement at and near cutoff.

The effective reactance of a driver at the cutoff frequency may be put in the form

$$X_d = \omega_0 M_d \left[1 - \left(\frac{f_r}{f_0}\right)^2\right]$$

and the reactance of the horn at cutoff is

$$X_h = \frac{\omega_0\, 42.7\, A_d^2}{T f_0 A_t}$$

If these two expressions are equated, the condition for reactance annulling at cutoff is obtained. Solving for the product $M_d f_0 A_t$, we obtain

$$M_d f_0 A_t = \frac{42.7\, A_d^2}{T\left[1 - \left(\frac{f_r}{f_0}\right)^2\right]}$$

Since the throat size is based on considerations of efficiency, electrical impedance, and in some cases permissible throat distortion, and the mass and the effective diaphragm area for a given driver are fixed, the variables in the preceding equation are f_0, f_r, and T. Figure 6 is a plot of the product of $M_d f_0 A_t$ against the ratio f_r/f_0, with T as a parameter. Since f_0 is chosen to satisfy lf performance requirements, the product $M_d f_0 A_t$ is determined, from which may be obtained the required ratio of f_r/f_0 and, therefore, the resonant frequency f_r for a given value of T. This figure is based on a 15-in. speaker. For a speaker of any other area A, multiply the value of $M_d f_0 A_t$ obtained from this chart by $(A/125)^2$.

Where the radiation from one side of the driver is utilized, the value of f_r can be adjusted by varying the volume of the cavity enclosing the nonradiating side. The cavity places a stiffness in series with the suspension system, and its value may be calculated from

$$S_c = \frac{2.26 \times 10^6\, D_d^4}{V}$$

The required cavity size may be obtained experimentally by adjusting the cavity volume until an impedance maximum occurs at the cutoff frequency. For this application a linear speaker of low resonance is used, and since the resonant frequency is increased appreciably by the cavity the controlling reactance becomes that of the cavity. This results in reduced distortion owing to the suspension system nonlinearities.

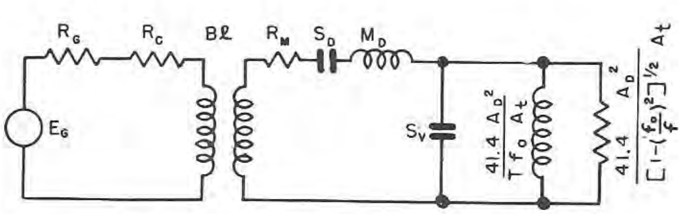

FIG. 5. Equivalent circuit of horn-type speaker.