ARCHIVES OF ACOUSTICS
25, 4, 509–543 (2000)

C H R O N I C L E

Polish Seminar on Acoustics (OSA 2000)

XLVII OSA'2000 is a significant scientific forum for presenting the experience and achievements from basic fields of both the experimental and theoretical acoustics as well as its applications.

The seminar is an overview of the recent, mainly Polish, contributions to the development of research in the field. It is also an opportunity for public discussion and exchange of scientific views concerning such an important interdisciplinary science as acoustics. Last but not least, it plays a crucial role in integrating the scientists.

The papers presented at XLVII OSA'2000 have been divided into plenary papers and papers concerning different areas of acoustics.

Plenary papers (8)

are interdisciplinary in nature and comprise a wide range of issues:
- Acoustics at the Outset of the 20th Century;
- Nonlinear Acoustics and its Applications: A Historical Perspective;
- Fractals in Acoustics;
- International Co-operation in Control of Vibroacoustic Threats;
- Sound Intensity;
- Methods of Assessing the Quality of Speech Transmission;
- Modern Techniques in Ultrasonographic Imaging;
- Recent Progress in Automatic Recognition of Noise Sources.

Papers concerning different areas of acoustics (Contributed reports)

1. Underwater Acoustics (12 papers)

This area comprises a wide range of acoustical issues concerning liquid media. The research done refers to navigation, localisation of underwater objects, as well as acoustical properties of various media.

2. General Linear Acoustics (6 papers)

The papers refer to a linear description of different aspects of an acoustical field, and the problem of energy radiation of sound sources. The research methods are mainly analytical and can be applied in research in other fields of acoustics.

3. Nonlinear Acoustics (2 papers)

The papers take into consideration a nonlinear description of different phenomena, as well as a number of significant properties of real acoustical systems.

4. Ultrasonics, Quantum Acoustics and Physical Effect of Sound (20 papers)

The papers present methods and applications of ultrasonic technology in the: research on physical properties of different substances and components, technological processes in various fields of industry, measurements in the area of medicine and physics, and a precise localization of objects in different media.

5. Bioacoustics (9 papers)

The issues are interdisciplinary in nature and combine such disciplines as acoustics, biology and medicine. The research refers to diagnostics and treatment of diseases with the application of acoustical methods.

6. Structural Acoustics and Vibration (9 papers)

The papers concern the research done on vibration and mechanical values of different physical structures and their vibrations. Vibration attenuation achieved in various ways, and acoustical field generated by vibrating structures are analysed.

7. Noise, its Effects and Control (12 papers)

The papers take up an important issue of vibroacoustic threats and ways of fighting, minimising, and preventing them, as well as the issues concerning the elimination of the noise effects, and the measurement methods. The research results allow to design, for example, the work and public places, so that they fulfil health and safety requirements determined by the standards.

8. Architectural Acoustics (4 papers)

The issues refer to the research into sound systems, quality of sound, and the level of noise indoors.

9. Transduction (11 papers)

The papers deal with properties and quality of signal transmission by electroacoustic measurement and sound transducers. Some of the papers refer to sound power devices.

10. Psychological and Physiological Acoustics (9 papers)

The papers concern the research into hearing. The results have a lot of applications, for example processing the sound signals in such a way that the best perception of sound within the range of audibility is assured.

11. Speech Production, Perception and Processing (10 papers)

The papers refer to the analysis technique, processing and recognition of speech signal, the analysis of the acoustical modelling of Polish phonemes, as well as the acoustical analysis of lack of fluency in pathological speech.

12. Music and Musical Instruments (3 papers)

The papers present the results of the research into musical properties of both the hearing organ and musical instruments.

Plenary reports

Acoustics at the outset of XXI century

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Changes of the behaviour and importance of acoustics form a separate branch of physics related with audible sound to the generally recognised interdisciplinary science. The evolution of the role and development of the diverse fields of acoustics in the course of XX century are presented in the quantitative way on the tables. The proportional participation of the indicated field of acoustics to: 1. References in the international databases on contemporary papers on acoustics for the periods 1949 – 1958, 1959 – 1963, 1982 – 1983, 1996 – 1997; 2. The papers presented at the international congresses on acoustics (ICA) 1965, 1983, 1998, at Forum Acusticum 1996, 1999 and at the Meetings of Acoustical Soc. of America 1967, 1982, 1999; 3. Papers presented at the Open Seminars on Acoustics OSA (Poland) 1965, 1983, and 1999. The items on the tables correspond to the following fields of acoustics: 1 – Physical acoustics, 2 – Physiological and psychological acoustics, 3 – Electroacoustics and acoustic signals processing, 4 – Speech acoustics, 5 – Musical acoustics, 6 – Architectural acoustics, 7 – Noise control, 8 – Vibroacoustics and structural acoustics, 9 – Ultrasonic applications. 10 – Hydroacoustics. The recent key problems related with applications of acoustics: 1. The acoustic methods for investigation: the objects of nature and engineering, the living organisms, the technological materials and physical-chemical processes. 2. The control and utilisation of the acoustic energy: noise and vibration, applications in medicine and manufacturing. Sound as a main medium for perception and transmission of information: the objective (physical) and subjective (psychological) evaluation of speech and music, the new hearing ends, the bioacoustics. The consequences of computerisation: digital and quantum definition of the acoustic field, statistical approach, collection and analysis of large databases. The integration of the acoustics as an interdisciplinary science is aided by the activities of a number of the national acoustical societies and the authorities of the acoustical journals.

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Nonlinear acoustics and its applications: A historical perspective

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The most important contributions to nonlinear acoustics since Euler's formulation of his equations of motion in 1755 and until 1960 are reviewed briefly in this paper. The review includes the works by Lagrange (1760), Poisson (1808), Stokes (1848), Earnshaw (1860), Riemann (1860), Rankine (1870), Hugoniot (1889), Rayleigh (1910), Taylor (1910), Fay (1931), Fubini (1935), Thuras, Jenkins & O'Neil (1935), Burgers (1948), Hopf (1950) and Cole (1951), and Beyer (1960). The development in the mathematical basis and in understanding of the physics behind nonlinear acoustics will be emphasised, and the potential applications of nonlinear acoustics will be discussed. The discussions have been restricted to nonlinear acoustics of fluids, and relations between nonlinear acoustics as an important discipline of acoustics, and fluid mechanics, are pointed out.

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Fractals in Acoustics

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The idea of fractals, fractal dimension and fractal measures have been presented. The examples of artificially constructed fractals and natural fractals have been given. The first are e.g. the Cantor set, Koch curve, Sierpinski carpet; the second ones are e.g. the line of the coast (the most characteristic for Norway). The relations between fractal and deterministic chaos have been defined. The acoustical and vibrating systems using fractals have been described. There are vibrations of the strongly nonlinear moving system of electrodynamic loudspeaker, with sound synthesis and composition of music, defects in materials under dynamic stresses and acoustic diffusors.

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International cooperation in control of vibroacoustic threats

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The paper presents international collaboration in vibroacoustical protections. International organizations, congresses and scientific conferences were presented. The papers present also the activity of Polish teams in this collaboration.

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Sound Intensity

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The advent of sound intensity measurement systems in the beginning of the 1980s had a significant influence on the noise control engineering. Today, the sound intensity measurements are routinely used in the determination of the sound power of machinery and other sources of noise in situ. Other important applications of sound intensity include the identification and rank ordering of partial noise sources, visualisation of sound fields, determination of the transmission losses of partitions, and determination of the radiation efficiencies of vibrating surfaces. Sound intensity is also an important research tool. This paper summarises the basic theory of sound intensity and its measurement, and gives an overview of the state of the art in various areas of application, with particular emphasis laid on recent developments.

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Methods of assessing the quality of speech transmission

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This paper presents subjective and objective methods of speech transmission quality evaluation, with particular attention paid to the research carried out at the Institute of Telecommunications and Acoustics of the Wrocław University of Technology. Within subjective methods, a method of logatom intelligibility measurements is discussed together with its modified version worked out at the Institute.

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The modern techniques in ultrasonographic imaging

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This paper reports the latest developments in the ultrasonic medical imaging. The review of the modern high-density, multi-elements linear array, phase array and annular array transducers will be

given. These new technologies benefit from the synthetic aperture and composite wide-band piezoelectric materials, opening a new era of a real time scanning of the biological structures with unprecedented quality. Flow velocity colour mapping, power Doppler, tissue Doppler, contrast agents echo enhancement and other new, exciting developments are discussed.

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Recent Progress in Automatic Recognition of Noise Sources
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The technique of automatic noise sources' identification had been first developed under the EU project called MADRAS (DG12). This technique enters today the domain of practical applications. The feedback from these new fields creates new needs and triggers some new interesting investigations. The paper presents the results of recent identification technique developments in two very different particular fields: environmental noise and vehicle noise. The environmental application focuses on a precise set of noise sources present in urban environment (street vehicles, planes, ...). A new way of detecting the acoustic events (which is the first step of the identification) is presented. It is based on the application of psychoacoustical criteria. Detection of relevant events leads only to a better correlation between the measured and detected sources and the perception of noise by urban population. The second application presented concerns the detection and the recognition of small disturbing (usually transient) noises in a passenger car, called squeaks and rattles. Although the signal characteristics of squeaks and rattles are significantly different from the urban sources, the modular and arborescent concept of the MADRAS technique allows an efficient processing in both cases. Finally, the paper presents the procedures under development and discusses some future issues.

Contributed reports

Underwater acoustics

Investigation of the pressure level changes of the fixed spectrum component of underwater ship noise
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The aim of the paper was the analysis of the underwater ship noise spectrum. Investigations were connected with changes of the pressure level of the spectrum component of underwater ship noise equal to 25 Hz. This frequency is characteristic for ships and, first of all, it is connected with the work of a generating set. Method of measurement of underwater ship noise and the method of its analysis were described in the paper. The paper presents some examples of underwater ship noise spectrum calculated for fixed ship speeds and changes of the pressure level of spectrum component equal 25 Hz as a function of the distance and the ship speed.

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Analysis of possibilities for experimental verification of sound agglomeration of gas bubbles in liquid
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The aim of this paper is to present an analysis of the possibilities for examination of the effect of concentration of gas bubbles in liquid — in the planes of nodes or antinodes of an ultrasonic standing wave applied. The interaction of ultrasonic waves with dispersions can be used for separating the dispersed gas bubbles from the fluid. Under the influence of the ultrasonic standing wave, the gas bubbles existing in the liquid experience a certain characteristic displacement, referred to as the drift. The drift force depends on the position of a gas bubble in relation to the nodes of the standing wave, on the gas bubble size, on the parameters of the acoustic field, and on the fluid. The paper presents an idea of a system,

which may be used to analyse this effect experimentally. The main objective of the experiment is to verify the theoretical results obtained. The effect has been observed (the quantitative verification) so far, and measurements are to be conducted in the future (qualitative verification).

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Comparative investigations of acoustic pressure generation of the ship propeller

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Knowledge of the acoustic pressure level generated by a ship to the water environment is an important exploitation problem. It is connected with assessment of technical conditions of' the ship mechanisms and the planned ship task.

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Seabed-type recognition using decision tree

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A decision tree classifier was developed for sea bottom recognition from the acoustic echoes. The decision-tree algorithm was derived and used to construct the decision-tree classifier operated on the data collected on 38 kHz and 120 kHz echosounder‘s frequencies. The system has been applied successfully to the task involving forty parameters retrieved from acoustic echoes, including the wavelet coefficients. The data have been acquired from acoustic surveys carried out on Lake Wasington, using DT4000 echosounder of 38 kHz and 120 kHz operating frequencies.

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Shaping the horizontal beam pattern of the high-resolution, ahead-looking sonar

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The paper discusses high angular and range resolution of ahead-looking sonars with a multi-stave transmitting-receiving linear array. By increasing the sonar's working frequency, the size of the array can be reduced; however, as the beam gets narrower, the number of array staves goes up. The result is a growing number of receiving channels and transmitting modules. The number of array staves can be reduced by increasing the spacing between the stave centres above 0.5λ. As a result, however, grating lobes are produced for receiving and transmitting the beam patterns. For both patterns the grating lobes always occur in the same directions. Narrowing the observation sector does not reduce the level of grating lobes of both patterns, neither does it change their position with respect of one another. The work shows that in order to reduce the level of grating lobes of transmitting and receiving beam patterns of the multi-stave array for $\lambda < d < 2\lambda$, the horizontal beam patterns of the staves should be shaped by increasing the size of the elements. For a stave whose element is $0.9d$ wide, the level of grating lobes of both central beam patterns is approximately -10 dB but for steered beam it goes up to -8 dB which is too high. Two methods of shaping the horizontal beam patterns of array staves are presented. The shaping is done by increasing the size of the element above d by mechanical coupling of the staves. Transmitting and receiving array beam patterns obtained by computer simulation are presented for d changing from λ to 2λ with grating lobes below -20 dB, which brings the level of grating lobes of the sonar below -40 dB.

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On dispersion of sound beams in bubbly liquid

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The dynamics of a bubbly liquid with small volume concentration of bubbles is considered. Beam propagation at a heterogeneous medium is treated in parabolic approximation. For source extended in one

direction (strip-like source) the resulting equation is equivalent to KP-II equation. For focused sources with appropriate choice of boundary conditions, a cylindrical KP (Johnson) equation is derived. We study terms solutions that could be expressed in the elementary, functions interpreting the singularities of them as poles in a complex plane. The position of the poles is shifted from the real axis on account for viscosity and thermoconductivity.

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Acoustical investigation of "stable" structure in water mixtures

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The velocity of ultrasound and density were measured in the mixture of diethylene glycol and water in the temperature ranges 283 – 308 K. From these results, the adiabatic compressibilities were calculated from the Laplace equation. The compressibility dependencies on the temperature and concentration are presented as a group of isotherms with one common point of intersection. Such relation between the adiabatic compressibility and concentration and temperature indicates the formation of a liquid stable structure which we tried to compare with the solid clathrate. This structure was suggested by Baumgarten and Atkinson as well as by Endo, although the interpretation was different. The first authors relate the formation of clathrate structure to the minima of the compressibility isotherms but according to Endo, the intersections of the compressibility isotherms are related to such a structure.

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Fractal modelling of seabed backscattering

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The numerical modelling of echosounder signals backscattering by a fractally corrugated sea bed surface is presented. In particular, the relations between fractal dimension describing the large scale roughness of sea bottom, and the received echo envelope shape, especially its complexity measured also by fractal dimension, were investigated. The fractal relief of seabed surface was generated assuming the power law form of the spatial frequency power spectrum, and subsequently applying the two-dimensional inverse FFT algorithm. In the second stage, the bottom echo waveform was calculated numerically as a sum of contributing echoes from all surface elements. For each element, the echo amplitude was calculated assuming the form of angular dependence of the bottom backscattering coefficient obtained previously for small-scale roughness by Kirchhoff approximation. The obtained results of simulations show that under some conditions, the seabed surface fractal structure is transferred onto the shape of its impulse response and the echo envelope. The empirical relation between fractal dimension of the fractal seabed surface and of the echo waveform was also found. The results are important in the context of newly developed algorithms for acoustical seafloor classification.

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Determining of accuracy zones of hydronavigational system

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In this paper, the method of accuracy zones determination of the hydronavigational system has been shown. This system works on the basis of time delay estimation between the underwater signals which descended from the moving underwater object. Analyse of accuracy zones allows to optimal place of receivers for secure the high accuracy of position determining in the designed zone.

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The forward and side scan sonar images computer simulation

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The generation of dynamic sonar images in simulators of new sonar's generation with computer processing and displaying is possible directly by a personal computer. The simulation could also include full signal processing as in the real sonar. The methods of computer generation of echo signals, reverberations and noise in the training simulator of forward and side scan snars are presented in this paper. The effects of sonar's simulator setting changes and some remarks about simulator constructions and the special communication network with the computer "teacher's" station are also shown. Some examples of real and simulated displays (for forward and side looking sonar) are compared.

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Distribution of assessment of fish resources in Solina Dam Reservoir monitored with an acoustic-cum-fishing method

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The objective of the study was to determine spatial distribution and densities of fish inhabiting the water column of Solina Dam Reservoir, using the method of acoustic-cum-fishing monitoring. An attempt was made to determine the fish stock composition, biomass and numbers, and to find possible relationships between these values and the environmental parameters, both natural and anthropogenic. Acoustic monitoring was performed at daytime as well as at night. Two research echosounders were used: Simrad EY-M (70 kHz) and Simrad EY-500 (120 kHz). Altogether 104 acoustic profiles were made along the pre-established routes, totalling about 100 km. Fish densities along the monitored routes were calculated using the programme HADAS and EP-500. Interpolating the net of the data thus obtained, maps of fish distribution and surface fish densities were worked out and fish numbers were calculated. Mean fish density as monitored with an echosounder EY-M was 264.3 fish/ha, while the respective result obtained with EY-500 was 440.9 fish/ha. The highest densities were registered in the area where Solinka and San rivers flew into the reservoir, and in the region close to habitable areas and recreation sites. Fish densities in Solina Reservoir are from several to over 40 times lower than in Polish lakes. In order to identify the fish species and to verify size composition of the stock, control catches were performed with pelagic trawl and gill nets. Composition of these catches was: 44.5% of bleak, 23.7% of roach and 15.0% of bream. Fish biomass was estimated at from 38 kg/ha to 63 kg/ha, depending on the echosounder used.

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The modern method of the digital synthesis of the broadband sounding pulses in echo ranging

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The method of digital synthesis of the broadband sounding pulses in active sonars is presented. The method uses the digital modulators, which are applied in the modern telecommunication systems. The characteristic features of the method are discussed on the basis of the designed digital transmitter of the chirp pulses. The sample sounding pulse along with the signal at the output of the matched filter are also presented.

General linear acoustics

Measuring the directional vibration of acoustic wave propagation caused by temperature gradients

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The article presents a fragment of measurements of acoustic intensity distribution taken in Wdzydze Lake. A source of the acoustic wave at a frequency of 220 kHz was placed near the shore and directed

horizontally towards the lake centre. Next, a motor boat was used to take measurements of the profiles of sound velocity and depth intensity distribution in several selected spots of the lake. The experiment was then repeated for new positions of the transmitting antenna, first inclined by 4 and then by 6 degrees towards the bottom of the lake.

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Operations of symmetry for any set of coherent point sources of zero order

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Any set of coherent point sources radiated under the free field conditions, that is when all sources interact, can be considered as a simplex graph, so its properties can be analysed by means of the graph theory. The paper presents an attempt of such an analysis. It is assumed that the symmetry of any set of coherent acoustic sources means the invariance of its total acoustic power emitted when some operations on the system are carried out. These operations may concern the whole set of sources (transformation of the co-ordinate system, translation etc.) or only some of the sources (rearrangement of position, variation of phase etc.) and so we deal correspondingly, with global or local symmetry. The formula for the acoustic center (in analogy to the center of mass in mechanics) has been presented as an example of the global symmetry. The cases of sources being in phase ($\varphi_i - \varphi_j = 0$, φ_i — i-source phase) or in antiphase ($\varphi_i - \varphi_j = \pi$) have been considered. It allows to formulate the criterion of equivalence: sets of acoustic sources are equivalent when and only when they have the same acoustic center and they radiate the same acoustic power.

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Some limiting transitions leading to the formulae for the sound power of a circular plate

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Several limiting transitions from the formulae describing sound radiation by a clamped annular plate to the formulae valid in the case of a clamped circular plate have been performed in this paper. The theoretical analysis of sample magnitudes, the active and reactive power of sound radiated by both the sources included, has been carried out. A good agreement of the results obtained herein with the result obtained by means of other analytical methods has been reached, which confirms the correctness of the research performed. The formulae describing sound radiation by a circular plate obtained by performing some limiting transitions is a confirmation of the greater generality of the formulae valid in the case of a clamped annular plate.

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The sound pressure distribution of a clamped annular plate at Fraunhoffer's zone

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In this paper, the acoustic field of vibrating clamped annular plate has been considered. The sound pressure at the Fraunhoffer zone has been reached. The sound radiation directionality indicator has been computed for the source. The plate vibrates harmonically under external pressure of axis symmetric distribution under the plate surface. The plate model by Kelvin-Voigt has been used, which made it possible to consider the plate's internal friction forces. The influence of the air column above the plate on the plate vibration modes has also been taken into account. The results of an annular plate free vibration analysis have been used.

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Approximation of the parabolic partial differential equation in studies of acoustic waves propagation in randomly inhomogeneous media

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Propagation of acoustic waves in randomly inhomogeneous media has been considered in the approximation of the parabolic-type differential equation. Application of the Feynman path integrals to solution of the parabolic partial differential equations has been described. Attenuation of acoustic waves, resulting from scattering in randomly inhomogeneous medium has been estimated for various forms of the correlation function of the acoustic refractive index fluctuations. In the case of a turbulent medium with von Kármán correlation function of the medium inhomogeneities, the scattering coefficient of acoustic waves has been calculated as a function of the parameter ν of the von Kármán function.

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The cutoff frequency of acoustic horns

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The accurate calculation of the cutoff frequency of a horn is important in designing the acoustical systems with horns. However, generally the difference between the experimental and theoretical values of cutoff frequencies amounts to about 20%. The calculation method of the cutoff frequency of horns is analysed in this paper, especially for Salmon's horns, which are commonly used. It is assumed that a one-dimentional infinitesimal wave is propagating in the horn without any loss of energy. The wave reflected from the open end is neglected. In the analysis, a formal analogy between the reduced Webster pressure equation and the Schr$\acute{}$odinger equation is used. It is stated that the wave-front shape approximation considerably influences the value of the cutoff frequency. The usually assumed plane wave approximation decreases the cutoff frequency value. The method of calculation of the cutoff frequency of horns in a spherical wave-front shape approximation is proposed. This method is based on a discussion of the wave equation of a horn without necessity of solving it.

Nonlinear acoustics

Field of nonlinear elastic wave of a focusing source in the post-focal region

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The focused intense ultrasound has been used for many applications in medicine and technology. The most interesting phenomenon is observed in the focal area. There are also many interesting features connected with the nonlinear propagation in the post-focal area. The main goal of this paper is to present some of them on the basis of the numerical as well as experimental investigations.

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Nonlinear evolution of acoustic wave in semi-ideal gas

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A system of coupled nonlinear equations for interacting modes of acoustic waves is derived using the projection technique. Three independent modes: leftwards, rightwards propagating and the stationary one are obtained by a set of orthogonal projectors of the linear problem. The projecting method yields a coupled system of interacting modes in the nonlinear problem. The final system is equivalent to the basic one up to the third-order nonlinear terms. A fluid medium is considered, caloric equation of state was taken as the Taylor expansion of the general form and then applied to a semi-ideal gas. Acoustic mode is analysed for ideal and semi-ideal gas models, the velocities and nonlinear coefficients are evaluated and compared for the case of CO_2.

Ultrasonics, quantum acoustics and physical effect of sound

The method of measurement of ultrasonic attenuation

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This paper describes a method for measurement of acoustic wave attenuation and velocity in the nearfield. The method is considered for the case of liquid media. It enables to investigate the medium with high ultrasonic attenuation the frequency area of new MEGC. Two transducers exciting acoustic waves in the medium are taken into account. These two waves are composed in the registration area in such a way that the compensation is achieved owing to adjustment of the frequency and amplitudes of the waves. The velocity of acoustic wave is found from the value of frequency while the attenuation from the value of amplitudes. In this paper, relations for determining the attenuation and velocity are derived. Conditions providing the maximum accuracy are revealed.

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Piezoceramic transducers with high temperature stability of resonance frequency

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Dependence of the relative change of the resonance frequency (Df_r/f_r) on the content of (x)$PbTiO_3$ in the solid solution $Pb(Zr_{1-x}Ti_x)O_3 - PbMb_{2/3}M_{1/3}O_3 - PbW_{1/2}Mn_{1/2}O_3$ — based piezoceramics has been investigated. The correlation between Df_r/f_r and internal friction (Q_m^{-1}) has been ascertained, as well as the relation between these quantities and the crystalline structure, which depends on concentration of (x)$PbTiO_3$ has been revealed. It was found that the smallest values of Df_r/f_r appear in the following two cases. Firstly, in case of piezoceramics with tetragonal structure (T) and mole fraction x within the range $0.53 < x < 0.63$; secondly, in case of piezoceramics with rhombohedral structure (Re) and mole fraction x within the range $0.20 < x < 0.30$. The smallest temperature stability, however, was found for piezoceramics with compositions from the morphotropic phase boundary region (Re+T) at small δ-parameter, which describes the degree of deformation of the regular elementary cell in a given phase, and at large η-parameter, which determines the degree of reorientation of the remanent domains different from 180° and caused by an electric field. It can be seen from Fig. 1 that decrease of the $PbTiO_3$ — mole fraction from the values typical for PZT morphotropic region (MR) is accompanied by structural phase transition, i.e. ceramics exhibits a rhombohedral phase. At the same time, an increase in stability of the resonance frequency (decrease in Df_r/f_r) and increase in mechanical quality Q_m (increase in internal friction Q_m^{-1}) can be seen. These changes are smaller as compared with transition from the morphotropic region to tetragonal phase, but they are conditioned by a strong decrease in the number of the domain walls (increase in h-parameter). As the $PbTiO_3$ mole fraction moves towards T-structure compositions, mobility of the domain walls decreases due to the increasing d-parameter.

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Investigation of diffusion process using photoacoustic effect

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Possibility of analysis of a drug penetration through membranes using photoacoustic effect is considered. Basing on the 2nd Fick's law, a problem of distribution of drug concentration in the membrane

in space and time is solved. The obtained solution allows to derive the distribution of heat sources arising in the membrane illuminated by modulated intensity light. Subsequently, the temperature of the illuminated membrane surface is analyzed numerically. This temperature is directly connected with a signal registered in photoacoustic measurement. Qualitative agreement between the calculated time-dependence of this temperature and the photoacoustic signal measured in the corresponding experiment is shown.

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Investigations of the termotropic liquid crystals in Epidian 3 by an application of acoustic methods

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The results of measurements in pentylcyanobiphenyl (PCB) liquid thermotropic crystal were used as a standard for investigations of Epidian 3. Studies of a sound speed and sound attenuation of the frequency of 2.5 MHz were performed with US-6 measurements set for high frequencies manufactured by IPPT PAN in Warsaw. These investigations were realized during the heating and cooling processes of a liquid crystal in a region of the phase transition: nematic-isotropic liquid, and also isotropic liquid-nematic in the constant magnetic field perpendicular or parallel to the direction of an ultrasonic wave propagation, and also without magnetic field. The obtained data are presented using the Fisher curve for liquid crystal in the nematic and in the isotropic liquid. On the basis of the graphs for critical parameters in a phase transition isotropic liquid-nematic, in the perpendicular or parallel magnetic field relating a direction of ultrasonic wave propagation some of these parameters were determined. Using these graphs, the temperatures of phase transitions were determined in the presence of magnetic field or without this field. Some differences between the temperatures of phase transition were observed during the heating and cooling process. The temperatures of a phase transition corresponding to an isotropic liquid-nematic are lower than those for a phase transition nematic-isotropic liquid. These differences are about 1 K. Investigations of the sound speed and sound attenuation for Epidian 3 were performed in an isotropic liquid at a temperature of the transition to glassy mesophase. The research project of physical properties for liquid litropic crystal has been started recently.

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Hysteresis of changes of ultrasonic wave absorption coefficient caused by the magnetic field

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The structure of ferrofluid changes under the influence of external magnetic field and does not return to the initial condition after turning off the magnetic field. Probably, the clusters remain in magnetic fluid. For this reason, the properties of ferrofluid depend on its magnetic history. This phenomenon was studied using the measurements of changes of the ultrasonic wave absorption coefficient.

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Dependence of ultrasound velocities on heat-treatment and magnetic field of the Fe–Cu–Nb–Si–B 17 mm thick amorphous ribbons

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Ultrasound velocities as the functions of the bias magnetic field and the annealing temperature were investigated in the $Fe_{72.5}Cu_1Nb_4Si_{13.5}B_9$ amorphous ribbons. The samples were 50 mm long, 3 mm wide

and 17 mm thick. The strip samples were annealed in vacuum for 1 h in the temperature range from 200 to 700° C. The maximum changes were observed after annealing at the temperature of 500° C when the magnetomechanical coupling coefficient reached the maximum value ($k = 0.71$). The ultrasound velocities were changing from 3.0 to 5.2 km/s, depending on the magnetic bias field and the thermal-treatment history.

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Sensitivity of ultrasonic hydrophone probes in frequency range 0.25 – 40 MHz

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This paper describes the development and implementation of acoustic measurement methods capable of determining absolute sensitivity of miniature ultrasonic hydrophone probes over a wide, 100 MHz bandwidth. Currently used calibration technology is usually limited to approx. 20 MHz and to address this issue, two wideband calibration techniques were developed. The techniques allow frequency responses of different PVDF polymer hydrophone probes, including bilaminar membranes and needle designs to be determined from 200 kHz to 100 MHz. The overall uncertainty of the measurement technique developed was estimated to be better than ±1.5 dB in the frequency range 0.2 MHz – 30 MHz and ±2 dB between 30 and 40 MHz. Absolutely calibrated probes are needed to determine and monitor the acoustic output of ultrasound imaging devices. The results of this work are necessary to implement the procedures for adequate determination of the Mechanical Index (MI) of ultrasound imaging devices and in development of therapeutic procedures based on the use of High Intensity Focused Ultrasound (HIFU).

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Evaluation of residual stress and textural anisotropy from ultrasonic measurements

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The texture of every polycrystalline aggregate and the presence of stress in the material contribute to the anisotropy of its macroscopic physical properties, e.g., they induce the dependence of the ultrasonic wave velocities on the directions of the wave propagation and polarization. In the paper, a proposal of ultrasonic measurements accompanied by analytical and computational analysis is presented and outlined, what enables us to determine separately each of the two contributions to the orthorhombic anisotropy of a polycrystal made of cubic crystals with the highest symmetry. The steps of utilizing this method are the following: In the first step, following Degtyar and Rokhlin [J. Appl. Phys. 78 (1995)], the initial stress is to be found simultaneously with the stress and texture-dependent effective stiffness moduli from inversion of the Christoffel equations. The measured angular dependencies of the velocities of ultrasonic bulk waves are used as the input. In the second step, following Lewandowski [Ultrasonics 3 (1995); Ndt&E International 32 (1999)], the use is to be made of the Jaynes principle of maximum Shannon entropy. In this way, it is shown that on the basis of the measurements of respectively chosen ultrasonic velocities, it is possible to find simultaneously the maximum-entropy distribution function of the crystallite orientation and the single crystallite stiffness moduli.

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Acoustic anomaly in critical point — characteristic frequency of concentration fluctuations in critical binary mixture of nitroethane-isooctane

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Sound propagation is a valuable tool in the investigation of dynamics of phase transitions in critical mixtures. All theoretical models of acoustic wave propagation in critical mixtures describe attenuation

and sound dispersion as a function of reduced frequency. Thus the first step in theoretical description of experimental results is to determine the amplitude of characteristic frequency of concentration fluctuations w_0. The viscosity of nitoethane-isooctane mixture was measured using a H'oppler viscometer in temperature ranges from 31 to 52° C. The obtained value of characteristic frequency was $w_0 = 5.44'10^{10}$ Hz.

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Recognition of the shapes, sizes and position of objects in gas medium using ultrasonic methods

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The work presents a new way of recognising the shapes, sizes and position of objects, based on a method used in ultrasound transmission tomography (UTT). The concept of UTT in a gas medium is close to the classical tomography. However, because of the measurement environment, the visualisation of the object's internal structure is not possible. What is possible is the imaging of the object's shape and size, and also its position in the space. If the dimensions of the object are larger than the wavelength, then for every measurement on the transmitter-object-receiver way, the ultrasonic wave is either reflected from the object air boundary or it reaches the receiver omitting the object. In the paper, the results of object's shape, size and position investigation applying the image reconstruction algorithm for parallel ray projection geometry are presented. The choice of the kind of geometry was bound up with the possibility to adapt the existing set-up research.

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Influence exerted on electrochemical deposition by acoustic streaming

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The paper describes the efficient method of improving diffusion of more noble metal through the barrier layer created during the electrochemical deposition process, by means of ultrasonic waves. Ultrasound was used to produce micro-edges, which transport an electrolyte at the wafer surface. The Schlichting streaming theory basically describes those micro-edges. The experiments have been carried out for Ni-Fe plating bath based on J. Horkans. The results indicate that by controlling the acoustic intensity, it is possible to change the edges angular velocity and thus to control the amount of liquid injected to the vicinity of cathode. In this way, apart from simple ion diffusion, the controlled migration inside the barrier layer can be accomplished and thus the inspection of the mass of more noble metal in the plated alloy is possible.

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Evaluation by Acoustic Emission (AE) method the critical stress and the pseudo-plasticity effect of ceramic materials

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The three-point-bending method was applied for the investigation of critical stress and pseudo-plasticity of structural ceramics. In the first case the cordierite was used for testing. The dependence between the acoustic emission counts sum during the last stage of materials destruction and its critical stress were measured and analysed. The thermal shocks ΔT in the range of temperature differences 0 to 320° C were used to cause several stages of destruction of ceramics. An empirical formula was established. The coefficient H_{AE} equal to the ratio of the AE counts sum for the defected sample to the AE counts sum for the "intact" sample is proportional to the H_m coefficient representing the squared ratio of critical stresses of "intact" and defected sample. In the second case, the effect of pseudo-plasticity was measured in the magnesite-oxide ceramics. The threshold stress when the uninterrupted acoustic

emission begins seems to be an adequate parameter to evaluate the influence of pseudo-plasticity on the reliability of ceramics. [Work supported by the State Committee for Scientific Research in Poland, Grant No. 7 T07B-03413].

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Oxide nanostructures: formation, deposition and acoustics methods of monitoring

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The paper reviews the methods of the oxide nanostructures formation and deposition. The velocity and attenuation measurements of ultrasonic waves were proposed to determine the specific properties of nanostructures such as high porosity, the real and imaginary parts of the complex moduli of elasticity, evaluation of the structure and mechanical strength of the medium. The acoustic emission method was used for continuous observation of the process of nanostructure creation. The properties of the processes appearing during generation of nanostructures cause that the acoustic methods can be a valuable source of information about the processes which are complementary to the microscopic methods. [Work supported by the Committee for Scientific Research in Warsaw, Grant No. 7-T07B04715].

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Ultrasonic meter of blood hematocrit

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The possibility of the noninvasive estimation of the blood hematocrit is important for the medical diagnosis. At present, only one method is known and it is based on measurement of the speed of sound. It is mainly used during patient's dialysis. We propose a novel approach to solve this problem. The instrumentation developed is based on the dependence of the absorption of ultrasonic wave in blood. The instrument is based on pulsed Doppler ultrasonic blood flowmeter, operating at frequency 20 MHz. Doppler signal is simultaneously recorded in two gates at two distinct depths. The ratio of signal power at two gates depends on the hematocrit only. The preliminary measurements were done *in vitro* using porcine blood. The red blood cells and plasma were mixed to obtain hematocrit in the range from 1% to 65%. The Doppler signal was recorded in two gates separated by 1.2 mm and 3.6 mm. A good agreement of hematocrit values calculated from the Doppler signal with laboratory measurements was obtained: for sample volumes separated by 3.6 mm and 1.2 mm, the correlation coefficients were equal to 0.96 and 0.79, respectively, for $p < .001$. Further investigations of applying this method *in vivo* in the common carotid artery are conducted. [Work supported by grant KBN No. 8T11E02317].

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Determination of structural parameters of viscous ferrofluid by acoustic and magnetic methods

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In this paper, the authors have presented experimental results of the dispersion research and anisotropy research of magnetic susceptibility, as well as the anisotropy measurements of an ultrasound wave absorption coefficient in a viscous ferrofluid, subjected to the test by an external magnetic field. According to the suitable theories, one can determine some parameters describing the structure of such a medium, and it is possible to explain the mechanism of an ultrasound wave absorption during a propagation. On the basis of magnetic research, the quantities such as: relaxation time of a magnetic susceptibility, average radius of a spherical cluster as well as the value of magnetic field strength causing saturation were determined.

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The velocity of sound in bcc ^{3}He crystals near absolute zero

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Very-low-temperature behaviour of all modes of the velocity of sound in solid bcc ^{3}He is briefly explained. Both for the transverse and longitudinal velocities of sound in isotropic solids, the general relation is derived. It appears that for the qualitative agreement with experimental data, the absolute zero limit of the Debye function and effective temperature has be used. In this paper we have dealt only with the possibility of a theoretical explanation of the behaviour of the sound velocity measurements near the absolute zero temperature.

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Construction of a new NaCl pressure scale and a universal equation of state for solids

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Recently a revised scale of pressure for NaCl was proposed by J.M. Brown (1999) as an updated approach of the 30-year old work of D.L. Decker (1965). An alternative approach to the analysis was utilised in conjunction with more recent data. The zero-Kelvin compression curve was parameterised using local basis function (splines) and constrained by accurate pressure-volume-temperature data. Pressure as a function of volume and temperature was calculated and listed. Now, the new approximate theory aiming at of describing the function $p = p(V, T)$ is proposed. It appears that theoretical results agree with experimental data within 0.2%.

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Mechanical properties investigation of the PZT type piezoceramics by mechanical spectroscopy method

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Ferroelectric ceramics of the PZT-type obtained on the basis of multiple solid solution $Pb(Zr_{1-x}Ti_x)O_3$ is used in many devices and piezoelectric transducers. Possibilities of utilization the piezoceramics in many branches of industry are connected with qualification of its basic values, both dielectric and mechanical. The present paper shows the research results concerning the mechanical properties of the PZT-type piezoceramic, obtained by two methods — of hot pressing and the conventional method in different circumstances. Acoustic frequencies relaxation of the RAK-2 type was used to carry on the measurements, making it possible to determine the temperature dependencies of internal friction and changes of the dynamic Young modulus. Application of the UMT-11 supersonic defectoscopy made it possible to measure the speed of propagation of longitudinal and transverse supersonic waves. Basing on the measurements, the basic mechanical properties, such as Young's modulus, elasticity modulus and Poisson's coefficient obtained in different conditions, were determined. The obtained results of the measurements contributed to the technological optimalization process of producing piezoceramics and widening its practical usage in different branches of industry.

Bioacoustics

The audiometric assessement of hearing abilities in 16–60 years old individuals

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Audiometric investigations (AAD-80) of 160 individuals at the age of 16-60 years were carried out. It was found, that the greatest loss of hearing in the frequency range of 250 – 2000 Hz was in the group of adolescents. Moreover, the percentage of individuals with a loss of hearing was maximum in this

age group. Instead, at the age of 50 – 59 years, the loss of hearing was minimal with respect to the physiological norm for this age group.

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Biological structure phantom for purposes of ultrasound transmission tomography

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In ultrasound transmission tomography (UTT), one of the most important parameters which allows to image the internal biological structure of the investigated object is the sound velocity. To estimate the accuracy and correctness of biological structures reconstructed on the basis of ultrasound velocity measurements, it is necessary to possess a phantom of this structure. In the paper, the parameters of the ultrasound velocity of an ultrasonic wave for chosen healthy organs and tissues and those affected by tumour are presented. Pathology may concern cells as well as tissues and can manifest itself by changes of sizes, shapes and densities of particular tissues. Using the latest literature on tissue parameters (healthy or with morbid symptoms), a laboratory investigation of different materials which could be used for the phantom building, was carried on. The results of this work enable us to build the biological structure phantom imitating healthy and pathological tissues. This phantom allows us to determine diagnostic possibilities of the ultrasonic apparatus based on the UTT method for internal structure imaging. [Work supported by the Committee for Scientific Research in Warsaw, Grant No. 8 T11E 029 14].

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Biological basis for hygienic standardisation of whole-body vibration
Part I: Experimental studies

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Experimental studies carried out with participation of young subjects in laboratory conditions in the 60 s and 70 s revealed the role of basic parameters of the whole body vibration in inducing biomechanical, psychophysical and physiological reactions of the human body. These studies determined the influence of the acceleration magnitude, frequency, direction of vibration and duration on the degree and character of the reaction of the body. It was observed that the transmissibility of vibration in the human body depends on the biomechanical properties of the body, which are modified by its different postures and positions. The results of the experimental studies were used to determine the threshold limit values of the whole-body vibration developed for the protection of the health of workers professionally exposed to vibration.

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Biological basis for hygienic standardization of whole-body vibration
Part II: Epidemiological studies

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Occupational exposure to the whole-body vibration may result in the development of unspecific diseases in many systems of the human organism. As scientific knowledge advances, the threshold limit values are updated. They are now more and more often associated with remote unspecific health effects observed in the exposed workers. The assessment of large groups of employees exposed to vibration indicates that the biggest changes are observed in the motor system. Less affected are the digestive system, the vestibulo-cochlear organ, the organs of senses and the peripheral circulatory system. The aim of this paper was to present the results of epidemiological examinations of the back pain of the workers occupationally exposed to the whole-body vibration. Medical examinations indicate that early changes

in the spine may occur, such as: discopathy and degenerative changes of discs and joints. This paper presents current data from the world literature on the relationship between the level of daily vibration dose as well as the period of occupational exposure and the probability of occurrence of disorders in the lumbar section of the spine. The results of the studies were used to develop national suggestions for the threshold limit values of the whole-body vibration.

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Influence of surgery argon laser on electric function of ear cochlea

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In the field of medicine, the argon laser is known as a surgery tool. At first the laser was used in dermatology and opthalmology, next, from the end of the 70 th, in ear microsurgery. Up to now, the side-effects of using the argon laser in stapedotomy are not exactly known. During stapedotomy, the side effects mainly concern ear cochlea and can appear by changes of its electric activity. In other words, changes of electric response of cochlea can be a measure of the side effects caused by laser irradiation of the one. Such possibility has been used by us to measure the changes of electric response (the cochlear potentials) of guinea pigs cochlea caused by the argon laser irradiation of the cochlea surface. Different laser pulse parameters were used in the experiment. Unlike electric responses of the cochlea have been described. Limits for safety argon laser irradiation of the cochlea surface have been initially formulated.

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Influence of biostimulation CTL-1106 MJ laser on electric function of ear cochlea

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Laser beam of appropriate wavelength affecting living tissue can stimulate different processes on the cell level. If laser beam power is less than about 500 mW, no photothermal effects take place in the target tissue. The aim of the experimental studies was to determine if and how far the biostimulation laser beam can change the electrical activity of ear cochlea of guinea pigs. The CTL-1106 MJ semiconductor laser produced by Laserinstruments (Warsaw) was used in the experiment. Fundamental parameters of the laser are the following: CW output power -100 mW, generated wavelength -810 nm. The experiment was performed on 10 pigmented animals. Very different responses of cochlea to laser exposure have been recorded. Lack of answer of the cochlea on the laser irradiation was observed in 20% of the cases examined.

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Arteriosclerosis risk evaluation on the basis of non-invasive ultrasonic examinations of the common carotid artery wall stiffness

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The authors present the new classification method for determining the arteriosclerotic risk factor group by means of the non-invasive ultrasonic examinations of the human common carotid artery wall stiffness. The evaluations of the common carotid artery wall stiffness were based on measurements of the logarithmic stiffness coefficient α. The examinations were performed using ultrasonic wall tracking system VED elaborated in IFTR-PAS in Warsaw. The sensitivity of the proposed method is 66% and its specificity 79%.

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Analysis of the input vascular impedance in the human common carotid artery on the basis of non-invasive ultrasonic examinations

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The authors present the results of the examinations of the input vascular impedance in the human common carotid artery for different degrees of stenosis of the internal carotid artery caused by arteriosclerosis. In analysis of the input impedance, a three-element model was applied. The examinations were based on simultaneous measurements of the blood flow and the blood pressure, using the ultrasonic Doppler and echo tracking methods. [Work supported by the Committee for Scientific Research in Warsaw, Grant No. 8T11E00316]

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Application of acoustic emission method for plant tissue investigation

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External loading causes cracking of structural elements of a plant tissue, e.g. cracking of cell's membranes and debonding of the cells. The aim of the present paper is to apply a method of acoustic emission to study the influence of turgor on the process of potato tissue cracking. The AE method has been used to determine the failure conditions as a critical strain and a critical stress for potato tuber tissue. The compression tests were carried out with constant strain rate for samples with different turgor. Increase in turgor causes decrease in the compressive strength and the critical stress. The turgor does not influence the critical strain and maximal strain. The experiment showed that there was a negative correlation between the total count sum, the total event sum and the compressive strength of the potato samples. The results show that the acoustic emission method can be used in investigation of cracking processes in plant tissues. [Work supported by the Committee for Scientific Research in Warsaw, Grant No. 5 P06 F01317].

Structural acoustics and vibration

Transfer path analysis as the tool for energy-based approach to vibroacoustical analysis

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The paper focuses on the application of energy flow to the analysis of mechanical behaviour. There are several different methods used for investigation of sound and vibration energy in spatial structures consisting of beams, shells and plates. Among them, the Transfer Path Analysis (TPA), as a test-based procedure, is used to trace of vibro-acoustic energy flow from a source to receiver through the set of known structure-born sound pathways. The main aim of TPA is to evaluate the energy flow contribution of each pathway in the total energy transfer. This method is used in the hybrid method - combination of Finite Element Method (FEM) and experimental modelling, for vibro-acoustic optimisation of a design. The presented approach leads to faster and better performance in modelling and in the analysis of large mechanical systems. In the article are presented the results of the energy flow analysis obtained from TPA between the chosen subsystems. The practical application aspects are discussed. Although the helicopter fuselage and elements of tram carriage suspension were basically used in the analysis, the same technique can be applied in other large mechanical structures.

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The influence of the radiation impedance on the resonance of the two-dimensional mechanical systems with losses

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The vibrations of the two-dimensional mechanical system are affected by the medium in which it is immersed. The influence of the medium on the resonance depends on the shape of vibrating system and on the ratio of density of the mechanical systems and the medium. In the presence of the medium, the resonance frequency of vibrating body decreases due to the mass of medium load. Overall losses of the vibrating systems are the sum of mechanical and acoustical losses. In the paper, the influence of the medium on the vibration of a thin cellulose plate is investigated. The influence of the medium load on the resonance frequency of a thin cellulose plate is of the order of several percent for gas, and of the order of some scores percent for liquid. Overall losses of the thin cellulose plate immersed in gas are defined by mechanical losses due to predominance of the mechanical resistance.

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Optimization of vibroacoustical energy flow in complex mechanical systems

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The paper shows a new advantages of an optimization method for energy flow. As the first stage, the algorithm is presented which allows to inevestigate the influence of the wide range of constructional parameters on vibroacoustical energy flow in complex mechanical structures. As a basis of analysis, the SE.4 method is used. The SEA calculations results create a data base for further optimality calculation with the arbitrarily chosen aim function. Using the described algorithm, some results are presented showing the variation of acoustical energy radiation with plate and stiffeners parameters for several stiffening configurations.

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An Analytical and Experimental Comparison of Optimal Actuator and Error Sensor Location for Vibration Attenuation

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Feedforward active control of the plate flexural waves in a finite plate has been analytically and experimentally investigated. The plate under consideration is simply supported along two parallel edges, and free at the other two edges. Point forces were used to generate the primary and secondary plate excitation. The error sensor is optimally located in order to achieve the best control performance.

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Directional characteristic of free-edge circular plate

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In this paper, the problem of determining the directional characteristic for a free-edge circular plate is considered. It was assumed that the axially-symmetric plate vibrations are forced by an external pressure, sinusoidally variable in time, acting on the central part of the plate surface with radius a_0. The dynamic influence of the waves emitted by the plate on its vibration velocity distribution as well as the losses in the plate material were neglected. Applying the well-known solution of the plate equation of motion and considering the continuity and boundary conditions, the system of six equations was obtained. Solving this system by computer methods, an expression allowing to determine the directional characteristics was found. [Work supported by the Grant 7T07B05118 from Committee for Scientific Research of Poland].

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Application of laser measurement technology for determination of vibration amplitude of free-edge circular plate

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This paper presents 3D plots of vibration velocity distribution of free-edge circular plate prepared on the basis of a mathematical model. These plots have been compared with the pictures of a vibrating plate obtained by experimental method, with the use of the laser measurement technology. Applying the holographic method of the time mean [2], the amplitude of plate vibration at chosen cross-section lines has been calculated. The photo of the (1,1) mode of a circular plate taken by the laser-method as well as corresponding diagrams of vibration amplitude for sample cross-sections have been enclosed. [Work supported by the Grant 7T07B05118 from Committee for Scientific Research of Poland].

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Application of trigonometric spline function to modelling the resonance vibration

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This paper presents a short introduction to the new original innovation of finite element method (FEM), very useful for vibration analysis of complex dynamical systems. The characteristic feature of the proposed innovation is application of the modified trigonometric splines (ZTFS) as a shape function in FEM model instead of the Hermite polynomials. The set of trigonometric splines has all the advantages of cubic polynomials. These splines have no limits in case of n-order differentiation. Therefore the finite element method with ZTFS can be made automatically with the use of symbolic computations. The example of the innovated FEM method showing its effectiveness is enclosed. [Work supported by the Grant 7T07B05118 from Committee for Scientific Research of Poland].

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Experimental study of vector field around flat structures inside acoustic flow field

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Most of the acoustic vector fields encountered in practice are too complicated to be precisely modelled mathematically. This is one of the reasons why the experimental investigation fields using sound intensity technique are a useful tool for the vector field distributions. In the article, the author presents the application of sound intensity technique to graphic presentation in 2D and 3D image of the spatial distribution of the acoustic energy flow over a hard disc and a rectangular plate. This description of acoustic vector field fully explains the physical meaning of wave phenomena and makes it possible to consider the mechanisms of propagation, radiation, diffraction or scattering on the obstacles.

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Prediction of sound transmission loss of crane cab using SEA

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The paper presents some results of calculations of transmission losses for a crane cab. Calculations ware performed using Statistical Energy Analysis Method and compared with the results obtained by means of classical methods. This method of calculation allows to create the conditions of acoustic comfort in lift cabs according to the acoustic field conditions in industrial halls.

Noise, its effects and control

Resonance sound absorbing elements adapted for high hygienic requirements

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In special industrial application, e.g. in food or pharmacological factories where high hygienic requirements are necessary, no usual acoustical absorbing systems and materials can be used. In extremely wet or chemically active environmental conditions, only resonance systems of stainless steel, aluminium or hardy plastics may be applied. In the paper, some calculations of the absorption coefficient of some Helmholtz resonators used as elements for constructing absorbing coffer systems were performed. Some models were constructed and their absorbing properties were measured using the impedance tube.

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Traffic noise at crossroads

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Acoustical climate dependence on urban structure and traffic parameters could be efficiently tested by computer simulation programs. Here, the PROP5 program is used to investigate the sound level along façades of buildings in the vicinity of a crossroad. The investigated urban structure has a form of a canyon-street of a given width. The dependence of the sound level at the ground floor and the sound level distribution along the building façade on parameters of the road as a noise source has been presented. These parameters are: the number of lanes and their positions in a canyon, concerning the road geometry, and vehicle streams parameters. The vehicles divided into classes are represented by the equivalent point sources of a given elevation above ground and the power spectrum. Their streams on a lane are characterised by the average speed and flow rate. The sound level distribution along the façades shows relatively smooth decrease with elevation. The decrease amounts to 3 dB(A) for the twelve-floor building. The addition of two lanes to the road results in the sound level increase of 2.5 dB(A), what is in agreement with the previously obtained results for a single canyon. Such details as the difference in the sound level, resulting from asymmetry of the crossroads, are also observed.

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Noise protection in low frequency range

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The papers presents a method of noise reduction in a control cabin in low-frequency noise. The models of sound absorber with Helmholtz resonators were described. Results of experimental investigations in low frequency range are included.

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Investigations of changes in protection properties of hearing protectors due to duration of use — preliminary results

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The paper presents the results of one-year-long investigations of changes in hearing protector's protection properties due to duration of use. Four comparable patterns: two Polish ones — Faser N1, Opta OS-5N and two Swedish ones — Bilsom Loton 2401 and Peltor H9A, were investigated. Investigations

were performed at real conditions in four factories. Measurement results of sound attenuation, insertion loss and headband force for each of the tested patterns are presented. Also presented are the changes of protection parameters H, M, L and SNR, compared to catalogue values and changes of insertion loss and headband force after one-year use. [Work supported by the Committee for Scientific Research in Warsaw, realized in the framework of the National Strategic Program "Occupational Safety abd Health Protection in the Working Environment" – SPR 03.7.20].

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Acoustic and mechanical properties of level-dependent ear-muffs

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The aim of the paper is to present the methods and some results of acoustic and mechanical measurements of four prototypes of level-dependent ear-muffs. The acoustic tests include measurements of sound attenuation of level-dependent ear-muffs in their passive mode, and criterion levels H, M, L with the electronic system in operation at full gain. The acoustic tests include testing of headband force, cushion pressure, adjustability and cup rotation. All the tests have been carried out according to the requirements of prEN 352-4:1999.

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Validation of selection anti-vibration gloves procedure for vibratory tools

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Occupational exposure to hand-transmitted vibration can cause many kinds of disorders in the human body. One of the methods of reduction of the risk of vibration damage is using antivibration gloves (AV) by vibratory tool users. However, positive classification of a glove as an AV one, does not mean that this glove will be equally efficient in case of using it by workers handling various vibratory tools. That is why the procedure of selection AV gloves for vibratory tools was elaborated. In this procedure it was established that the glove efficiency in reducing vibration produced by a particular vibratory tool will be characterised by two protection efficiency indices (PEI). These indices depend on the visco-elastic properties of the glove as well as on the vibration spectra of a particular tool. The results of validation of the procedure, obtained by comparing the calculated indices and achieved by "in-situ" measurements, is presented in this paper. [Work supported by the Committee for Scientific Research in Warsaw, Project 03.8.7 realized in the frame of the National Strategic Program "Occupational Safety and Health Protection in the working environment"].

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Influence of amplitude and frequency of excitation signal on vibration transmission from tool handle into the operator hand

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The influence of amplitude and frequency of the excitation signal on the vibration transmission from the tool handle into the operator hand was investigated. The results obtained from these investigations are presented in this paper. The analysis of results achieved during examinations produced the data which constituted a basis to define proposals of the forms of two indices typical for transmission of vibration in the "operator's hand – manual tool" system. [Work supported by the Committee for Scientific Research in Warsaw, Project 02.4.8 realized in the frame of the National Strategic Program "Occupational Safety and Health Protection in the working environment"].

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Determination of the sound power level of the reference sound source using engineering and sound pressure survey methods in different test conditions

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The sound power level of the reference sound source using an engineering method (PN-EN ISO 3744) and a sound pressure survey method (PN-EN ISO 3746) were determined to check the precision of these methods for determination of L_w expressed as a standard deviation of reproducibility. It was made in two rooms and in a free field.

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Acoustic assessment of machines on the basis of emission sound pressure levels

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The European Standards series EN ISO 11200 specifies the methods for determining the emission sound pressure levels at a workstation and at other specified positions. According to the Machinery Directive 98/37fEC, the emission sound pressure level must be taken into consideration, together with the sound power level, in carrying out the acoustic assessment of machines. The results of the experimental tests have proved a great consistence of the values of the emission sound pressure levels determined by using different methods specified in the European Standards series EN ISD 11200. However, the acoustic assessment of the machine, carried out only according to the requirements of the Directive 98137/L 'C, does not enable a complete assessment. In this connection, an acoustic assessment of the machine using an emission index is proposed. The value of the emission index is calculated on the basis of the value of the emission sound pressure level.

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Evaluation of the long term sound pressure level from power lines based on measuring under fair weather conditions

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The corona noise depends strongly on weather conditions hence, according to Polish Standard PN-N-1339, it is necessary to perform measuring under fair and bad weather conditions. Although, because of some technical difficulties in taking measurement under bad conditions (rain, fog, etc.) as well as temporary character of those conditions and, on the other hand, steady state corona noise level (independent of the other reasons such as airborne substances, scratches etc.), an attempt was made to evaluate a long-term corona noise level (for one year period) based only on the measurement results. In that case the corona noise level in practice depends only on geometry of the transmission line layout and technical conditions, and its value can change by more than 10 dB. In order to estimate the corona noise level under bad conditions, an empirical model was used which was fitted according to the measurement results in the vicinity of 400 kV transmission lines in different parts of Poland. The long-term corona noise level was evaluated using algorithms known from the standard mentioned earlier.

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Noise level in the vicinity of road junction

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The computer-aided model for equivalent noise level near the road junction is presented in the paper. Acoustical parameters such as sound power level and directivity index for accelerating and decelerating

vehicle were determined on the basis of time history recorded at a reference point near the road. A distance as well as a speed of a single vehicle at the beginning and in final phase of motion where known. The computer model written in Delphi3 was tested and showed that it is the phase of acceleration which causes an increase of noise level in the vicinity of road junction in comparison with that for freely flowing traffic. The model was verified in traffic conditions in Wrocław for several road junctions with traffic lights and showed a good agreement between calculated and measured data.

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Hearing protectors: Attenuation of peak sound pressure of acoustic impulses

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Peak sound pressure attenuation introduced by a hearing protector for acoustic impulses was measured for a sample of 23 protectors made by different manufacturers. The impulses were generated in the laboratory with the use of a foil blaster or a steel plate which was hit by a hammer. Their peak levels ranged from 130 to 155 dB. The peak pressure level attenuation was compared with the protector parameters H, M, L, and SNR. The investigation revealed that attenuation of a hearing protector measured for peak pressure of impulses with a short rise is usually smaller than the attenuation measured for steady-state noise signals (H, M, L, and SNR values). For the impulses used in the experiment, the M, L and SNR values were in better agreement with the peak sound attenuation than the H values.

Architectural acoustics

The sound reinforcement systems of sports halls

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The specific properties of sound reinforcement systems of multiple functions sports halls are presented in this paper on the examples of the sound reinforcement systems of Hala Ludowa and "Orbita" hall in Wrocław and the sports hall in Chełm Lubelski designed by the authors. The systems are well suited for operation with the following usage variants: sports events, competitions, training, fairs, exhibitions, stage performances, meetings. Factors influencing the quality of sound reinforcement systems are described starting with room acoustics, through electroacoustic circuits, to properties of loudspeakers and their distribution within the hall.

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The influence of stage house and diffusion modeling on the theatre reverberation time

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In the paper are presented two topics dealing with the computer modeling of theatre acoustics. In the modeling the Raynoise simulator has been used. The influence of the diffusive reflection and the method of the stage house modeling on the reverberation time were examined. The modeling results were compared with the measurement results of the existing theatre – Bogusławski Hall at National Theatre in Warsaw. With the creation of complete model of the theatre, with a hall and a stage house, a conformity of measurements and modeling has been obtained. Taking diffusive reflection into consideration, the reverberation time in the frequency range of diffusive reflection was made shorter.

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Measurement and evaluation of noise in buildings according to new European standard

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In the paper, a brief description of the noise measurement method proposed in the standard pr EN ISO 16032 is given. The problems of measurement and assessment methods are discussed. The results

of noise measurement in dwellings carried out according to pr EN ISO 16032 and PN-87/B-02156 are compared.

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Direction of arrival algorithms for sound reinforcement systems
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The paper concerns one of the possible directions in the development of sound reinforcement systems. The main topic is connected with the use of adaptive algorithms, in particular with the development of determination of the direction of arrival of acoustic wave finding (DOA Algorithms). The authors present the role of the DOA algorithms in sound reinforcement systems, which are a method of analysing the original acoustic filed. This study examines the construction of the microphone-loudspeaker system, in which we can apply an adaptive steering for an acoustic panorama. The electroacoustic system also enables the possibility of synthesis in the first reflections of a listening space. This type of system solution is referred to as an "artificial" acoustic reinforcement system.

Transduction

Model of spatial impulse response of loudspeaker
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In this paper we describe our investigations of the model of spatial impulse response of a loudspeaker. We try to obtain the impulse response of source in a given direction, based on the impulse response on main axis of the sound source.

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Psychoacoustic criteria for digital loudspeaker equalization
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One of the problems to be solved at digital equalization filters is to limit its dynamic range if the frequency response of the corrected object which has large irregularities. In the paper, the preview of knowledge on the perception of peaks and notches of the frequency response is presented. Application of this information in the design process can allow to remove unperceived irregularities from the response, making the dynamic range higher. The real-time filtering makes also these filters more expensive, so a compromise between the order of filter and the quality of equalization is needed. The threshold values connected with linear distortion also allows to define a minimal speed of signal processor which should be used for the equalization, making the corrected irregularities unperceived. This paper also presents analytical equations describing the different frequency scales which may be helpful for the defining the l parameter connected with the warped filters.

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Microphone systems vs. perception of the sound source
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In the paper, the basic aspects of perception of the sound source position resulting from the recordings made by various microphone systems, are discussed. The previously obtained results (theoretical and experimental ones) were the start point for research on the relations between the perceived sound source

position coming from a particular microphone system, and theoretically defined stereo imaging. In the course of modelling, it has been found that the sound source position depends strongly on the system used for the recording. The results have been discussed from the points of view of cohesion and spaciousness of the recording.

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Secondary breakdown of transistors in high power audio amplifiers with enlarged output voltage

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This paper deals with the secondary breakdown of output stage bipolar transistors of high power audio amplifiers. The amplifiers' output voltage is larger than that delivered by the applied integrated circuit alone. Therefore such amplifiers are particularly endangered to a failure. The worst conditions of the transistors' operation with respect to the secondary breakdown occur when the amplifier is loaded by a loudspeaker device model. Particularly critical transistor operating conditions occur at the frequency of 10 Hz, when the phase of loudspeaker device impedance equals 40O. Secondary breakdown is a destructive failure and its laboratory tests are difficult, time-consuming and expensive. Therefore computer simulation is an effective and convenient way to investigate this problem. However, for a computer simulation, the circuit element models are necessary. In order to fulfil this conditions, the relevant models of bipolar transistor, high-power audio amplifiers and loudspeaker device are used. The model of the transistor is a behavioral one and takes into account the dynamics of the secondary breakdown. It makes the calculations more effective and convenient. The obtained simulation results, using the PSpice computer program, confirm the serviceability of the proposed circuit element models.

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Virtual acoustic objects

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Convolution of the testing signal and impulse response of the object or loudspeakers can improve the quality of listen-oriented tests and make them easier. The described hardware and software solutions have been developed and evaluated since several years. They are implemented on DSP 5630xx, 9600x and ADSP 2106x processors and also on IBM PC compatible computers. In PC-solutions, a sound card is used as an I/O device and convolution calculations are realized by a system processor. It is possible to realize real-time testing signal convolution with minimal pre-delay using multiprocessor devices and an algorithm based on divided impulse response. With the aid of PIII processors calculation power and multitask possibilities, the software based on minimal cost algorithm was built. It is possible to build virtual rooms using this software. Using such virtual rooms it will be possible to evaluate more precisely the transmission quality of acoustic signal in real or model rooms.

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Dispersive delay lines with nonlinear frequency modulation

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A comparison between dispersive delay lines with linear and nonlinear frequency modulation is presented. Using nonlinear frequency modulations makes it possible to obtain low sidelobes level without using the amplitude weighting in the compressor. It allows to eliminate the receiver mismatch loss (in the linear frequency-modulated signals the mismatch losses are about 1.4 dB).

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The influence of acting signal on the creation of NARMAX model of dynamic loudspeaker
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In the case of linear object modelling, the choice of acting signal is not a critical step, because the important requirement is that this signal should have equal and wide spectrum. The choice of the signal is more important for NARMAX model because it is a nonlinear model. In the paper, the influence of the kind of acting signal on the accuracy of the dynamic loudspeaker NARMAX model, is presented. The noise with the uniform and Gaussian distribution, MLS signal, Chirp and rectangular impulse were the investigated signals. [Work supported by Polish State Committee for Scientific Research, Grant: 8 T11D 026 15].

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Optimization of NARMAX model for dynamic loudspeakers
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In modelling the nonlinearities with the NARMAX-method, the polynomial representation of this model is used very often. This allows to obtain the coefficients in a more effective and simple manner. However, the high number of them and the fact that nonlinear representation is not known, make the obtained model inaccurate. Implementation of the optimisation method of NARMAX model based on the choice of significant coefficients, is presented in the paper. The algorithm has been tested on the mathematical models and measurement results of a dynamic loudspeaker. [Work supported by Polish State Committee for Scientific Research, Grant: 8 T11D 026 15].

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Modification of high power operational amplifier macromodel for computer-aided design of audio high-power amplifiers
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Efficiency of computer-aided design of electronic circuit depends on the models of applied circuit components. It particularly deals with modelling of integrated circuits, usually replaced by their macromodels. Power audio amplifiers can be built using high-power operational amplifiers which capable of delivering maximum output current of large value (up to 15 A). Macromodels of such amplifiers are known, but modelling of their saturation voltage is not accurate enough. In the paper, a macromodel modification of integrated high-power operational amplifiers including FET transistors in the input stage is presented. The modification improves the model accuracy (the saturation voltage of integrated circuit with respect to the output current is modelled). It results in a wider operating area, where the macromodel maintains a satisfactory accuracy. Furthermore, the structure and the manner of choosing the macromodel parameters and elements modelling the amplifier saturation voltage versus its output current are proposed. Improved macromodel accuracy has been obtained without using additional macromodel elements. As an example, a macromodel of the OPA502 integrated circuit and its accuracy estimation are given.

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Compatibility of stereo imaging taken with different microphone systems
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The basic amplitude-phase patterns for different microphone systems used in concert and studio recording are described in the paper. These patterns have been obtained first by theoretical considerations, and next they have been measured practically. The subjects of research were: MS, XY and two AB systems (with cardioid and omnidirectional capsules). It turned out that large differences appeared in

the comparison of the model and real systems. They were caused by the fact that "theoretical" systems did not take into consideration all the aspects of the receiving of the acoustic signal. In addition, full compatibility of particular systems does not exists what has been confirmed experimentally. For example, the MS system is not compatible with the others, both in the amplitude and phase domains.

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The influence of the enclosure on loudspeaker nonlinear distortions
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Variation of the equivalent stiffness (stiffness of moving system suspensions and the air closed in the enclosure) and electromechanical coupling coefficient Bl with displacement of the moving system are assumed to be the main sources of nonlinear effects at low frequencies around the basic resonant frequency. The mechanical system of lumped parameters and the corresponding electric equivalent circuit governed by the set of two ordinary differential equations of second order are the basis of investigations with the use of MATHCAD worksheet. The multi-parameter model takes into consideration the loudspeaker moving system parameters, dimensions of the vented or closed enclosure and acoustic coupling of loudspeaker diaphragm and vent orifice. The distorted period of the acoustic pressure at the given point, the Fourier spectrum of that period, the magnitude of the nonlinear distortion coefficient as well as the frequency characteristics of the on-axis pressure and the nonlinear distortion coefficient, are the results of calculations. The research shows that it is possible to design the loudspeaker enclosure with respect of nonlinear distortions level. For this purpose, the nonlinear characteristics of suspensions and magnetic field should be known.

Psychological and physiological acoustics

The problem of sample size in the 2AFC procedure
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Statistical evaluation of the data sets from psychophysical experiments carried out with the 2AFC procedure is given. The procedure presented can be used in proper planning of the experimental algorithm with reference to the number of subjects and number of replications. It can be also used for estimation of statistical reliability of the results obtained.

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Examining the influence of visual cues on perception of sound localization in home theatre systems
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The presented study deals with the analysis of the influence of visual cues on sound localization in home theater systems. In order to develop the concepts how to record and mix the multichannel sound for the purpose of TV presentations, one should examine in which way and how the visual context interferes with the surrounding sound. Therefore, one of the purposes of experiments is to associate properly the surrounding sound with digital video presented at the TV screen. This problem will be examined with the application of fuzzy logic to the processing of subjective test results. [Work supported by the Committee for Scientific Research in Warsaw, Grant No. 8 T11D 00218]

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The peripheral and central processes in hearing
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It is assumed that the peripheral auditory system contains a bank of overlapping bandpass filters called auditory filters. The detection and discrimination of narrowband signals has traditionally been

explained by considering just one auditory filter at a time, this one which gives the highest signal-to-masker ratio. Although this model works well in many situations, it clearly fails in others. In some cases, the outputs of auditory filters tuned away from the signal frequency can be used to enhance signal detection as in CMR (comodulation masking release). In other cases such as in MDI (modulation detection/discrimination interference), the outputs of auditory filters tuned away from signal frequency degrade the signal detection. It seems likely that CMR and MDI can be produced by both peripheral within-channel processes and central cross-channel processes. The postulate is that CMR and MDI play a specific role in the analysis of auditory scene: the bridge between the peripheral and central processes in hearing.

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Masking in the amplitude modulation rate domain

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This paper is concerned with masking in the amplitude modulation domain. AM detection threshold was determined for 4-kHz sinusoidal carrier signal, modulated by a simple tone at frequencies: 2, 4, 8, 12, 16, 20, 24, 28, 32, 40 Hz in the presence of on of the two masking modulators. 16-Hz tone and 8-Hz width low-noise noise centred at 16 Hz were masking modulating signals producing clearly audible amplitude fluctuation. The most effective masking was observed in the frequency range close to the masking signal frequency. It seems that results of this experiment are consistent with a hypothesis of the modulation filter bank in the auditory system.

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Binaural perception of two-tone complexes

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The study deals with the binaural perception of two-tone complexes with determined physical parameters. The psychoacoustic experiment revealed that the binaural interaction of those signals creates the auditory sensation close to that of an AM signal. The measured modulation depth (m) of the signals under investigation suggest a mechanism of a linear interaction of those signals, but only for small values of m. For higher values of m, the perceived modulation depth decreases when m increases.

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Effect of modulator spectral structure on the AM detection thresholds

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This paper is concerned with measurements of AM thresholds of 4-kHz tone modulated by means of harmonics complex consisting of three sinusoids of equal amplitudes. The experiment tested the effect of relative modulator phase and component frequency on the detection of the multi-tone modulator applied to the sinusoidal carrier. The RMS value of the modulator was the only factor determining the AM detection. AM detection thresholds were found to be independent of the relative modulation phase and of the frequency spacing of the components. This pattern of the results suggests that a second stage of filtering in the auditory system, if there is any, is not a simple analogue to the first stage of filtering where the auditory filters act.

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Examining properties of acoustical elements of the hearing aid using physical modelling

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The aim of this paper is to present a new method of examining the properties of the acoustical system. A physical model of the acoustical element is designed and implemented. Next, this model is

used to perform computer simulations, in which the influence of the parameters of the model and on its transfer function are examined. Results of the experiments are presented and discussed. An application of this method to the process of fitting the acoustical elements of the hearing aid to the individual needs of the patient is proposed. [Work supported by the Committee for Scientific Research in Warsaw, Grant No. 8 T11E 034 15].

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Computer simulation of the dynamic range control system in hearing aids
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In this paper, a computer model of the hearing aid dynamic range control system is presented. In this model, dynamic range of the signal is controlled in six independent frequency bands. Two-threshold dynamic range blocks are used in each frequency band. Thus, the high speech quality in hearing aid may be obtained by means of accurate shaping of the dynamic range of the signal. [Work supported by the Committee for Scientific Research in Warsaw, Grant No. 8 T11E 034 15].

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Model of the binaural perception of FM frequency deviation
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Model of the binaural perception of FM frequency deviation has been considered in this paper. The model combines elements of the generally accepted function model of the auditory periphery, elements of Zwicker's model and principles of the auditory grouping. The results of the model simulation when the range of average values of the relative neural activity correlate well with the psychoacoustic experimental data.

Speech production, perception and processing

Methods of enhancement of noisy speech signal
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This paper presents a review of methods of enhancement of signals degraded by noise, with special consideration to the program Sound Laundry for enhancement of speech corrupted by acoustic noise. The efficiency of enhancement of speech by the Sound Laundry is presented.

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An analysis of the individual pitch change range in Polish
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With a view to evaluating the inter-subject variability concerning fundamental frequency contours, a statistical analysis of pitch changes in the productions by 40 speakers (male and female voices) was carried out. The input text material (based on railway timetable information) included statements, wh-questions, yes/no questions, and instructions (over 2000 semantically diversified speech items altogether). The statistical analyses have shown the possibility of normalisation for pitch changes on the basis of the individual minimum fundamental frequency value and a variable register (defined by a changeable mean value). The results of the research can be used both in the evaluation of the applicability of fundamental frequency distribution statistical parameters for voice identification, and in the verification of an intonational phrase model which assumes pitch changes on three levels: L (Low), M (Medium)

and H (High). [Work supported by the Committee for Scientific Research in Warsaw, Grant No. 8 T11E 022 17].

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A collection of comparative data base for the investigations of vocal canal pathologies

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The work concerns the collection of comparative data base for future investigations of a vocal canal and its pathologies. The investigations were carried out using the portable device type MiniDisc (Sony) and the sound analyser SVAN 912 (Svantek). The data base is collected on the basis of subtle acoustic spectra of Polish vowels of persons without any speech abnormalities. The results may be useful for setting the postoperative treatment and for diagnosis of a vocal organ.

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Statistical modeling of Polish phonemes

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In the paper the results of modelling the Polish phonemes are presented. Starting with acoustic modelling for Polish, we began with standard CDHMMs (context-dependent phones) and standard front-end (cepstral coefficients and their derivatives). The acoustic models have been created on the basis of the fully annotated first speech database for Polish. Similar acoustic states have been tied by using tree-based clustering to ensure that all state distributions can be robustly estimated. The preliminary results of the detailed analysis of the obtained models are presented from the phonetic point of view. [Work supported by the Committee for Scientific Research in Warsaw, Grant No. KBN 8 T11E 022 17].

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Wavelet packets transform for stop consonants classification

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It was proved that the traditional DFT based methods of feature generation are not well suited for classification of non-stationary acoustic signals. Stop consonants are the examples of such signals. Wavelet packets transform (WPT) has been used to generate a feature set for context-independent recognition of three classes of unvoiced stop consonants: /p/, /t/, /k/. WPT is the generalized version of wavelet transform. It is redundant and the choice of the orthogonal base may be arbitrary. The best features base for classification has been sought, as well as the method of features space reduction providing the highest interclass separability. Two reduction strategies have been used. Features selection by the Local Discriminant Basis search algorithm (LDB) provides a choice of the best subset of features according to a given criterion. Features projection by Principal Components Analysis (PCA) results in creating the best combination of features enabling the most efficient clustering of data. Classification has been performed using NN. Classification rate for WPT-PCA features set is the highest in comparison with the other methods of features generation and reduction examined.

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Application of automatic speech recognition system with parametric noise reduction for speech intelligibility measurements

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The article includes the results of investigation of automatic speech recognition system application for objective assessment of speech transmission quality, made in the Institute of Telecommunication and

Acoustics of Wrocław University of Technology. These investigations are a continuation and development of previous ones, the results of which were presented in 1996 and 1998. The investigations were aimed at construction of automatic system enabling objective evaluation of speech quality according to the subjective measurements results and independent of the kind of telecommunication channel. Parametric noise reduction unit was added to the applied limited-state memoryless automatic system for isolated phrases recognition in order to obtain the results consistent with the subjective measurements.

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The concentration of CO_2 in the air exhaled during speaking and the fluency of speaking

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We present results of an experiment, which is a continuation of our research series on correlation between the concentration of CO_2 in the air exhaled during speaking and the speech fluency. The experiment had a simulated character. The subject was one person, who repeated a test 10 times, which consisted of reading and 5 simulations of clonic stuttering and 5 simulations of tonic stuttering at various degrees of speech disfluency. The obtained results indicate that there exists a firm correlation between an absolute increment of the CO_2 concentration in the air exhaled during speaking, related to the level of the CO_2 registering during free respiration, and the degree of speech disfluency expressed as a number of errors made during utterance. For simulation of clonic stuttering, a ratio of correlation $r = -0.97$ was obtained, and for simulations of tonic stuttering a ratio $r = 0.83$ was obtained.

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Recognising vowels in continuous speech

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The presented results are a part of a research programme aimed at preparing a new visual-feedback-based method of stutterers' therapy. An animated image of mouth steered with speech signals and shown on a computer screen is to be employed, the recognised sounds in the utterance being vowels only. First the correctness was examined using our method of vowel classification realised in isolation as well as CVC and CVCV syllables. On the basis of the obtained results, identification maps were made separately for the groups of male, female and childish voices. At present, with the use of the maps, vowels are being recognised for male (stutterers') voices in a typical fragment of continuous speech, in which the vowel frequency has been set on the level characteristic of the Polish language. The percentage was evaluated of correctly identified vowels in the situations of individual reading and reading chorally with the echo. For 5 analysed voices, 74% correct recognitions were made. What was also examined is the significance of vowel's position (middle or end) in words in correct identification. For middle position, 77% correct identifications were achieved, and for end position — 67%.

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Acoustical analysis of the disfluencies in stutterers' speech

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In stutterers' utterances disfluent fricatives and plosives frequently occur at the beginnings of words. In the article, the results of spectrographic analyses of these disfluencies have been presented. The examined subjects read a text in two situations: with SAF (simultaneous auditory feedback) and with echo. Analyses have been made with the use of 1/3 octave filters in time intervals of 0.02 s. The prolongations of the fricatives are characterised by an increase in the sound intensity level within the range of higher frequencies as well as by extending the spectrum towards the high frequencies. The disfluent plosives are characterised by very short impulses occurring in significant time intervals with components within the range of high frequencies, which do not occur in fluently realised sounds, as well as by an infrequently significant reduction of the spectrum within the range of frequencies which are characteristic of fluent

utterances. The acoustic analysis of disfluencies in stutterers' utterances is a step towards objective diagnosing and greater possibilities for therapy of this disorder.

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The evaluation of effectiveness of various neural network types in pathological speech analysis

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In the present paper, partial results are described of a study concerning the utility of artificial intelligence methods, and in particular the neural network techniques, in the analysis and evaluation of pathological speech. In many problems of medical diagnosis, as well as in therapy and rehabilitation, an evaluation is required of the pathological speech signal quality. While in the typical problems concerning speech recognition the goal is to reveal (by selected parameters) the semantic aspects of the statement, in the tasks of medical diagnosis based on the speech signal analysis, the semantic contents of the statement is totally irrelevant (and it should be even regarded as interfering). In such problems the standard methods of speech signal processing and classification, used in the speech or voice recognition, totally fail. Also the standard parameterization techniques, like linear prediction coefficients or cepstral coefficients, cannot satisfactorily describe the pathological speech, because of its acoustic and phonetic structure, which is considerably different from the correct speech signal, and because the aim of the recognition process in completely different for such problems. In the paper, an application of three classes of neural networks (error backpropagation, resonant and Kohonen networks) is presented in the tasks of analysis and evaluation of pathological speech, and their utility in selected problems is discussed.

Music and musical instruments

Gap detection thresholds in 1/3-octave white noise centred at 4 kHz in young musicians with normal hearing and with very high frequency sloping hearing loss

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Gap detection thresholds in 1/3-octave white noise centred at 4 kHz were determined in young musicians with normal hearing preserved and with very high frequency sloping hearing loss. The thresholds were determined in the control group of 20 with normal hearing, i.e. flat audiogram up to 16 kHz, and in the experimental group of 15 with high frequency sloping hearing loss exceeding 30 dB at 12 kHz or at 16 kHz, the so-called peculiar hearing loss. A group of 7 older subjects exhibiting also peculiar hearing loss was included for comparison. The results show the gap detection thresholds in the normal hearing subjects ranging from 1 ms to 6 ms which are in good agreement with the earlier data obtained by the present authors. However, few examples of higher gap detection thresholds (11, 26 ms) in normal hearing were also observed. For the experimental group with high frequency sloping hearing loss at 12 kHz or at 16 kHz, the gap detection thresholds found were on the average significantly higher, ranging from 6 ms to 26 ms. In the group of older subjects, the gap detection thresholds were on the average still significantly higher.

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The measurement of pitch strength by the method of adjustment and by absolute magnitude estimation

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Pitch strength of musical sounds was investigated by the method of adjustment and by absolute magnitude estimation. When adjustment was employed, the subjects' task was to adjust the frequency of a comparison pure tone to make the tone equal in pitch to the sound investigated. For most sounds, distribution of the comparison tone frequencies obtained in 72 adjustments (9 subjects ′ 8 series of adjustments) was polymodal. The measure of pitch strength was defined as reciprocal of the measure of dispersion of frequencies belonging to the lowest mode, called the main mode, multiplied by the factor of monochromaticity. The highest values of pitch strength were obtained for the xylophone, the vibraphone,

the violin, and the marimba. The lowest values of pitch strength were found for the bass drum and the triangle. The values of pitch strength derived from pitch adjustments were in agreement with those obtained by absolute magnitude estimation. [Work supported by the Committee for Scientific Research, Grant No. T07B 023 14].

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Hearing thresholds of children age 7 – 10 years

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Resting hearing thresholds were measured in 107 children aged 7-10 years, from primary schools in Warsaw. The children were recruited regardless of priority of these in which problems with hearing acuity were observed or expected. The measurements were performed with the use of tonal audiometry with intermittent 250/250 ms signal, in the frequency range 100 – 16000 Hz. In the children with deeper hearing loss, both air and bone conduction procedures were used. In the tested group, normal hearing within ±10 dB was found in only 13% of the children. In the rest of the group, hearing loss of various nature was found, i.e.: wide-band (8%), high-frequency (24%), selective v-dip type (36%), low-frequency (54%) and other (16%). In the fraction with low-frequency hearing loss, often the conductive hearing loss was found, whilst in the case of high-frequency hearing loss, bone conduction audiometry indicated sensorineural type of hearing loss. Hearing loss in excess of 20 dB was found in 25% of the children tested. In the fraction with deep hearing loss in 25% of the children tested, hearing loss of approximately 40 dB was found.