ATTENUATION CURVES FOR 2 : 1 RECTANGULAR, SQUARE AND CIRCULAR WAVE GUIDES

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(1) INTRODUCTION

The use of wave guides for the transmission of ultra-high-frequency energy is widespread, but graphical information about them has been very limited. This became evident some years ago when studies were made of the possibilities of the transmission of television and speech channels on a u.h.f. carrier by wave guides, and as a result the system of curves of constant attenuation given below were prepared.

(2) GENERAL DESCRIPTION OF ATTENUATION CURVES

Although the curves represent an upper limit of what may be achieved and ignore losses due to jointing, manufacturing imperfections, instability of polarization, etc., they proved invaluable in comparing alternative systems employing different numbers of repeaters in a given length of line, enabling an immediate estimate to be made of the optimum size of guide and operating frequency for each system.

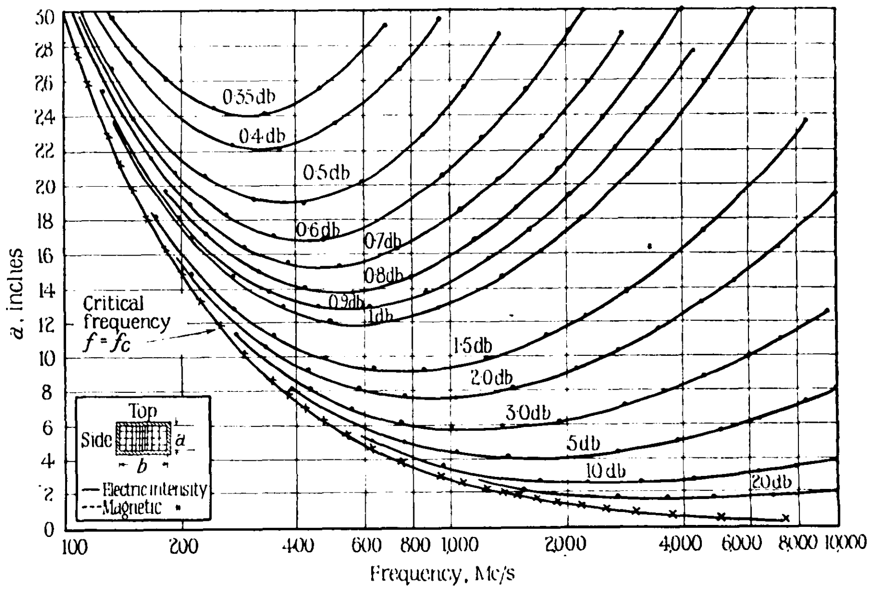

Fig. 1.—Attenuation curves for rectangular copper wave guides where $b = 2a$.

The H_0-mode has been omitted due to its inherent instability and there seems to be some practical grounds for preferring square or rectangular guides to circular ones on the basis of improved stability of polarization.

To the right of the line of critical frequency, $f = f_c$, the propagation in the duct has the characteristic patterns of wave-guide propagation, while on the line and to the left of it the propagation is scattered and rapidly attenuated. This type of propagation is sometimes called "evanescent," and it occurs when boundary conditions are such that at the operating wavelength no direction exists for reinforcement of the reflected propagation, such as corresponds to normal wave-guide operation at frequencies above the critical frequency.

The curves also serve to emphasize the increase in the width of the pass band of the wave guides as their size is reduced.

(2.1) Rectangular Guides

In the case of rectangular wave guides with a width/depth ratio of 2 : 1,

$$\alpha = \frac{K}{b^{3/2}} \frac{(f/f_c)^{-\frac{1}{2}} + (b/2a)(f/f_c)^{3/2}}{[(f/f_c)^2 - 1]^{\frac{1}{2}}} \text{ db/mile}$$

$$= \frac{236 \cdot 5}{b^{3/2}} \frac{1 + 1 \cdot 777 f_1^2 a^2}{[1 \cdot 333 f_1 a(1 \cdot 777 f_1^2 a^2 - 1)]^{\frac{1}{2}}} \text{ db/mile}$$

(2.2) Square Guides

$$\alpha = \frac{K}{d^{3/2}} \frac{(f/f_c)^{-\frac{1}{2}} + \frac{1}{2}(f/f_c)^{3/2}}{[(f/f_c)^2 - 1]^{\frac{1}{2}}} \text{ db/mile}$$

$$= \frac{236 \cdot 5}{d^{3/2}} \frac{1 + 0 \cdot 2222 f_1^2 d^2}{[0 \cdot 6666 f_1 d(0 \cdot 4444 f_1^2 d^2 - 1)]^{\frac{1}{2}}} \text{ db/mile}$$

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(2.3) Circular Guides

$$\alpha = \frac{0 \cdot 3824K}{r^{3/2}} \frac{(f/f_c)^{-\frac{1}{2}} + (1/2 \cdot 38)(f/f_c)^{3/2}}{[(f/f_c)^2 - 1]^{\frac{1}{2}}} \text{ db/mile}$$

$$= \frac{90 \cdot 438}{r^{3/2}} \frac{1 + 0 \cdot 559 f_1^2 r^2}{[1 \cdot 1534 f_1 r(1 \cdot 3303 f_1^2 r^2 - 1)]^{\frac{1}{2}}} \text{ db/mile}$$

where α = attenuation in decibels/mile.
K = a constant depending on guide walls, etc.
= 236·5 for copper.
a = internal length of shorter side of rectangular guide in centimetres.
$b = 2a$.
d = internal length of side of square guide in centimetres.
r = internal radius of circular guide in centimetres.
f_c = critical frequency of guide.
$f_1 = f \times 10^{-10}$.

Note that the attenuation is given in decibels/mile. Decibels per 100 ft = decibels/mile × 0·0189.

The formulae are tedious to compute for a constant attenuation, but can be made simpler by injecting appropriate values for $f_1 a$, $f_1 d$ or $f_1 r$ in the equation and hence calculating the consequent values of $\alpha b^{3/2}$, $\alpha d^{3/2}$, or $\alpha r^{3/2}$ as the case may be.

From the results so obtained it is a simple matter to complete the computation and draw the graphs for frequency versus physical size for any given attenuation.

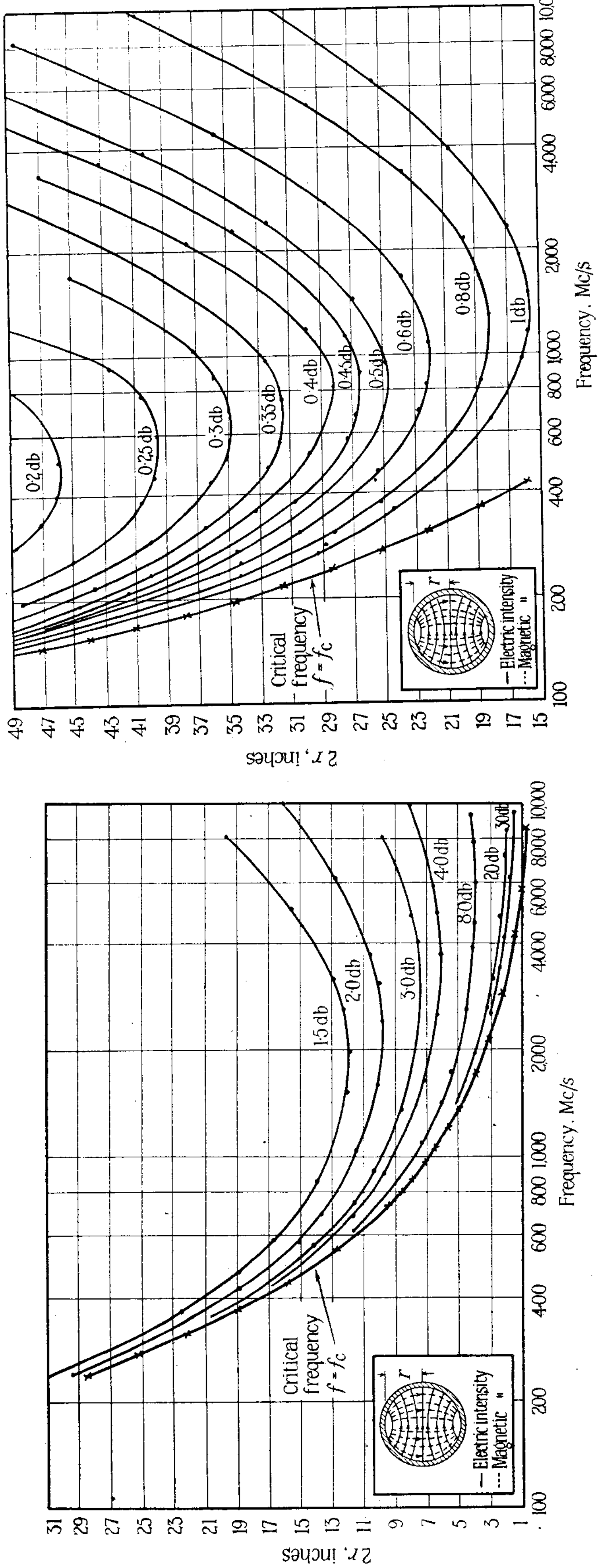

Fig. 2.—Attenuation curves for circular copper wave guides.

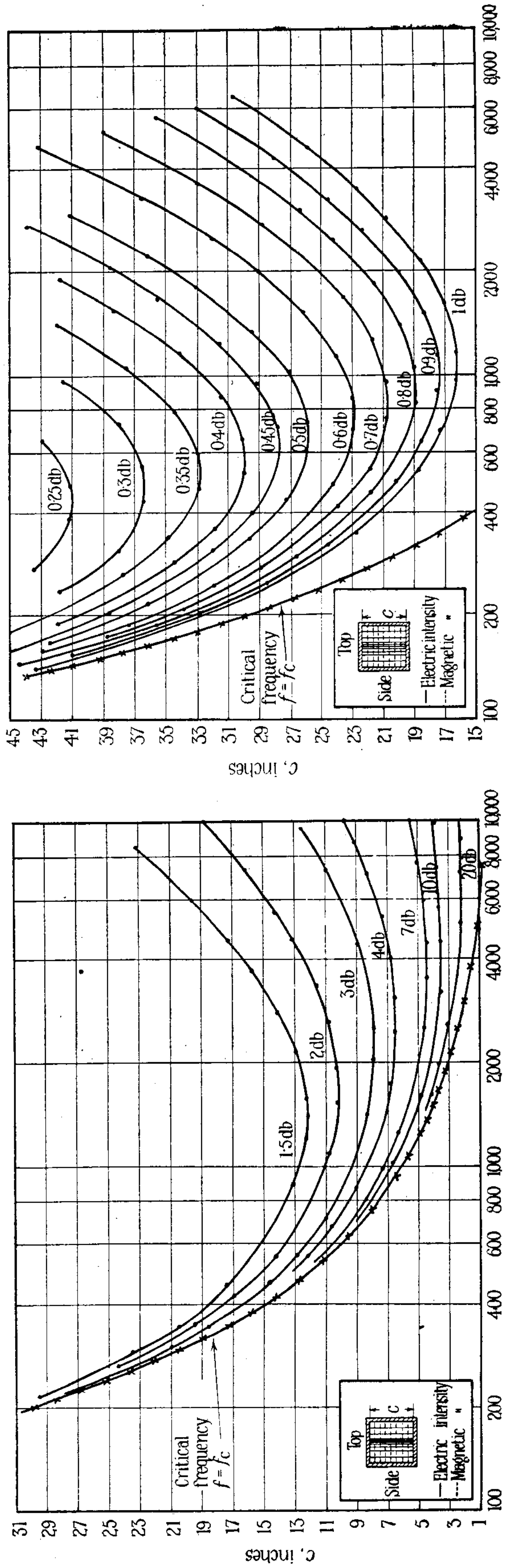

Fig. 3.—Attenuation curves for square copper wave guides.