expensive and designed to be worn with safety caps. Noise attenuation provided by these earmuffs compares favorably to protection provided by alternate methods. Development and continued refinement of this "metal-less" muff has provided a viable means of personal hearing protection for power plant employees.

M4. Noise Abatement Program. MAURICE H. MILLER, *Speech Pathology and Audiology, New York University, New York, New York 10003.*—Baseline threshold audiometry is performed in the sound-isolated test area of the specially constructed mobile van. The van is moved to the power generation site where four men are tested simultaneously with a discrete-frequency automatic audiometer. The program functions as part of the Medical Department under supervision of the Medical Director. An audiological case history is obtained including information on past industrial and nonindustrial noise exposure and potentially significant medical conditions. Testing is performed by students majoring in audiology and speech pathology under the supervision of an audiologist certified by the American Speech and Hearing Association. The Con Ed audiological consultant reviews all audiometric records. Workers whose initial automatic tests are unsatisfactory are retested on the automatic audiometer with additional individual supervision. If the second test remains unsatisfactory, a manual audiometric test is performed. Criteria for referral of the worker for additional audiologic testing and otological examination will be presented. A variety of audiological procedures are performed both in the trailer and in the home office as well as at several comprehensive audiological facilities in the community with which Con Ed is affiliated. Statistical data will be presented showing the numbers of workers at different plants requiring audiometric retesting and complete audiological evaluations of various types.

M5. Polyphase Induction Motor Noise and Its Control. BOB BROZEK, *General Dynamics; Electro Dynamic Division, 150 Avenel Street, Avenel, New Jersey 07001.*—A plethora of sources have arisen over the years that have made noise control desirable and mandatory. The growing national concern of "the environment" has culminated in many studies in the acoustical arena dealing with noise-related hearing loss, worker inefficiency, and many other physiological and psychological areas. The result of this noise awareness has been to effectuate a wealth of noise limitations. These range from federal, state, and local municipal ordinances to those found in the specifications of the motor buyer. The motor manufacturer has not been immune from this onslaught of noise restrictions. Whether the motivating agent is to meet a specification or simply remain competitive, the motor supplier has had to suddenly add a third dimension to motor design. Where previously only electrical and mechanical parameters were considered, sonance properties must now also be deliberated. In this paper, the gravitation towards the quiet motor will be presented. Of all the possible motor noise sources, only two have been found to have a major impact on the motor's airborne noise level, these being air movement (fan and ventilation passages) and magnetic (slot combination) in nature. While abatement of the former is possible by source, enclosure and/or acoustical treatment, magnetic noise is controllable solely through source diminishment. In summary, motor noise sources are enumerated, distinction as to whether peculiar to high- or low-speed machinery is explained, and means of abatement are discussed. Both calculations and test data are also presented to verify the assertions made. Finally, it is suggested that reforms necessary to reduce motor airborne noise levels were not as debilitating as first imagined. Some related areas of further investigation are delineated at the conclusion of the paper.

M6. Design Considerations for Power-Plant Pump Noise Reduction. NORMAN L. MEYERSON, *Ostergaard Associates, Caldwell, New Jersey 07006.*—Reduction in vibration, pressure pulsations, and noise in power-plant centrifugal pumps can be achieved by increased impeller to volute tongue distances, improved geometric relationship between the tongue and impeller to minimize the shock of sudden fluid deceleration, control of impeller suction and discharge recirculation effects, and the elimination of hydraulic whirl set up in wearing ring annuli. In addition to the benefits of lower noise and vibration, less destruction of the surfaces of the impeller and volute by cavitation erosion is experienced.

M7. Steam Turbine Noise. RONALD L. BANNISTER AND PADAMAKAR M. NISKODE, *Technology Development, Steam Turbine Division, Westinghouse Electric Corporation, Lester, Pennsylvania 19113,* AND JOHN H. CAREY, *Acoustics and Noise Control Research, Westinghouse Electric Corporation, Research and Development Center, Pittsburgh, Pennsylvania 15235.*—The heavy demand for electrical energy has required turbomachinery manufacturers to design and build steam turbine–generator units which can produce over 1000 MW. Based upon numerous field surveys and experimental programs conducted in the laboratory, this paper identifies the major sources of sound produced by large fossil and nuclear steam turbines. Basic differences in operation between the two types of machinery are explained. Typical sound spectra are reviewed and measurements are used to show how the sound level varies as a function of such parameters as rotor unbalance, unit size and load, steam flow, and structural resonances. Basic sound mechanisms are discussed and general guidelines are given for designing quiet steam turbines, including such components as valves and piping systems. Additional measurements show that the sound level on the main turbine floor depends not only on the sound radiation characteristics of the turbine–generator unit, but on the building architecture and plant layout. Measurement problems associated with predicting steam-turbine sound levels are also discussed.