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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

Letter Circular 226

(April 16, 1927)

THE DESIGN OF AN EXPONENTIAL ACOUSTIC HORN

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This letter circular is written in order to give a means for designing quickly an exponential horn and without the use of tables. With respect to other details the reader is referred to the following references:

A. G. Webster, Proc.Nat.Acad.Sci. 5 (1919) p.275;
Hanna and Slepian, Trans.A.I.E.E. 43, 1924 p.393;
Goldsmith and Minton, Proc.I.R.E. 1924, p.423.

An exponential horn is one in which the cross sectional area varies according to the following law:

$$A = A_1 e^{Tx} \quad \text{- - - - - - - - - -} \quad (1)$$

where (see figure 1)

A_1 = area at little end of horn

A = area at distance x from A_1

e = base of natural logarithms = 2.71828

T = a number giving the taper of the horn.

In actual design it is more convenient to deal with the radius instead of cross sectional area. The radius r for the cross section at a distance x from the little end of the horn is given by the formula:

$$r = r_1 \sqrt{e^{Tx}} \quad \text{- - - - - - - - -} \quad (2)$$

The value of T to be chosen depends on the taper desired and on the unit used for x. In the construction of an exponential horn the length is usually given, and the diameter at the small end is fixed by the size of the opening in the case of the loud speaking telephone. The diameter at the large end may depend upon the use to which the horn is put. With these quantities fixed the chief problem of design is the determination of the radius at any point between the two ends of the

horn. It is customary to state the length of a horn in feet and to measure the radius at either end in inches. The curves in Figure 2 have been calculated with this in mind.

The two curves in Figure 2 are really two parts of the same curve, which is too long to be conveniently drawn on the sheet. The vertical scale of numbers at the left side refers to curve #1 and that at the right side to curve #2. Both curves refer to the same values of Tx at the bottom of the diagram.

The choice of the quantity T, for one who is unaccustomed to using logarithms, is readily made by trial. As an example, suppose it is desired to design a horn 4 feet long, with a diameter of half an inch at the little end. Here $r_1 = 1/4$ inch and $x = 4$ feet. Assuming for trial $T = 1.5$, Tx is 6.0. Using curve #2, we find $\sqrt{e^{Tx}} = 20$. Multiplying r_1 (1/4 inch) by 20 we obtain for r, the radius at the large end, 5 inches, a reasonable size.

If, however, a 6 foot horn is to be constructed, the same value of T gives $Tx = 9.0$, and from curve #2, $\sqrt{e^{Tx}}$ is found to be exceedingly large, lying beyond the limits of the diagram. In this case a smaller value of T must be chosen. $T = 1.1$ will give $Tx = 6.6$, and by curve #2 the value of $\sqrt{e^{Tx}}$ is found to be 27. Multiplying this by r_1 (1/4 inch) the radius at the large end is found to be 6 3/4 inches, a more convenient size.

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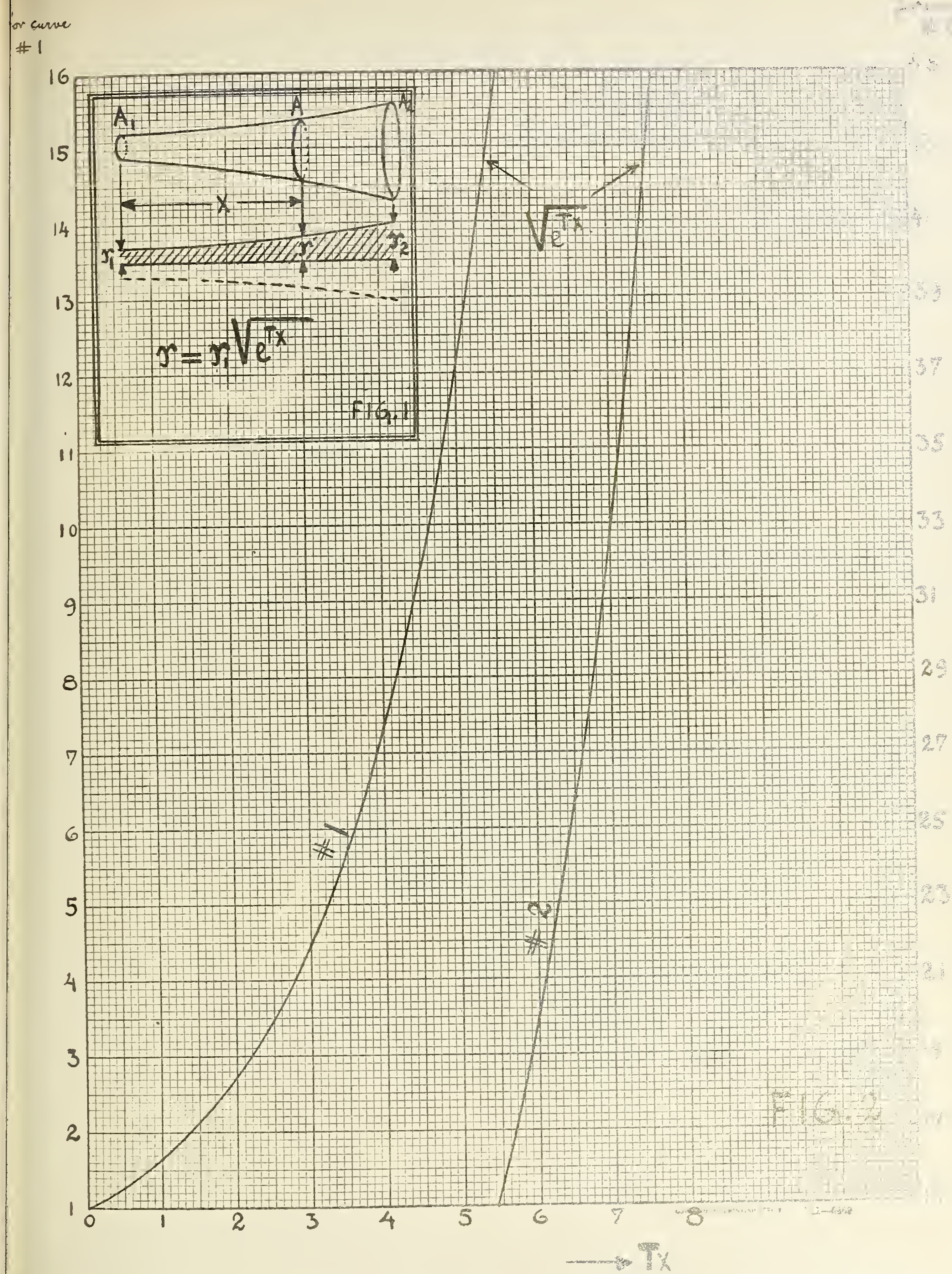

or curve
#1
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
#1
#2
$\sqrt{e^{Tx}}$
A_1
A
A_2
x
r_1
r
r_2
$r = r_1\sqrt{e^{Tx}}$
FIG. 1
$\to Tx$

FIG. 2