Meetings and Conferences

FOURTH ALL-UNION ACOUSTICS CONFERENCE

V. D. TARTAKOVSKIĬ

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THE Fourth All-Union Acoustics Conference was held in Moscow from May 26 to June 4, 1958. The conference was called by the Commission on Acoustics, Academy of Sciences USSR, the Acoustics Institute, Academy of Sciences USSR, and the M. V. Lomonosov Moscow Order of Lenin and Order of Labor Red Banner State University "Lomonosov." More than 700 scientists and engineers took part in the conference. These came from 55 cities of the Soviet Union, and also included 40 foreign acousticians, coming from East Germany, China, Poland, the United States of America, West Germany, and Czechoslovakia.

A total of 170 papers on the most important current problems of physical acoustics were read at the conference. The meetings of the conference were divided into plenary sessions and seven specialized sections:

1. Sound propagation in inhomogeneous media.
2. Nonlinear acoustics.
3. Radiation and diffraction of sound.
4. Ultrasonics.
5. Electroacoustics.
6. Acoustical measurements.
7. Architectural and constructional acoustics.

The plenary sessions were devoted to review papers which delineated the most significant present trends in physical and technological acoustics. The meetings of the technical sections were given over to reports on original research completed in 1957-58.

The chairman of the Commission on Acoustics of the Academy of Sciences of the USSR, Academician **N. N. Andreev**, in opening the conference, noted the great importance of the meeting in summing up the researches of numerous Soviet acousticians, and pointed out the great problem confronting Soviet acousticians in the general development of science and technology in the USSR. He further took note of the participation in the conference of a large number of foreign acousticians; this, he said, should aid in further association between Soviet and foreign scientists, to their mutual advantage.

Corresponding Member of the Academy of Sciences of the USSR **L. M. Brekhovskikh** read an interesting general paper "On Surface Waves in Acoustics" at the first plenary session. Surface waves can be propagated without damping along a surface with elastic impedance iZ. In air acoustics, such a surface can be obtained by mounting a comb of fibers on a rigid wall; the distance between the fibers is made much shorter than the wavelength of the sound. In liquids, one can use a surface of porous rubber.* The attenuation coefficient in the direction normal to the surface is equal to $\alpha = \omega\rho/Z$. Cylindrical surface waves can be propagated along a fibered wall in air, or along an air cord (or cord of porous rubber) in a liquid. The speaker pointed out examples of the possible application of such surface waves in acoustics. By making a surface wave impinge at a certain angle on a band of sound absorbing material, one can measure the reflection coefficient as a function of the angle of incidence. By restricting a certain part of the surface by means of short solid walls, one can obtain an unusual "plane" reverberation chamber. Professor Brekhovskikh noted that it is possible that the results of measurement in such chambers may prove to be equal in merit to the results of measurements in the usual large "volume" reverberation chambers. Another advantage of plane chambers is their portability. Theory shows that to produce radiators or receivers of high directivity we can use cylindrical surface waves which propagate along rods of sufficiently small diameter. The half width of the principal lobe depends on the length of the rod l and is equal to $\pi\sqrt{\lambda/l}$.

V. A. Krasil'nikov considered "Certain Problems of Aerothermoacoustics," pointing out the great significance of problems of the propagation of radiation in a medium with random inhomogeneities in the index of refraction, produced by turbulence, and the production of sound (noise) from turbulence. Some

*Surface waves cannot be propagated independently along a solid, nonrigid surface without a source distributed over the entire surface, since in such a case the inertial impedance prevails over the elastic. In the propagation of surface Rayleigh waves, the inertia and the elasticity are comparable because of the presence of shear rigidity.

substantial progress has been made in the study of propagation problems, due in part to the application of the basic results of the statistical theory of local isotropic turbulence in line with the ideas of A. N. Kolmogorov. The problem of sound generation, while possessing great practical importance, has been less studied. The principal problems in the solution of this question consist in the determination of the dependence of the intensity, frequency spectrum, and spatial distribution of the sound on the properties of the turbulent flow. The lecture included a brief critical review of the theoretical (Lighthull et al.) and experimental researches and, within the framework of the existing theoretical ideas, the problems of the interaction of sound fields (scattering of sound by sound) were considered, as well as some problems of thermoacoustics.

In his paper, "Lateral Amplitude Diffusion in Wave Diffraction, Propagation and Reflection," **G. D. Malyuzhinets** (at the second plenary session of the conference, May 28) considered the behavior of approximately traveling waves which possess a sufficiently defined direction of propagation at each point and a certain smooth distribution over the wave front. Just as the propagation in the direction of the ray is according to the wave law, an equalization of amplitude takes place, according to the laws of diffusion, in the transverse direction, i.e., along the front. The coefficient of this transverse diffusion, which is complex, is proportional to the wavelength. As a consequence of the complex coefficient, wave diffusion, in contrast to the usual case, is accompanied by oscillations and phase shifts. As was shown by the author in 1946, the phenomenon of transverse diffusion in the general case is described mathematically by differential equations of the parabolic type in radial coordinates that are defined by the Fermat principle. In addition to computational advantages, the principle of transverse diffusion gives a clear interpretation to a wide class of wave phenomena, allowing us to describe qualitatively the features of wave field before carrying out a calculation or experiment. This also applies to those cases in which Huygens' principle is of no avail for a clear representation. In particular, the process of amplitude attenuation on a wave front that slides along the absorbing surface is analogous to the cooling of a heated plate which is kept cold at its edge.

M. A. Isakovich gave a review of certain problems of statistical acoustics, which have been treated in recent years at the Acoustics Institute, Academy of Sciences, USSSR. These refer to the question of the scattering from randomly rough surfaces, the problem of the scattering and radiation of waves in acoustically inhomogeneous and statistically vibrating surfaces, the problem of the investigation of elastic surfaces found under the action of statistically distributed lateral forces, and also a number of problems on the propagation of sound in non-regular channels.

In the paper of **Uno Ingard** (USA) on "Propagation of Sound in the Atmosphere," laboratory and field measurements of sound propagation in an inhomogenous and turbulent atmosphere were reviewed and discussed. The field measurements were carried out over a wide range of atmospheric conditions, and included studies of the shadow zone, brought about by the temperature or wind distribution, attenuation resulting from the scattering on turbulent inhomogeneities, the energy spectrum of atmospheric turbulence, etc. The laboratory investigations included measurement of the sound field in a shadow zone brought about by a temperature inhomogeneity, the dependence of the shadow zones on the boundary conditions, and also a study of the propagation of collimated beams and spherical waves in a turbulent medium. The laboratory measurements in the shadow zone agreed well with diffraction theory; however, the results of the field measurements in the shadow zone could not be explained by diffraction alone. The data of field measurements on attenuation and brought about by scattering in the case of the use of sound forces with comparatively small directivity, agreed with calculations based on data on scattering in the reverse direction. From this point of view, one could decide on the dependence of the energy spectrum of turbulence on the wind velocity, and the comparatively weak dependence on the wind velocity of the measured attenuation.

In the following plenary session, problems of signal transmission and architectural acoustics were discussed.

I. E. Goron and **A. V. Rimskiĭ-Korsakov** reported on "Investigations of the Significance of Distortion and Interference in a Radio-broadcast Channel." Comparing the transmission through a channel with a measured distortion (or interference), and transmission through a non-distorting channel, they determined threshold amounts of distortions (or interference) of different forms. Statistical analysis was carried out and the reliability of results obtained in various musical and speech programs with a large number of experts was determined. Thresholds were found for the limitation of the band of transmitted frequencies, the compression of the dynamic range, nonlinear dispersion noise and interference, and also for several simultaneous distortions and interferences.

The investigation allows one to make a classification of the quality of broadcast channels and to specify standards for permissible distortion and interference.

The old concepts of estimating the quality of acoustical auditoria by the reverberation process have undergone a revision in recent years. New hypotheses have been employed which connect high quality of hearing with different characteristics of the sound field in an auditorium, in particular, with the spatial and other inhomogeneities of the field. Judging, in the purely physical aspect, the "Frequency and Spatial Irregularity in the Establishment of an Acoustic Field in Rooms," **R. Bolt** (USA) observed that the fluctuations of the sound pressure at a certain point in a room (in which a sound field from a sinusoidal sound source has been established) is brought about by fluctuations in the position of the sound source and the frequency of the radiation and can be represented as an irregular superposition of pressures connected with the different normal modes. The resulting frequency irregularity F (db/cps) increases with frequency at low frequencies and tends to a constant limit at high frequencies. In buildings with a high degree of symmetry, F has (at a certain frequency) a clearly indicated maximum. Below this frequency, F decreases upon increase of absorption in the room and diffuseness of the field; above, it depends only on the absorption. The lecturer pointed out that the previous theory which gives the variation of F in regions of high and low frequencies, coincides with the present theory in the intermediate region. Theoretical rules for the spatial non-regularity, S db/half wavelength, were discussed and representative data for their measurement were given.

Professor E. **Meyer** (West Germany) reported on "New Studies of Architectural Acoustics at Göttingen." Electroacoustical experiments are being carried out in which the separate reflections of sound from surfaces of a room, together with reverberations in the proper sense of the word (and without them), are imitated. The threshold of discrimination of reverberation times of damped noise processes was also investigated. The amount and intensity of the most powerful reflections (from the surface of a room) were investigated; these reflections are characterized by a small retardation time. Furthermore, the speaker reported on the results of a measurement of the diffuseness of the direction in stationary excitation and of the dependence of the diffuseness on time in excitation by sound pulses, which permits one to note several objective criteria characterizing the acoustical properties of rooms.

In recent years the problem of the struggle against noise has acquired vital significance. Besides the further extension of already known methods of reducing vibration and the noise brought about by it, researches have been carried out on new ways for the solution of this problem. One of the new methods consists of placing on the vibrating parts of machines and structures layers of materials which possess an increased internal damping. This increases the active loss of mechanical vibrations of these parts. The amplitude of the vibration is decreased in the resonance region and the damping time of vibrations after impact are decreased. As a result, the level of the radiated airborne sound is decreased. **B. D. Tartakovskiĭ** pointed out the fundamental theoretical and experimental researches on vibratory absorbtive materials and structures, compared the different methods for their measurement, particularly the methods applied in the Acoustics Institute, and showed the possible regions of applicability of such materials and structures.

From the general theory of phase transitions of second order, it follows that the time for establishing the state of thermodynamic equilibrium (the relaxation time) ought to increase significantly, in a system close to the critical point. This should lead to an increased absorption of sound. Calculation of this time has enabled L. D. Landau and I. M. Khalatnikov to give a quantitative explanation of the anomalous absorption of first sound in liquid helium near its critical point at 2.19°K. Carrying out a thermodynamical generalization of the results referred to above, **I. A. Yakovlev, T. S. Velichkina,** and K. N. **Baranskiĭ** investigated relaxational absorption in a solid body which undergoes a phase transition of the second order. An effect of a substantial increase in the absorption of a transverse wave in piezoelectric salts close to the upper Curie point was observed. The results of the investigations were in excellent agreement with the theory of the phenomenon developed by Landau for this particular case.

A "magnetoacoustic effect" was shown by L. L. **Myasnikov** to arise in the interaction of sound (ultrasonic) waves in a conducting or semi-conducting solid or liquid medium with a magnetic field, as a consequence of which an alternating electromagnetic field is formed. In metals, the magnetoacoustic effect also appears in the dependence on the phase velocity and the damping of sound on the frequency and magnetic induction. It is found that in all alloys of nickel and manganese with iron, the magnetic dispersion of sound depends upon the amount of iron content; this permits us to suggest a new method of magnetic analysis. In the megacycle range, the magnetoacoustic effect takes place only in a thin surface layer. Therefore, it is easy to obtain it and to observe it with the help of surface ultrasonic waves. The lecturer spoke about several possible practical applications of the magnetoacoustical effect in measurements, defectoscopy, etc.

L. D. Rozenberg summed up investigations of the physical mechanism of ultrasonic cleaning of surfaces of solid bodies from contamination (surface films). As a result of a series of investigations, it was made clear that the role of vibrational acceleration in the cleaning is insignificant: in uniform accelerations, the cleaning proceeds in a liquid medium and does not take place in a gas. It was established by means of high-speed motion-picture photography that the cleaning takes place through the catastrophic disruption and scaling off of the surface film. The disruption takes place in the case of partial or complete annihilation by cavitation bubbles, as a consequence of which shock waves arise. The magnitude of the cavitation energy depends on the temperature; it has a maximum that depends on the liquid employed in the cleaning. Corrosion increases with temperature, which is explained by the increase in the number of cavitation bubbles. The corrosion depends on the magnitude and nature of the dissolved gas and increases with decrease in the solubility of the gas. Therefore, if water in contact with air is used for cleaning, the erosion is greater than in the case of the use of organic solvents.

At the last plenary session, Bruel (Holland) gave a review paper on the development of electroacoustical methods of measurement and the handling of electroacoustical measuring apparatus. The lecturer spoke in detail about developments pioneered and carried out at the scientific investigatory laboratories of the firm of Bruel and Kjaer, which in recent years has become one of the centers of production of acoustical apparatus in western Europe. The paper was accompanied by demonstrations of complicated measuring apparatus and was listened to by the audience with great interest.

The section "Propagation of Sound in Inhomogeneous Media," considered problems of the propagation of waves in statistically and regularly inhomogenous media, peculiarities of interference and focusing of waves, which are propagated statistically in a inhomogeneous medium. A second important group of papers were devoted to waveguides of various types, the propagation of waves in the presence of reflecting boundaries, and reflections from rough surfaces. The majority of the papers given were grouped in accordance with the general trends developing in the several scientific schools. These refer to: (a) investigations completed at the Acoustical Institute on propagation in wave guides and channels and in statistically inhomogenous media; (b) researches at the Leningrad State University on ray theory; (c) researches on the propagation and focusing in statistically inhomogenous media completed in the Yaroslavl Pedagogical Institute under the direction of L. A. Chernov; (d) the works of the group of V. I. Tatarskiĭ in the Institute of Atmospheric Physics on the study of the effect of turbulence on the propagation of waves.

In the papers of **B. M. Babich**, and also **A. S. Alekseev** and **B. Ya. Gelchinskiĭ**, there were descriptions of the ray method of calculation of the intensity of wave fronts, of successive approximations in this method, and of its application to the problem of propagation in the presence of boundaries. The determination of the intensity and shape of frontal waves in an elastic medium by the ray method was also discussed.

In analogy with the well-known methods of J. Hadamard and S. L. Sobolev of the solution of the Cauchy problem for parabolic equations, one could carry out the calculation of the intensity of wave fronts by considering the equations describing the wave processes to be satisfied on characteristic surfaces. Taking "wave front" to mean either the surface of discontinuity of the solution or its derivative or (in the case of higher frequencies) the surface of equal phases of vibration, and employing, close to the wave front $[t = \tau(x, y, z)]$, the expansion

$$U(x, y, z, t) = \sum_{n=0}^{\infty} U_n(x, y, z) f_n(t-\tau),$$

where

$$\frac{d}{dt} f_n(t) = f_{n-1}(t), \qquad f_n(t) \gg f_{n+1}(t),$$

we can obtain from the differential equations that are satisfied by V, differential equations from which we can determine U_n step by step. The quantity U_0 represents the intensity of the wave front (having at high frequencies the sense of amplitude). In the case of a point source of pulsed vibrations, one can demonstrate the convergence of the expansions carried out in the usual sense, based on certain results of Hadamard. In the case of caustics, the type of discontinuity [described by the function $f_0(t)$] may vary. However, in first approximation, one can find the character of the discontinuity and the intensity of the wave which passes the caustic.

For the solution of problems connected with the change in the type of discontinuity (for example, reflection of a wave behind the limiting angle), it is possible to apply the complex form of the ray method.

For this purpose, the field of an elastic wave excited by a point source that is applied sharply is represented in the neighborhood of the surface of the front in the form

$$U(x, y, z, t) = \mathrm{Im} \sum_{n=0}^{\infty} U_n(x, y, z) f_n(t-\tau),$$

where $U_n(x, y, z)$ is a complex vector; $\tau(x,y,z)$ is the eikonal of the wave under consideration, and $f_n(t-\tau)$ is a complex function which has a discontinuity in the n-th derivative at the surface of the front $t = \tau$. Recurrent differential relations for U_n (wherein their values are determined in the case of media with arbitrary inhomogeneity) follow from the Lamé equations of motion.

Considering the setting up of boundary problems in the ray method, **A. S. Alekseev** and **B. Ya. Gelchinskiĭ** have found that in the illuminated regions the boundary conditions must be satisfied at the points of intersection of the wave fronts with the surface of separation. From the condition of compensation of discontinuities of identical order, they obtained a system of algebraic equations for the complex amplitudes of n-th order. Using the ray method, we can compute the intensity of the head wave on the plane boundary of separation when the incident wave has an arbitrarily curved front. Depending on the ratio of the velocities of propagation of longitudinal and transverse waves in the boundary media, and on the type of head wave, the boundary conditions are not satisfied without introducing the so-called "inhomogeneous boundary" waves which have discontinuities only on the boundary of separation. The speakers clarified the number and character of the inhomogeneous waves and generalized the results obtained to the case in which one of the media is one-dimensionally inhomogeneous.

In a number of papers, propagation was considered in media and wave guides with regular inhomogeneities. As is well-known, in the calculation of a pulse generated in an inhomogeneous medium by a point source, the problem can be solved by finding the spectrum of the whole field for the particular case of an initial δ pulse, by multiplication of the result by the spectrum of the given initial pulse and integration over the frequency. In the case of layered inhomogeneous media, the expression obtained for the spectrum is quite complicated and calculation of the integral is difficult. **Yu. L. Gazaryan** has shown that the exact formulas for the high-frequency spectrum of the incident pulse can be replaced by approximate values which give its asymptotic value in the frequency. Application of this method to the computation of the pulse propagated along a pencil of rays which forms a caustic (under the assumption that the points of contact of the rays with the caustic are not singular) leads, for an outgoing pulse with time dependence in the form $p(t)$, to an expression of the form $\int_{-\infty}^{\infty} p'(\tau) F(t, \tau) d\tau$, which permits us to compute the approximate value of the pulse both at distant and at short-range distances from the caustic in the exposed region and close to the caustic in the shadow region.

N. B. Tsepelev has found a solution of the problem of the "Propagation of Waves in a Medium with an Inhomogeneous Transition Layer" of thickness H characterized by a velocity distribution $v(z) = v_0 e^{\epsilon z}$ (the velocities of propagation in the homogeneous half spaces are v_0 and $v_0 e^{\epsilon H}$). Investigating the solution by the method of contour integration, the speaker separated the principal parts of the solution describing the field of the displacement in the vicinity of the propagating wave fronts, and determined the reflection properties of the boundary on which the discontinuity of the derivative of the velocity and temperature takes place. The possibility was shown of a partial generalization of the method for the equations of elasticity theory.

A. N. Barkhatov and **I. I. Shmelev** investigated experimentally "Focusing of Sound in a Waveguide" formed by a layered inhomogeneous medium, in which the function describing the vertical distribution of the index of refraction has a maximum at some altitude. By means of diffusion between the several mixed liquids in a tank, two types of wave guides (which have a width many times larger than the wavelength) were obtained and investigated, one on the surface and one below the surface of the liquid. Measurements made on pulses in the frequency range from 500 kcs to 2.7 Mcs. At short distances (in the range of applicability of the ray theory) the pressure on the axis of the wave guide falls off by a spherical law, while at larger distances it falls off approximately in cylindrical fashion. The investigated structure of the foci for horizontal and vertical cuts at different positions of the source were compared with the ray and wave theories.

E. P. Masterov considered wave propagation of sound in a medium the square of the refractive index of which changes according to a biexponential law. He obtained an equation for the sound waves, found in integral representation of a field of a point source for harmonic radiation, and investigated the solution for the case of an unbounded medium.

N. S. Ageeva analyzed "The Propagation of Sound

Pulses in a Sound Channel," comparing the forms of the signal on the recorder with the ray picture calculated according to the conditions of experiment. The signal, which has initially the form of double and triple pulses, takes on a more complicated shape at large distances (up to 20 km). Controlled experiments with a short pulse showed that the complicated signal consists of individual pulses which correspond to different pulses at the point of reception at an instant of time that coincides with the calculated values. The amplitudes of these pulses agree with the calculation which takes into account the focusing factor and the directivity pattern of the source. With increase in distance between the source and the receiver (located at one horizontal position close to the axis of the channel), the total length of the signal increases. In this case, in correspondence with the ray calculation, the amplitudes of the first pulses, corresponding to the rays which pass earlier, are less than the amplitudes of the subsequent pulses. The shape of the signal is stable, which indicates the small effect of the micro-inhomogeneity of the medium (thermal fluctuations) on the direct field.

It is known that the propagation of normal waves in a medium within variable depth is similar to the propagation of waves in an inhomogeneous medium. Therefore, by preparing a layer with a specially chosen profile, we can obtain different focusing effects.

V. K. **Kuznetsov** investigated experimentally the effect of focusing normal waves by different inhomogeneities, built into a plane layer, representing the results of the measurement in the form of a continuous recording of the amplitude and phase of the sound field on a film of a loop oscillograph. Satisfactory agreement with calculations was obtained.

For the clarification of the applicability of the ray approach to the investigation of wave guides in a layered inhomogeneous medium, V. A. **Polyanskaya** calculated approximately and exactly the group velocities for some plane wave guides with continuous change in the velocity of sound. It was shown that for a definite distribution of the velocity of sound, the monotonic rise of the group velocity was broken by the appearance of extrema due to focusing in the medium and leading to some dependence of the field on the distance

S. **Kalinski** and E. **Kurlandski** (Poland) considered "Several Problems of the Propagation of Waves in Anisotropic Elastic and Non-elastic Media."

I. A. **Urosovskiĭ** solved the problem of "The Scattering of Sound on a Surface of Sinusoidal Shape Characterized by a Periodically-varying Normal Impedance." Assuming that the pressure pi in an incident monochromatic wave depends only on the coordinates x and z (plane problem) while an uneven surface has the form $z = \xi(x)$, the lecturer found that the relation

$$\frac{\partial p}{\partial n}[x\xi(x)] = ik\eta(x)\, p[x, \xi(x)],$$

where $p(x, \xi)$ is the total pressure on the surface, n is the unit normal to the surface, k is the wave number, and $\eta(x)$ is a specified function. For a sufficiently sloping surface we can obtain the value of the total pressure on the surface with the aid of the inverse Fourier transform of the function

$$E(m) = \int_{-\infty}^{+\infty} p[x, \xi(x)]\, e^{imx}\, dx.$$

The value of $p(x, z)$ is an arbitrary point under the surfaces expressed by $p[x, \xi(x)]$ with the aid of the Green's function. The reflection of a plane wave was considered in detail.

Up to the present time the ray representation is used in seismic exploration for the construction of a geological profile. However, the wavelengths are not small in comparison with the thickness of the exploration layers, and the approximation given by such a construction is far from sufficient. By recording the vibrations produced by an explosion on magnetic tape, it is possible, M. A. Antokol'skiĭ pointed out, to amplify the regular wave fronts in comparison to the incoherent vibrations and to obtain additional information on the layers. Reproduction of the magnetic recordings permits us to investigate the decay of the intensity of the vibrations produced by the explosion.

A group of papers was devoted to the propagation and focusing of waves in statistically inhomogeneous media.

V. I. **Tatarskiĭ** considered "The Fluctuations of Amplitude and Phase of Plane Waves Propagating in a Turbulent Medium with Slowly Changing Average Characteristics." The correlation functions of the fluctuation of the index of refraction in such a medium depend not only on the difference in the coordinates at the points of observation $\mathbf{r}_1 - \mathbf{r}_2$, but also on the pair of points in space which is characterized by the vector $\mathbf{r} = \frac{1}{r}(\mathbf{r}_1 + \mathbf{r}_2)$. The form of the functions describing the local properties of a turbulent medium does not depend on the position of a pair of points of observation in space. Propagation of waves in such a medium is described with the aid of a linearized eikonal equation, in which the second derivatives with respect to the coordinates are preserved (the Rytov method of smooth perturbations). The lecturer expressed the spatical two-dimensional spectral density of the fluctuations of the logarithm of the amplitude and the phase of the wave in the plane $x = l$ (the incident plane wave is propagated along the x axis) in terms of the spectral density of fluctuations of the index of refraction. The special case in which the fluctuations of the index of refraction of the medium are described by the "two-thirds law" was considered in detail.

A. S. Gurvich, V. I. Tatarskiĭ, and **L. R. Tsvang** measured the quantity $\sigma^2(\overline{1-\bar{I}})^2/I^2$ (where i is the density of luminous flux) with the help of specially constructed apparatus. They also measured the spatial correlation function, the probability distribution function, and the frequency spectrum of the fluctuations and the luminous flux from the light source placed in the ground layer of the atmosphere at distances from 250 to 2500 m in the frequency range 0.05 — 1000 cps for different (controlled) meteorological conditions. The radius of the correlation function of the intensity is determined by the quantity $\sqrt{\lambda L}$, while the probability distribution function of the fluctuations is satisfactorily described by a logarithmic normal law. The form of the frequency spectrum is in qualitative agreement with the calculated spectral density of the fluctuations. The frequency spectrum of the fluctuations is approximately uniform in the range from 0.05 to 10 cps; above, up to 200 cycles, the spectral density of the fluctuations falls off.

Investigating "Propagation of a Modulated Wave in a Statistically Inhomogeneous Medium," **V. A. Zverev** considered the effect of statistical inhomogeneities (whose correlation radius is much greater than the wavelength) on the phase (PR) and amplitude (AR) relations of a simple third-harmonic wave. In geometric approximation ($L \ll l^2/\lambda$) the effects, which consists in the change of PR and AR relations, are proportional to the magnitudes of the fluctuations of phase and amplitude of the wave. In the case of large distances ($L \gg l^2/\lambda$) there appears an additional factor p equal to the ratio λ/l and l/λ. Since the expressions, for the change of PR and AR contains the sound pressure p in different degrees, they can be used for the experimental examination of p, and consequently for the radius of correlation. **V. A. Zverev** showed a block diagram for the simultaneous recording of PR and AR which allowed him to measure the pressure p.

In order to bring about agreement between the equation of a wave propagating in a medium with large scale random inhomogeneities and the conservation of energy, it is necessary to introduce the normalizing factor $\exp(-L^2)$, which depends on the mean square fluctuation of the level. The normalizing factor for this requirement is determined non-uniquely, with accuracy up to an arbitrary phase factor $e^{i\varphi}$. With the aim of clearing up the ambiguity, **L. A. Chernov** and **T. A. Shirokova** applied a method for the determination of the "Normal field of a wave in a statistically inhomogeneous medium," which is based on a consideration of the second approximation in Rytov's method. They showed that the phase φ in the general case is not equal to zero. (However, this is not important for energy considerations, inasmuch as the energy is determined by the square of the amplitude.)

M. N. **Krom** and L. A. **Chernov** reported that the "Dependencies of the Diffraction Image in a Lens on the Magnitude of the Fluctuations of the Incident Wave" lead to the appearance of pulsations in the diffraction image and to deformation of the central diffraction image. They cleared up the effect of the dimensions of the objective on the relative fluctuations at the focus without limitation on the smallness of the excitation in the incident wave.

É. A. **Blyakhman** applied the spectral method for the investigation of the effect of a focusing system on the pulsation of the field of the wave which traverses a medium containing random inhomogeneities. For chaotic motion of the inhomogeneities, values of the spectral density were obtained in limiting cases of large and small fluctuations of the field of the incident wave and the dimensions of the lens that were large and small in comparison with the scale of the inhomogeneities. It was shown that for regular motion of the inhomogeneities in the special form of the correlation function of the pulsation of the field in the incident wave the lens acts as a filter separating out the characteristic frequencies.

V. N. **Karavaĭnikov** computed the coefficient of mutual correlation between the fluctuation of amplitudes and phase and also the correlation of longitudinal and transverse auto-correlation of the fluctuation of amplitudes and phases in a spherical wave.

"Distribution Functions for Fluctuations of the Field in the Shadow Zone" was reported by **B. E. Kinber** and **L. G. Solov'ev**. The fluctuations of the field propagated across a statistically inhomogenous medium in the shadow zone are determined by two factors. From the change of the gradient of the index of refraction, the scale of which is commensurate with the distance between the source and the receiver, the scattering angle changes, which produces slow fluctuations of the field. The field of isolated inhomogeneities, whose scale exceeds the wavelength but is much smaller than the distance between the receiver and the source, combines with the random inhomogeneities which produces a rapid fluctuation of the field. The differential and integral distribution of the resulting signal was considered under the assumption of a statistical inhomogeneity of the slow and fast fluctuations in the reception at one and at two receivers. This distribution is well approximated by a Gaussian distribution of a quadratic polynomial for the logarithm of the signal.

A. D. Lapin solved the problem "Of the Scattering of Sound Waves in Irregular Waveguides" with consideration of multiple scattering, that is, in the case in which the first approximation of the method of small perturbation turns out to be inadequate. For each of the plane waves of which the incident normal wave is composed he applies the method of Rytov and finds the scattered field from these plane waves under the condition that the total field satisfied the boundary conditions on the walls of the wave guide. By way of irregularities, he considered small fluctuations of the parameters of the medium filling the wave guide and also roughness and inhomogeneity of the walls of the guide.

Ordinarily the problem of a long line with random inhomogeneities is solved by the method of successive approximations. Actually only the first approximation is found, in which the coefficients of reflection are added vectorially, while the attenuation of the initial incident wave resulting from reflection from the inhomogeneities and multiple reflection are not considered. **M. E. Gertsenshteĭn** and **V. B. Vasil'ev** obtained an exact equation for the probability density of the reflection coefficient for a lossless line with random inhomogeneities located at a great distance from one another. The equation takes into account multiple reflections and the attenuation of the initial wave, while to each new inhomogeneity there corresponds a fractional linear transformation of the curved diagram. Inasmuch as the inhomogeneities are statistically independent, the problem reduces to finding the resulting random fractional linear transformations. It turns out that in summing up a large number of random small vectors the probability density $w(x, y)$, as a function of the coordinates x, y, of the vector of total reflection coefficient, satisfies the diffusion equation.

In connection with problems of the investigation of noise, interest has been aroused in the study of elastic walls which vibrate under the action of statistical distributions of forces. **M. A. Isakovich** has considered the field generated in the Fraunhoffer region of a plane elastic surface bounded by a liquid and containing vibrations under the actions of statistically distributed surface forces. Taking the radius of correlation of these forces to be small in comparison with the dimensions of the surface under investigation, he solved the problem with the aid of an expansion of the surface forces in a double Fourier integral over the surface by application of the Rayleigh method. This permitted him to consider the reaction of the medium to the vibrating surface and to solve the dynamical part of the problem, representing the normal displacements of the surface also in the form of a double Fourier integral. Then the desired field was represented in the form of a single-term Green's function, whence he obtained for the Fraunhoffer region characteristics of the directivity of the radiation, expressed in terms of the correlation function of the surface forces. It was shown in particular that the radiation in the direction of the normal to the surface does not depend on the elastic properties of the surface; computed formulas were given for special cases of an elastic surface comprising a tightly-drawn membrane and in the form of an elastic disc subject to flexural vibrations. The results obtained can also be applied to the problem of a slightly curved elastic surface.

L. M. Brekhovskikh considered the Rayleigh surface wave that propagates along a rough free surface of a solid body. Assuming that the depth of the inhomogeneities (regular or statistical) is small in comparison with the length of the Rayleigh wave, he solved the problem by the method of successive approximations. The first approximation corresponds to the propagation of the wave along the plane free surface. In the first approximation the effect of inhomogeneities is equivalent to the action of an additional stresses distributed over the plane surface. These stresses produce scattered waves which are transverse and longitudinal, and which go out from the surface, and also new surface waves, which propagate along the surface with velocities that differ from the velocity of the Rayleigh waves. The waves diverging from the surface produce a damping of the original wave. Being superimposed on the first wave, they create, in the case of propagation of a monochromatic wave, a picture of spatial beats and in the propagation of a pulse they distort its shape.

A large part of the papers of the sessions on "Nonlinear Acoustics" were devoted to problems of the propagation and absorption of waves of finite amplitude in gasses and liquids.

Considering the propagation of plane waves of finite amplitude in a viscous medium, **V. A. Burov** combined the Navier-Stokes equation and the equation of continuity (under the assumption of smallness of the Mach number and of the change of shape and amplitude of the wave in a single wavelength and also of the adiabatic equation of states) to form a quasi-linear equation. Solving this equation for harmonic boundary conditions he found that at a certain distance the wave took on a saw-toothed shape and had a large absorption coefficient in comparison with that of small amplitude waves.

Considering "The Propagation of Spherical Waves of Finite Amplitude in a Viscous Thermally Conducting Medium" in Lagrangian coordinates, **K. A. Naugol'nykh** got rid of the nonlinearity of motion and simplified the giving of boundary conditions. He solved the equation, which describes with accuracy up to terms of second order in the Mach number, by the method of Krylov-Bogolyubov. K. A. Naugol'nykh found that, for sufficiently high intensities, an initial sinusoidal wave changes to a sawtooth form at a finite distance from the source, in spite of the fact that in addition to viscous absorption there is a great decrease of the amplitude as a result of the divergence.

This was experimentally verified by **E. V. Romanenko**, who demonstrated that in spite of the large decrease in the amplitude of the wave because of spreading, the wave took on a markedly sawtoothed shape while the second harmonic increased in magnitude to thirty per cent of the first harmonic. The measurements were carried out in the range 0.8 — 1.2 Mcs and at intensities up to 300 w/cm^2 in a pulsed mode with miniature piezoelectric receivers and quartz plates. The role of cavitation in the distortion of a (plane) wave was also investigated. It was shown that increase in pressure up to 18 atmos does not affect the shape of the wave.

However, observing the shape of a plane sawtooth wave at a frequency of one megacycle and intensity 35 w/cm^2 in tap water, **V. A. Burov, L. K. Zarembo, V. A. Krasil'nikov,** and **V. V. Shklovskaya-Kordi** established the fact that a decrease in the amplitude of the original takes place in time (~ 10 to 30 sec) and came to the conclusion that this "limitation" is a consequence of cavitation. They also measured at a frequency of 1.5 and 4.5 Mcs the mean phase velocity of propagation of a wave of finite amplitude in a solution of methyl alcohol and water, which is characterized by a small temperature coefficient of velocity (two orders of magnitude smaller than the pure liquids). The velocity increases smoothly with the intensity slowly at the beginning and then in a jump coincident with the "limitation." The general increase in the velocity was of the order of tens of centimeters per second.

Measuring the intensity of ultrasonic waves of finite amplitude in water at frequencies of 1.5 to 6 Mcs, **D. V. Khaminov** found that the absorption coefficient as the function of the initial intensity (which reached 1 w/cm^2 at the source) increased in water at the absence of cavitation by a factor of 5 — 40. The frequency dependence of the absorption coefficients satisfies the law $\alpha_{max} \sim f$. For a given frequency, the relation $\alpha_{max} l$ = const was observed approximately, where l is the distance for stabilization of the wave shape.

Investigating the diffraction of light by ultrasonic waves of finite amplitude, **I. G. Mikhailov** and **V. A. Shutilov** discovered a sharp asymmetry in the distribution of light around the diffraction maximum. Considering the diffraction of light with account of phase modulation by sound waves of sawtooth form, they constructed models of these waves according to the photographs of the spectra for different distances from the source and computed their intensity. The results obtained agreed, within the limits of experimental error, with the results of measurement of the absolute intensity of ultrasonic waves. By allowing the ultrasonic wave to pass through glass plates of thickness of one fourth, one third etc., of the wave, the authors separated from the spectrum of the distorted sound wave the various harmonic components, observing in this way the corresponding double, triple, etc., distance between the diffraction maximum.

Eikhenval'd, has already considered the acoustic field of finite amplitude which arises in a non-viscous thermally conducting gas between rigid walls for an initial sinusoidal propagation velocity of the particles. **Z. A. Gol'dberg** generalized these results to the case of an arbitrary medium with viscosity and heat conduction, which leads to an exponential damping in time. Considering the wave field established in the case in which one of the walls is rigid while the other vibrates, the author established the dependence of the amplitude of quantities of second order on the spatial coordinates and the presence in the second approximation of two terms, one of which leads to a symmetric and the other to an asymmetric (relative to the nodes) distortion of the form of the field.

A. L. Polyakova considered the propagation of sound of finite amplitude in a relaxing medium as a non-equilibrium process and obtained, on the basis of thermodynamics of irreversible processes, an expression for the energy dissipated in this process (the nonlinearity of the equations of hydrodynamics was preserved in this case). Considering the shape of the wave in an actual relaxing process to be Riemann, and expanding in a series, she found corrections of the second order to the absorption coefficient of the wave (according to the ratio of the dissipated energy averaged over time to the total energy stored in the wave).

Similar problems were taken up by **E. V. Stupochenko** and **I. P. Stakhanov**, who considered the theory of stationary flows of liquid (acoustic wind, Dvorzhin's phenomenon) in relaxing media. On the basis of the calculation, they set up the equations of motion of a viscous liquid supplemented by the "reaction" equation that describes the change in time of the parameter ξ (which characterizes the departure of the medium from the state of thermodynamic equilibrium), and the equation for the increase of entropy as a result of irreversible processes connected with change in ξ. Averaging the terms of the equation over times which are long in comparison with the period of the sound, and small in comparison with the characteristic time of the cumulative perturbation, the authors solved the equations which describe the quasi-stationary flows in second approximation in the case of cylindrical sound fields (for an arbitrary, radially-symmetric distribution of the sound intensity). In this case, account is taken of the attenuation of sound which is propagated along the axis of the cylinder; this is especially significant for frequencies close to the reciprocal of the relaxation time. In the limiting case of small relaxation times, the theory just developed describes the acoustical wind in a medium with volume relaxation in which, however, the attenuation of sound is taken into account.

The theory of secondary flows was also considered by **P. N. Kubanskiĭ**, He concerned himself with the mechanism of vortex formation in a resonator with a flange for the flow of air past its neck. The transverse flow which moves around the neck of the resonator forms a turbulent stream about it which experiences a lateral pressure produced by the flow in the cavity of the resonator. With increase in the velocity of flow, the force acting on the stream increases, the flow is diverted beyond the limit of the neck and gives an exit to the vortex from the cavity of the resonator. The self-oscillations that arise in such a case are characterized by large amplitudes of vibration of the stream; therefore secondary external streams arise in the neck of the resonator. The author assumed that the vortex formation in the neck of the resonator represents a superposition of vortices emitted periodically from the cavity of the resonator and which are generated by the vibrations of the stream.

Measuring the absorption of ultrasonic waves of infinitely small amplitude in solutions of rubbers and polymers, **I. G. Mikhailov** and **N. M. Federova** found that it differs only slightly from the absorption in the pure solvent although the macroscopic viscosity of the solution can exceed the viscosity of the solvent by a significant amount. A small additional absorption in the solutions is produced by losses in friction arising in the motion of the solvent relative to the polymer chains. In the transition to ultrasonic waves of finite amplitude, the forces of friction are so increased that there arises a disruption of the polymer chain. At this moment, the magnitude and character of the absorption in the polymer solution changes sharply. Evidently the process of disruption of the polymer possesses an activation character connected with the jump across the potential barrier; therefore, the threshold voltage on the quartz (for which the disruption of the structure of the solution takes place) is proportional to U/RT (U is the energy of coupling of the links of the chain, T is the temperature, and R is the gas constant). Investigating the temperature dependence of the threshold voltage, the authors found the magnitude of U for certain solutions of polymers, indicating in this way the possibility of use of ultrasonic waves of finite amplitude for the study of the interaction of polymer molecules in solution.

For a number of practical problems in hydroacoustics, there is an urgent need of increasing the intensity of the source. But the intensity of ordinary sound sources is sharply limited by the increase in nonlinear effects. New possibilities are presented by the phenomenon of sound production by sparks and corona discharges in water, investigated by **N. A. Roĭ**, **D. P. Frolov** and **A. L. Polyakova**. Studying the conditions of sparks of maximum duration, the electrical and acoustical characteristics of spark discharge, they found it possible to obtain high electro-acoustical efficiency. Applying the corona discharges they could spread out the sound formation over a large volume, decreasing the slopes of the fronts of the acoustic pulses and at the same time lowering the dissipation of the energy of the pulses in the medium. However, the electro-acoustical efficiency of the corona discharges are not large and research is needed towards their increase.

Several papers were devoted to problems of propagation of shock disturbances in various media. For the medium whose internal energy is determined by the specific volume and entropy, the form and properties of the shock adiabatic could be established (using differential relations which hold along the Hugoniot adiabatic), if the sign of the second derivative of the depression with respect to its specific volume is constant throughout the whole region. **G. Ya. Galin** succeeded (by obtaining additional evidence on the shock adiabatics) in establishing the form of the Hugoniot adiabatics and investigating the properties of the shock transition for media with arbitrary equations of state (when the derivative $\partial^2 p/\partial s^2$ changes sign along the Poisson adiabatic). He clarified the propagation of the disturbance in such ideal compressible media and showed, in particular, the possibility of the existence of more than just a single solution. For the choice of the latter, use was made of considerations of the stability of the surfaces of strong discontinuity.

N. N. **Kochina** investigated the problem of a powerful point explosion in an ideal compressible medium. If the internal energy of the medium has the form

$$\varepsilon(p, \rho) = \frac{p}{\rho}\varphi\left(\frac{\rho}{\rho_0}\right)$$

(where ρ_0 is a certain density), the problem is self-similar and reduces to the solution of an ordinary differential equation of first order, the form of which depends on the function $\varphi(\rho/\rho_0)$ and its derivative. Obtaining a special exact solution [which holds for an arbitrary function $\varphi(\rho/\rho_0)$], Kochina solved as examples some problems involving a strong shock, in particular, a shock in a medium similar to water, and found estimates for the time during which we can consider the shock to be strong.

Solving the equations of gas dynamics, which describe the propagation of waves of small amplitude (under the supposition that the width of the disturbance region is small in comparison with the characteristic dimensions of the problem), **K. E. Gubkin** found that the nonlinear character of the motion appears in significant fashion when the wave has traveled a distance which is appreciably greater than the width of the disturbed region. Account of nonlinear factors leads to a change in the profile of the wave and the formation of discontinuities in it, and also to an additional damping of the shock front. At large distances, the profile of the pressure wave behind the front is always close to linear, independent of the initial shape.

S. I. Sidorkina considered the formation of a shock wave by a flat massive plate which is also excited by a shock wave. The author made clear the fact that in a nonstationary shock the maximum intensity of the secondary wave is necessarily smaller than the primary, and obtained results of the approximate calculation of the motion of the plate in the gas behind it.

The research of the section on "Radiation and Diffraction of Sound" was devoted principally to the development and to the comparison between the different exact and approximate mathematical methods of the solution of stationary and nonstationary wave problems. In connection with the development of the acoustics of solids, a great deal of attention was given to vector wave equations, in addition to the consideration of the scalar wave equation.

In a group of papers presented by **G. I. Petrashen'** and his coworkers, there was put forth and developed a general method of the exact consideration of diffraction in corners which generalizes the Smirnov-Soboleva method, and the method of integral representation of Sommerfeld, developed in the researches of G. D. Malyuzhinets and his school. **G. I. Petrashen'** and **B. G. Nikolaev** noted that this method permits us to solve "naturally" and uniquely all the known classical stationary and nonstationary problems of diffraction from a doubly bounded angle, and also leads to the final result in a series of cases not considered previously.

Reporting on the results of the calculation of diffraction fields in stationary and nonstationary acoustical problems, **B. G. Nikolev** and **M. V. Vasil'eva** developed detailed formulas for computations and considered the qualitative and quantitative laws in the change of the field in the diffraction region. Detailed consideration was given to the case of a plane incident wave from plane and point sources.

An "Approximate Consideration of the Wave Field Close to a Randomly Rough Surface," was applied by **G. D. Malyuzhinets** to the approximation of transverse diffusion (change of the elliptical equation to the parabolic); he showed that the result of statistical averaging of the field of random functions over the ensemble coincides with the solution of the simplest problem involving the reflections of a wave created by the same source from an infinite bounding plane, characterized by some normal impedance. The magnitude of this "average" impedance depends on the spectrum of the random function and can be computed or determined by experiment. The effect of attenuation with increasing distance from the source can be estimated in terms of the "average field." The field close to the random surface can be represented as the sum of this field and the random one, corresponding to the effect of scattering and leading to fluctuations.

A new, simple and exact method of solution was considered by **M. D. Khaskind** for the problems of propagation and diffraction of sinusoidal waves in a half-space the boundary conditions on whose plane boundary are of the third kind. Using the general solution obtained, the author determined a simple form for the function of the radiation of cylincrical, spherical, and other sources and gave a method for the determination of exact solutions of problems of radiation and diffraction of sound waves by a vertical plate which partially encloses the half-space, by a plate containing a closed region, by a horizontal half-plane which encloses the part of the boundary of the liquid, etc.

The paper of **A. S. Goryainov** also contained an exact solution of one of the diffraction problems — the diffraction of a plane sound wave on a rigid infinite cone (and, correspondingly, of a plane electromagnetic wave on a conducting cone). The solution, which contains a diffraction series, is transformed into a contour integral, in which the incident wave is separated out. The contour integrals, which contain only the field reflected from the surface of the strip, are evaluated by numerical methods. The speaker compared the results of the exact theory with geometrical optics, and also with some approximate methods in the special case of axial incidence of the plane wave. For the case of reflection from it, a simple formula was obtained which gives excellent agreement with the exact theory.

Approximate solutions of diffraction problems were considered by **A. A. Fedorov** and **I. N. Kanevskiĭ**. The first of these, using the method of V. A. Fock, and assuming that the diffracting body of revolution was sufficiently large ($ka \gg 1$, a being a characteristic dimension of the body), summed the diffraction series asymptotically, the series representing the exact solution of the problem. Putting the computed formulas in the form of a product of Bessel functions and tabulated functions, and carrying out numerical computations for $ka = 5$ and 10, the author found that satisfactory agreement with the calculations from the exact theory is obtained for a sphere for $ka \gg 5$. The field in the distant zone is the result of the interference of the wave reflected according to geometrical optics and the waves which bend around the sphere by the meridional path (diffraction waves). The relations obtained for certain physical assumptions relative to the phase and amplitude of the diffraction waves can be generalized for spheroids.

To date, the results of experimental investigations of the field at the focus of sound focusing systems have been compared with the calculation of a field which does not consider the diffraction of the sound itself on the receiver. In the same way, in the calculations of sound concentrators, no consideration was given to diffraction on irradiated objects placed at the focus. Considering the diffraction of a converging cylindrical infinite front on an infinite cylinder (placed coaxially with the front), and also on a sphere (the center of which is located on the axis of the front), **I. N. Kanevskiĭ** found expressions for the potential, pressure and velocity of the resulting field, computed the distribution of the pressure and the velocity of the surface of a rigid cylinder and obtained asymptotic expressions for the intensity and total scattered power of the wave. A comparison carried out for the case of the diffraction of a plane wave by a cylinder and a sphere permitted him to make clear the characteristic peculiarities of the problem.

In discussions arising during the talks, **G. D. Malyuzhinets** interpreted some results with the help of a representation of the transverse diffusion of the amplitude over the wave front.

The next three papers were devoted to vibrations of elastic bodies. In the paper of **S. V. Kaliski** (Poland), the difficult problem of the vibrations of a finite elastic cylinder was first subjected to an exact analysis. In this case, the method of solution was based on a knowledge of the problem for a completely regular infinite system of algebraic equations.

V. V. Tyutekin took up the diffraction of a plane longitudinal wave propagated in an isotropic elastic medium on a cylindrical cavity of infinite length for an arbitrary direction of the incident wave. The scattered field was given in terms of scalar and vector potentials. The components of the vector potential were determined with the aid of three vector functions, each of which satisfies the vector wave equation. The solution is an unbounded sum of cylindrical waves of different orders, in which the zero term corresponds to pulsating vibrations of the walls of the cavity for different angles of incidence. In this way the author solved the problem of the scattering of a plane sound wave incident, at an arbitrary angle, on an elastic cylinder of arbitrary radius. It was shown that if one of the characteristic values of the wave number inside the cylinder coincides with the projection of the wave number in the medium on the axis of the cylinder, an intense scattering of the sound takes place.

L. Ya. Tutin discussed flexural vibrations of an infinite strip with supported edges and showed that if the width of the strip is less than half the width of the flexural wave, an undamped traveling flexural wave is not possible. For infinite length of a strip with free edges, he determined the dependence of the velocity of propagation of flexural waves on the ratio of the width of the strip to the flexural wavelength.

In connection with problems of the elimination of vibrations and the noises produced by them, there was great interest in the physical investigation of the interaction of the vibrations of the elastic plates and shells with an acoustic field in the surrounding medium, and a series of papers was given on the subject.

L. A. Molotkov and **G. I. Petrashen'** gave a paper on "Certain Dynamical Properties of Thin Elastic Layers." They considered free, thin, plane-parallel layers immersed in a liquid, and in contact with an elastic medium. On the basis of an exact solution, they clarified the question of the character of external dynamical influences, for which the layer can be replaced by an equivalent membrane, plate, or other degenerate system. The type of the degenerate system depends essentially on the medium in which the layer is found, and also on the character of the influence. For example, a thin elastic layer can be regarded as a plate if it is located in a cavity, but not so if it is immersed in a liquid.

L. M. **Lyamshev** considered the scattering of a statistical sound field from a thin elastic homogeneous shell when this field is defined by a certain distribution of random sources in a homogeneous medium, where the shell is found; he also considered the radiation of the statistical sound field of the vibrating elastic shell located in a homogeneous medium when the vibrations of the shell are defined by certain surface statistical forces. Both problems are solved by an application of the reciprocity theorem to the statistical field and the auxiliary diffraction (nonstatistical) field defined by a source located at the point in space at which it is necessary to determine the intensity of the statistical field. In this case the results obtained previously are used for the calculation of diffraction on the shells. The author computed the spectral intensity of the statistical field in the case of spherical and cylindrical shells and thin plates at distances that are large in comparison with the dimensions of the body.

An "Exact Solution of the Plane Wave Diffraction Problem on a Semi-infinite Elastic Plate" was obtained in the form of a Sommerfeld integral by **G. D. Malyuzhinets** by a generalization of the method used previously in the problem of diffraction on a wedge with boundary conditions of the third kind (with given edge impedances). The differential equations of flexural and longitudinal vibrations of a thin plate (with account of the external force distribution) serve as boundary conditions for the sound pressure p which satisfies the wave equation $\nabla^2 p + k^2 p = 0$ outside the plate. The vibrations of the plate in turn satisfy the boundary conditions of general form (with consideration of possible external influence) on the edge $x = 0$. Giving the amplitudes of the waves incident on the edge from infinity, waves which are propagated both in the surrounding medium and along the plate itself, the author found a solution which is continuous in the region and on the boundary, and which also satisfies the condition of extinction. As special cases he considered: diffraction on the plate of a plane wave incident at an arbitrary angle, reflection from the edge of the plate and radiation into the surrounding space of a flexural or longitudinal wave which passes along the plate from infinity, and propagation and radiation of a wave which is excited in the plate for a given reaction on the edge.

V. S. Buldyrev, applying the method of contour integration developed in the researches of G. I. Petrashen' and his coworkers, solved the nonstationary problem of the diffraction of sound waves on a membrane of a cylindrical shell. He found that the excitation of a reflected wave in the vicinity of its front is independent, in first approximation, on the parameters of the shell, and coincides with the excitation of a wave reflected from an absolutely rigid cylinder. As a consequence of the velocity dispersion in the shell, the disturbance before the front of the head wave is different from zero. The dependence of the intensity of the head wave at its front on the different parameters of the problem was made clear, and the possibility of replacement of thin elastic layers bounding the medium (in which the propagation of the waves take place) by models of the type of membranes and shells were discussed.

Too few experimental investigations make a significant contribution to the study of diffraction phenomena. Continuing their long-standing research on the visualization of ultrasonic fields, **S. N. Rzhevkin** and **V. I. Makarov** investigated, both experimentally and theoretically, the process of the excitation of ultrasonic waves in plates and cylindrical shells in the exposure of them from a liquid medium. The importance of discrete "excitation bands" on the shells was made clear and the possibility of simultaneous excitation of several types of waves in a solid layer was established. It was shown that the sound field in a cavity enclosed by a shell, excited by ultrasound, forms a region limited by a caustic surface, inside which there is no sound. The sound field outside the shell forms a stable interference picture of the bands, perpendicular to the shell (in the establishment of standing waves in the shell).

In the last paper of this group, given by **L. Ya.**

Gutin, the approximate relation between the mean square amplitude of the vibrational velocity and the radiated power for a complicated form of the excitation of rectangular plates with supported borders was given. It was first established that the coefficient of radiation of such a plate is almost identical for the excitation at resonant frequencies in the frequency range whose lower limit is determined by the ratio of the smallest dimension of the plate to the wavelength, and the upper limit, for the frequency at which the length of a free flexural wave in the plate is equal to the wavelength in the surrounding medium ("critical frequency"). It was then assumed that in the expansion of the force F in eigenfunctions $F = F_{mn}\psi_{mn}$, all F_{mn} are constant, and that intervals of frequencies between the exciting forces and the eigenfrequencies of the plate are equally probable.

The section on ultrasonics covered physical investigations of the propagation and absorption on nonlinear (together with the section on nonlinear acoustics) and linear ultrasonic vibrations in gases, liquids and solids, and investigations of a physicotechnical character, connected in large or small measure with the application of ultrasonic vibrations in technology. Papers of a purely technical and applied character were not given, since such researches were discussed in a series of specialized conferences.

The first session was devoted to problems of the acoustics of solids.

K. N. Baranskii told of measurements of the attenuation of longitudinal vibrations with frequencies from 2×10^8 to 7.5×10^8 cps in (X-cut) quartz plates, excited in the higher harmonics of their base frequency. In this case a method was developed and applied which makes use of the phenomenon of the diffraction of light on ultrasound and which permits one to determine the temporal absorption coefficient from an investigation of periodic processes of establishment and attenuation of elastic vibrations in a quartz plate in its excitation by rectangular pulses of a high-frequency electric field. The form of the diffracted light pulses obtained were studied by a photomultiplier and an electronic oscilloscope. Values of the absorption coefficient obtained by this method, at a frequency of 5×10^8 cps, varied for different plates from 0.1 to 0.2 cm^{-1}. The values obtained agreed in order of magnitude with the theory developed by I. G. Shaposhnikov and S. N. Tkachenko.

The velocity of longitudinal and transverse vibrations in binary solid solutions of nickel-chromium and nickel-titanium for different amounts of plastic deformation and concentration of the chromium was measured by **T. Ya. Benieva,** who used a pulse method.

E. Ranachowski and **B. Lesniak** (Poland) studied experimentally the relation between the dielectric loss factor and the absorption of ultrasound in bakelite resin and polystyrene. They made an attempt to explain the mechanism of this loss in connection with this phenomenon.

Z. Pawlowski (Poland) considered the possibility of measurement of the elastic modulus of polycrystals by means of the determination of the angle of total reflection of ultrasonic waves. The results of the measurement were compared with data obtained by statistical methods.

O. I. Silaeva and **O. G. Shamina** gave reports on the peculiarities of measurements of the velocity and absorption of longitudinal and transverse waves on different laboratory specimens (plates, rods, massive blocks). It was established that the absorption coefficient of longitudinal waves in rods, plates and unbounded media have different values, which agrees with the theoretical data of G. I. Gurevich.

The special characteristics of propagation of surface waves was the subject of widespread discussion in the ultrasonics section. This is explained by their increasing role in the control of surface defects. Considering the problem of the possibility of formation and propagation of Rayleigh waves in a plane elastic layer with free boundaries, **I. A. Viktorov** showed that among the totality of normal waves excited by the source of Rayleigh waves placed on one of the free surfaces of the elastic layer, there is a component which is similar to a Rayleigh wave in the region close to the source. The lecturer investigated experimentally the origin and behavior of this component and obtained satisfactory agreement with calculations. He also computed the spatial coefficients of attenuation of the Rayleigh waves in aluminum and steel in terms of the corresponding coefficients of longitudinal and transverse waves and compared them with the experimental values. Qualitative agreement was obtained.

K. N. Vinogradov and **G. K. Ul'yanov** measured the phase velocity and attenuation of ultrasonic surface waves in certain metals, alloys and glasses. The vibrations were excited by the wedge method. In the measurement of the phase velocity, the receiver consisted of a noncontact magnetoacoustic receiver moved along the specimen. The attenuation was measured by the pulse method in a frequency range up to 5 megacycles with the help of wedge transducers. It was shown that the attenuation depends strongly on the purity of the preparation and the protective covering.

N. N. Egorov spoke on some peculiarities of the propagation of ultrasound along the surface of a double layered solid medium (the thickness of the upper layer was approximately equal to the wavelength). Since the attenuation of the ultrasound turned out to be strongly dependent on d/λ and for constant λ is (in a certain interval of thickness) a linear function of the thickness, it became possible to make an ultrasonic instrument for the measurement of the depth of the surface of hardened, cemented and certain other surface-hardened layers.

Some data on the diffraction of surface ultrasonic waves on a solid wedge, which are useful for the determination of the profile of a sample in an interferometric measurement of the velocity of propagation of surface waves, were given by **I. P. Denisov**.

A great deal of attention in the section was paid to the problem of the propagation and absorption of ultrasound in liquid media and alloys. **V. F. Nozdrev, N. I. Koshkin,** and **M. A. Gorbunov** gave a review paper on studies of the physico-chemical properties of complicated thermodynamical systems by ultrasonic means.

The investigation of binary liquid-crystal phase systems in the case of organic liquids showed the interdependence of the absorption coefficient and the peculiarities of the crystalline structure of the material. The absorption in the transition region is connected with the behavior of other physico-chemical parameters (heat capacity, coefficient of volume expansion, index of refraction, etc). The character of the dependence of the absorption on temperature in the transition region was explained qualitatively by them, beginning with the theoretical considerations of Ya. I. Frenkel' on the presence of quasi-crystalline regions. Investigations of the propagation and absorption of ultrasonic waves in the liquid-vapor system along the saturation curve and in the critical region permitted them to make clear the relation between the velocities of sound in the liquid and saturated vapor under conditions of dynamic equilibrium. The data on acoustical measurements were used for the calculation of the heat capacity and other physico-chemical parameters of the liquid.

Considering the problem of the absorption of ultrasound as the result of the excitation of two or more discrete energy levels, **R. Beyer** (USA) showed that the total absorption coefficient could be expressed as the sum of coefficients defined by the separate relaxation processes with normal modes of relaxation. Studying the ratio of the frequencies of these normal modes to the reactions rate corresponding to the excitation of a single level, he found that in many cases the frequency of the relaxation of lowest excited level is the normal frequency.

Analyzing new comparative data on dielectric relaxation and on ultrasonic shear and bulk relaxations in viscous associated liquids, **T. A. Litovitz** (USA) came to the conclusion that the ultrasonic relaxation times were frequently close in value. So far as the relations of the ultrasonic relaxation times and the dielectric relaxations are concerned, for some molecules they are close together, while for others of the same structure, this is not the case.

I. G. Mikhailov analyzed current experimental data on the absorption of ultrasonic waves in ethyl acetate, including measurements made in the author's laboratory by a pulse method in the frequency range of 5 — 25 megacycles. The most reliable experimental data agree well with the theoretical relaxational dependence of the absorption for a single relaxation time of the bulk viscosity.

This point of view was disputed in debates by **B. B. Kudryavtsev** and others. The discussion centering on this question was continued in a specially organized seminar.

B. B. Kudryavtsev gave a review paper on the application of ultrasonic measurements to the study of liquids. Setting forth briefly the phenomenological and molecular-kinetic theory of sound propagation in liquids, the lecturer demonstrated by several examples the possibility of the use of acoustical measurements in the study of the nature and properties of liquids.

The paper by **I. Z. Fisher** was devoted to the problem of establishing the connection of the sound velocity in liquids (and compressed gasses) with the molecular characteristics of the material. He analyzed two models, achieving an exact solution of the problem of the velocity of sound for arbitrary temperatures and pressures; a one-dimensional model of a liquid with an arbitrary law of interaction between the particles, and a three-dimensional model of a system of non-interacting spheres. Using the results and methods of contemporary statistical mechanics, he succeeded in both cases in expressing the sound velocity exactly in terms of thermodynamical parameters and the molecular characteristics of the system (mass and dimensions of the particles, potential of the intermolecular forces), which allowed him to give an exaustive analysis of the solution.

V. F. **Nozdrev** and B. I. **Kal'yanov** investigated the velocity and absorption of ultrasound in liquids by the pulse method for constant density as a function of temperature only. This permitted them to simplify the theoretical analysis of the relaxational processes that have been discovered and investigated experimentally.

M. S. **Pesin** and I. L. **Fabelinskiĭ** spoke about a continuation of investigations begun previously of the dispersion of the velocity of hyper-sound (with frequency $f = 10^{10}$ cps) in liquids with large volume viscosity coefficient; the measurements were carried out by the method of studying the fine structure of the Rayleigh scattering line. Dispersion of the velocity of sound was discovered (10 — 15%) in liquid methylene chloride, methylene bromide, and chloroform. The relaxation time of the second viscosity coefficient and the coefficient of absorption of these liquids were determined and discussed from the viewpoint of the relaxational theory of the absorption of sound in a liquid.

The widespread application of acoustics in the study of the physical properties of material was illustrated by a series of papers on the propagation of sonic vibrations in mixtures of different kinds and the connection of acoustical and other characteristics of these materials in the critical regions and at points of transition.

M. V. **Bessonov** talked about some peculiarities of the propagation of ultrasound in molten salts, in fused resin and in fused lead (frequency of 2.4 megacycles). For cooling in the region of vitrification, a sharp change takes place in the sound velocity. The measured values of the velocity were applied to the calculation of the coefficients of thermal conductivity by Bridgman's formula, in which satisfactory agreement with the results of direct measurements of these quantities was obtained.

N. F. **Otpushchennikov** measured the velocity of ultrasonic waves in the transition from the liquid state to the solid in naphthalene, hyposulfite, phenol and in low-melting-point alloys, and found that in the region 3 — 6°C from the beginning of crystallization of the material, the sound velocity changed anomalously (not by a linear law) with temperature. This shows that the process of crystallization is not a process which takes place only at the temperature of solidification and that, in a certain precrystallizing region, a process takes place involving the preparation of the material for crystallization. The latter conclusion is confirmed by other nonacoustical investigations of the physical properties of a number of materials close to the temperature of melting and crystallization.

V. I. **Ilgunas** and E. P. **Yaronis** studied the magnetic dispersion of ultrasound in mercury, liquid sodium and calcium with the use of interferometers. The interferometers were placed in a transverse magnetic field with an induction of 6 to 9 kilogausses at frequencies of 2.5 to 4 megacycles. For a roughness of measurement of ± 3 millimicrons, no effects of the magnetic field on the ultrasonic velocity were observed, which contradicts the theory of N. S. Anderson. Theoretical calculation of the magnetoacoustic effect, carried out by the authors by the method of hydrodynamic theory of sound with consideration of thermodynamic and electromagnetic factors, showed that the change in the sound velocity in the liquid metals investigated (in the limits of ultrasonic frequencies) gave a magnitude of the effect only of the order of 10^{-5} to 10^{-9} m/sec.

Z. L. **Khodov** spoke on measurements of the ultrasonic velocity in binary alloys Bi-Cd and Bi-Pb. The measurements were made by the pulse method at temperatures exceeding the melting point by 5 — 10°. It was established that the concentration dependence of the ultrasonic velocity is the same as for the alloys Bi-Sn (studied earlier), and is expressed by two straight lines that intersect at a point corresponding to the eutectic composition of the alloy. The concentration dependence of the coefficient of adiabatic compressibility (computed from the known values of the velocity and density of the alloys) is represented by two curves that intersect at this same point. The concentration dependence of the velocity for alloys of the system Bi-Pb of eutectic mixture and with an excess of lead is represented by a straight line.

The experimental investigation of ultrasonic absorption in suspensions is of great theoretical and practical interest. In spite of this fact, few investigations have been carried out. This is explained by the very great experimental difficulties, one of which is the difficulty in obtaining a monodisperse dispersion which does not coagulate during the measuring process. I. G. **Mikhailova** and K. N. **Marenina** have investigated the absorption of sound in the frequency range 0.6 — 18 megacycles in suspensions (not subject to coagulation) of quartz sand, lycopodium, wood, and paper pulp and other materials in water, kerosene, and alcohol. In qualitative agreement with conclusions of theory, a linear dependence was established between the coefficient of ultrasonic absorption in the mixture and the concentration of the suspension; a more complicated dependence was found for the absorption on the dimensions of the particles and on the frequency of the sound. The results obtained were used to produce instruments for the ultrasonic control of suspensions (for example, for the control of paper pulp fed into a paper-producing machine).

Observing the attraction of bubbles of gas in an ultrasonic field **Kornfel'd** and **Suvorov** have assumed that it is determined by Bjerknes forces (which are directly proportional to the product of the volume velocities of two pulsating spheres and the density of the liquid, and inversely proportional to the square of the separation distance). V. F. Kazantsev found the theoretical time dependence of the distance between bubbles for a given sound pressure, frequency, bubble radius and density, and verified it experimentally in the frequency region 7 — 13 kilocycles. The motion of the bubbles was studied with the help of a velocity plotting. Experimental and theoretical dependencies were found to be in good agreement.

Considering the universality of the pulse method for the measurement of ultrasonic velocity in liquids, **G. N. Feofanov** worked out a method for increasing the accuracy of this method. It is based on the observation of the interference of the previous pulse through the liquid with the reference signal of the same frequency, which was coherent with the vibrations of the source sending out the pulses. The reference signal can be introduced in various parts of the circuit, which makes it possible to create several variants of the pulse interferometer. The accuracy of the measurement is not less than the accuracy of measurement by the usual ultrasonic interferometer.

I. I. Ol'khovskiĭ considered the problem of propagation of ultrasound in monatomic gasses. In applying the method of moments for the solution of the kinetic equation of Boltzmann (for which no limitations are assumed on the relation between the frequency of the sound and the collision frequency of the gas particles) and generalized hydrodynamical equations (which are valid for the description of fast processes), the author made clear the effect of field intensity and thermal conductivity on the translational dispersion of plane waves in monatomic gases. In the particular case the results coincide with the theory of relaxation processes of Mandel'shtam and Leontovich. They also solved the problem of the effect of the boundary on the dispersion of ultrasound, while the obtained results were shown to be in satisfactory agreement with the experimental data of Meyer and Sesler.

In the classical linear theory of propagation of acoustical waves of Stokes-Rayleigh, the ray was considered in very simplified form (according to Newton's law) which was not at all connected with the optical properties of the medium. Later, this theory was repeated in unchanged form. **V. A. Prokof'ev** considered this problem, making use of the theory of propagation of small disturbances (pressure waves and thermal waves) on the basis of the hydrodynamical equations of Navier-Stokes and the equations of the theory of the radiation field. He established the fact that the characteristics of forced plane harmonic waves depend on two dimensionless radiation numbers, which describe the processes of emission and absorption of radiant energy. For special cases (long and short waves, barotropic medium, etc.) equations are obtained for the velocity and absorption coefficients of the waves. In the propagation of infrasonic and low frequency sound waves, radiation plays a role that is dominant in comparison with viscosity and thermal conductivity. For sufficiently high frequencies, it can be completely neglected. At the same time the insufficiency of the conclusions derived earlier (Stokes, Rayleigh, etc.) on the role of radiation in the propagation of acoustical waves can be shown.

The ever widening application of ultrasonic control of construction materials found its reflection in a number of papers in the section. E. **Ranachowski** (Poland) pointed out the connection of several properties of ceramic materials with the velocity of ultrasound and its absorption, and decided on the possibility of the use of this connection for the control of the quality of ceramic materials and the introduction of a rational process for their annealing.

V. **Koltonski** (Poland) advanced theoretical and experimental conditions for the propagation of ultrasound in magmatic, sedimentary, and metamorphic rocks, and established the dependence of the parameters of the propagation of sound of the frequency of the wave and the structure of the rock. He also investigated the effect of typical inhomogeneities of the rocks on the propagation of ultrasound in them and showed the possibility of a practical application of the ultrasonic method for the qualitative control of rocks directly in stone quarries.

D. S. Shreĭber gave a short report on the characteristics of propagation and scattering of polarized transverse vibrations in solid media, and pointed out that they possess certain advantages from the viewpoint of their application in ultrasonic defectoscopy. In the use of identical polarized source and receiver, less obstacles are presented by scattering of the ultrasonic vibrations on fine inhomogeneities.

Investigating the effect of ultrasonics on the phase transition in solid metals and alloys, L. N.

Larikov and I. G. Polotskiĭ came to the conclusion that the observed effect of ultrasound on natural aging of certain alloys is not the result of the direct action of the ultrasound, but arises from the higher temperature which results from the absorption of the ultrasonic energy by the alloy. Measurements were carried out with 750-kcs ultrasound at a limiting power of 10 w/cm^2.

L. A. **Sergeev** investigated the velocity of ultrasound in petroleum, and water saturated with methane, for estimating the sound reflecting capability of petroleum layers. Measurements were performed by the pulse method at 200 kilocycles in a high-pressure bomb. In water and petroleum different changes were observed in the velocity of ultrasound as functions of pressure and temperature. With higher temperature and saturation pressure (in proportion to the transition to the deeper layers) the difference in velocities for water and petroleum increased; at 72.5°C and 26°C, the pressure amounted to 30%. This, and also the difference of velocities of transverse and longitudinal waves in compressed sands permits one to undertake the exploration of petroleum deposits by ultrasonic methods.

For more reliable determination of the stratification of the sea bottom, the method of ultrasonic echo location applied in underwater seismic exploration for petroleum was improved by L. A. **Sergeev**. For this purpose, along with the ordinary recording on sounding diagrams of the time of propagation of signals, he determined the forms of the reflected signals and the repeated echo. The reading of the soundings was controlled and supplemented by electrical plotting of the bottom.

It is known that one can rid gases of aerosols by sonic coagulation of these particles. However, in addition to aerosols, the atmosphere frequently contains contaminating impurities. One such harmful impurity is sulfur dioxide, which is generated in certain blast furnaces in the treatment of ore contaminated with sulfur compounds, in the combustion of low calorie coals with a high content of sulfur in boiler furnaces, etc. I. V. **Slavik** (Czechoslovakia) advanced and developed an original ultrasonic method for cleaning air in blast furnaces from harmful contaminations. For this purpose he used gaseous reagents which, combining with the harmful impurities of the gases, formed solid particles that were then coagulated with the help of ultrasonic vibrations. The possibility of a wide region of application of ultrasonic coagulation aroused great interest.

Papers were read on the sources of ultrasound employed in techniques of sonic coagulation of aerosols. Investigating a generator of the Hartman type, P. **Lesniak** (Poland) determined the characteristics of the structure of the gas current which is emitted under pressure from the nozzle as a function of the velocity of flow. M. L. **Varlamov** and others presented a paper on the improvement of a generator of the Hartman type (a change in the distance between the nozzles and the resonator and the depth of the resonator while preserving axial alignment), and on the investigation of its sound field with the help of a small dimensional thermoelectric probe. Successful experiments were carried out by them on the coagulation of a fog produced by the cooling of SO_3 which is formed by contact oxidation of gaseous sulfur.

During recent years the problem of radiation and detection of ultrasonic vibrations has spilled over into the region of electroacoustics, obtaining equal weight with the problems of the detection and radiation of sonic frequencies. A small number of papers were devoted to this subject explaining the piezoelectric transducers in the ultrasonic section.

Many published researches have been devoted to the calculation of ultrasonic transducers within the framework of linear theory. However, in the majority of cases, the system considered were either single element or symmetric. V. N. **Tyulin** carried out a step-by-step theoretical analysis of many element non-symmetric transducers and determined their characteristics (frequency characteristics, power radiation, sensitivity in the receiving regime).

Some considerations on the effect of a matching layer on the frequency characteristics of piezoelectric transducers of the piston type, obtained as a result of the solution of the equations of the transducers in the general case were put forth by K. V. **Goncharov**.

Rod ultrasonic concentrators, widely used in the ultrasonic treatment of the solids, have been considered up to the present time without analysis of the effect of loading. In this connection, for example, it has been recognized that multi-step concentrators are better than exponential. Considering both exponential and multistep concentrators for a given loading of the circuit, L. O. **Markarov** showed that the first is more advantageous, since the change in the reactive loading (for example, as a result of deterioration of the instruments) brings about in them a smaller disorder in the vibrating system.

The section on acoustical measurements heard papers on new methods for measurement of the treatment and improvement of instruments for acoustical measurements and on increase in the accuracy of standard methods of acoustical measurements.

Applying sawtooth modulation to an acoustical source, **V. A. Zverev** and **A. I. Kalachev** determined the location and velocity of reflected sounds from objects according to the form of the frequency spectrum obtained as a result of detection of the received signal. The speakers showed the possibility of the application of this method to the measurement of sound absorption of partitions, measurements in defectoscopy, etc.

V. A. Zverev and **E. F. Orlov** described an arrangement for the analysis of spectra of optical photographs with the use of optical filters which excluded the effect of instability of the velocity of motion of the photograph and allows a simplification of the electrical part of the analyzer spectrum. Optical filters (made with an arbitrary initial frequency characteristic) can be applied successfully to the spectral analysis of a large number of recorded oscillograms of different types of fluctuations, etc.

The possibility and advantage of the application of tunable ferrite filters as a selective system of analyzers and spectrometers of sonic and ultrasonic range were discussed in the paper of **B. M. Beskarovaĭnyĭ**, **V. M. Vol'f**, **V. S. Gorbenko**, **M. I. Karnovskiĭ**, **B. I. Shotskiĭ**, and **A. A. Yur'ev**. As a result of the investigation, a spectrometer and analyzer of sound frequencies was constructed with an attenuation of 35 db when detuned a half octave.

Yu. M. Il'yashuk reported on the development of a miniature one-third octave spectrometer (25 transmission bands in the 36 to 11,000 cps range) with a fall off of 60 db per octave at the bounding frequencies of the band. Semiautomatic switching of the transmission bands permitted automatic recording of the results of measurement.

D. Z. Lopashev undertook to carry out several corrections in the readings of an objective noise meter which permits these readings to be closer to the true level of loudness of the noise.

An interesting paper on an oscillographic measurement of the two-dimensional probability density distribution of a random process was given by **Lyu Yung-Uzun** (China). The vertical and horizontal displacements of the beam of a cathode-ray tube correspond to the signal and to its retarded signal. The degree of darkening of a film exposed throughout the duration of the signal corresponds to the desired probability. For quantitative analysis, the degree of darkening was investigated by a densitometer.

V. I. Solov'ev spoke on the possibility of the application of correlation methods to the study of diffraction images of ultrasonic fields and for the measurement of signals of threshold levels. The speaker described circuits and principles of operation of an instrument which permits one to reduce the fluctuation interference by 35 db and correspondingly to amplify the range of threshold measurements and also discussed apparatus for the investigation of fine structure of ultrasonic fields in undeadened rooms.

V. P. Glotov and **R. A. Vadov** reported on measurements of small losses in liquids at frequencies from 3 to 15 kilocycles by determination of the rate of damping of separate normal modes of a cylindrical tank filled with the liquid under investigation and excited by a sound pulse. The rate of damping depends upon the amount of loss in the liquid and on the amount of loss in the tank. Measures were taken by the authors for a uniform reduction of the losses of the tank and for their calculation.

V. P. Glotov also reported on measurements of shear and volume viscosity in solids by a resonant-reverberation acoustical method (by means of the speed of damping of characteristic spherical and radio vibrations of samples prepared in the form of solid spheres). The error of the measurement amounted to about 5%.

By placing solid objects of special shape in a water tank and making use of the transformation of longitudinal waves into shear waves in these objects, **K. V. Goncharov** measured the damping of shear waves in them.

In the reports of **A. N. Krishtalevich** and **A. N. Rivin**, problems were considered of the increase in accuracy of the calibration of measuring microphones.

J. Merhaut (Czechoslovakia) considered error factors that can affect the accuracy of the absolute calibration of measuring microphones by the method of the pistonphone. A new type of pistonphone permits absolute calibration of microphones with an accuracy of 0.1 db.

L. B. Langans reported on a setup for the calibration of sound pressure receivers in the audio-frequency region in water. The error of measurement did not exceed ± 0.4 db.

I. L. Krasil'shchik reported on calculations of the characteristics of reference measuring hydrophones, in which a piezoceramic hollow sphere of barium titanate with calcium impurity was used as the sensitive element. The minimum pressure measured by these hydrophones in the frequency range from 50 cycles to 100 kilocycles amounted to 10 — 50 dynes/cm^2 in the case of a signal level exceeding that of the noises of the hydrophonic instrument by a factor of 5.

In the section on electroacoustics, the three most important problems of the reproduction and detection of sound vibrations were considered:

(a) Improvement of the quality of loudspeakers and microphones with the aim of bringing the quality of the recorded sound closer to the natural sound.

(b) Development of effective piezoelectric and other types of ultrasonic transducers which satisfy the conditions for their application in scientific-research and industrial devices and instruments.

(c) The study of the physiological properties of the human ear and speech.

Inasmuch as architectural and building acoustics is also closely concerned with the latter problem, the speakers on physiological acoustics met in joint session with the section on electro- and architectural acoustics.

Significant improvement of the sound quality of radio and telephone receivers has been obtained in recent years by split amplification and improvement of the low and high audio frequencies. High frequency speakers added to the lateral walls of receivers create a certain sensation of stereophonic sound.

D. Kh. Shifman, A. I. Dneprovskiĭ, V. I. Samarskiĭ, and **E. A. Timofeeva** spoke on further measures for the improvement of the quality of the sound of receivers. In particular, distributed acoustical systems were prepared consisting of low frequency (40 — 4000 cps) and medium frequency (300 — 6000 cps) speakers located on the front wall of the room, and two high-frequency loud speakers (3000 — 15000 cps) located on the side walls of the room. Such an arrangement of sound sources creates the illusion of sound of a large orchestra in the center of the living room. High quality and high frequencies loudspeakers of the horn and diffusion type were developed and also condenser high frequency speakers.

Recently, a tendency has been noted toward a deeper mathematical analysis of electro-mechanical processes going on in sources. An example of investigations of this type was provided by the paper of **J. Kacprowski**, (Poland) who considered the coefficient of transmission of an exponential horn. Use of the theory of quadrupoles permitted the author to obtain a series of fertile analogues between vibrational processes in a horn and processes involving transmission lines, etc. He showed that the horn can be regarded as a transformer with a constant and frequency-independent transmission coefficient only under certain conditions.

S. T. Ter-Osipyants noted that the inadequacies of sound recording by contemporary dynamic loudspeakers can be removed by the introduction of damping in the vibratory and radiating sections of the speaker system. This was established by him for a particular distribution of porous sound absorbing material close to the speaker. Active resistance was introduced into the highly vibrating layer of air in this case of such a form that the active linear loading was applied almost to all the vibrating elements of the speaker. As a consequence of this, multiple resonances both of the diffuser and of the volume of the cabinet were damped in a very wide range of frequencies. This significantly improved the timbre of the sound of the loudspeakers.

In the paper of **V. Murevskiĭ** on the results of the development of a high quality system of controlled loudspeakers which reproduce the frequency spectra from 40 cycles to 15 kilocycles, it was also pointed out that the damping by sound absorbing material in a reliable fashion by means of internal cavities of a labyrinth in the housing of low frequency apparatus permitted a reduction of the resonance maxima.

G. V. Butakov spoke on "Some Investigations of Mechanical-acoustical Systems of Electrostatic Sound Receivers." The method of electric modeling permitted him to explain the effect of any of the parameters of a complicated vibratory system (for example the combination capsule of the Brownmull and Weber type). The results obtained by such a method are in excellent agreement with the experimental data of real systems.

A. D. Tkachenko spoke on a new method of excitation of a microphone in speech transmission by means of the use of vibrations of the side faces which act [by means of the enclosed air space (acoustical coupling)] on the diaphragm of the microphone which is pressed toward the face close to the ear. In comparison to ordinary microphones located in front of the mouth, this method (which is practical with the use of electro-magnetic microphones) possess a number of advantages.

V. S. Grigro'ev, L. P. Nikitina, and **Yu. A. Ukhanov** reported on investigations of a model of an electromechanical transducer, based on the pondermotive interaction of a magnetic field with the displacement current in a dielectric (which is determined by the variable displacement of the charges of the dielectric). With values of the dielectric susceptibility of the order of tenths of units, the effectiveness of such a transducer is close to the effectiveness of the ordinary electrodynamic transducer (which is based on the use of conduction current). The application of dielectrics with large dielectric susceptibility permits one to increase the efficiency of the transducers being investigated.

Investigating the properties of nickel ferrite and a series of nickel-zinc ferrites, **I. P. Golyamina** demonstrated the expediency of their application in magnetostrictive ultrasonic transducers. Ferrites can be applied also to power sources; however, the efficiency of the latter depends on the power consumed in this case. In the paper the problems of the technology of production of acoustical ferrites was discussed, in particular, the application of die casting instead of dry pressing.

The method of hot die casting was also applied for the preparation of barium-titanate ceramics. (**A. V. Sosnov** and **M. A. Ugryumova**). They obtained ceramic materials which were volume-homogeneous and accurate in dimensions (thin cylinders, cones, spheres), which could not be prepared by the ordinary semi-dry pressing.

B. A. Finagin spoke on the advisability of the use in a number of cases of nonthickness vibrations of quartz and tourmaline sources of different shape. In comparison with the thickness vibrations ordinarily used, it appears possible to increase the intensity of the sound field for the same voltage on the source and to obtain an intense ultrasonic field at a number of different harmonics.

E. P. Kolokolov showed that, applying wedge shaped quartz plates (X-cut) in the transformation of high frequency pulses in liquid and solid media, he could expand the frequency region of transmission and decrease the loss in transduction in comparison with ordinary flat transducers.

Great interest in the problems of physiological acoustics was shown by foreign acousticians who made up almost the entire program at the joint session of the section on electroacoustics and building and architectural acoustics.

In spite of the depth and the number of researches on the investigation of curves of the estimate of loudness, the results of separate authors obtained by different methods has remained uncorrelated to date. Comparing the loudness curves obtained by the step method of Kwiek and the method of Garner with the previous methods of Laird, Taylor, Gamp and others, **J. Fazanowicz, D. Grzesik, A. Lampkowski** and **E. Porwik** (Poland) came to the conclusion that the results of all works obtained by the step method and method of the division of loudness, agree with one another after some recalculations. But these results cannot be in agreement with data obtained by integration of the function of the minimum distinguishable increase in loudness.

Comparatively recently, interest has arisen in the investigation of the phenomenon of residual masking (sometimes called short-time ear fatigue), that is, masking which is observed after the sensation of the sounding of the masking tone.

C. M. Harris (USA) reported on accurate experimental determination of the threshold of hearing within a second after the cessation of a masking tone at low frequencies in a free field. He also reported frequency characteristics of auditory sensitivity (by the method of Munson and Gardner). It appears that, at low frequency, the peaks of these characteristics are much sharper than the peaks of the frequency characteristics of the amplitudes of vibration of the basilar membrane. The mechanism of the increase in the frequency selectivity in the auditory preception remains unknown.

M. Kwiek, E. Karaskiewicz, A. Sliwinski and **I. Malecki** (Poland) reported on results of experimental investigation of acceptable echo amplitudes (for which the echo blends with the original signal) for time intervals between the fundamental signal and echo in the range 0 to 60 milliseconds, and for a frequency spectrum of the echo which differs from the spectrum of the original signal.

H. Niese (West Germany) discussed the problem of the perception of loud noises with low periodicity. He showed that the level of loudness lies within the limits of effective and peak values of the sound pressure, being dependent on the frequency of repetition; for very low frequencies, there arise two different judgments on the loudness. The speaker constructed an electrical circuit for the objective measurement of the loudness, employing the subjective data that have been found.

Visualization of speech attracted considerable attention in connection with those aspects which are amenable to objective methods in the investigation of speech and in practical applications. **S. Steinbach** (West Germany) developed an apparatus with the help of which speech is continuously recorded on a magnetic tape. The signal from a probe attachment which rotates at high velocity is analyzed by a system of band filters, the output of which is applied by an electronic commutator to the modulator of the brightness of a cathode-ray tube with a horizontal time sweep. The vertical deflection of the beam corresponds to the band of frequencies switched on at the given instant. Thus a picture appears on the screen of the tube of a traveling recording of the speech. The report was illustrated by pictures of separate sounds and discontinuous speech.

The section on architectural and building acoustics devoted its sessions to problems of the investigation of the spatial acoustics of residences and their sound insulation, and also to problems of the development and measurement of acoustical materials and structures.

V. V. **Furduev** and G. A. **Gol'dberg** made a detailed review of the methods of artificial reverberation which are applicable for sound recording for architectural-acoustical investigations, for the improvement of room acoustics, etc. Reverberation models were discussed with a different number of measurements, imitating a wave process in the room and a structure with a delay line, imitating a successive reflection at some point in the room. Criteria were given in the paper for the quality of reverberators, and possible ways for their improvement were noted.

Investigating the reverberation of moving picture theatres, A. N. **Kacherovich** explained that it is appropriate to represent the reverberation curve in the form of two parts: the first, which can be constructed on the basis of a geometric approach, and the final, which is computed on the basis of a statistical theory. The mean absorption coefficient connected with reverberations of the second type depends not only on the amount of sound absorption but also on its position. With a corresponding arrangement of absorptions, one can obtain a higher dispersion for relatively larger reverberation times.

B. M. **Gardash'yan** reported on investigations of the acoustical properties of rooms in acoustic models with a scale factor of 1/40. Reverberation and pulse measurements on the models were carried out at an average frequency of 20 kilocycles. In the case of models of the Moscow Panoramic Movie Theatre, acoustic defects were discovered which were later removed in the final construction.

Applying pulse signals, O. D. **Burkov** investigated the acoustics of several large halls. In addition to obtaining a picture of individual reflections for the reverberation curve in different frequency ranges, reflections which correspond to the initial part of the reverberation, he found the acoustic defects of some of the rooms and the reasons for their appearance.

I. G. **Leĭzer** compared the reverberation time measured in twelve rooms and auditoria, with volumes from 1000 up to 28,000 m^3, with that computed by the Eyring formula (with use of coefficients of absorption known from the literature) and discovered that in all cases there was a significant increase in the sound absorption. This absorption (which is brought about by an armature with different slots and openings in the walls of the room, with flexural elements in the structure, etc.) can be considered as a certain addition to the ordinarily computed mean coefficient which enters into the Eyring formula.

I. **Malecki** (Poland) spoke of the acoustical properties of the so-called spatial absorbers, in particular, those completed in the form of freely suspended spheres with perforated transparent walls. With a choice of the corresponding form of internal partitions in the absorber it is possible to produce a multiresonant system with an optimal frequency characteristic of absorption of background noises.

I. V. **Lebedeva** spoke on results of measurement (in a reverberation chamber) of several types of resonant sound absorbing structures in the form of perforated sheets of plywood or duralumin located at some distance from a solid wall. The measured frequency characteristics of the coefficient of sound absorption in the diffuse field agree well with the calculated values. In comparison with the case of normal incidence, the characteristic of absorption was broader, without sharp maxima and minima.

L. **Keibs** (East Germany) described a simple method of measurement of impedance on the surface of a closed airspace by means of recording the sound pressure in the space before and after the introduction of the specimen being used. Comparison of the data obtained this way with a normalized set of curves allows the determination of the components of mass rigidity and friction impedance. The method described is simpler than the usual method of Kundt's tube and is suitable for measurement of already prepared wall coverings.

In the paper of N. I. **Naumkina**, B. D. **Tartakovskiĭ** and M. M. **Éfrussi** data were reported on the investigation of vibration absorbing materials, consisting of mixture of asphalt and rubber pellets. Measurements of the elastic modulus and the coefficient of attenuation of different shapes of these materials, differing in composition and in technique of preparation were carried out on a rod undergoing flexural vibrations. Measurements were carried out at room temperature in the frequency range from 30 to 100 cps. It was found that some of these materials, particularly layered materials, can be used for the absorption of vibration of metallic structures.

In the fight against noise, researches have been carried out in the direction of the improvement of metal-rubber vibration reducers. In this connection, systematic analyses were carried out of viscoelastic properties of rubber in a wide temperature and frequency range. The distinctive characteristic of the measuring apparatus applied for this purpose by I. L. **Orem** was the strengthening of a movable system of electromechanical transducers with the aid of several forms of materials which operate on shear.

Measuring the sound isolation of homogeneous plates (20 × 20 cm) **R. P. Golovinskiĭ** discovered that with an increase in the rigidity on the bending of specimens, their sound isolation in the frequency range 100 to 500 cps increased by 10 db.

In view of the crudeness of measurement of sound insulation of natural building elements, **I. G. Leĭzer** carried out investigations on the sound insulation in models in a scale of 1/5. The model and the original were made from identical materials, the coefficient of attenuation of which was frequency dependent. This condition, along with the exact relation of the geometrical dimensions and identical conditions of construction, guaranteed the satisfaction of the condition of similarity.

Acoustical modeling was also applied by **E. Meyer** and **G. Kutruff** (West Germany) for the clarification of measures with whose help it is possible to obtain diffuse reverberation fields in a chamber with an absorber. It was explained that the covering of several walls by rigid half cylinders and the suspension of a scatterer allowed him to increase the weak diffusivity that is characteristic of a rectangular room. Deviation from the rectangular shape of a room also somewhat increases the diffusivity of the reverberation field.

The sound field in a deadened room is usually considered as a free field, while the reflections from the surfaces of the walls are regarded as interference. Going along these lines, **I. A. Bazhina** considered (by the method of simulated sources) the correction applied to the first reflections in the curves of the incidence of a sound field in a rectangular room covered with material having an absorption coefficient independent of the angle of incidence. In the phenomenon of standing waves, the effect of partial reflection lies in a certain displacement of the extremes of sound pressure and vibration velocity relative to each other. The calculations agree very well with experiment.

A. S. Osakchenko approached the problem somewhat differently. He assumed that each point of the surface of the room (sphere, ellipsoid, and parallelopiped) is a source of reflected spherical waves, and considered the formation of a sound field in this fashion. He found the relation between the volume of the chamber and the absorption coefficient for a given deviation of the sound pressure from the value corresponding to an infinite medium. These dependencies can be used in planning rooms.

K. N. Ivanov-Shits reported on the results of the experimental investigation of the sound field of the anechoic chamber of Moscow State University at various frequencies.

M. G. Burle and **A. F. Osakchenko** measured absorbing structures of variable cross section of capron fiber in a tube. Absorbers were prepared in the form of pyramids of different slopes and a layered construction of several plane layers of different thickness and density. The optimum conditions were found for which the coefficient absorption at 60 to 600 cps was larger than 0.985.

I. Tichy (Czechoslovakia) analyzed the conditions of the sound power and spectral composition of noise of typical sources at electrical stations measured by him with the help of objective instruments. Estimating by conversion the audibility of these noises, the author noted the measures for combating noise at electric power stations.

In the paper of **B. Klimes** (Czechoslovakia) consideration was given to the principles involved in planning an airport with the purpose of a universal reduction of the sound of airplanes which have their unpleasant effect on passengers and operating personnel. For calculation of the location of regions with minimum noise level (where one ought to locate the building) it is necessary as a preliminary to measure the noises of the airplanes.

In a final note by Academician **N. N. Andreev**, the great importance of the conference was noted in demonstrating the quantitative and qualitative growth of the scientific investigations in the field of physical and technical acoustics. A valuable result of the conference is the establishment of many friendly contacts between Soviet and foreign acousticians.

The organizing committee of the conference (presided over by L. M. Brekhovskikh) made it possible for all those taking part in the conference to become acquainted with the scientific researches carried out at the Acoustics Institute of the Academy of Sciences, USSR, at the Chair of Acoustics, Moscow State University, and in a number of other Moscow acoustical scientific laboratories. Excursions were also organized for tours of the acoustical laboratories and apparatus of the Sound Recording House of the Telecenter, the Panoramic Movie Theater, and other scientific technical establishments, and also for friendly meetings between Soviet and foreign acousticians.

Translated by R. T. Beyer