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TITLE: "Stresses in Gun Tubes, Stresses in Guns under Combined Band and Gas Pressures, Part 10, Matching of the External Tangential Strain Data in Smooth-Bored Elastic Guns under a Discontinuous Band c Internal Radial Pressure by a Simple Mathematical Expression."

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BINDING AREA

Original Drawings of Figures 1 and 2 filed Applied Mechanics Branch.

Watertown Arsenal Laboratory
Report Number 730/137-9
Problem Number L-7.2
(Partial Report)

21 October 1946

SUBJECT

Stresses in Gun Tubes
Stresses in Guns under Combined Band and Gas Pressures, Part 10,
Matching of the External Tangential Strain Data in Smooth-bored
Elastic Guns under a Discontinuous Band of Internal Radial
Pressure by a Simple Mathematical Expression

OBJECT

To present a simple mathematical expression from which the external tangential strains in smooth-bored elastic guns under a discontinuous band of internal radial pressure may be calculated.

SUMMARY

The external tangential strains in smooth-bored gun tubes loaded by a semi-infinite band of internal radial pressure may be represented by an expression of the form

$$e^{-\alpha s}\left\{C_1 \cos \beta s + C_2 \sin \beta s\right\}$$

where α, β, C_1 and C_2 are constants varying with wall ratio of the tube. Curves of these constants plotted versus wall ratio are contained in Figures 1 and 2. For wall ratios of 1.00 to 2.50, values of these constants may be found from Figures 1 and 2, and the external tangential strains may be computed. The derivatives of the external tangential strains may of course be found similarly by using the given values of α, β, C_1 and C_2 and using the differentiated form of the above expression.

O. L. Bowie

APPROVED:

D. G. LUDLAM
Col., Ord. Dept.
Director of Laboratory

O. L. BOWIE
Mathematician

DISCUSSION

The elastic strains at the outer surface of smooth-bored gun tubes under internal radial pressure loading have been presented in report[1] WAL 730/137-1. A semi-infinite band of pressure of unit magnitude extending over the left side of the infinite tube was taken for the loading distribution. For convenience, the strains were divided by the strain corresponding to a uniform radial pressure as given by the usual Lamé formula for an open-ended tube. The external tangential strains were thus presented in the form

$$\frac{w^2-1}{2} Ee_t$$

where,

w = wall ratio of tube = $\frac{\text{outside diameter}}{\text{inside diameter}}$
E = Young's Modulus
e_t = external tangential strain due to the semi-infinite band of pressure.

This expression, of course, varies along the axial distance of the tube. e_t is, therefore, a function of α where α is measured in the positive direction to the right of the point of discontinuity of loading. α is considered negative at all points to the left of the discontinuity of loading. α is axial distance measured in units of the bore radius.

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[1] Report Number WAL 730/137-1, "Stresses in Gun Tubes, Stresses in Guns under Combined Band and Gas Pressures, Part 2, Elastic Strains at the Outer Surface for Internal Radial Pressure, Basic Data."

Dr. R. Beeuwkes, Jr. has presented in a recent report[2] an interesting discussion as to the matching of the function e_t. He points out that an expression of the form

$$e^{-\alpha s}\left\{C_1 \cos \beta s + C_2 \sin \beta s\right\}$$

with the proper choice of the constants α, β, C_1 and C_2 will fit the external tangential strain data.

The external tangential strains may be, therefore, calculated from

$$\frac{w^2-1}{2} Ee_t = e^{-\alpha s}\left\{C_1 \cos \beta s + C_2 \sin \beta s\right\} \text{ for } z \geq 0$$

$$= 1 - e^{-\alpha s}\left\{C_1 \cos \beta s + C_2 \sin \beta s\right\} \text{ for } s \leq 0$$

where values of α, β, C_1 and C_2 are found for any wall ratio from $w = 1.00$ to $w = 2.50$ in Figures 1 and 2.

In order to correlate α and β with thin wall theory, α and β have been divided by λ where

$$\lambda = \frac{\left[12(1-\mu^2)\right]^{\frac{1}{4}}}{\left[w^2-1\right]^{\frac{1}{2}}} = \frac{1.8222}{\left[w^2-1\right]^{\frac{1}{2}}} \text{ where } \mu = 0.285.$$

From the data in Figures 1 and 2, the values of $\frac{w^2-1}{2} Ee_t$ will be represented at least up to an accuracy of .005, except for very large values of s, at large values of w, where the original data in some places is in error by as much as .020.

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[2] Report Number WAL 730/419, "Stresses in Thick Walled Cylinders."

The derivatives of the external tangential strains which appeared in WAL 730/137-7 can, of course, be calculated by using the α, β, C_1 and C_2 values in Figures 1 and 2 and substituting them in the derivative of

$$e^{-\alpha z}\left\{C_1 \cos \beta z + C_2 \sin \beta z\right\} .$$

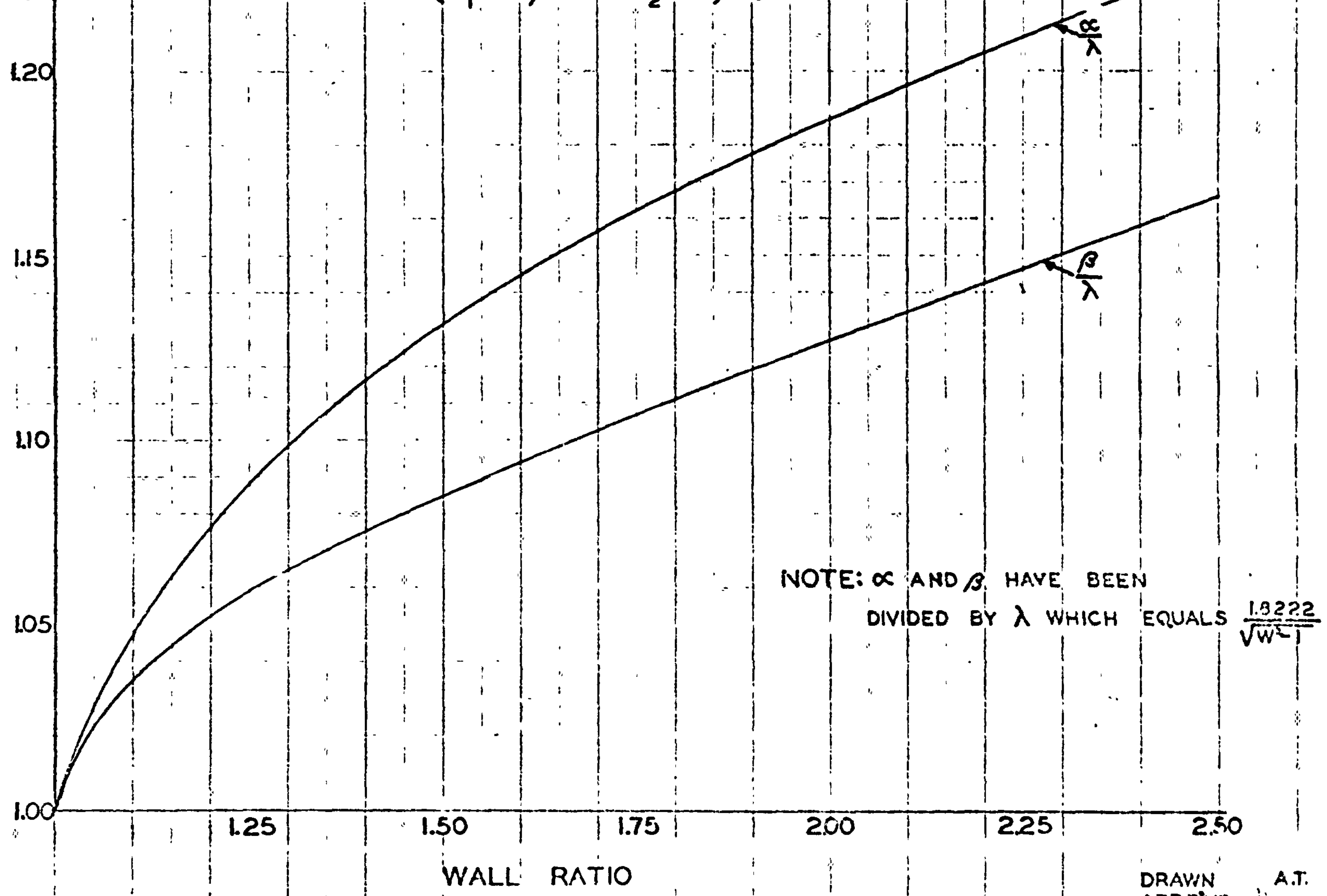
ACKNOWLEDGMENT

In addition to the direction and advice of R. Beeuwkes, Jr., much of the actual calculation was performed by A. Tashjian of the Applied Mechanics Branch, Watertown Arsenal Laboratory.

CONSTANTS α AND β VERSUS WALL RATIO

APPEARING IN THE EXPRESSION

$$e^{-\alpha z}(C_1 \cos \beta z + C_2 \sin \beta z)$$



NOTE: α AND β HAVE BEEN DIVIDED BY λ WHICH EQUALS $\frac{1.8222}{\sqrt{W^2-1}}$

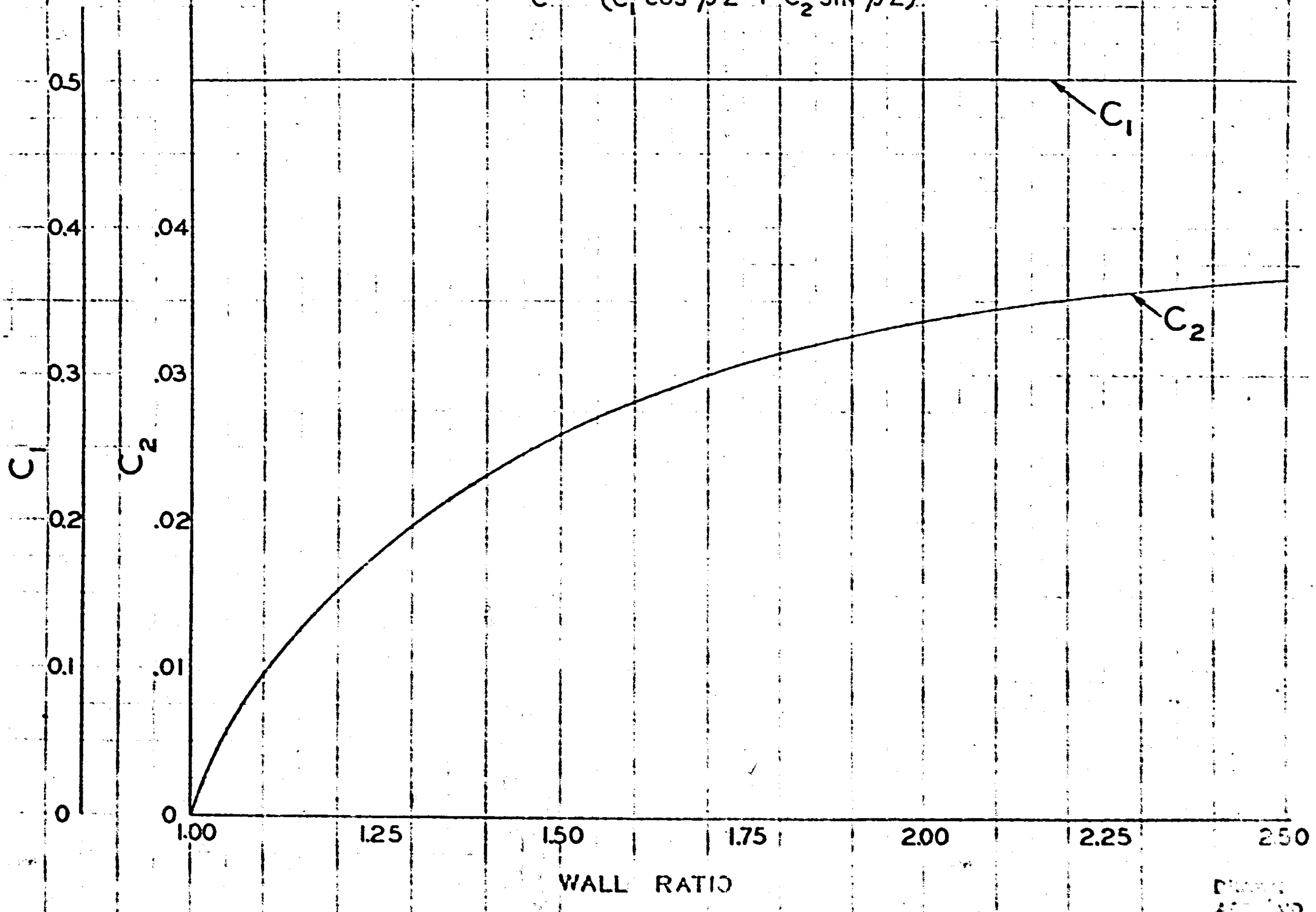
DRAWN A.T.
APPR'VD
AM-2C7-933
16, OCT., 1946

FIG. 1

CONSTANTS C_1 AND C_2 VERSUS WALL RATIO

APPEARING IN THE EXPRESSION

$$e^{-\alpha z}(C_1 \cos \beta z + C_2 \sin \beta z)$$



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