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Follow-Up Report on Audio Analgesia FREE

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AND G. J. THIESSEN, *Division of Applied Physics, National Research Council, Ottawa, Canada.*—Following a noise survey of twenty-one offices devoted to card processing with business machines it is suggested that the criteria determining whether a given background noise level is acceptable or not may be upgraded in locations which meet certain specific acoustic requirements. The offices surveyed had been selected by a "nonacoustical" authority from those in which personnel had made complaints; in some only noise had been a specific complaint. The survey included both physical measurements (tape recordings) and public opinoin polls (questionnaires). In most cases the results are in very good agreement with Beranek [J. Acoust. Soc. Am. **28**, 833 (1956) and Noise Control **3**, 19 (January, 1957)]. In a few locations levels of NC-60 and even NC-65 are found to be acceptable. These are distinguished from those requiring a criterion of NC-50 to NC-55 by (i) very good acoustic absorption on both walls and ceiling, (ii) comparative absence of scattering objects such as filing cabinets, (iii) a ceiling height no greater than about 12 ft, (iv) a floor plan which has its principal dimensions in a ratio lying between 1.2:1 and 1.6:1 and which has its maximum dimension less than about 50 ft.

P5. Noise Surveys of Cocktail Parties. R. F. LEGGET AND T. D. NORTHWOOD, *Division of Building Research, National Research Council, Ottawa, Canada.*—This paper discusses and enlarges on a recent theoretical paper by W. R. MacLean on the acoustics of cocktail parties. The discussion is supported by experimental evidence accumulated during the past two years. MacLean's analysis suggests that there is a critical density of participants above which a "quiet" cocktail party becomes abruptly "noisy." It would appear that one might actually plan a quiet or noisy party as required (assuming control over the number of participants). Unfortunately the cases studied experimentally do not show this quiet-noisy transition, and it is believed that factors not considered in the theory result in a blurring of the distinction. Indications are that there is a gradual increase in sound level to a saturation value that is independent of the properties of the room, of the beverages served, and of the number of participants. There is, however, dependence on the sex of the participants.

P6. On the Presentation of Data on Fan Noise. H. M. FITZPATRICK, *Cleveland Pneumatic Industries, Washington 6, D. C.*—The form of the relation among: speed of rotation, size of fan, flow rate, spectral density of radiated sound power, and sound frequency is derivable from simple considerations of dimensions and acoustic theory. Examples are given.

P7. Source of Noise in Fans. HOWARD C. HARDY, *Howard C. Hardy and Associates, Chicago, Illinois.*—Many of the phenomena of noise of fans can be predicted from the simple assumption that the source of noise power is a pressure pulse created by the motion of the blade or impellor. From this assumption the well known fan sound laws can be derived: (1) the sound power varies as the fifth power of the blade tip speed, and (2) the sound power is approximately proportional to the product of the brake horsepower and the static pressure. The sound power spectrum is the resultant of the combination of a coherent and incoherent spectrum. The coherent or "harmonic" spectrum is characterized by a series of pure tones whose magnitudes are predicted from the magnitude of the Fourier coefficients of the Fourier series which describes the pressure pulse. The incoherent or "pulse" spectrum has a broad-band characteristic which can be derived from the Fourier integral of the pressure-time curve of the pulse. It appears that the spectrum follows closely what would be predicted for an exponential pulse. The octave, or other proportional band plots, show a rate of increase of three decibels per octave to a broad maximum frequency, and thence a decrease of approximately six decibels per octave.

P8. Method for the Measurement and Analysis of the Near Noise Field of Jet Aircraft. G. C. TOLHURST AND S. N. MORRILL, *Acoustic Laboratory, U. S. Naval School of Aviation Medicine, Pensacola, Florida.*—Due to the limitations of area available during the operational launching of carrier-based aircraft, the near noise field (12.5, 25, 50, 100 and 200 foot radii) of new or experimental engines needs accurate definition. A system was designed to obtain two simultaneous noise sampling channels, an annotation facility, and two continuous graphic sound pressure level records. An intercommunication network was also provided between the microphone carriers and the recording engineer. The noise analysis was accomplished by employing loops of magnetic recording tape and one-third octave filters. All of the recording and analyzing equipment was housed in a mobile trailer unit fitted with reels for microphone and power cables. Noise profiles of two aircraft will be presented, abstracted from data obtained by the unit described.

P9. Jet Noise Generation and Suppression. ERIK MOLLÖ-CHRISTENSEN, *Department of Aeronautical Engineering, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.*—On the basis of similarity laws obtained from controlled experiment, a theory of the generation of the sound emitted to the far field from a jet is presented. The sound is generated in the high shear region immediately downstream of the nozzle exit, and is scattered by the remainder of the flow. The scattering is partly coherent, partly omnidirectional. The principal features of the far field spectra can be explained in terms of these processes. On the basis of this theory, the mechanisms involved in sound suppressors are discussed, and suggestions are made for a systematic approach to sound suppressor analysis.

P10. Some Characteristics of the Noise Produced by Several Contemporary Army Weapons. NORMAN DOELLING AND KARL D. KRYTER, *Bolt Beranek and Newman Inc., Cambridge, Massachusetts.*—Measurements of the noise produced by several contemporary Army weapons have been made as part of a larger study of the effects of weapons noise on hearing that is being carried out by the Sound Section of the Army Medical Research Laboratory at Fort Knox, Kentucky. The study is seeking to discover correlations between noise exposures and the hearing acuity of the exposed personnel. Noise measurements were made in and around a weapons carrier and two tanks, and near personnel during the firing of a 30 caliber M-1 rifle, 30 caliber and 50 caliber machine guns, a 76-mm gun, a 90-mm gun, and a 105-mm howitzer. The noise exposure parameters that have been investigated are (1) acoustical stability of the weapons as noise sources; (2) the rise times; (3) the durations; (4) the peak value of sound pressure level; (5) the spectra of the "integrated" sound pressure; and (6) the distribution of these parameters in and around the weapons. Typical data are presented to illustrate the results which have been obtained. (This work was sponsored by the Surgeon General, U. S. Army under Contract No. DA-49-007-MD985.)

P11. Follow-Up Report on Audio Analgesia. WALLACE J. GARDNER, *Cambridge, Massachusetts,* AND J. C. R. LICKLIDER, *Bolt Beranek and Newman Inc., Cambridge 38, Massachusetts.*—The procedure described at the Fall Meeting—the procedure in which music and noise under the control of the dental patient are used to mask the sound of the dental drill and the pain produced by drilling or extraction—has now been employed on over 500 patients with approximately 90% success. It is now considered definite on the basis of more than 50 extractions (in which the drill did not enter the picture) that the masking noise actually masks pain. The device used to present the acoustic signals to the patient ("Audio Analgesiac") has been considerably improved, and it is now being used on an experimental basis by several dentists, whose reports are beginning to come in. The use of noise signals more pleasing to the ear than filtered random noise is being explored. The experience to date will be summarized and preferred music and noise signals will be demonstrated.

Session Q. Acoustical Measurements, Room Acoustics

PAUL S. VENEKLASEN, *Chairman*

Contributed Papers

Q1. Sound Absorption by Free-Hanging Resistive Sheets. RICHARD H. BOLT, *Bolt Beranek and Newman Inc., and Massachusetts Institute of Technology, Cambridge 39, Massachusetts.*—Absorption, reflection, and transmission coefficients have been derived for a plane wave of sound at an arbitrary angle of incidence on a thin sheet of flow resistance $r=R/\rho c$ and specific mass $m=M/\rho c$, freely suspended in anechoic space. At normal incidence, for large ωm, the absorption reaches a maximum of 0.50, which occurs at $r=2$. The statistical coefficient (appropriately averaged over angle) exceeds 0.40 over a considerable range of r and ωm. In a room with fully diffused sound, a sheet of dimensions large compared with wavelength, suspended away from room boundaries, introduces a number of absorptive units (sabins) which approaches (at high frequencies) twice the absorption coefficient times the sheet area. Confirming measurements in a reverberation chamber suggest certain configurations of "space sheets" for sound absorption in rooms.

Q2. Optimized Absorption of Sound by a Flexible, Porous Medium. WILLIAM W. LANG, *Product Development Laboratory, International Business Machines Corporation, Poughkeepsie, New York.*—At the 56th meeting of the Acoustical Society of America [J. Acoust. Soc. Am. **31**, 115 (1959)], some results were presented of a study of a flexible, porous medium represented by a simple equivalent circuit. The lumped circuit elements of the analog corresponded to the significant physical constants which characterize the medium. Physically realizable flexible porous materials have widely varying properties. To select media with physical properties which are optimum for the absorption of sound, a program for an IBM 704 computer has been written. This program selects combinations of properties which yield absorptive behavior meeting specified requirements. Results of an analysis covering wide ranges of physical properties of flexible, porous materials are presented.

Q3. High-Temperature Acoustical Properties of Materials. WILLIAM E. LAWRIE, *Armour Research Foundation of Illinois Institute of Technology, Chicago, Illinois.*—The normal absorption coefficient and the normal specific acoustic impedance of the following several materials were measured as a function of temperature for temperatures up to 1500°F and frequencies up to 1800 cps. The specific acoustic impedance of all materials measured increased with temperature and caused a variation in absorption which is dependent upon the variation of the specific acoustic impedance of the material relative to the specific characteristic impedance of air. An acoustic impedance tube with the sample holder inserted into an electric furnace was used for the measurements. Both longitudinal and vertical temperature gradients were present in the tube. Empirical corrections were made to the data, but the detailed effect of the gradients on the measured absorptions and impedances has not yet been completely determined. (This research was supported by Wright Air Development Center).

Q4. On the Imperfect Problems of Acoustics. OSMAN K. MAWARDI, *Massachusetts Institute of Technology, Cambridge 39, Massachusetts.*—A thesis is presented to the effect that the approximate formulation of a physical problem bears a remarkable analogy to the performing of a mental experiment. Using the criteria for the evaluation of "meaningful" experiments, variational principles in acoustics are discussed. Several acoustical quantities such as reverberation, time, frequency irregularity, etc., are examined in the light of this analogy.

Q5. Random Sound Field in Reverberation Chambers. C. G. BALACHANDRAN,* *Division of Building Research, National Research Council, Ottawa, Canada.*—The production of random sound fields in reverberation chambers is very necessary for the determination of sound absorption coefficients and sound transmission losses. Various techniques for randomizing sound fields have been proposed in the past. The aim of this paper is to present experimental results comparing the suitability or otherwise of some of the practices of randomizing sound fields, *viz.*, altering the room geometry by a rotating vane, by fixed scattering surfaces on the walls or in space, or by absorbing patches on the walls. To assess the state of randomness of the sound field three methods were used: the correlation coefficient between two observation points, the standard deviation of reverberation time measurements, and the measurement of the sound absorption coefficient of a standard sample.

* On leave from Central Building Research Institute, Roorkee, India.

Q6. On the Determination of Sound Power in Semi-reverberant Spaces. FRANCIS M. WIENER, *Bolt Beranek and Newman Inc., Cambridge 38, Massachusetts.*—The principles and limitations of determining the radiated acoustic power of sources of sound in reverberation chambers and in anechoic rooms are reasonably well understood. By necessity, the practicing acoustician must frequently carry out sound power determinations in ordinary spaces such as factory or office areas. The limitations governing sound power measurements in such semireverberant spaces [R. J. Wells, Power App. and Systems No. 21 (1955)] are less well understood at present. To obtain a better estimate of the accuracies obtainable in practice in such spaces the results of a series of sound power determinations on two small sound sources in several semireverberant spaces are presented and compared with the results obtained outdoors. One of the sound sources is in the process of being tested at other laboratories for further cross comparison.

Q7. Improvement of Acoustic Feedback Stability in Public Address Systems. M. R. SCHROEDER, *Bell Telephone Laboratories, Inc., Murray Hill, New Jersey.*—It has been shown previously that the frequency response of a large room has fluctuations of an average magnitude of 10 db. A related result which has been obtained recently is that the *highest* peak of the response in the audio band is typically about 12