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REPORT ON THE ACOUSTIC
TRANSMISSION AND VIBRATION DAMPING
CHARACTERISTICS OF MATERIALS FOR USE ON SONAR DOMES.

SF 013 13 01 TASK 0908

LAB. PROJECT 9300-16, TECHNICAL MEMORANDUM #11

1 APR 1965

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MATERIAL SCIENCES DIVISION

Approved: D. H. Kallas
D.H. KALLAS
Associate Technical Director

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Lab. Project 9300-16
Techncial Memorandum #11

Ref: (a) BUSHIPS ltr F013-13-01, Ser 634C1-441 of 9 May 1962
(b) NAVAPLSCIENLAB Program Summary of 1 Nov 1964, "Vibration and Noise Reduction", SF 013-13-01, Task 0908
(c) NAVAPLSCIENLAB Program Summary of 1 Nov 1964,"Materials Support Study", SF 099-03-01, Task 1481
(d) MATLABNAVSHIPYD NYK Lab. Project 6062,Progress Report 39 of 6 Nov 1962
(e) NAVAPLSCIENLAB Lab. Project 9300-16, Technical Memorandum #8 of 30 Nov 1964
(f) NAVAPLSCIENLAB Lab. Project 9300-16, Technical Memorandum #9 of 3 Dec 1964
(g) NAVAPLSCIENLAB Lab. Project 9300-16, Technical Memorandum #10 of 2 Dec 1964
(h) NAVAPLSCIENLAB Lab. Project 9300-16, Technical Memorandum # 3 of 6 Dec 1963
(i) Spec MIL-S-24062 (SHIPS) of 11 May 1964; Sprayable Vibration Damping Material for Surface Vessels
(j) Spec MIL-P-22581A (SHIPS) of 12 Jun 1962; Plastic Sheet, Vibration Damping (type ML-D2)
(k) NAVAPLSCIENLAB ltr 9370:AWC:nr,9674 of 1 Dec 1964
(l) NAVAPLSCIENLAB ltr. 9370:AWC:nr, Lab. Project 9300-16, of 24 Feb 1965

FIGURES

TABLE

INTRODUCTION

1. The development of an acoustically transparent vibration damping material for sonar domes as authorized in reference (a), protective coatings for sonar domes as referred to in reference (b), and acoustically transparent encapsulating systems for hydrophones as referred to in reference (c), is continuing at the U.S. Naval Applied Science Laboratory.

2. This report presents the underwater acoustic transmission and the vibration damping characteristics of five NAVAPLSCIENLAB-developed and two commercially available materials, intended for use in sonar domes.

Background

3. Although instrumentation for sonar detection has progressed to a fairly advanced stage, the presence of interference noise still remains the fundamental controlling factor in establishing sonar range and accuracy. Some of the interference noise is transmitted to the sonar transducers as a result of vibrations due to hydrodynamic or structure-borne excitations in the hull-mounted sonar dome itself. One of the methods currently used to reduce the vibrations in the AN/SQS-23 sonar dome is to fill its lower section, below the acoustic "window", with approximately 5-6 inches of Ottawa sand and to blanket this sand with foamed-in-place, high density polyurethane foam. However, field reports have indicated that the foam blanket loosened and permitted water to penetrate the sand. This water penetration, coupled with movement of the sand, resulted in both corrosion and erosion degradation of the dome and decreased damping efficiency. In order to overcome this difficulty, and in view of the successful development of the ML-D2 viscoelastic vibration damping tiles at the NAVAPLSCIENLAB as described in reference (j), the Laboratory was authorized to develop a sprayable viscoelastic vibration damping material for use in sonar domes. Such a sprayable material, designated as ML-SD15 and which is described in reference (d), was developed. Service applications of the material were made on the domes of the USS RICH (DD-820) and the USS MAC - KENZIE (DD-836). The results of the service tests, as reported in reference (h), indicated that the performance of the domes damped with the ML-SD15 material was essentially equal to or better than domes damped with the conventional sand foam system. To futher decrease the vibrations in the domes and thereby increase the sonar efficiency, NAVAPLSCIENLAB was also authorized to develop an acoustically transparent damping material for the window area of the dome. The Laboratory is currently engaged in this development.

Materials Investigated

4. The materials evaluated and discussed in this report, as described further in Table 1, are NAVAPLSCIENLAB-developed epoxy-polyamide formulations and commercially available urethane and butyl rubber formulations.

Methods of Test

5. Sound Transmission - The NASL underwater sound transmission measuring facility, shown in Figure 1, and described in references (d) and (e), was used to measure the sound transmission reduction of the materials under test. The materials were coated on one side of 30" X 30" X 1/16" steel panel which the coating facing the interior of the chamber. The electrical input to the random noise projector, inside the chamber, was maintained constant (at 10 volts and 13 millamps) for all measurements made. The sound pressure level at the receiving hydrophone located outside the chamber, was analyzed in 1/3 octave bands. The reduction in sound transmission wasobtained

from the difference in the sound pressure levels (at the re eiving hydrophone) measured for coated and uncoated panels.

NOTE: The acoustic transparency of a material is reported in terms of "sound transmission reduction"; for example, low transmission reduction implies high transparency.

6. Vibration Damping

Evaluation of the damping characteristics of materials was determined by the decay rate of free vibration of a coated steel beam, 15" long, 1 1/2" wide, and 3/8" thick. A block diagram of the 15" free-free beam system used for this purpose is shown in Figure 2. The coated beam was vibrated at each of its first 5 resonant modes, keeping the input voltage to the vibration generator constant at 1.5 volts. The decay rate of each coated beam was then obtained by simultaneously: (a) cutting off the oscillator signal to the vibration generator, (b) triggering the memoscope, and(c) allowing the decay signal from the accelerometer to pass through the filter and logger and be recorded on the memoscope. The slope of the recorded decay signal was them measured, and the percent critical damping calculated therefrom.

Results of Test

7. Sound Transmission Characteristics

The transmission reduction results obtained for the seven materials under test are shown on Figure 3 and Table 1.

8. Vibration Damping Characteristics

The vibration damping results obtained for the seven materials under test are shown on Figure 4 and Table 1.

ANALYSIS OF TEST DATA

9. An analysis of the vibration damping and transmission reduction characteristics of the various materials tested herein indicates that several formulations show promise as potentially effective acoustically transparent damping materials. Three materials in particular, namely, the butyl rubber, polyurethane and the ML-SD15 without sand filler, exhibit relatively low sound transmission reduction characteristics and generally high vibration damping characteristics. The test results of the materials evaluated to date indicate the following:

a. The modified ML-SD15 (no sand, cast), because of its generally good vibration damping characteristics in the frequency range between 1.0 and 10.0 KCPS and because of its low (although not zero) sound transmission reduction between 3.0 and 20.0 KCPS, should be further developed with respect to sound transmission.

b. The butyl rubber, which showed zero sound transmission reduction in the frequency range of 1.0 to 20.0 KCPS, and critical damping of less than 1/2% over the frequency range of 1 to 5 KCPS, should be investigated to improve its vibration damping characteristics.

c. The urethane material showed merit but will also require further development to increase its sound transmission between 2.5 to 20.0 KCPS.

CONCLUSION

10. On the basis of the favorable results of the characteristics of the butyl rubber, polyurethane, and modified ML-SD15 materials, presented in this report, it appears probable that a sprayable acoustically transparent damping material can be developed. However as indicated in reference (1), the certainty of the success of such development cannot be assured, in view of the manifold material and application problems.

DISCUSSION

11. In preparation of the NAVAPLSCIENLAB specimens for this evaluation, it was noted that considerable amounts of minute air voids were generated in the materials due to the method of mixing the consitituents, and to the method of application. When the materials were cast, only a limited amount of additional voids were generated in addition to those generated during mixing. However when the ML-SD15 material was applied by spraying, the material was broken up during the process, which resulted in a fluffy highly porous coating. Thus the sprayed ML-SD15 material coated with anti-fouling showed a high transmission reduction rate (11db at 5 KCPS rising to 24db at 20 KCPS), while the ML-SD15 materials which were cast showed transmission rate reductions of less the 2db. In examining the specimens of the different modifications of the ML-SD15 material, it was noted that the amount voids varied considerably from modification to modification. It is believed that this void formation can be eliminated to a considerable degree by controlling the mixing of the ingredients and by the method of application. In this connection, the Laboratory is investigating an air-less spray gun which, it is understood, will permit application of a coating under high pressure, without entrapping air which tends to form voids as is experienced with conventional atomizing spray guns.

FUTURE WORK

12. Work on the development of an acoustically transparent damping material is continuing as follows:

a. The ML-SD15 (no sand, cast) type material and the urethane material supplied by Philadelphia Resins Co., are being developed further. Study is being made to control the mixing of the ingredients and the method of application to prevent entrapment of air and generation of minute air voids in the material.

b. Evaluation will be made of urethane materials developed in-house, and two urethane materials developed by the Minnesota Mining & Mfg. Co.,

c. Determination will be made of the damping and acoustical transmission characteristic of the thicker butyl rubber sheet (up to 5/8" thick),

d. Based on the data obtained to date on butyl rubber and urethane, a composite material will be formulated from butyl rubber and a urethane resin that will be applicable with an air-less spray gun.

Recommendation

13. In view of the anticipated difficulty of the solution of this problem, and in order to take advantage of the possibility of other technical approaches, thus enhancing the expectation of success, it is recommended that a contract be awarded for a parallel effort. This contract should be awarded to a bidder who can provide an imaginative concept and approach. It is recommended that such proposals be forwarded to the Laboratory for review and evaluation, or alternately, the Laboratory be authorized to issue and monitor the contract.

Principle Investigator

U.S. NAVAL APPLIED SCIENCE LABORATORY

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FIG (1)

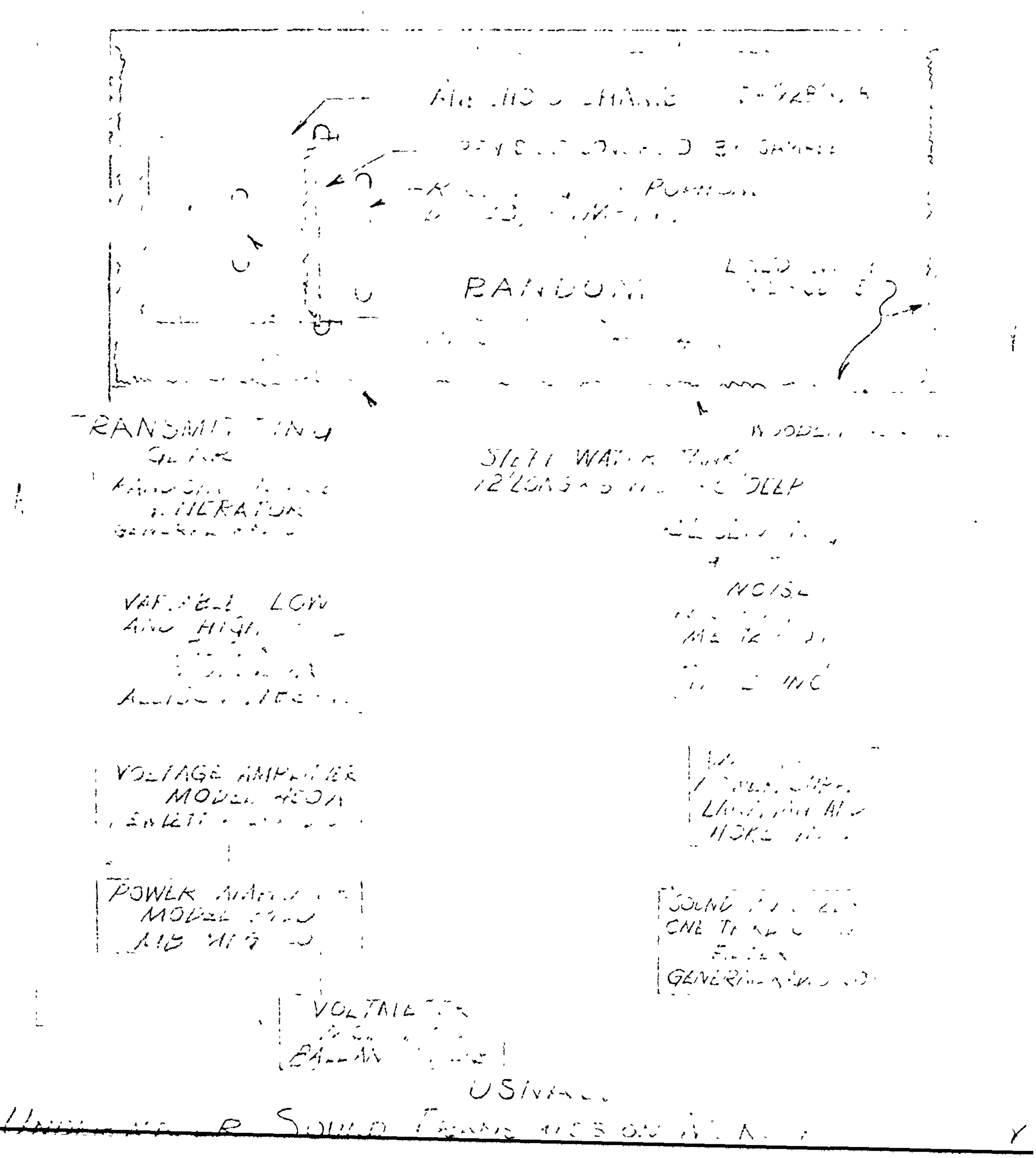

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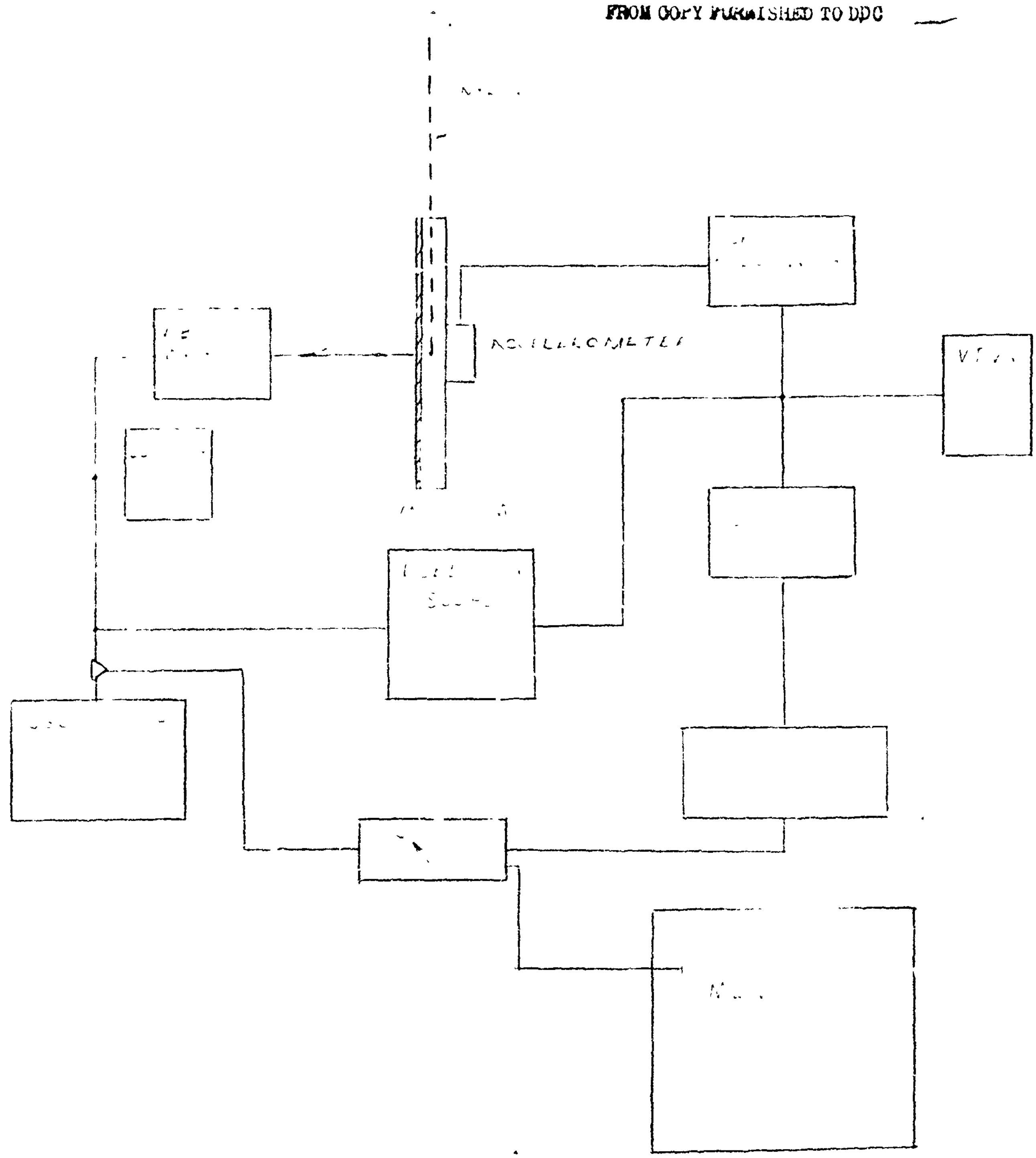
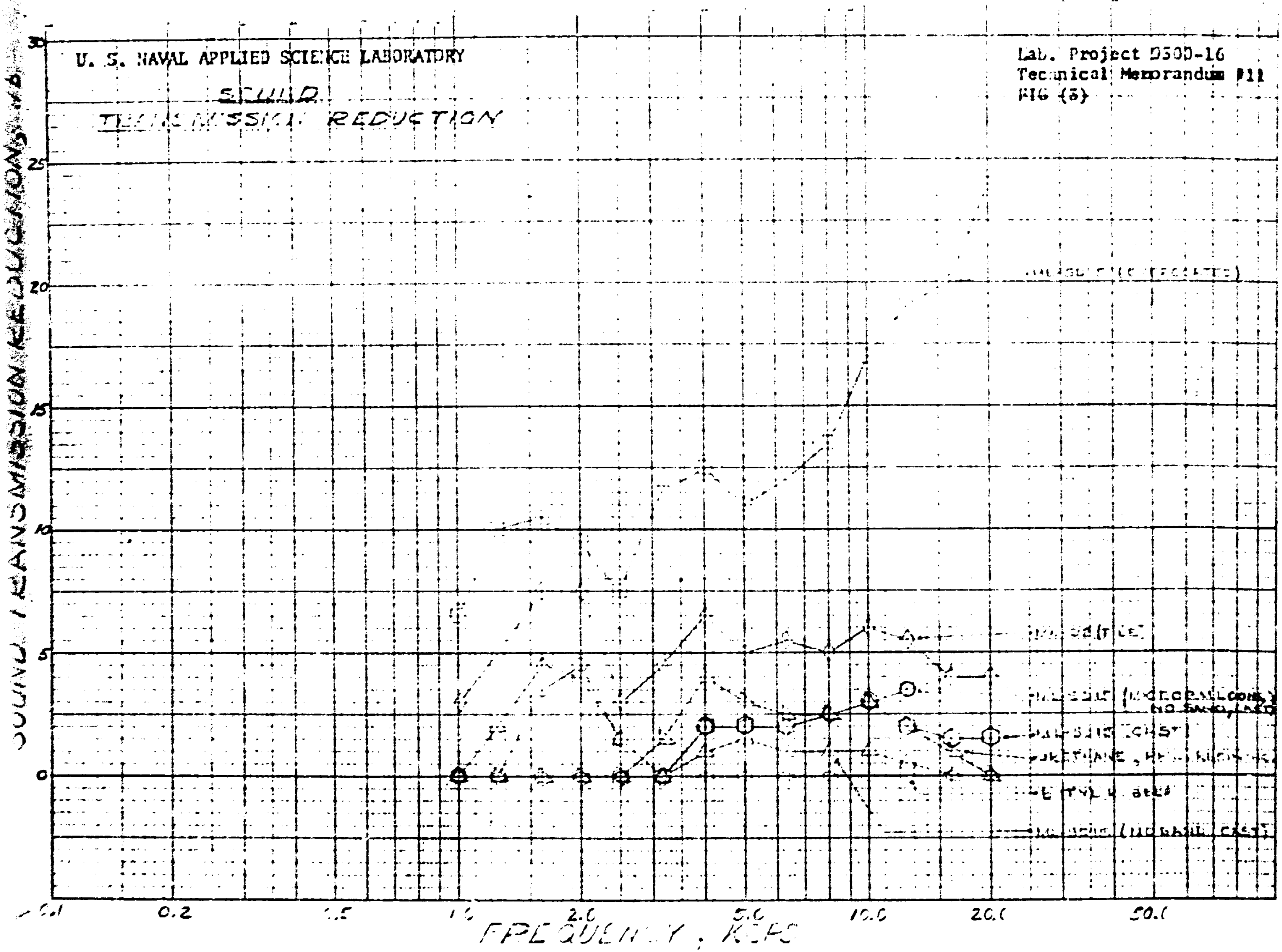
FIG (2)



15" FREE-FREE BEAM SYSTEM
FOR THE DETERMINATION OF THE
DAMPING CHARACTERISTICS OF
MATERIALS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SOUND
TRANSMISSION REDUCTION
Lab. Project 5500-16
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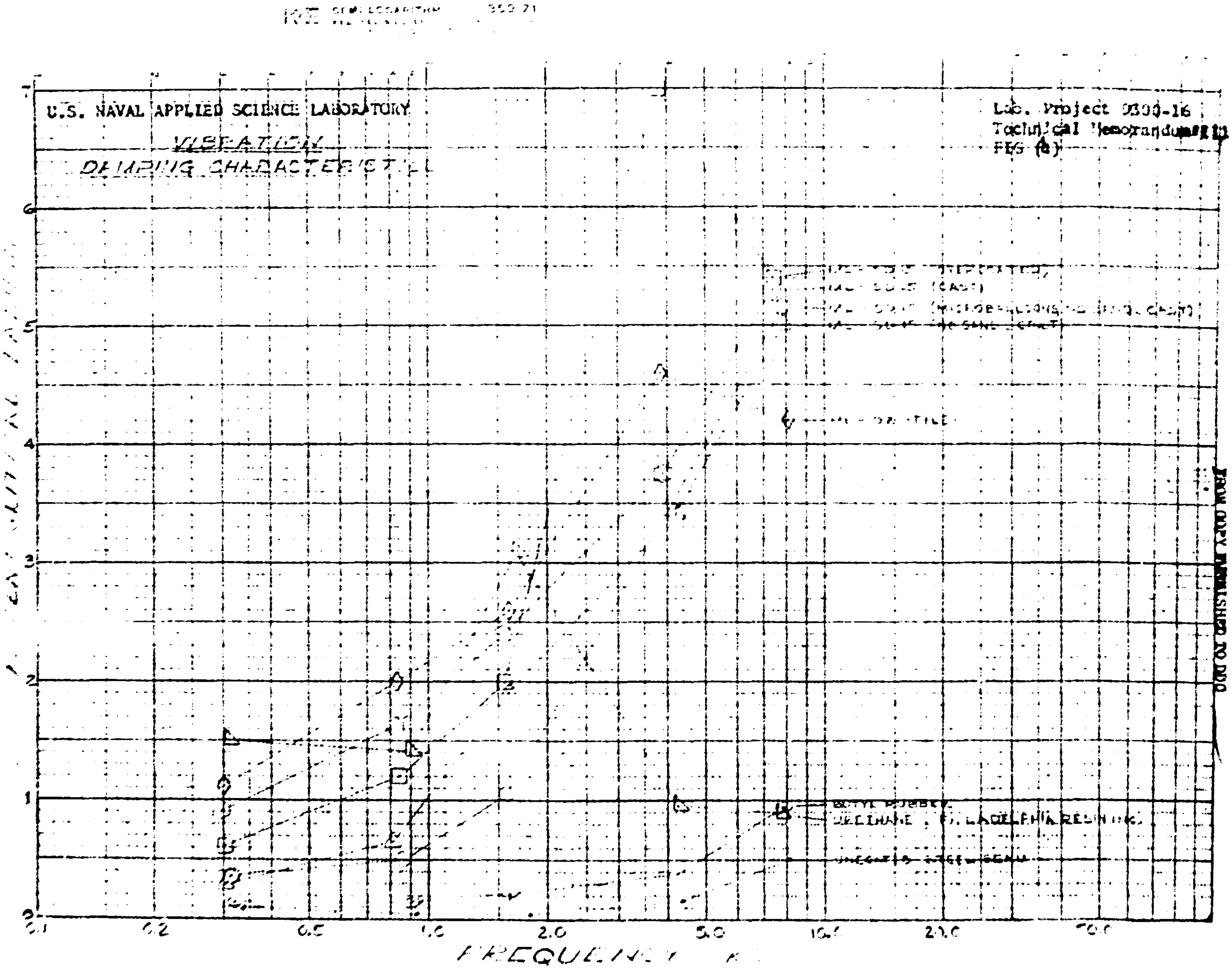
FIG (3)
SOUND TRANSMISSION REDUCTION, DB
FREQUENCY, KCPS
30
25
20
15
10
5
0
0.2
2.0
5.0
10.0
20.0
50.0


U.S. NAVAL APPLIED SCIENCE LABORATORY
VIBRATION
DAMPING CHARACTERISTIC
Lab. Project 9300-16
Technical Memorandum
FIG (8)
0.1
0.2
0.5
1.0
2.0
5.0
10.0
20.0
50.0
FREQUENCY
0
1
2
3
4
5
6
7

U. S. Naval Applied Science Laboratory

Description Of Materials

SAMPLE NO.	MATERIAL DESIGNATION (note (b))	FORMULATION	METHOD OF APPLICATION	T
1	ML-SD15 (overcoated as described in note (a) below)	Described in ref (i)	Sprayed, onto steel plates; with equipment described in reference (g)	
2	ML-SD15 (cast)	Described in ref (i)	Cast, onto steel plates	
3	ML-SD15 (with microballoons, no sand, cast)	Described in ref (i); except for elimination of all sand and cab-o-sil and the addition of 25% (by weight of resin) of phenolic microballoons	Cast onto steel plates	
4	ML-SD15 (no sand, cast)	Described in ref (i), except for elimination of all sand.	Cast onto steel plates	
5	ML-D2 (TILE)	Described in ref (j)	Adhered with ML-D2 Epoxy cement	
6	BUTYL RUBBER	Obtained from Navy Stores	Adhered with cement conforming to MIL-A-5092	
7	URETHANE	Prepared by Philadelphia Resin Company, Inc. 7637 Queen St. Philadelphia, Pa.	Cast onto steel plates	

NOTE: (a) Coated with 2 coates PR 1015 Epoxy Coating plus 2 coates formulation 121 Antifouling coating.

(b) All steel plates were sandblasted and primed with 117 primer.

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Table 1

Materials And Results Of Tests

ION	NOMINAL THICKNESS	MATERIAL WEIGHT LBS./SQ. FT.	FREQUENCY RANGE KCPS	AVERAGE TRANSMISSION REDUCTION, db	MINIMUM AND MAXIMUM % CRITICAL DAMPING MINIMUM	MAXIMUM
ent nce	5/8"	4.50	1 to 10	Increasing from 7 to 17	1.2	7.0
ates	1/2"	4.50	1 to 10	1.5	1.6	5.3
tes	1/2"	2.10	1 to 10	2.0	0.5	5.1
cos	1/2"	2.70	1 to 10	1.0	0.6	5.0
	1/2"	4.50	1 to 10	5.0	2.0	4.6
	1/8"	0.20	1 to 10	0	0.1	0.9
es	1/2"	2.30	1 to 10	2.0	0.9	3.1