easy to compute. Linear splines are wholly adequate for monthly fluctuations. [Work supported by ONR.]

2:32

Q9. Effects of quasistationary noise on the detection of quasistationary signals. J.C. Heine and J.R. Nitsche (Bolt Beranek and Newman Inc., 50 Moulton St., Cambridge, MA 02138)

Receiver operator characteristics derived for post detection integration receivers are significantly perturbed if the signal power fluctuates with a characteristic time roughly two or more times the receiver integration time. In this paper, the effects on detection performance of slow fluctuations in both signal power and in noise power, such as occur in the 10–200-Hz region due to merchant shipping, are explicitly considered and are compared to results for signal fluctuations alone. Further degradation in detection performance in the region of $P_D \geq 0.5$ is shown to occur and the sensitivity of the degradation to the characteristic times of the fluctuations and to the statistics of the noise power fluctuations is demonstrated. The effects of the noise statistics on experimental determination of sonar system performance is discussed.

2:36

Q10. Bubble noise measurement facility. T.C. Mathews and D.J. Paladino (Ship Acoustics Department, David W. Taylor Naval Ship R & D Center, Bethesda, MD 20084)

A facility has been constructed at the David W. Taylor Naval Ship R & D Center for the measurement of bubble splitting noise. The facility is patterned after the bubble splitting apparatus of Sevik and Park of Pennsylvania State University [M. Sevik and S.H. Park, J. Basic Eng. Trans. ASME, Paper No. 72-WA/FE-32, 1–8 (1972)]. The difference in the new facility is the provision for measurement of bubble splitting noise. In addition to the measurement of sound pressure levels associated with controlled bubble splitting the acoustic capabilities of the facility provide a means for measuring the bubble size distribution under different flow conditions. Flow characteristics of the facility, background noise spectra and bubble noise data are presented.

2:40

Q11. Point sensor for vertical directional noise environments. A.J. Friedman, E.H. Hyams, and D. Jaarsma (Planning Systems Inc., 7900 Westpark Dr., Suite 507, McLean, VA 22101)

A new point-sensor concept is defined, evaluated, and shown to have enhanced performance, relative to other simple configurations, in ocean environments which exhibit noise vertical directivity. This property is characteristic of deep ocean areas at low frequencies, and the successful exploitation of the acoustics of such an environment imply special sensor and processing design factors. The concept treated in this paper involves three orthogonal, directional elements and a single omnidirectional element, with all elements colocated. The receiver utilizes cross correlation between one directional element, oriented along the vertical, and the other elements as well as individual element power spectra. The outputs are suitably combined to produce log-likelihood statistics and maximize detection probability for weak signals arriving along angles at or near the noise peak. Analytical results are presented for detection performance of this concept relative to other concepts in representative signal and noise environments. [Work supported by Naval Electronics Systems Command, Code 320.]

2:44

Q12. Single hydrophone technique for obtaining spectral source levels of marine mammals in coastal waters. LCDR R. Bostian and H. Medwin (Physics Department, Naval Postgraduate School, Monterey, CA 93940)

During the *Gray Whale* migration from the Aleutians to Baja California the mammal travels in coastal waters, thereby presenting an opportunity for the study of its sound spectral source levels. Using the theory of rough surface scattering, the knowledge of the bottom impedance, and correlation techniques, it should be possible to decompose the shallow water reverberation into the contributions from different paths. From this, the range, the depth, and the spectral source levels of the sounds of the mammal can be determined by use of only one hydrophone rather than the conventional three or four. Results are presented of an experimental study in the NPS Ocean Acoustic Wave Facility using models of the whale's pulsed radiation and of the coastal environment. [Work supported by ONR.]

WEDNESDAY, 14 DECEMBER 1977 CYPRESS ROOM, 2:00 P.M.

Session R. Architectural Acoustics III: General Architectural Acoustics

David G. Fagen, Jr., Chairman

Fagen & Associates, Incorporated, 2625 Central Avenue, St. Petersburg, Florida 33713

Contributed Papers

2:00

R1. Sound transmission loss of gypsum wallboard wall partitions. David W. Green and C.W. Sherry (Department of Forestry and Forest Products, 210 Cheatham Hall, Virginia Polytechnic Institute, and State University, Blacksburg, VA 24061) and Domtar Research, Senneville, Quebec, H9X-3L7, Canada)

Using the data bank of the acoustic laboratory of Domtar Research, statistical equations based on frequency and surface density were derived for predicting sound transmission loss (STL) and sound transmission class (STC) of double leaf wall partitions constructed using gypsum wallboard and either steel or wood studs. The equations show close agreement with experimental data for all frequency bands except those near the

coincidence dip. Results predicted using these equations also agree closely with experimental results published by other laboratories. Using these equations the effect of frequency, surface density and cavity filler on STL and STC is easily seen. However, the study also revealed some unexpected results: (1) Whether or not a partition was "Balanced" as to board placement did not significantly affect the STC of either steel or wood stud partitions. (2) For multilayer wood stud partitions attaching the second layer of board to the first with screws, rather than using glue, dramatically reduced the STL at higher frequencies. For higher surface density partitions this decrease may negate any benefits to be derived from adding fiberglass to the cavity space.

2:15

R2. Use of computers in the study of room acoustics. Robert Berkovitz (Teledyne Acoustic Research, Norwood, MA 02062) and Theodore J. Schultz (Bolt Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138)

A number of attempts have been made to apply the enormous calculating capabilities of digital computers to the solution of problems in the acoustical design of large rooms, such as concert halls. We believe that it is premature to rely on computer studies for concert hall design purposes, but point out the great advantage that computer programs can provide by promoting a useful intuitive grasp of the elements of such acoustics problems. Some examples will be presented.

2:30

R3. Use of quantitative criteria for optimum design of concert halls. D.E. Baxa (Department of Engineering, University of Wisconsin-Extension, Madison, WI 53706) and A. Seireg (Department of Mechanical Engineering, University of Wisconsin, Madison, WI 53706)

This paper describes a set of eight quantitative merit criteria for the design of concert halls which are used in a developed automated computer optimization procedure based on the ray-tracing method. Idealized optimum hall configurations and surface absorption coefficients are determined based on each criteria for illustration. The acoustical merits of the optimum designs for a hall with given floor and stage areas are evaluated and compared to those of an existing hall with acclaimed acoustical quality. They are also compared to those calculated when the total sum of all the eight merit criteria is used as the optimizing objective function. The study represents a first attempt at optimizing acoustic space based on quantitative figures of merit. The developed technique can be invaluable in giving insight into the effect of improving a particular design objective on the configuration and absorption coefficients as well as how the improvement of one merit criterion can affect the other criteria.

2:45

R4. Towards a consistent acoustical design methodology for concert halls and recording studios. John P. Walsh (Faculty of Music, University of Western Ontario, London, Ontario N6A 5B8, Canada)

In the acoustical design of environments for musical performance, reverberation time specification has served as a useful abstraction of the anticipated behavior of the sound field in the hall. However, recent trends in recording studio design point to the need to isolate two aspects of this abstraction: the diffusion of directional components in the radiation patterns of musical instruments and the imposition of a decay envelope upon delayed components of the sound. An examination of near-field and reverberant field spectral characteristics of a number of musical instruments indicates that the highly directional components associated with many of these instruments will frequently preclude any assumption of the existence of a diffuse sound field within a concert hall. Therefore special attention must be paid to diffusing these components, preferably within the first few reflections. The distinction between directional component diffusion and decay envelope allows the modelling of room performance in a hierarchical manner, and should permit the adoption of a consistent design methodology for both concert halls and studios.

3:00

R5. Reflection of sound waves from a rotating diffuser. K.P. Roy and J. Tichy (The Pennsylvania State University, Graduate Program in Acoustics, P.O. Box 30, State College, PA 16801)

The reflection of sound waves from a rotating diffuser was studied in both anechoic and reverberant environments. A simple mathematical model was developed for the rotating diffuser in the free field based upon its similarities with the oscillating plane reflector. It is found that due to the Doppler effect the reflected wave is modulated. The model developed allows the determination of both the sideband frequency spacing and the relative sideband amplitudes. The modulated signal spectra depend on the speed of rotation, diffuser size and configuration, the source frequency and the diffuser scattering function. In the reverberant environment the reflections from the diffuser are very complex. The effect on the modulation of modal frequencies of the lowest modes was studied and qualitative conclusions on the diffuser effect were made.

3:15

R6. Effect of a moving reflector on the power output of a source. R.V. Waterhouse and J.E. Brooks (David W. Taylor Naval Ship R & D Center, Code 194, Bethesda, MD 20084)

A source radiates a pure tone in a reverberation chamber which contains a reflector large compared to the wavelength of sound in air. When the reflector is stationary, the signal picked up by a microphone in the sound field is a simple harmonic signal. When the reflector is rotated about a fixed axis, experiment has shown that the signal picked up by the microphone resembles a frequency-modulated signal. The energy spectrum contains sidebands, equally spaced along the frequency axis, the frequency difference between any two adjacent sidebands being equal to the frequency of rotation of the reflector. We give here an analysis of a simplified model of this situation, where the reflector is a rigid flat plat which reciprocates sinusoidally. Results are given for the energy spectrum of the resultant sound field which are in general agreement with the experimental results cited.

3:30

R7. Reverberation time, absorption, and impedance. Earl H. Dowell (Department of Aerospace and Mechanical Sciences, 2 Aers Lab, Princeton University, Princeton, NJ 08540)

A rigorous theoretical model is derived and used to calculate reverberation time of a room in terms of impedance of absorption materials on the wall and geometrical factors associated with such materials and the room. In addition the reverberation time also depends upon the initial state of the pressure field before decay begins as well as the single measure of pressure, for example spatial root-mean-square, used to characterize the decay time history. The theoretical model, which consists of a system of harmonic oscillators with damping provided through the wall impedance, is sufficiently general to take into account all of these factors. A numerical example is given to illustrate the procedure. A brief review of current methods for calculation of reverberation time is given including a discussion of random and normal absorption coefficients. It is shown how these two quantities can be related by the present theoretical model. Current practice is to use an empirical relationship between them.