Journal of Research of the National Bureau of Standards Vol. 48, No. 2, February 1952 Research Paper 2293

Chart for the TE_{11} Mode Piston Attenuator

Charles M. Allred

A nomogram is given and described that expedites the determination of the dependence of attenuation on frequency, conductivity, and radius in a cylindrical waveguide, TE_{11} mode, piston attenuator.

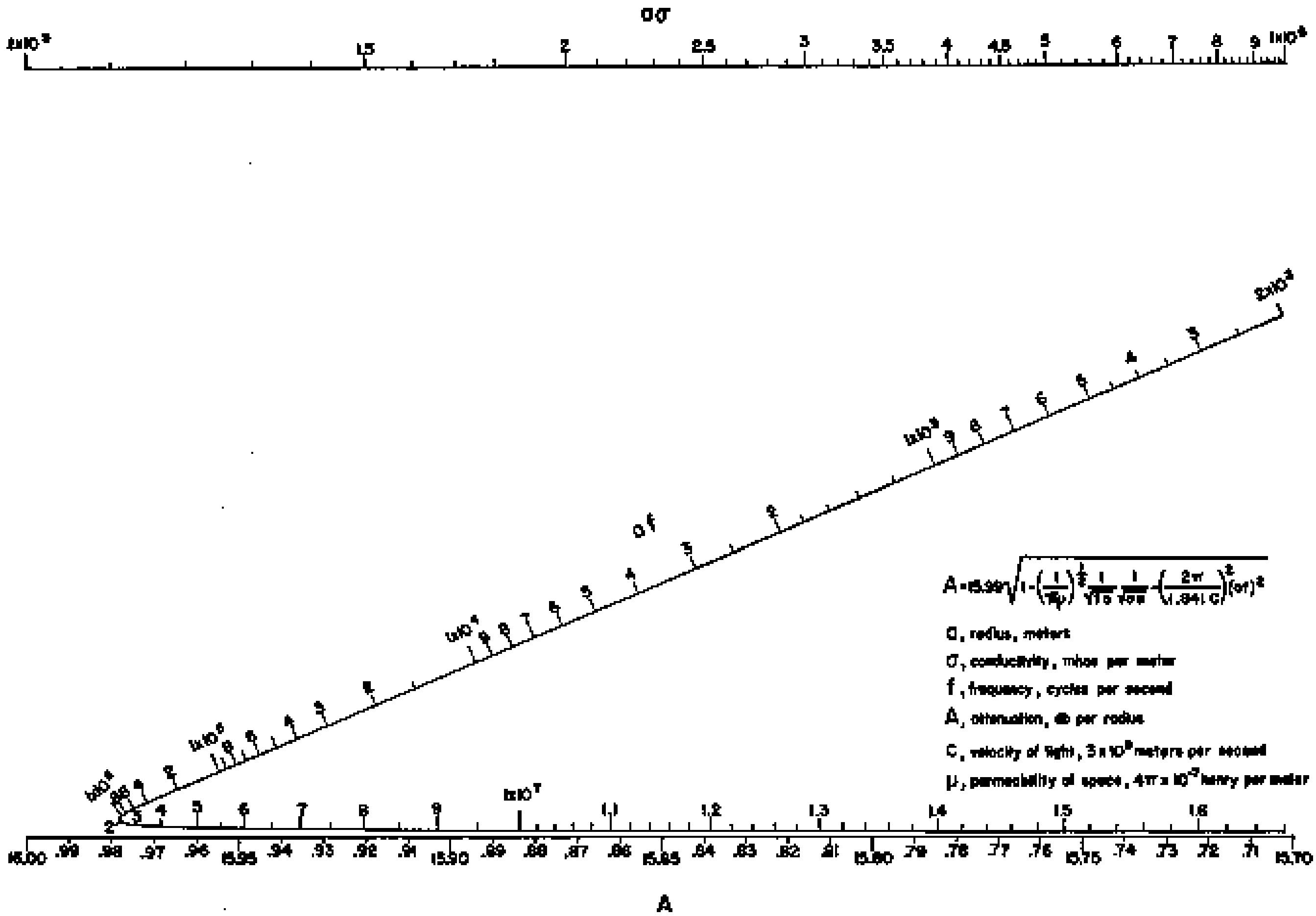

FIGURE 1. TE_{11} *mode piston attenuator chart.*

Piston attenuators (waveguide-below-cutoff) are extensively used as adjustable attenuators because of their desirable characteristics, namely, a linear decibel scale and potentially high accuracy.[1] However, their attenuation constant (decibels per radius of travel) is a slowly changing function of frequency. This variation is due to two factors: (1) the proximity of the operating frequency to the cutoff frequency, and (2) the frequency dependence of skin-depth, which alters the effective diameter of the attenuator.

The accompanying nomograph expedites the determination of the attenuation constant, A, for the most commonly used TE_{11} mode in a cylindrical guide. A good approximate functional relationship of A, the conductivity of the guide (nonmagnetic material), its radius, and the operating frequency is shown on the nomograph, and is the equation the nomograph solves. The effect of skin-depth is negligible for the TM_{01} mode, and a nomograph for this mode along with the TE_{11} mode for the case of infinite conductivity is already available.[2]

[1] R. E. Grantham and J. J. Freeman, A standard of attenuation for microwave measurements, Trans. Am. Inst. Elec. Engrs. **67**, 536 (1948).

[2] R. E. Lafferty, Piston attenuator chart. Electronics **21**, No. 2, 132 (1948).

This nomograph may be used in designing an attenuator to secure minimum frequency dependence over a given frequency range and to determine that dependence after its construction. To exemplify the latter, consider the radius $a=2$ cm, the conductivity $\sigma=1.5\times10^7$ mhos per meter, and the frequency $f=1\times10^6$ cycles per second; then $a\sigma=3\times10^5$ mhos, $af=2\times10^4$ meters per second, and the extension to the A scale of a straight line passing through the above points on the $a\sigma$ and af scales gives a value of 15.94 db per radius for A. In designing an attenuator, one simply chooses values of a and σ to place the operating point preferably on the right end of the $a\sigma$ scale and about the knee of the af scale.

WASHINGTON, October 29, 1951.