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SHIP-SHORE DIVISION - CENTIMETER WAVE SECTION

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ATTENUATION OF BRASS WAVEGUIDE HAVING "MILL FINISH" AND "BRIGHT FINISH"

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- Report R-2709 -

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NRL Problem S556R-C

ABSTRACT

This paper describes tests and gives results of attenuation measurements on 1 inch x 1/2 inch waveguides having "mill finish" and "bright finish". The tests indicate that the mill finish gives lower loss and should be used on long runs.

TABLE OF CONTENTS

Distribution:

BuShips Code 938 (for 915) (5)
BuOrd (3)
NEL (1)
CBA (1)
BuAer (1)
CNO (Op-413-B2)(3)
Com. Gen. AAF (1)
OCSigO ASF (1)

INTRODUCTION

1. In certain situations it is necessary to run wave-guide over a considerable distance. In such cases the attenuation of the guide may represent several decibels loss. The measurements reported here were made in an effort to select the finish which gives the lowest loss without resorting to silver or silver plate.

2. Brass waveguide, composed of 90 percent copper and 10 percent zinc is commonly furnished by the mills in two finishes, the so-called mill or red oxide finish and the bright finish.

3. After the waveguide has been rolled to size it has both the red cuprous oxide and the black cupric oxide on the surface. It is then given a pickling bath of 10 to 15 per-cent sulphuric acid which removes the black oxide and leaves the red. This is known as red oxide or mill finish. The tubing may then be given a dichromate pickle which oxidizes the red oxide to black, which is then soluable in sulphuric acid. This leaves the familiar yellow color of brass and is known as "bright finish".

4. The red oxide finish has a suspicious metalic look and it was thought possible there might be a high concentration of copper at the surface. A spectroscopic analysis confirmed this and it was decided to compare the calculated attenuation values of 90-10 brass guide and pure copper guide with measured values of mill finish and bright finish guide. These tests were made in connection with problem S556R-C in which it was necessary to have a continuous 40 ft. length of guide at X band with as little attenuation as possible.

THEORETICAL CALCULATIONS:

Using the following formula: (See ref. (b)) for the attenuation in a waveguide of rectangular cross section.

$$\alpha = 8.63\sqrt{\frac{2\pi\mu_2}{v_1\epsilon_2\mu_1^2}}\;Z_o^{-\frac{3}{2}}\left\{\frac{\frac{Z_o}{2y_o}\left(\frac{f}{(f_o)_{01}}\right)^{-\frac{3}{2}}}{\sqrt{\left(\frac{f}{(f_o)_{c1}}\right)^2-1}}+\frac{\left(\frac{f}{(f_o)_{01}}\right)^{-\frac{1}{2}}}{\sqrt{\left(\frac{f}{(f_o)_{c1}}\right)^2-1}}\right\}\ \text{db/meter}$$

where:

α = attenuation per meter

μ_2 = the magnetic permeability of the metalic medium = 1.257×10^{-6} $\frac{\text{henry}}{\text{meter}}$

μ_1 = the magnetic permeability of the dieletric medium = 1.257×10^{-6} $\frac{\text{henry}}{\text{meter}}$

v_1 = velocity of light in free space c = 3×10^{8} m/sec

y_o = guide dimension in E direction = .01017 meters

[redacted]

THEORETICAL CALCULATIONS (CONT'D)

z_c = guide dimension in H direction= .2285 meters
f = frequency at which measurements were made = 9.380×10^{9} ~#/sec
f_o = critical frequency of waveguide= 6.560×10 ~#/sec

Using ϵ for copper = 5.65×10^{5} mho-m
α = .117 db/m

Using ϵ for 90-10 brass= 1.46×10^{5}
α = .23 db/m

METHOD OF MEASUREMENT

6. Two methods were used to measure the loss through the two type guides.

7. The first method consisted of measuring the power delivered by the oscillator and the power received at the far end of the guide. Power was measured by means of a bolometer. The accuracy of this method is influenced somewhat by the source impedence and bolometer match. Fig. 1 shows the set up.

8. The second method consisted of shorting the far end of the guide and measuring the standing wave ratio at the sending end. The one way loss is given by the following formulas:

$$\text{reflection coeficient } K = \frac{E_{max} - E_{min}}{E_{max} + E_{min}}$$

$$10 \log K = \text{loss in db.}$$

If good standing wave ratio measuring equipment is used the method should be adequately accurate. Fig. 2 shows the set up for this measurement. The TAA-16EA amplifier provides an accurate means of measuring high standing wave ratios. The crystal law was measured and accounted for.

RESULTS

9. The bolometer measurements were found to vary over wide limits and were consequently abandoned. Using the standing wave ratio method the bright finish guide was found to have .234 db/m attenuation and the mill finish guide was found to have .171 db/m. Seven measurements were averaged to get the above values.

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CONCLUSIONS

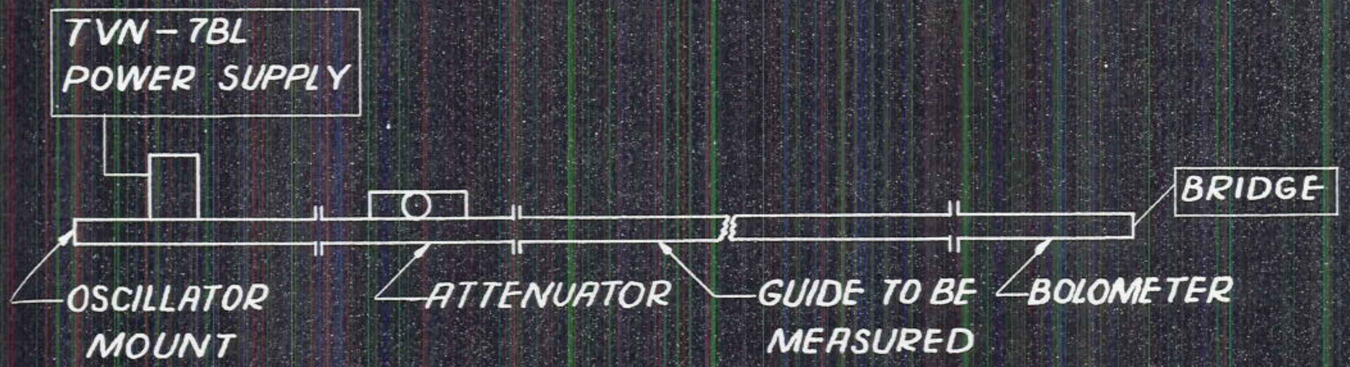
10. The measured value of attenuation for bright finish agrees closely with the theoretical indicating satisfactory measurements. The attenuation of the mill finish guide is found to fall between the theoretical values for pure copper and for bright finish brass. This indicates that there is a high concentration of copper in the mill finish. It is recommended that this finish be specified for all long waveguide runs and that personnel be warned against cleaning the guide by means of steel wool or any agent which might damage the inside surface.

11. Information on the method of manufacture of waveguide and sample lengths of guide for tests were obtained from the Chase Brass Company, Waterbury, Connecticut.

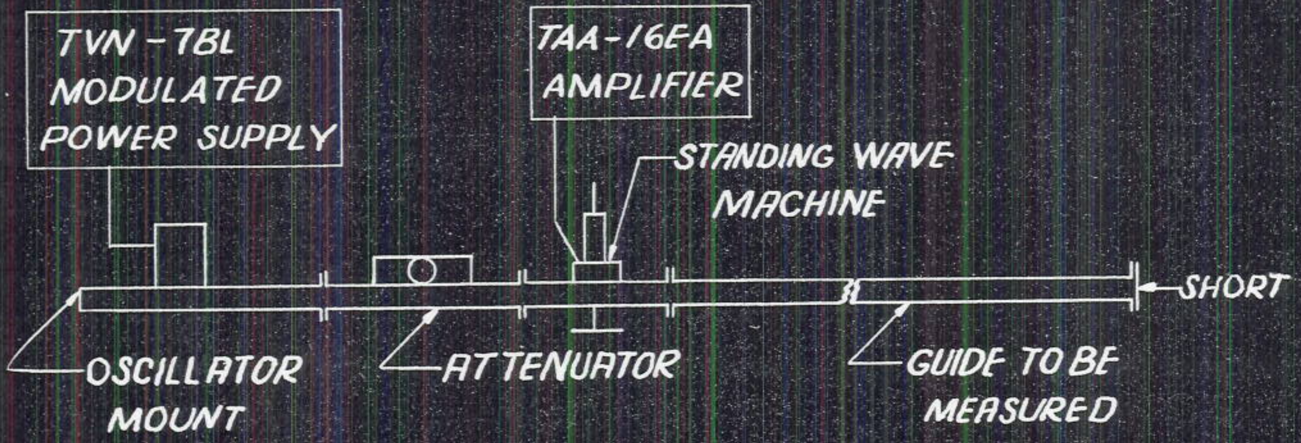
REFERENCES:

(a) BuShips ltr (915A) Ser C-915A-8654 of 5 Aug. 1944 to Dir. NRL (SRPPB)

(b) Sarbacher and Edson, Hyper and Ultra-high Frequency Engineering, John Wylie and Sons; Page 220.



BOLOMETER TEST SETUP
FIGURE I



STANDING WAVE TEST SETUP
FIGURE 2