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# INFORMATION REPORT

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| Author | Title of Paper |
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| L M Brekhovskikh, Acoustical Institute of AS, USSR, Moscow | Focusing of Sound Waves in Inhomogeneous Media |
| Yu P Lysanov, Acoustical Institute of AS, USSR, Moscow | An Approximate Solution of a Problem of Sound Scattering from Rough Surfaces. |
| " " " " | Sound Scattering from Plane Inhomogeneous Surfaces with Acoustic Admittance Changing Periodically along the Surface. |
| L D Rosenberg ) A S Bebtchouk ) L O Makarov ) Acoustical Institute of AS, USSR, Moscow | Mechanism of Destruction of Solid Surface Films by Acoustically Induced Cavitation. |
| B D Tartakovsky, Acoustical Institute of AS, USSR, Moscow | Filters and Matching Layers for Ultrasound. |
| I N Kanevsky ) L D Rosenberg ) Acoustical Institute of AS, USSR, Moscow. | Diffraction Pattern Near the Focal Line of a Converging Cylindrical Wave. |
| Yu L Gasarjan, Acoustical Institute of AS, USSR, Moscow | On Waveguide Propagation in Inhomogeneous Media |

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| Author | Title of Paper |
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| M A Issakovitch, Acoustical Institute of AS, USSR, Moscow | The Application of Solid Layers for the Removing of Shear Waves Appearing at the Reflection of Sound Waves from the Boundary of a Solid. |
| " " " " " " | The Use of Kirchgoff's Principle in the Solution of Some Problems Relating to Scattering and Radiation of Sound. |
| A N Leporsky, Acoustical Institute of AS, USSR, Moscow | Investigation of the Scattering of Sound Waves on Corrugated Surfaces. |
| A V Rimsky-Korsakov, Acoustical Institute of AS, USSR, Moscow | Audibility of Nonlinear Distortion in Sound Transmission Systems. |
| A N Barkhatov, Gor'kiy State University (?) | Experimental Investigations of Some Cases of Sound Propagation in a Stratified-Inhomogeneous Medium. |
| (Signature Illegible) | Some Theoretical Considerations on the Flexural Vibrations of Plates and the Associated Radiation of Sound. |
| M I Karnovsky, Central Research Institute, Leningrad | Calculation of Sirens |
| B B Koodriavtsev, | Velocity of Sound in Pure Liquids and Liquid Mixtures. |
| I G Mikhailov, Leningrad State University | The Differential Method of Measuring Ultrasonic Absorption in Liquids. |
| " " " " " " | Ultrasonic Absorption in Viscous Liquids |
| V F Nozdrev ), Moscow State University<br>V D Sobolev )<br>A M Sultanov )<br>U N Bormosov ) | Experimental Investigation of Relaxation Processes Arising When Ultrasonic Waves Pass Through Liquids. |
| V F Nozdrev, Moscow State University | Investigation of Acoustic Properties of Organic Substances in the Critical Region. |
| S N Rzhevkin, Marine Hydrophysics Inst. Academy of Sciences. | Some Results of the Analysis of Singing Voice |
| M L Levin, D Sc, Ivanovo Pedagogical Institute )<br>S M Rytov, D Sc, P N Lebedev Physical Institute of the Academy of Sciences of the USSR. ) | On the Transition to the Geometrical Approximation in the Theory of Elasticity. |

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| Author | Title of Paper |
| --- | --- |
| S M Rytov, D Sc, P N Lebedev Physical Institute of the Academy of Sciences of the USSR | Acoustical Properties of a Laminated Medium. |
| Prof Leo Chernov, D Sc, Head of the Department of Physics, Yaroslavl Pedagogical Institute, Yaroslavl, USSR | Correlative Properties of Wave in a Randomly Inhomogeneous Medium |
| V F Yakovlev ) V D Sobolev ) V F Nozdrew ) N I Koshkin ) M G Shirkevitch ) Moscow State University | Impulse Method of Fixed Distances, Its Physical Basis and Practical Application. |
| V A Krasilnikov, Moscow Order Lenin State University ) A. M. Obukhov, Academy of Sciences ) | On Wave Propagation in Media with Irregular Fluctuations of the Refractive Index |
| G V Gershuni, Pavlov Institute of Physiology of the Academy of Science of the USSR, Leningrad. | About New Methods of Measurement of Hearing in Man. |
| Leonid Michailovitch Ljamshev, Acoustical Institute of AS, USSR, Moscow, | Non-specular Reflection of Sound by Finite Plates and Shells in Liquids. |
| I Ye El'Piner Mbr. Bioch. Inst. im. A N. Bakh. (Signature Questionable) Dept. of Chem. Sci., Academy of Sciences | On Biological Action of Ultrasound. |
| V A Zverev, | A Modulation Method for Measurements of Ultrasonic Dispersion. |

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N N Andreev, Director, Acoustical Institute of the A. S. USSR, Moscow.
Member of the Academy of Sciences, USSR.
Chairman of the Acoustical Commission of the USSR.

Technical Interests: General acoustics; architectural acoustics; absorbing materials; piezoelectric transducers; second-order effects in large amplitude sound waves.

Invited to be chairman of the special session on Large Amplitude Sound Waves, under physical acoustics.

Publications include:

"Architectural Acoustics" by N N Andreev, BSE (Bol'shaya sovetskaya entsiklopediya - Great Soviet Encyclopedia), 2, 97 (1926).

"Structural Acoustics", by N N Andreev, Teknicheskaya entsiklopediya (Technical Encyclopedia) 22, 183 (1933)

"On the Flow of Sound Along Absorbing Boundaries", by N N Andreev, Isv. AN SSSR (Akademii Nauk SSSR -- News of the Academy of Sciences USSR), Physical Series, 5, 625 (1936).

"Porous Sound Absorbing Materials" by N N Andreev, Trudy Akusticheskoy Komissii AN SSSR, 3, page 9 (1939).

"Ueber die Energie ausdrucke in der Akustik" by N N Andreev Journal of Physics, USSR, 2, 305-312 (1940).

"Contemporary Acoustics" by N N Andreev, Vestnik Akademii Nauk SSSR, No. 1-2, page 46 (1945).

"On Certain Second-Order Quantities in Acoustics" by N N Andreev, Acoust. Journal USSR, 1, 1, 3-11 (1955).

L M Brekhovskikh, Acoustical Institute of A.S. USSR, Moscow
(in charge of the theoretical division)

Technical interests: Theory of sound propagation; inhomogeneous and moving media; irregular boundaries.

Invited to present a paper on sound propagation in inhomogeneous media, in the symposium on physical acoustics and sonics.

Contributed title and abstract:

"Focusing of Sound Waves in Inhomogeneous Media" by L M Brekhovskikh.

Publications include:

"The Field of a Point Source of Radiation in a Stratified Inhomogeneous Medium", by L M Brekhovskikh, Izv. Akad. Nauk SSSR, Ser. Fiz. 13, Part I p. 505, Part II p. 515, Part III p. 534 (1949).

"The Distribution of Sound in an Underwater Sound Channel", by L M Brekhovskikh, Dokl. Akad. Nauk SSSR 69, 157 (1949)

Brekhovskikh is of particular interest because of the 1949 paper by him indicating his discovery of the SOFAR layer which was highly classified by the US Navy until recently.

"Diffraction of Sound at Uneven Surfaces", by L M Brekhovskikh, Dokl. Akad. Nauk SSSR 79, 585 (1951).

"On a Special Form of Damping in Wave Propagation in Laminar Inhomogeneous Media", by L M Brekhovskikh and I D Ivanov, Acoust. Journ. of USSR, 1, 1, 23-30 (1955).

G. V. Gershuni, Pavlov Institute of Physiology of the Academy of Sciences of the USSR, Leningrad.

Technical Interests: Physiological acoustics; mechanism and measurement of hearing; the electrical stimulation; effects of blast.

Invited to present a paper in the special session on bio-acoustics.

Contributed title and abstract:

"About New Methods of Measurement of Hearing in Man", by G V Gershuni.

Publications include:

"On the Sensory and Subsensory Reactions Evoked by External Stimuli Acting Upon the Human Sense Organs", by G V Gershuni, Bull. Acad. Sci. USSR (Biol. Ser.) 2, 210-228 (1945).

"Transformation of Auditory Function from the Effect of Sound" by G V Gershuni, Trobl. Fiziol. Akust. Moskva 1, 5-19 (1949).

"Physiological Principles of Objective Audiometry", by G V Gershuni, Trobl. Fiziol. Akust. Moskva, 2, 3-7 (1950).

"Quantitative Investigation of the Range of Action of Imperceptible Sound Stimulations", by G V Gershuni, Trobl. Fiziol. Akust. Moskva, 2, 29-36 (1950).

V A Krasilnikov, Physics Research Institute, Lomonosov State University of Moscow

Technical Interests: Interaction of sound and turbulence; propagation in the atmosphere.

Invited to give paper in special session on Interaction of Sound with Turbulence and Shock, under physical acoustics.

Contributed title and abstract:

"On Wave Propagation in Media with Irregular Fluctuations of the Refractive Index" by V A Krasilnikov and A M Obukhov.

Publications include:

"Some New Experiments on the Propagation of Sound in the Atmosphere", by V A Krasilnikov and K M Ivanov-Sits, Dokl. Akad. Nauk, 67, 639 (1949).

"Fluctuations in the Phase of Ultrasonic Waves Propagated in a Layer of Air Near the Earth", by V A Krasilnikov, Dokl. Akad. Nauk, 88, 657 (1953).

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"Dispersion of Sound in a Turbulent Flow" by V A Krasilnikov and V I Tatarskii, Dokl. Akad. Nauk, 90, 159 (1953).

I G Mikhailov, Leningrad State University

Technical interests: Piezoelectric crystals; absorption and velocity of sound in liquids and liquid mixtures; mechanical properties of polymers.

Invited to present paper in special session on sound absorption phenomena under the general area of physical acoustics and sonics.

Contributed titles and abstracts:

"The Differential Method of Measuring Ultrasonic Absorption in Liquids" by I G Mikhailov

"Ultrasonic Absorption in Viscous Liquids" by I G Mikhailov.

Publications include:

"Velocity of Ultrasonic Waves in Certain Binary Mixtures of Organic Liquids", by I G Mikhailov and A A Tsistorazum, Dokl. Akad. Nauk, 81, 779 (1951).

"The Absorption of Ultrasonic Waves in Liquids and the Molecular Mechanism of Bulk Viscosity", by I G Mikhailov and V A Solovev, Usp. Fiz. Nauk, 50, 3-50 (1953).

"Propagation of Ultrasonic Waves in Polymer Solutions", by I G Mikhailov and L A Sagalova, Dokl. Akad. Nauk, 89, 829 (1953).

"The Absorption of Ultrasonic Waves in Binary Mixtures of Liquids with One Relaxing Component", by I G Mikhailov and L I Savina, Dokl. Akad. Nauk, SSSR, 96, 1147 (1954).

"Application of Composite Piezoelectric Vibrators to an Investigation of the Mechanical Properties of Polymers", by I G Mikhailov and B A Solovev, Acoust. Journal of USSR 1, 4, 343-347 (1955).

L D Rosenberg, Acoustical Institute of A. S. USSR, Moscow

Technical Interests: Transducers, including focussing devices and multiple source arrays; long-distance propagation; cavitation; radiation properties in general.

Invited to present paper in a special session on sonics under physical acoustics.

Contributed titles and abstracts:

"Mechanism of Destruction of Solid Surface Films by Acoustically Induced Cavitation", by L D Rosenberg, A S Bebtchouk and L O Makarov.

"Diffraction Pattern Near the Focal Line of a Converging Cylindrical Wave" by I N Kanevsky and L D Rosenberg.

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Publications include:

"The Effect of the Mean Coefficient of Sound Absorption on the Level of Sound" by L D Rosenberg and A B Slavinsky, Part I, Journal of Technical Physics, USSR, 19, 1634 (1940).

"The Directional Properties of the Ear Carried Out on a Dummy" by L D Rosenberg and B D Tartakovsky, Comptes Rendus (Doklady) de l'Acad. des Sciences USSR, 26 578 (1940).

"Distributed Systems of Radiators Employed in Architectural Acoustics", by L D Rosenberg, Comptes Rendus (Doklady) des l'Acad. des Sciences USSR 31, 883 (1941).

"The Sound Field Obtained when Music is Reproduced by a System of Distributed Radiators" by L D Rosenberg, Zhurnal Tekhnisheskoi Fiziki 12, 211 (1942).

"Sound Fields Formed by Distributed Systems of Radiators", by L D Rosenberg, Zhurnal Tekhnisheskoi Fiziki 12, 102, 220 (1942).

"On the Distribution of Sound Absorbing Material in a Closed Room" by L D Rosenberg, DAN SSSR, 51, 599 (1946).

"An Experimental Investigation of Diffraction in the Focus of a Zone Plate" by A A Kavpacheva, L D Rosenberg and B D Tartakovskiy, C R Acad Sci., URSS 54, 395 (1947).

"Sound Wedge and Homogeneous Sound Lens", by L D Rosenberg, Journal of Technical Physics USSR 18, 11 (1948).

"A New Phenomenon in Hydroacoustics" by L D Rosenberg, Dokl. Akad. Nauk, SSSR 69, 175 (1949).

"Development of Work on Sound Focussing", by L D Rosenberg, Izv. Akad. Nauk, SSSR, Sev. Fiz., 13, 710 (1948).

"On the Focussing of Sound Waves by a Parabolic Mirror" by L D Rosenberg, J. Tech. Phip. USSR, 20, 385 (1950).

"Two-Mirror Concentration of Ultrasonic Waves" by L D Rosenberg, Dokl. Akad. Nauk SSSR 91, 1091 (1953).

"Calculation of Amplification Produced by Cylindrical Sound-Focussing Systems" by L D Rosenberg, Akusticheskii Zh. 1, 70 (1955).

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L.M.Brekhovskikh.

## Focusing of sound waves in inhomogeneous media.

The sound field from a point source in a stratified inhomogeneous medium is represented in an integral form in terms of plane waves coefficients of reflection. At sufficiently high frequencies coefficients of reflection can be calculated by means of BWK method. Then the application of the method of steepest descent gives the ray approximation for the sound pressure. In developing this theory equations of caustics were obtained and sound pressure near caustics and in the neighbourhood of a cusps of caustics was determined. The development of the field in a sum of modes (1) did'nt appear necessary. Examples are given. The theory of focusing action of stratified media appears to be quite analogous to the theory of focusing by optical systems when aberration is present.

---

(1) Haskell,N.A. J.Appl.Phys., 22, 157-168, 1951.

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Moscow.

Acoustical Institute of A.S. USSR.

Yu.P.Lysanov.

# An approximate solution of a problem of sound scattering from rough surfaces.

A method is developed of calculating the scattered sound field from a rough surface. The method is based on the solution of an approximate integral equation for the normal component of velocity on the surface.

The method is valid for pressure release surfaces. When the amplitude of roughness is great as compared with the wavelength of the incident radiation there is a more rigid limit for the values of the slope.

For periodically rough surfaces, satisfying the conditions stated above, the scattered field is calculated for both the infinite and finite rough surfaces.

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Moscow.

Acoustical Institute of A.S. USSR.

Yu.P.Lysanov.

# Sound scattering from plane inhomogeneous surfaces with acoustic admittance changing periodically along the surface.

A method is given for calculating the scattered sound field from plane inhomogeneous surfaces having normal impedance or admittance independent of the angle of incidence.

The expression for the scattered field is represented in the form of power series of a parameter determining the relative inhomogeneity of the surface. A recurrent expression is given for the n - th term of the series. Several particular cases are considered in more detail.

The proposed method is valid for any ratio $\lambda/L$ where $\lambda$ is the wavelength of the incident radiation and $L$ the spatial period of inhomogeneity. A comparison is made with the approximate solution obtained on the assumption that the change of admittance is small at the distance of the order of one wavelength; it means that it is possible to neglect diffraction effects in the immediate vicinity of the surface. A criterion is given for the validity of this approximate method.

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Moscow.

Acoustical Institute of A.S. USSR.

...erg., A.S.Bebtchouk and L.O.Makarov.

**Mechanism of destruction of solid surface films by acoustically induced cavitation.**

The cavitational destruction of a thin layer of varnish put on a glass plate was studied by means of high speed photography at the rate of 2000 frames per second. Expe- riments were carried on in an inactive liquid (water) at the frequency 8000 cps. It was found that the destruction of the film is caused at least by two different factors. Primarily it is observed as the result of big cavitation bubble collapse in the immediate vicinity of the surface. The observation of such bubbles indicates large amplitudes and complex forms of vibration. It is important to note that the process itself of bubble formation and its osci- llations at the very surface of the film are without in- fluence on the film; but the bubble collapse leads in the first $^{1}/_{2000}$ sec. to destruction of the film extending on a circle with the center coinciding with the position of the bubble at the moment of collapse. Another type of des- truction is caused by small bubbles with smooth surfaces which quickly penetrate between the film and the glass at a destructed spot, causing small irregular bits of film to defach from the surface.

Moscow.

Acoustical Institute of A.S. USSR.

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B.D.Tartakovsky.

# Filters and matching layers for ultrasound.

Methods of acoustical matching on the boundaries of different media by means of matching layers are studied theoretically and experimentally. Conditions are found giving the least transmission loss in a wide frequency band for a given number of layers. One and two-layered elements made of different materials were tested experimentally. The resulting matching of ultrasonic lenses and prisms in the water increased the transmission coefficient to the value of 98-99%. The transmission coefficient of a steel plate covered with matching layers reaches 90%. Interference filter composed from three layers exert a wide band filtering action on inclined rays and correct the form of the wave-front.

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Acoustical Institute of A.S. USSR.

I.N.Kanevsky and L.D.Rosenberg.

## Diffraction pattern near the focal line of a converging cylindrical wave.

Assuming the small value of the ratio of the wavelength $\lambda$ to the dimensions of the radiator, expressions are found for pressure and velocity distribution near the axis of a convergent cylindrical wave front. For some concrete cases (ceramical transducer with radial polarization, ceramical transducer with axial polarization and a reflector in the form of a parabolic cylinder) focusing factors, gain and width of focal strip for pressure and velocities are calculated. A constant angular distribution of the amplitude on the surface of the converging front gives maximum value of the pressure focusing factor. In this case the following expression gives the width $z_0$ of the focal strip:

$$(kz_0)^2 = \frac{\alpha_m^2}{\frac{\alpha_m^2}{2} - \frac{\alpha_m}{4}\sin 2\alpha_m - 4\sin^4\frac{\alpha_m}{2}}$$

where $k = 2\pi/\lambda$ and $\alpha_m$ is the aperture angle.

The approximate expression $z_0/\lambda = 0{,}5/\sin\alpha_m$ is accurate enough for the most practical purposes. Corresponding expressions for different other cases are obtained.

Finally some formulas are quoted connecting the pressure on the axis with the focusing factor and total incident energy. It is shown, that in the case of a finite length of radiator, the obtained results are valid on the whole length of the axis except small portions at the ends measuring about $\sqrt{\lambda f}$ where $f$ is focal distance.

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Moscow.

Acoustical Institute of A.S. USSR.

Yu.L.Gasarjan.

# On waveguide propagation in inhomogeneous media.

The representation in an integral form of the sound field radiated by a simple point source in the medium with the velocity depth dependence according to Epstein x) is given. The case of waveguide propagation is studied in detail. At long distances, the field is represented by a sum of normal modes and a head-wave. There is a very simple dependence of eigenvalues on parameters of the problem. The vertical field distribution of separate modes is given by Jacobi polinomials. In the case of symmetrical distribution of velocities the solution is obtained likewise in the presence of a perfectly reflecting surface on the axis of the waveguide. A comparison is made between the exact solution and the approximate solution obtained by the WKB method.



x) P.S.Epstein Proc.Nat.Acad.Sc.USA., 1930, 16, N10,627.

Moscow.

Acoustical Institute of A.S. USSR.

M.A.Issakovitch.

# The application of solid layers for the removing of shear waves appearing at the reflection of sound waves from the boundary of a solid.

At the incidence of a longitudinal wave on a plane boundary of a solid, covered with a layer of another solid substance rigidly fixed to the former, the reflected energy is divided between a longitudinal wave and a shear wave.

The amplitude of the latter depends on the density and elastic properties of materials, on the thickness of the layer and on the angle of incidence.

For different combinations of materials and for different angles of incidence, the thickness of layers is computed giving zero amplitude of the reflected shear wave.

In this case the longitudinal wave is reflected totally and no transformation into shear wave occurs.

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Moscow.

Acoustical Institute of A.S. USSR.

M. A. Issakovitch.

# The use of Kirchgoff's principle in the solution of problems relating to scattering and radiation of sound.

This is a study of some problems relating to sound scattering by randomly inhomogeneous surfaces and to sound radiation by randomly oscillating surfaces. It is assumed (Kirchgoff's assumption) that the field in any point of the surface is the same as if it were built up by a tangent plane having the same properties at this point. In the problem of scattering this assumption means the independence of the field on a plane surface from the change of its properties from point to point. In the radiation problem the field in any point of a curved surface is assumed to be equal to the field that would be built up by the tangent plane with the same velocity distribution. The intensity of scattered or radiated field in the Fraunhofer's zone is expressed in terms of correlation functions of normal velocities or parameters of the surface.

Moscow.

Acoustical Institute of A.S. USSR.

A.N.Lepo[illegible]sky.

# Investigation of the scattering of sound waves on corrugated surfaces.

Experiments on the scattering of sound waves by models with periodically corrugated frontal surfaces are described. Results of measurements are discussed and compared with existing theories (1,2). It is shown, that scattered field resolves into separate spectral beams at the distance $R \approx (4 \div 6)\frac{DL}{\lambda}$, where $L$ - spatial period of corrugation, $D$ - length of corrugated surface, $\lambda$ - wave-length of incident sound. The angle of incidence $\vartheta_0$ and corresponding angles $\vartheta_m$ of spectra of different orders agree within the experimental error with theoretical expression:

$$\sin \vartheta_m = \sin \vartheta_0 + m \frac{\lambda}{L},$$

where $m$ is the order of a particular spectrum. In the regions of validity of mentioned theories, the agreement between experimental and computed data for the relative values of sound pressure amplitudes is satisfactory.

1. L.M.Brekhovskikh , Zhur.Eksptl. i Teort.Fiz., 23, 1952.
2. Yu.P.Lysanov , Dissertation, 1955.

Moscow.

Acoustical Institute of A.S. USSR.

A.V.Rimsky-Korsakov.

## Audibility of non-linear distortion in sound transmission systems.

The non-linearity to be allowed in sound transmission systems is usually found experimentally. For this purpose a group of persons is proposed to find (by listening to a program) the grade of non-linearity at which distortion is noticeable. The resulting data may depend on the hearing sharpness of these people, on the sequence of the experiments, on the form of non-linearity, frequency band and transmitted program. Therefore the value of such data is limited. Distortion hearing thresholds for various programs and forms of non-linearity were measured. In a single experiment for a group of people they are distributed in a good agreement with the Gaussian law. A method of computing the non-linear distortion audibility was developed. The transmitted signal is considered to be a stationary oscillating process with normal distribution law. The probability for the non-linear products to exceed the hearing threshold which is influenced by the main transmitted signal (masked) was computed. Calculation for a constant amplitude spectrum signal and transmission system with a frequency band 100-5000 cps. and various distortion factors was done. The probability of noticing second order non-linear products for a distortion factor = 3% was found to be 0,035; as for a distortion factor = 5% nearly $^1/_7$- $^1/_5$ of the whole program may be spoiled by non-linear effects.



Acoustical Institute of A.S. USSR.

# Experimental Investigations of Some Cases of Sound Propagation in a Stratified - Inhomogeneous Medium.

A.N.Parkhatov

The proof and the description of the method of a laboratory investigation of sound propagation in stratified-inhomogeneous media are given in this article.

The method has been used for sound intensity measurements in the medium with a constant negative gradient of the sound velocity and in a similar medium with a surface quasi-isothermal layer.

There has been made a comparison between experimental and theoretical data, in particular, there has been considered the problem of the legality of applying the geometrical acoustics in certain cases.

The interference picture has been shown to be observed in the region nearest to the source in the medium with a constant negative gradient of the sound velocity, at an average the inverse square dependence of intensity upon distance taking place. The position of the extrema may be computed by means of the geometrical acoustics, the difference between the experimental and theoretical values increasing with the approach of the boundary of the geometrical shadow. In the latter zone the measured values of sound decay are in essential agreement with the wave theory [6,7]

There have been made experiments on measuring sound decay in the surface isothermal layer and in the lower lying inhomogeneous medium with a constant negative gradient of the sound velocity at different values of the parameter $\delta$ [10]. It has been shown that the sound field may be divided into two regions - the zone of interference and the "effective shadow" zone.

In the latter zone the measured values of sound decay correspond to the theoretical ones at $\bar{\bar{s}} < 1$ [10,11]. It has been found that the boundary of the application of geometrical theory when the sound is propagating in a homogeneous surface layer may be valued by means of Brekhovskich's theory [10].

The described method may also be used for the investigations of sound propagation in other stratified-inhomogeneous media.

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# АННОТАЦИЯ НА АНГЛИЙСКОМ ЯЗЫКЕ

Some theoretical considerations on the flexural vibrations of plates and the associated radiation of sound.

An expression is derived for the reflection coefficient of a plane progressive wave of flexure, arriving normally or at an angle to the boundary of a plate, assumed to be loaded along the boundary by impedances to force and moment. The logarithmic decrement for the free vibrations of a rod / or a plate in the onedimensional case/ is expressed on terms of the reflection coefficients at the boundaries, accounting for the energyleakage across the boundaries. Simple expressions are derived for the radiation resistance of a plate with a standing wave on it in one direction and in both directions, valid for frequencies below the "coincidence" frequency. Using these expressions and certain simplifying approximations, an attempt is made to calculate the frequency dependence of the radiated power for a plate driven in a complex way in terms of the known frequency dependence of the mean square value of the amplitude over the plate, averaged over a frequency range equal to the mean spacing between adjacent fundamental frequencies of the plate.

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# ANNOTATION

TO REPORT " CALCULATION OF SIRENS " BY M.I.KARNOVSKY PRESENTED AT SECOND INTERNATIONAL CONGRESS OF SPECIALISTS IN ACOUSTICS AT CAMBRIDGE ( U.S.A. ).

To determine the sound field of a siren a method of approximation developed by N.N.Andreyev, B.P. Konstantinov and E.A.Nepomnyashchy [I] while investigating sound generation of airscrews is used. It is assumed that beyond the boundary surfase surrounding a siren the sound field is described by a linear wave equation, whereas the processes within the boundary surface are described by the non-linear equations of gas dynamics. The total siren sound radiation is represented as a sum of radiations of the zero and first orders. It has been shown that, as a rule, sound radiation of the first order (dipole) is small as compared with that of the zero order.

A relationship is established between the acoustic and gas dynamic parameters of the siren. Besides, it is supposed that the gas dynamic processes in the siren chamber are described by means of the Bernoulli equation. Investigation is made of the influence of the value of ~~surplus~~ pressure inside the siren chamber on power of radiation.

The influence of constructive siren parameters (spaces between discs, faults of disc production, etc.)

upon the acoustic properties of a siren is discussed. The influence of the shape of the orifice upon the efficiency of the siren is investigated.

The approximation analysis of siren operation is made of both low frequencies, for which the siren disc dimensions are small compared with the wave length, and of high frequencies. Sirens with and without horns are considered.

I. B.P.Konstantinov. On the "Sound of the Rotation of an Airscrew". Journal of Technical Physics, I942, XII, 2-3, p. 86.

I8-I-I956.

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# VELOCITY OF SOUND IN PURE LIQUIDS AND LIQUID MIXTURES.

B.B. KOODRIAVTSEV.

The velocity of sound was expressed in terms of internal energy and some physical constants, and an equation was derived to calculate the velocity of sound in pure liquids and liquid mixtures. Acoustical velocities were calculated for a number of binary mixtures of organic liquids and compared with experimental data , The olserved variation of sound velocities with concentration was explained . The agreement between the theory and the experiment is quite satisfactory. The sound velocity equation was used to calculate the velocity of sound in aqueous solutions of electrolytes . The values predicted by theory are in good agreement with the experimental data . These values were used to determine the adiabatic compressibility for aqueous solutions of various alkali halides. Some conclusions were drawn concerning the acoustical properties of electrolyte solutions and the possibilities of applying acoustic measurments to calculation of various physico-chemical data.

Summary of the Report of the 2nd Acoustic Congress in Cambridge USA

I.G.Mikhailov "The Differencial Method of Measuring Ultrasonic Absorption in Liquids".

We give a new method of measuring the difference of ultrasonic absorption of two liquids.

Two pulse generators excite two ultrasonic quartz transducers in two vessels. Having passed through the two vessels, the pulses are reflected from the opposite walls of the vessels and are received by the same quartz transducers.

The received signals are amplified, detected, and then amplified again by a differencial d.c.amplifier at the output of which there is a milliammeter.

The milliammeter readings are proportional to the difference of two liquids absorption coefficients.

The sensibility of the apparatus is evaluated by the value $x\Delta\alpha$ giving a current 1 mA ($x$ - the double width of the vessel, $\Delta\alpha$ - the difference between absorption coefficients).

For example at $x = 9$ cm. the sensibility equals $\Delta\alpha = 0.01\ cm^{-1}$ per 1 mA. The accuracy of $\Delta\alpha$ measurement is nearly 3-5%.

By means of the above described apparatus one can measure the absorption of ultrasonic diluted solutions, the temperature absorption coefficients of ultrasonic waves in liquids, coefficients of reflections from solid-liquid, liquid-liquid boundaries, and other applications.

25X1

Sumary of the Report of the 2nd Acoustic Congress
in Cambridge USA

I.G.Mikhailov "Ultrasonic Absorption in Viscous Liquids".

1. The simplest phenomenological relaxation theory taking into account the relaxation of the shear and second viscosity gives the following expression of sound absorption coefficient

$$\alpha = \frac{\omega^2}{3\rho c^3}\left[\frac{\frac{4}{3}\mu}{1+\omega^2\tau_1^2} + \frac{\zeta}{1+\omega^2\tau_2^2}\right]$$

where $\mu$ and $\zeta$ are the shear and second viscosities, $\omega$ - cyclic frequency, $c$ - sound velocity, $\rho$ -density, $\tau_1$ and $\tau_2$ -time of relaxation of the shear and second viscosities.

At low frequencies in case when $\omega\tau_1 \ll 1$ and $\omega\tau_2 \ll 1$ this expression coincides with the common hydrodynamic expressions for the absorption coefficient, taking into consideration the second viscosity.

2. With the increase of frequency two regions of relaxation must exist: when $\omega\tau_1 \sim 1$ and $\omega\tau_2 \sim 1$. The Problem whether $\tau_1 > \tau_2$ or $\tau_1 < \tau_2$ may be solved experimentally or by means of theoretical calculations of the time of relaxation. Up to this time such kinds of calculations have been performed for a few liquids only.

3. The experimental data now available make it perhaps possible to assert that in all liquids having a low viscosity $\tau_2 > \tau_1$ i.e. by increasing frequency the second viscosity relaxes first.



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One experimental data show however that this rule is not always followed. It has been found that in a series of viscous liquids (castor-oil and other oils),the shear viscosity relaxes first, the time of relaxation of $\tau_1$ and $\tau_2$ being near each other with regard to value. I such a way both relaxing regions follow each other and the absorption in a comparatively small range of frequencies (0.5mc - 5.0 mc) pass from the higher Stokes value to the lower one. Up till now the shear viscosity was supposed to relax in case the absorption in liquids is lower than of Stokes.

25X1

V.F.Nozdrev, V.D.Sobolev,
A.M.Sultanov, U.N. Bormosov

## Experimental Investigation of Relaxation Processes Arising When Ultrasonic Waves Pass through Liquids

(An Abstract)

The article describes relaxation processes in acetates and formiates found experimentally. The investigation was carried on by impulse and optical methods at frequencies I - 30 m.g.c.

In the interval of temperatures from -40° C to + 30 C in methyl acetate, athyl acetate, methyl formiate, and athyl formiate to complete regions of relaxation are found in every substance.

In athyl acetate an investigation of ultrasonic waves absorption along the line of saturation was carried on, including critical and supercritical regions: one in the interval of temperatures I60° - 2I0° C, the other in the critical region of the liquid phase of athyl acetate.

For every relaxation region the time of relaxation and frequencies corresponding to the centre of relaxation were determined and volumetric viscosity of thermal capacity, relating to internal and external degrees of freedom and heats of activation were calculated.

In conclusion possible mechanisms of experimentally established relaxation processes are discussed.

V.F.Nozdrev

# Investigation of Acoustic Properties of Organic Substances in the Critical Region.

( An Abstract )

The article gives an account of the results of an experimental and theoretical investigation of the velocity and absorption of ultrasonic waves in the critical region of the system liquid-vapour in I5 organic liquids by optical and impulse methods. The availability of an extensive experimental material on the velocity of ultra sound in the critical region permit to establish a number of conformities to laws and rules.

The article states simple formulas, obtained by generalizing experimental material, for the correlation of sound velocity to other thermodynamic parameters of the liquid phase and saturated vapour in the critical region.

Experimental establishment of the rectilinear diameter of wave impedance and its theoretical basis brought to the establishment of simple relation between the velocity of sound in a liquid and in saturated vapour in the critical region.

The investigation of ultrasonic waves absorption in the critical region ( xylole, taluene, athyl acetate ) alongside with studying the velocity of ultra sound permitted to calculate volumetric viscosity and thermal capacity.

The velocity and absorption of ultrasonic waves in supercritical region are also investigated in this article.

In conclusion the possibilities of using the results obtained in thermotechnics are examined.

SOME RESULTS OF THE ANALYSIS OF SINGING VOICE.

by S.N.Rshevkin.

Oscillographic records of some masculine voices were made by means of high quality electro-acoustic devices. Vowels u(oo),o,a(ah),e,i(ee) of various pitch from 94 hz till 490 hz were recorded. The records lasting o,1 sec. were made at the moment of the ~~stable~~ stationary, prolonged sounding of vowel.

The harmonic analysis of different periods of the voice of an artistic singer showed a sharply defined increase of harmonic components in two narrow bands of the spectrum: about 400-600 hz and about 2200-2800 hz. Doubtless in well trained, good voices there are characteristic "singing formants", practically the same for all the vowels. For the vowels "u"(oo) and "i"(ee) the lower formant sometimes gets as low as 250-300 hz. The higher formant is characteristic for a "metallic" timbre of voice.

In the voice of an inexperienced singer (baritone) with a strong, but sharp timbre of voice and noticable fall of loudness higher than mi♭ (325 hz), these sharply defined singing formants are not observed; the whole region of hormonies higher than 1500 hz shows a general increase.

It is suggested that the singer arranges formant regions characteristic of a vowel and necessary for good articulation only in the beginning of a vowel,(in the period of attack), after which he quickly rearranges the vocal apparatus to the singing position, which is almost the same for all the vowels. The quick and distinct rearrengement to the singing position is a necessary quality of a trained voice.

The above mentioned results agree with our former investigations of 1927 and with the investigations of Bartholomew who found a high singing formant in the region ca. 2800-3200 hz.

# On the Transition to the Geometrical Approximation in the Theory of Elasticity.

By M.L.Levin, D.Sc., Ivanovo Pedagogical Institute, and S.M.Rytov, D.Sc., P.N.Lebedev Physical Institute of the Academy of Sciences of the USSR.

As it was shown previously by one of the authors (S.M.R.), the transition to the approximation of geometrical optics not from scalar wave equation but from Maxwell's equations permits to obtain a new complementary result, viz. the law, accordingly the polarization alters along the ray:

$$\frac{d\varphi}{ds} = \frac{1}{T} \qquad (1)$$

Here $\varphi$ denotes the angle between the electric field strength and the principal normal of the ray, ds and T denote an element of the length of the ray and its radius of torsion respectively.

In the present paper it is shown that the same law (1) follows in geometrical approximation from the equations of the linear theory of elasticity for inhomogeneous media. Thus only for such an inhomogenity of a medium, for which the rays appear to be the plane curves, the unit vector of the transversal displacement u is immovable relative to the natural trihedr (the angle $\varphi$ between the principal normal $\vec{n}$ and $\vec{u}$ is not changed).

The rotation of $\vec{u}$ obeys the law:

$$\frac{d\vec{u}}{ds} = -\vec{t}\,\frac{\cos\varphi}{R} \qquad (2)$$

where t and R denote the unite tangent of the ray and its radius of curvature respectively. According to (2), the rotation of $\vec{u}$ with respect to the independent fixed co-ordinates stops at those points of the ray, where $\vec{u}$ is collinear to the binormal ( $\varphi = \pm\frac{\pi}{2}$ ), and at the points of the zero curvature.

These results might find their application in the problems concerning the propagation of seismic waves.

January,20, 1956.

Acoustical Properties of a Laminated Medium

by S.M.Rytov,D.Sc., P.N.Lebedev Physical Institute of the Academy of Sciences of the USSR.

Elastic and electromagnetic properties of laminated media were studied by various authors, in particular for the case when the layers are thin in comparison with a macroscopical wavelength. Under this last condition the medium seems to be homogeneous but anisotropic or, more definitely , a cristall with the hexagonal simmetry as concerns to the elastic properties. Consequently, it is characterized by five elastic constants $\lambda_i$ $(i=1,..,5)$ ,which define the velocities of propagation of the waves of dilatation and of rotation:

$$C_{xx}^2 = \frac{\lambda_2}{\rho}, \quad C_{xz}^2 = C_{zx}^2 = \frac{\lambda_5}{\rho}, \quad C_{xy}^2 = \frac{\lambda_4}{\rho}, \quad C_{zz}^2 = \frac{\lambda_1}{\rho}$$

Here $\rho$ denotes the mean density of the medium, the first subscript at c indicates the direction of propagation and the second one denotes the direction of the displacement (the layers are parallel to the plane xy). The module $\lambda_3$ enters in the expression for C only for the waves propagating in the direction inclined to z axis at angle $\vartheta \neq 0$ or $\frac{\pi}{2}$ .

In the papers known to the author only two directions of propagation were discussed, namely parallel to the layers and a normal one. This permits to obtain only four of the modules $\lambda_i$ ( $\lambda_1, \lambda_2, \lambda_4$ and $\lambda_5$ ).

By means of differential equations with periodic coefficients the author has obtained all the effective modules for the medium consisting of alternating thin layers of two solid substances. The formulae are also held when one of the substances is so viscous liquid that the length of the transversal wave within it is much greater than the thickness of the liquid layer.

In the opposite case the liquid may be considered as a perfect one. The medium consisting of the alternating thin layers of a solid substance and of a perfect fluid is also a cristall with the hexagonal simmetry but it has such elastic modules, which are impossible in any real cristalls (in particular, the module $\lambda_2$ is two-valued and $\lambda_5 = 0$).

The above results might be of interest in connection with artificial anisotropic materials used for a vibroinsulation or for directional filters, the efficiency of which must main in the wide frequency range.

January, 20, 1956.

# CORRELATIVE PROPERTIES OF WAVE IN A RANDOMLY INHOMOGENEOUS MEDIUM.

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A theory of correlative functions is set forth for the wave field in a randomly inhomogeneous medium. A calculation is made of 1) the coefficient of reciprocal correlation of the fluctuation level and phase in the point of reception, 2) coefficient of space autocorrelation of levels ( or phases), 3) coefficient of time autocorrelation of levels ( or phases).

It is shown that the reciprocal correlation of the level and phase fluctuations is lessening as the distance from the source increases.

The cross-correlation of levels( or phases) extends over a distance of the order of the radius of correlation of the refractive index in a medium. The longitudinal correlation extends over a considerably longer distance then does the cross-correlation.

It is further shown that the coefficient of time autocorrelation of levels is practically independent of the range from source to receiver but has a considerable dependence on the speed of the movement of the observer.

Some of the theoretical conclusions are compared with the experimental data obtained by Sheehy.



(Lev Chernov)

V.F.Yakovlev, N.I Koshkin,
V.D.Sobolev, M.G.Shirkevitch,
V.F.Nozdrev.

## Impulse Method of Fixed Distances, Its Physical Basis and Practical Application.

( An Abstract )

The article gives the basis of a new worked out method of impulse measuring of ultra-sound absorption. In contradistinction to the widely used method according to which it is necessary to transpose the irradiator (emitter) and the reflector in respect to each other, according to the mew method the irradiator and the reflector remain stationary.

These circumstances not only considerably simplify the construction of the measuring chamber and accelerate the process of measuring but permit to use the impulse method more successfully for measuring absorption at high temperatures and pressures, as well as at various kinds of phase transitions.

The article states the results of measuring of ultra sound absorption coefficient carried out by the method of fixed distances. The experimental data are compared with the results abtained by other methods.

The possibility of using the impulse method of fixed distances as a means of control in industry is pointed out in the article.

# On wave propagation in media with irregular fluctuations of the refractive index

Krassilnikov V.A. and Obukhov A.M.

Summary

The paper describes the principal methods of the theory of wave propagation in media with small, irregular fluctuations of the refractive index, the application of the method of disturbance to wave equations and the utilization of these equations to disturbances of phases and amplitudes (linearization of the "eukonal"-equation, keeping the diffraction term). The application of simplified equations of the geometrical theory is also mentioned. The advisability of the use of statistical methods to describe the field of irregular fluctuations is shown.

The theoretical and experimental data of the wind pulsations and the temperature variations in the atmosphere are also given.

The method of calculation of the root mean square fluctuations of the waves for the case, when radiation propagates in the irregular inhomogeneous medium of known statistical properties and the method for a calculation of the parameters of the wave scattering are given.

In conclusion examples of a calculation of phase and amplitude fluctuations, when sound waves propagate in turbulent atmospheres, are being analysed. Some experimental data are also mentioned.

# ABOUT NEW METHODS OF MEASUREMENT OF HEARING IN MAN.

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It is known, that the main quantitative characteristics of hearing in man, are obtained by so-called psychophysical methods; in these methods the responses to sound stimuli are based upon the use of verbal instructions.

This paper gives a description of methods of measurements of hearing based upon the use of different other responses to sound stimuli and worked out by the auther and his collaborators.

For this purpose a set of different conditioned responses was used (galvanic-skin reflexes, lid-reflexes, electrocortical reactions, etc.) The data obtained by these methods show the following: I) Absolute auditory thresholds and difference limens for frequency and intensity of pure tones can be measured with the same accuracy by these reactions as by verbal responses; 2) In certain cases conditioned reflexes subliminal to the verbal responses in the range of I to 6 db may be detected; 3) Changes of absolute and differential sensitivity attaining 25 to 30 db., and dependent on the condition under which the reactions take place, can be detected.

The presented data of hearing measurements obtained by means of different responses are considered as highly characteristic of the process of sound discrimination in man and animals.



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# Non-specular reflection of sound by finite plates and shells in liquids.

L j a m s h e v, L. M.

Results are given of a detailed theoretical and experimental investigation of the non-speculer reflection (N.R.) of sound by thin plates due to flexural waves, as well as of a new type of N.R., due to longitudinal waves in a thin plates, and the phenomenon of N.R. in cylindrical shells and thick plates found by the author.

It is shown that during N.R. takes place an effect of coincidence-resonance. The fine structure of N.R. due to coincidence-resonance has been experimentally observed and investigated.

It is shown that N.R. takes place also in case of scattering of sound by finite thin cylindrical shells and thick plates.

The peculiarities of N.R. in the above mentioned cases are stated.

It is shown that if the radius of the cylindrical shell is substantially greater than the wavelength of sound in liquid the direction of N.R. from a shell coincides with the direction of N.R. from a plate of the same thickness and material.

It is shown further that in case of a thick plate the number of maximums of N.R. at great thicknesses and high frequencies of vibrations is very high and decreases with the decrease of frequence.

In limiting case are observed only two N.R. (thin plate).

The N.R. in thick plates is shown to be due to the propagation of the so called normal waves in the plate considered as an elastic layer of finite thickness.

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# On biological action of ultrasound

In this report, the literature on biological effects of ultrasonic waves is reviewed and the results of author's own investigations are summed up.

The action of ultrasonics on biological systems (microorganisms) is not limited to mechanical rupture of cells and cell structures. This agent can also cause biochemical and functional changes, without subsequent death of the organism. These changes are mainly due to the action of ultrasonic waves on intracellular molecular complexes. Ultrasound appears to have the ability for "shaking loose" the molecular complexes in tissue and cell structures, which results in liberation or increased activity of cell enzymes. Thus in ultrasonic treated yeast cells (Saccharomyces globosus and Endomyces magnusii) the activity of invertase is considerably increased. Until recently, this enzyme has been thought to be lacking in Saccharomyces globosus. The increase of activity of cholinesterase in cerebral tissue is similarly brought about by ultrasonic irradiation. (This enzyme will be inactivated when treated after extraction from brain tissue). The influence of ultrasound upon intracellular molecular complexes is also evidenced by the fact that more ergosterol can be extracted from treated yeast cells than from untreated.

The action of ultrasound on protein complexes is accompanied by the rise in sensitivity of corresponding enzymes to the action of venoms. This rise probably accounts for the fact that sublethal doses of $H_2O_2$, ammonia, and formalin kill infusoria and trematodes pretreated with ultrasonics not intensive enough to cause the death of these organisms.

The report includes a discussion of mechanisms by which the above-mentioned phenomena are brought about.

25X1

# [illegible] of Ultrasonic Dispersion

Zverev V A

A new metod for measurements of the dispersion [illegible] is described. The experiment gives directly the value of $D = d^2K/d\omega^2$ ($K$, wave number; $\omega$, angular freqency). The measurement of $D$ is based on the transformation of phase modulation in amplitude modulation and vice-versa, when a modulated sine wave travels through a dispersive medium. The sensivity of the method depends only on the noise level in the receiver and it is independent of the unavoidable small random variations of the sound velocity in the medium under test.

The results of experiments on ultrasonic waves in thin wires (longitudal waves where used) and in water at I Mc/sec (modulation frequency: I00 Kc/sec) are given. The experiments were undertaken for determining the possibilities of the method in acoustics. In the case of longitudal waves in a thin wire the dispersion can be calculated from the teory of elasticity. The value of $D$ obtained experimentally is in a good agreement with the calculated one. The relative change of the phase velocity corresponding to the frequency interval of I00 Kc/sec was about $10^{-4}$. In water no dispersion was observed that agrees whith the theory. A variation of velocity of I cm/sec in a frequency interval of I00 Kc/sec was detectable when the receiver band was about I Kc/sec. In order to prevent reflected waves an optical indicator of ultrasonic waves was used.

25X1