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EVALUATION AND DEVELOPMENT OF NOISE-ISOLATION MOUNTS
AND MOUNT MATERIALS

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NS 713-067

by

Leo Rubinowitz

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INTRODUCTION

The work at the David Taylor Model Basin on noise-isolation mounts is being conducted under Project SRD1586/48, Index No. NS 713-067, entitled "Development of Standards and Methods for Evaluation of Sound-Isolation Mountings" (1).*

One objective of this project is to develop equipment and methods for evaluating the extent to which shipboard sound-isolation mounts reduce the machinery noise transmitted into the water in the frequency range of 30 to 30,000 cps. The only means now available is to measure the underwater noise due to a particular machine before and after installation of the mount. However, this procedure is cumbersome and expensive; a method that is simpler and that is adaptable to controlled laboratory conditions is needed if development of mounts is to proceed methodically and expeditiously.

Evaluation methods can hardly be intelligently developed until a more complete knowledge of the basic principles of sound isolation are acquired. Therefore, a second objective of the project is to determine the basic principles of sound-isolation mounts by both theoretical and experimental studies, and to design mounts on the basis of these studies.

Considerations of shock protection are purposely being deferred in order to avoid confusion. The problem of how to design a mount that will serve for both sound isolation and shock protection will not be attacked until the criteria for each are better understood.

As the project is concerned with mounts, transmission of air-borne machinery-generated noise into the water through the ship's hull is not of direct concern. However, as will be seen later, it is hoped to obtain from the experimental program some information as to the relative importance of structure-borne and air-borne noise, concerning which there appears to be considerable uncertainty.

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*Numbers in parentheses indicate references at the end of this report.

BASIC CONSIDERATIONS

The basic physical phenomena applicable to attenuation of sound in solid materials may be considered as falling into three categories:

1. Dissipation by internal hysteresis.

2. Reflection and destructive interference by "impedance mismatch."

3. Filtration by mechanical filters analogous to electrical wave filters.

Considerable work has been done by various investigators in recent years on the internal damping of materials, particularly of the rubberlike materials (2). Much more information is needed, however, on the effects of static loadings and of temperature. The types of loadings should include tension, compression, shear, flexure, and torsion, as any of these may be encountered in future mount designs. Any combination of the several types of elastic waves, namely, longitudinal, transverse, torsional, flexural, and surface, may occur in a service installation, and the internal damping with regard to each type of wave must be determined separately. A search for materials and combinations of materials with high internal damping should be one of the first steps in the program.

The principle of "impedance mismatch" can actually be considered a special case of the third item, filtration, but it is important enough to warrant classification as a separate item. It is based on the passage of sound waves through alternate layers of materials with widely different radiation resistances. The resultant reflections at the boundaries produce destructive interference, with consequent attenuation. In general, the attenuation is increased by increasing the difference in radiation resistances between the alternate layers. Therefore, a second step in the program should be a search for unusually low ρc materials which can be used in combination with high ρc materials, such as steel, to take maximum advantage of this phenomenon. Here again, the effects of static loadings, temperature, and the several types of waves must be taken into consideration.

The possibilities of using mechanical filters designed by methods analogous to electric filters have been explored to some extent theoretically, mainly by R.B. Lindsay (3). Even less experimental work has been performed. A partial exception to this statement must be made for the standard types of vibration- and shock-isolation mounts which can be considered as simple low-pass filters. The design of such mounts, however, has been based largely on lumped-parameter methods which may not be applicable to the higher-frequency sound ranges where the wave lengths approach the dimensions of the mount. Theoretical investigation of these mounts by distributed-impedance methods coupled with experimental investigation to determine their characteristics at higher frequencies is very much in order. In addition, intensive investigation of the possibilities of other forms of acoustical filters appears highly desirable.

It does not seem likely that any one of the methods discussed will answer the problem of noise isolation completely. Internal damping alone will probably require impractically long path lengths; impedance-mismatch combinations and filters will in all likelihood be limited as to frequency ranges and types of waves which practical designs will accommodate. The probability is that combinations of all three will be needed to provide effective isolation, and mounts will have to be designed to fit the noise spectra of the individual machines. The apparent effectiveness of the standard vibration- and shock-isolation mounts is probably due to the presence of elements of all three factors in their construction - high internal damping of the rubber in the mount, plus the low ρc of the rubber in combination with steel, plus the low-pass filter configuration of heavy mass of machine and low spring rate of mount.

DESIRABLE PROPERTIES OF MOUNTS AND MOUNT MATERIALS

Based on the previous discussion, it can be stated that the most desirable acoustical properties of mount materials are high internal damping and low radiation resistance. A mount may possibly also be internally damped by means other than hysteresis in the material itself. For example, combinations of laminated materials may produce high damping by friction in boundary surfaces. Porous materials also bear investigation because of the possibility of viscous energy dissipation in the pores. These properties must not be adversely affected by the range of temperatures likely to be encountered in service. A factor to be considered in this connection is the internal heating of a mount with high damping.

For structural purposes, high strength of the mount is desirable to avoid excessive bulk, particularly for main machinery mounts. Comparatively rigid structures are desirable in order to avoid excessive deflections of machinery components, which are a source of difficulty to the machinery designer. Lastly, resistance to deterioration by oil, oxidation, heating effects, and other factors is of prime importance.

PROGRESS TO DATE

Shortly after the project at the Taylor Model Basin was undertaken, it was learned that the National Bureau of Standards was making a study of the attenuation of sound in materials at frequencies up to 10 kc. After some discussion, the Bureau of Standards expressed willingness to extend its study to include frequencies up to 30 kc and also to include various combinations of materials. As a result, the Taylor Model Basin arranged a transfer of funds to the Bureau of Standards, which permitted the Bureau to extend the scope of its project as described.

Preliminary studies at the Bureau of Standards have been completed and a setup designed for measuring attenuation of compressional waves in small specimens of materials or combinations thereof under a range of compressive loads. The setup will measure both the internal damping and the velocity of sound in the specimen, the latter measurement permitting the ready calculation of the radiation resistance. Designs of equipment for measurement of attenuation of other types of waves and with other kinds of loads are in the preliminary stages.

The rubberlike materials will be studied first, as they are the best-known materials with high internal damping and low radiation resistance. Certain plastics will be studied also, as they approach these characteristics of the rubbers and offer the possibilities of better structural strength and greater resistance to deterioration. Metallic materials will also receive attention. A particularly interesting group of metals which will be investigated is a family of copper-manganese alloys developed by R.S. Dean (4), which appear to possess exceptional damping properties and satisfactory structural properties.

The eventual objective of the Bureau of Standards project is to arrive at a fundamental physical explanation for attenuation in solid materials and to derive therefrom new forms or combinations of materials with improved attenuation characteristics.

Work at the Taylor Model Basin meanwhile is emphasizing first the procurement and development of equipment for evaluating mounts in the laboratory. Preliminary designs of a setup are underway which will comprise a floating vessel with a structure proportioned to simulate the distributed impedance of a typical ship's hull, suitable mounting brackets for the isolation mounts, an adjustable dead-weight mass to simulate the machine mass, and vibration generators with variable-frequency power supply which can be mounted to generate the several types of waves in the simulated machine.

The question of how to simulate a ship's hull acoustically on a model scale is a very complex one, but it is felt that little would be gained by attempting to explore this problem in detail at this time. A more fruitful approach will probably be to make a rough approximation in the design at first and to keep this aspect of the problem in mind as analysis of the experimental work proceeds.

With regard to the vibration generator, an electromechanical type is dictated by the high-frequency requirements and the necessity for rather large amplitudes because of the relative "softness" of the systems to be vibrated. Commercial sources are being canvassed for this equipment, but it is too early to say whether they will be of assistance. In any case some development will be necessary to obtain a suitable generator, as a search of the literature has uncovered no existing vibrator of this type with a frequency range above 20 kc.

Procurement of suitable pickups for measurement of transmission will also require development, as for these also the upper limit of existing equipment appears to be 20 kc. Here, too, commercial sources are being canvassed in the hope that time and manpower can be saved by avoiding the necessity for development of the equipment at the Taylor Model Basin.

Simultaneously with the development of the evaluation equipment, theoretical investigation of mount designs will continue at the Model Basin. Close liaison with the Bureau of Standards will make the results of their measurements immediately available for use in this study.

In conclusion, it will be a comparatively simple matter to design the floating vessel so that a source of air-borne sound can be suspended within the vessel independently of the structure. Such an experiment is contemplated as a part of the program. The extra effort required will be small and should produce some information as to the relative importance of air-borne and structure-borne sound.

REFERENCES

(1) BuShips letter S60-0(332), TMB file A11/Noise, to DTMB of 5 May 1948, the original directive setting up this project.

(2) "Methods for Measuring Dynamic Mechanical Properties of Rubber-Like Materials," by A.W. Nolle, J. Applied Physics, Vol. 19, No. 8, p. 753, August 1948.

(3) "The Filtration of Sound, II," by R.B. Lindsay, J. Applied Physics, Vol. 10, No. 10, p. 680, October 1939.

(4) "The Damping Capacity of Copper-Manganese Alloys," by R.S. Dean et al., Trans. Am. Soc. Metals, Vol. 40, p. 355, 1948.