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A BIBLIOGRAPHY ON PROPAGATION OF SOUND THROUGH PLATES

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ABSTRACT

This report is a bibliography on propagation of sound through plates. The abstracted material is organized in accordance with a detailed subject outline having five major topics: Transmission Through Plates; Wave Propagation; Properties of Materials; Vibrating Surfaces and Plates; General References. Literature surveyed is principally in the period from 1929 to 1958. Approximately 450 abstracts are given.

CONTENTS

1. INTRODUCTION

This report is concerned with the transmission of sound through plates. Thus, it is concerned with the propagation of sound through the fluid in which the plate is immersed and through the plate material itself. Consideration must be given to reflection and refraction of the dilatational waves, shear waves, and other types of waves not bearing specific names at the interface between plate and fluid. The media may in general have a complete range of physical properties such as viscosity and imperfect elasticity. The fluid media may also be in motion.

Both theoretical and experimental references have been sought in preparing this bibliography. Studies related to small signal effects are emphasized as opposed to effects of nonlinear elasticity, shock waves, and large-amplitude acoustic waves. The references obtained have been grouped, with some duplication due to cross references, into five broad categories. These five categories are as follows.

A. References on Transmission Through Plates

This group contains references which are directly involved with the acoustic field on both sides of the transmitting plate. The group is subdivided according to experimental studies, theoretical studies of elastic plates, multiple-layered plates, viscoelastic plates, and specific transmission phenomena.

B. References on Wave Propagation

Here special wave proparation problems related to the sound transmission are considered. Considered are such things as reflection and refraction of elastic waves, propagation through viscoelastic media, propagation in single channels, interfacial waves, and acoustic radiation.

C. References on Properties of Materials

Mechanical properties of materials as related to wave propagation are considered. Methods of description of mechanical properties, methods of measurement, and absorption of energy are emphasized.

D. References on Vibrating Surfaces and Plates

Here the types of surface motion that can occur, in particular for thin plates, and their relation to edge conditions for the finite plate and the radiation of sound from the vibrating surface are considered. Viscoelastic treatments of the vibrating plate are particularly noted.

E. General References

This includes sources of a scope broader than could be fitted into one of the above categories. They include texts, bibliographies, and review articles.

The principal sources surveyed for references on the topics given above were as follows.

Science Abstracts, Section A (Physics) 1935-1958,
Applied Mechanics Reviews 1949-1958,
Journal of the Acoustical Society of America 1929-1958,
Acustica 1952-1958, and
Soviet Physics-Acoustics 1955-1958.

Some references were obtained through the Engineering Index, Index of Government Publications, and Technical Abstract Bulletin of the Armed Services Technical Information Agency. The references publications are generally available as part of the scientific literature. Publications carrying security classification are not referenced in this report.

2. SUBJECT OUTLINE AND METHOD OF USE

The articles referenced have been classified in accordance with a detailed subject outline. To use this bibliography, one first seeks the specific subjects in the subject outline that have direct bearing on the information sought. This subject outline is as follows.

A. References on Transmission Through Plates

1. Elastic Plates
2. Viscoelastic Plates
3. Membranes and Shells
4. Layered Plates
5. Optical Techniques and Studies
6. Special Transmission Phenomena
7. Transducer Housings

B. References on Wave Propagation

1. Single Channels
2. Layered Media
3. Shells
4. Interfacial Phenomena
5. Viscoelastic Media
6. Unusual Media
7. Radiation and Field Parameters
8. Experimental Methods
9. Surveys

C. References on Properties of Materials

1. Viscoelastic Materials
2. Rubberlike Materials
3. Internal Friction in Metals
4. Energy Dissipation in Solids
5. Acoustic Properties of Materials
6. Ultrasonic Methods of Study of Materials
7. Miscellaneous Apparatus and Methods of Study of Materials

D. References on Vibrating Surfaces and Plates

1. Plate and Surface Motions
2. Acoustic Effects
3. Viscoelastic Treatments

E. General References

1. Bibliographies
2. Acoustics
3. Waves and Vibrations
4. Rheology and Elasticity

Having selected the subjects of interest and noted their corresponding letter and number designations in the outline, one next turns to Sect. 3, Subject Outline with Author and Title. In this section the subject outline is repeated with author, title of publication, and date of publication of references. For convenience of location of subjects the letter and numeral designations are repeated at the top of the pages on which the subject is treated. Complete abstracts of the papers included in the subject outline are given in Sect. 4. Here they are listed in alphabetical order according to author. A list of abbreviations of journal titles is given in Appendix A.

3. SUBJECT OUTLINE WITH AUTHOR AND TITLE

A. References on Transmission Through Plates

1. Elastic Plates

Bar, R. (1938) TRANSMISSION OF SUPERSONIC WAVES THROUGH THIN SHEETS.

Beranek, L. L. (1949) "Sound Transmission Through Partitions," Noise and Sound Transmission.

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Fay, R. D., and Fortier, O. V. (1951) TRANSMISSION OF SOUND THROUGH STEEL PLATES IMMERSED IN WATER.

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Reissner, H. (1938) TRANSMISSION OF COMPRESSION WAVES THROUGH SOLID PLATE IMMERSED IN A FLUID.

Renault, L. (1939) TRANSMISSION OF SOUND THROUGH SINGLE AND DOUBLE SHEETS OF PLATE GLASS.

Sabine, P. E., and Ramer, L. G. (1938) ABSORPTION EFFECTS IN SOUND TRANSMISSION MEASUREMENTS.

Sanders, F. H. (1939) TRANSMISSION OF SOUND THROUGH THIN PLATES.

Schoch, A. (1950) PROPAGATION OF ULTRASONIC WAVES THROUGH PLATES.

Schoch, A., and Feher, K. (1952) THE MECHANISM OF SOUND TRANSMISSION THROUGH SINGLE LEAF PARTITIONS, INVESTIGATED USING SMALL SCALE MODELS.

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Thomson, W. T. (1950) THE EQUIVALENT CIRCUIT FOR THE TRANSMISSION OF PLANE ELASTIC WAVES THROUGH A PLATE AT OBLIQUE INCIDENCE.

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Kastner, Siegfried (1956) THE REFLECTION AND TRANSMISSION OF A PLANE SOUND WAVE INCIDENT AT ANY ANGLE ON A LAYERED VISCOELASTIC MEDIUM, I.

Kastner, Siegfried (1956) THE REFLECTION AND TRANSMISSION OF PLANE SOUND WAVE INCIDENT AT ANY ANGLE ON A LAYER-SYSTEM VISCOELASTIC MEDIUM, II.

Nolle, A. W., and Mowry, S. C. (1948) MEASUREMENT OF ULTRANSONIC BULK-WAVE PROPAGATION IN HIGH POLYMERS.

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4. ABSTRACTS

Abramowitz, M., and Cahill, W. F. (1955) ON THE VIBRATION OF A SQUARE CLAMPED PLATE. J. Assn. Comp. Machy., 2, 162-168.

The method of finite differences with better approximation to the boundary conditions is utilized. Results indicate more significant improvements in accuracy by this means than by the decrease in mesh width; for a fixed mesh width there is an optimum rule to be used.

Adler, F. T., Sawyer, W. M., and Ferry, J. D. (1949) PROPAGATION OF TRANSVERSE WAVES IN VISCOELASTIC MEDIA. J. Appl. Phys., 20, 1036-1041.

In calculating elastic constants of viscoelastic media from transverse wave propagation, it has been customary heretofore to assume a plane disturbance in a medium of infinite extent. Equations have now been derived for conditions which approach much more closely the experimental arrangement, namely, propagation from a finite source plate in a rectangular cell, and representative numerical calculations have been made. The new theory shows that the finite dimensions of cell and source should have very little influence on the wavelength as determined from observations of strain double refraction, but the attentuations should be perceptibly different from that of the plane wave case. Experimental data confirm these conclusions. Nevertheless, the simple plane theory is adequate within present experimental error for the majority of cases. Only in certain specified ranges of mechanical consistency will it be necessary to apply corrections, taking into account the sizes of the cell and source.

Ageeva, N. S., Zhukov, I. P., Isakovich, M. S., Sosedova, A. L., and Sukharevsii, Yu. M. (1952) ELECTRO-MECHANICAL Q-METER: A SET-UP FOR MEASURING THE ELASTIC MODULUS AND LOSSES OF MATERIALS BY ULTRASONIC OSCILLATIONS. Zh. Tekh. Fiz., 22, 1029-1042. (In Russian)

The main part of the installation is a "resonating packet," i.e., a rod of tested material, or, if the losses are large, a well resonating rod with pieces of the tested material cemented to its ends. To the centre of the rod piezo-quartz plates are cemented, the capacitances and losses of which, together with the mechanical resistance of the rod (and thus of the tested material) are measured by an ordinary electrical Q-meter. The theory of the instrument is given and formulae and graphs elucidate the method of determining from the electrical measurements Young's modulus (for solid materials) or the shear modulus (for elastomers) and damping decrement. The elastic moduli and damping decrements of some solid materials so determined are given and also temperature and pressure relations of shear modulus and damping decrement of rubber so established.

Aggarwal, Ram Ratan (1952, 1953) AXIALLY SYMMETRIC VIBRATIONS OF A FINITE ISOTROPIC DISK, I, II, III. J. Acoust. Soc. Am., 24, 463-467, 663-666; 25, 533-535.

Some frequencies for the symmetrical normal nodes of a finite, isotropic disk are calculated by satisfying the boundary conditions exactly at the flat surfaces and approximately at the curved surface. It is found that two sets of frequencies occur for each vibration pattern. One set approaches the odd order thickness compressional frequencies, whereas the other approaches the even order thickness shear frequencies, as the radius of the disk increases indefinitely. As a test of the validity of the approximations, the maximum residual stresses at the curved surface are compared with the compressional component of the stress at the center of the disk.

The calculations presented in Part I of the paper have been extended so as to include vibrations which are antisymmetric with respect to the central plane of the disk. Curves showing the normal components of the displacements at the boundary surfaces are also drawn, to get the vibration patterns according to the theoretical assumptions made.

Alekseev, A.; see Babich, V., and Alekseev, A. (1953).

Alfrey, T. (1944) NON-HONOGENEOUS STRESSES IN VISCOELASTIC MEDIA. Quart. Appl. Math., 2, 113-119.

The theory of elasticity is extended to include viscoelastic media, the materials considered being isotropic and incompressible and characterized by near relations between the components of stress-strain and their time derivatives. Only small strains are considered; body forces (e.g., inertia forces) are neglected. In the first boundary value problem, the surface forces are given as functions of the position and the time, and the stress distribution is determined. In the second problem, the surface displacements are given as functions of the position and the time, and the displacements in the interior of the body are found. In each case the solution is reduced to that of an equivalent boundary-value problem of elasticity and the determination of the response of the viscoelastic material under consideration is reduced to that of a simple shearing stress or strain.

Alfrey, T. (1945) METHODS OF REPRESENTING THE PROPERTIES OF VISCOELASTIC MATERIALS. Quart. Appl. Math., 3, 143-150.

A differential equation, E, is given which describes the mechanical behavior of a viscoelastic material in pure shear. This behavior is also expressed in terms of a mechanical analogue or model consisting of springs and dashpots. Two typical models are shown, consisting respectively of Voigt elements in series and Maxwell elements in parallel. Methods are given for changing readily from one method of description to the other; namely, given the constants in E, the constants of the equivalent Voigt or Maxwell model are found, and conversely.

Alfrey, Turner, Jr. (1948) Mechanical Behavior of High Polymers. Interscience Publishers, Inc., New York.

The phenomenological basis of elasticity, viscous and plastic flow, and simple viscoelasticity is presented. Both the microscopic and macroscopic behavior of several basic polymeric materials are described. Appendices on tensor representation of stress and strain, mathematical methods, nonhomogeneous stresses in viscoelastic media, and experimental methods are given.

Altenburg, K., and Kastner, S. (1953) WAVE PROPAGATION IN STRATIFIED MEDIA FOR NORMAL INCIDENCE, AND ITS APPLICATION TO CIRCUIT THEORY, ELECTROMAGNETIC WAVES, OPTICS, ACOUSTICS, WAVE MECHANICS, AND TO MECHANICAL AND ELECTRICAL QUADRIPOLE NETWORKS. Ann. Physik, 13, 1-43. (In German)

The above phenomena in the one-dimensional case have the same two simultaneous first-order linear partial differential equations (or simultaneous difference equations) with constant coefficients, for which the general periodic solutions containing 3 complex constants are obtained for a homogeneous (or discrete) medium. The transparency, reflection (and normal modes) for a set of finite layers (or discrete elements) are treated by a matrix method. Applications include antireflection films, transmission lines, concentric Lecher lines, tunnel effect, vibrations of infinite chain of coupled mass points, etc. Analogue computers for one type of system are discussed in terms of a system more amenable to experimentation. 67 references.

Ambrose, J. S.; see Curry, B., Hsi, Eugene, Ambrose, J. S., and Wilcox, F. W. (1951).

Angona, F. A.; see White, J. E., and Angona, F. A. (1955).

Arnold, J. S., and Martner, J. G. (1958) METHOD FOR ANALYZING VIBRATION AT A SURFACE POINT. Rev. Sci. Instr., 29, 779-783.

The path (trajectory) traversed by a point on a vibrating surface is described in terms of two components normal to each other and contained in a plane perpendicular to the surface. For the analysis of this motion a biaxial vibration pickup (BVP) using acceleration-responsive piezoelectric transducers has been developed. The signals for the BVP are combined by an X-Y oscilloscope to synthesize the amplified trajectory of the surface point to which the pickup is applied.

Phase and amplitude of the component signals are measured with a double-beam oscilloscope so that a motion map of the vibrating surface can be made.

Arnold, R. N., Bycroft, G. N., and Warburton, G. B. (1955) FORCED VIBRATIONS OF A BODY ON AN INFINITE ELASTIC SOLID. J. Appl. Mech., 22, 391-400.

Authors analyze forced vibrations of a rigid disk resting on a semi-infinite, lossless, elastic medium; four types of forced motion are studied: vertical and horizontal translations and rotations about vertical and horizontal axes. Approximate solutions of equations of motion of elastic medium are obtained by assuming a stress distribution similar to distribution produced by appropriate static load. Case of a disk resting on stratum of finite depth is also analyzed, but quantitative results are evaluated only for rotation about vertical axis. Experiments were performed on all four types of motion for the semi-infinite medium and the stratum, the elastic medium being foam rubber excited by electromagnetic vibrator. Agreement with theoretical results is good. This investigation sheds light on problems of vibrations of machine foundations. Paper exemplifies the combination of advanced mathematical analysis with good experimental techniques as applied to a problem of practical interest.

Astbury, N. F. (1949) SOME THEORETICAL CONSIDERATIONS ON THE DYNAMIC PROPERTIES OF PLASTICS. Proc. Roy. Soc. (London) A, 196, 92-105.

The marked similarity between the mechanical behavior of plastics and the electric behavior of certain dielectrics provides a starting-point for the derivation of a mechanical stress-strain relationship for plastic materials, from which experssions are deduced for the velocity of sound in, and the transmission and reflection of sound by, plastic plates. The effect of absorption on departures from Rayleigh's theory is indicated, and limited experimental data are reported.

Awatani, Jobu (1957) NOTE ON ACOUSTIC RADIATION PRESSURE. J. Acoust. Soc. Am., 29, 392.

A method of obtaining the acoustic radiation force (i.e., the process of integrating the force on every surface element of the object placed in sound waves) is criticized. This process yields the sum of the contribution of the true radiation pressure and that of the mean pressure. Though there is no effect in plane progressive waves, the mean pressure has a considerable effect on the result obtained in plane standing waves or progressive spherical waves.

Babich, V., and Alekseev, A. (1953) SCREENING ACTION OF A THIN ELASTIC LAYER. Dokl. Akad. Nauk SSSR, 91, 763-765. (In Russian)

When a wave is propagated in laminated media, it occasionally occurs that the wave is incident on a thin layer at an angle exceeding that for total internal reflection but, in spite of this, the disturbance partially penetrates the screening layer. The penetration becomes greater when the thickness of the layer is reduced and the angle of incidence approaches the critical value. The problem is studied theoretically in the present paper, the solution of the problem in the theory of elasticity being constructed by the method of incomplete separation of variables. For simplicity, it is assumed that the velocities in the material above and below the screening layer are equal and lower than that in the layer. It is found that the results obtained cannot be explained by theories based on geometrical optics, and it is concluded that future progress in this field of geophysics depends on the full application of the dynamical theory of elasticity.

Bancroft, Dennison, and Jacobs, R. B. (1938) AN ELECTROSTATIC METHOD OF MEASURING ELASTIC CONSTANTS. Rev. Sci. Instr., 9, 279-281.

This apparatus was designed to give accurate pick-up and sharp resonance.

Bar, R. (1938) TRANSMISSION OF SUPERSONIC WAVES THROUGH THIN SHEETS. Helv. Phys. Acta, 11, 397-407. (In German)

The author extends the mathematical analysis of the transmission of waves through thin sheets. It is recalled that when compression waves fall on a thin sheet immersed in a fluid, in general, both compression waves and flexural waves are excited in the sheet. Four simple cases are now dealt with: (1) only compression waves are produced in the sheet; this is the case of perpendicular incidence, dealt with by Rayleigh; (2) only flexural waves are produced in the sheet; this occurs when the angle of refraction of flexural waves in 45 deg.; (3) only one refracted compression wave is produced, which by internal reflection at the second surface is converted to a flexural wave; and (4) the converse case when only one refracted flexural wave is produced which is converted to a compression wave. In cases (3) and (4) the angles of incidence and the sheet thickness are such that the transmission is unity.

Bar, R., and Walti, A. (1934) DETERMINATION OF POISSON'S RATIO BY ULTRASONIC VIBRATIONS. Helv. Phys. Acta, 7, 658-661. (In German)

By comparing the wavelengths of longitudinal and torsional stationary waves in a solid, it is possible to deduce Poisson's ratio. The longitudinal waves are excited alone by disposing the solid with its surface normal to the incident wave; the torsional wave by arranging that the angle incidence is greater than the angle of total reflection for longitudinal waves. The results of experiments with a glass wedge are given.

Barducci, I., and Pisent, G. (1957) EXPERIMENTAL INVESTIGATION ON THE FLEXURAL NATURAL FREQUENCIES OF PRISMATIC BARS AS A FUNCTION OF THE THICKNESS/LENGTH RATIO. Acustica, 7, 288-292.

A series of prismatic bars of equal length, but different width, have been employed in order to investigate the dependence of their natural flexural frequencies on their width to length ratio.

Experimental results are compared with a mathematical theory developed by W. T. Thomson.

Barnes, R. Bowling, and Burton, C. J. (1949) VISUAL METHODS FOR STUDYING ULTRASONIC PHENOMENA. J. Appl. Phys., 20, 286.

After a brief review of various applications of ultrasonic techniques, considerable attention is paid to the established methods employed for making sound waves visible. It is shown that these methods are primarily modifications of the technique of "schlieren photography" developed by Foucault and used frequently for photographing phenomena (e.g., air flow analysis) in which refractive index gradients are set up. The advantages and disadvantages of the various techniques are discussed in some detail and it is shown that a technique employed by Willard is particularly well adapted to the visualization of ultrasonic waves. A modification of this method is discussed, the experimental apparatus is described and typical photographs of ultrasonic wave patterns are shown. In particular, the close analogy existing between light waves and ultrasonic waves with respect to the wave phenomena of refraction, diffraction, and interference is demonstrated in a number of photographs.

Barnes, R. B.; see Burton, C. J., and Barnes, R. B. (1949).

Baumgardt, E. (1938) TRANSPARENCY OF SOLID PLATES TO SUPERSONIC WAVES. Compt. Rend., 206, 1284-1286.

To test if the elastic constants of iron vary under the influence of supersonic frequencies of 4000 kc and greater, discs of 40 mm dia. and varying thickness are put into a stream of supersonic waves and the acoustical energy which penetrates is measured by a torsion balance. The position of the transparency is sharp enough to measure the velocity of propagation of the waves to 1% in soft steel. This gives a result for the elasticity near enough to that measured statically to show that frequency does not enter into the results. Experiments are now being made using the diffraction of light by supersonics, thus eliminating sources of error by reducing the energy used.

Becker, G. W.; see Oberst, Hermann, Becker, G. W., and Frankenfeld, K. (1954).

Bennewitz, K. (1947) MECHANICAL PROPERTIES OF SOLIDS. V. INTERNAL DAMPING OF SOLIDS. Physics of Solids, I, 179-188. (In German)

This concept which affects all transport properties of solids such as heat conduction and viscosity received much attention during the war. Experiments on many properties of solids as functions of time are recorded, especially on sodium silicate and Na-Ca glasses. The difference between thermal and diffusion damping, forced oscillations, resonance conditions, and general quantum conditions for the internal atomic arrangements of solids are fully discussed.

Beranek, L. L. (1949) "Sound Transmission Through Partitions." Phys. Soc. (London), Report on the 1948 Summer Symposium of the Acoustics Group. Noise and Sound Transmission, 1-6.

A method is described for measuring the transmission and absorption of sound by panels using a battery of loud-speakers closely coupled to the panel. Experiments are described which verify that the attenuation of sound by multiple absorptive structures can be calculated from the density flow resistance and dimensions of the components.

Beranek, L. L., and Work, G. A. (1949) SOUND TRANSMISSION THROUGH MULTIPLE STRUCTURES CONTAINING FLEXIBLE BLANKETS. J. Acoust. Soc. Am., 21, 419-428.

A general theory of sound transmission for normal wave incidence is developed for a structure containing two impervious layers, an air space, and two acoustical blankets. Equations for more simple structures are derived from the general case by setting some of the parameters equal to zero. A number of design charts are presented giving attenuation in db v. frequency for different structures with specific acoustic resistivity of the blanket material as a parameter. Experimental results are found to be in good agreement with the theoretical predictions. It is found that panels deviate from mass law behavior as their thickness is increased. Mass law behavior is obtained for panels of any thickness when a laminated construction is used to damp out flexural waves.

Bergassoli, A., Canac, F., and Vogel, T. (1954) THE TRANSMISSION OF SOUND BY SPHERICAL SHELLS. Acustica, 4, 403-406. (In French)

The acoustical insulation of spherical shells has been found to be appreciably greater than that of plane disks in the lower frequency range. This result is accounted for in a theoretical discussion of the natural frequencies of the shell, under the assumption of extensional vibrations.

Berry, B. S. (1955) APPARATUS FOR THE MEASUREMENT OF THE INTERNAL FRICTION OF METALS IN TRANSVERSE VIBRATION. Rev. Sci. Instr., 26, 884-887.

Apparatus incorporating a specially designed piezoelectric pick-up serving in turn as an exciter and detector is described for the measurement of the internal friction of vertically suspended specimens vibrating transversely in vacuo in the free-free mode. Measurements have been made by the free decay method in the frequency range 5 c/s - 2 kc/s and at maximum strain amplitudes of 10^{-4} - 5 x 10^{-7}. The method of frequency variation by loading with weights has been applied successfully to the fundamental vibration. Methods of investigating external energy losses are described, and results presented to show that the total external loss is small, rarely exceeding 5% of the observed internal friction.

Bez-Bardili, W. (1935) ULTRASONIC TOTAL REFLECTOMETER TO MEASURE SPEED OF SOUND AND ELASTIC CONSTANTS OF SOLIDS. A. Phys., 96, 11-12.

The critical angle of total reflection was measured, and the velocity of sound calculated, for longitudinal, and transverse waves of frequencies from 10^6 to 2 x 10^7, in various metal and glass plates in xylol. Also a new method was employed to determine the speed from the transparency maxima of the plates as dependent on the angle of incidence. A decrease of speed of transverse waves was found with smaller angles of incidence, and a constant speed for larger angles. It was also found that a certain dependence of transverse and longitudinal waves on the frequency could be explained by the presence of coupled longitudinal and transverse waves. With diminishing wavelength an asymptotic value is reached, the velocity in an infinite medium, from which all the elastic constants of the plates were determined. The value found for xylol was 1321 ± 4 m/sec at 20°C. The speeds calculated for audible frequencies were : Al 4990, Fe 5110, Cu 3630, brass 3520, and glass 5230 m/s.

Biot, M. A. (1940) THE INFLUENCE OF INITIAL STRESS ON ELASTIC WAVES. J. Appl. Phys., 11, 522-530.

A rigorous treatment is given of the problem of wave propagation in an elastic continuum when the influence of the initial stress is taken into account. After a short review of the theory various cases of initial stress are considered. It is shown that a uniform hydrostatic pressure does not change the laws of propagation. A hydrostatic pressure gradient produces a buoyancy effect which causes coupling between rotational and dilatational waves. Bromwich's equations for the effect of gravity on Rayleigh's waves are derived from the general theory, and the transition from Rayleigh waves in a very rigid medium to pure gravity waves in a liquid is discussed. The case of the vertical uniform stress is also considered and it is shown that the effect of the initial stress on the waves in this case cannot be accounted for by elastic anisotropy alone. Reflections may be produced by a discontinuity in stress without discontinuity of elastic properties. This paper is concerned with a theoretical treatment of the effect of initial stress on elastic wave propagation in a perfectly elastic medium. Uniform hydrostatic pressure has no effect, but a pressure gradient causes coupling between rotational and dilatational waves. Reflection can be obtained from discontinuity of stress.

Biot, M. A. (1954) THEORY OF STRESS-STRAIN RELATIONS IN ANISOTROPIC VISCOELASTICITY AND RELAXATION PHENOMENA. J. Appl. Phys., 25, 1385-1391.

A thermodynamic derivation is given for the representation of a system having viscoelastic or relaxation properties by means of a potential and dissipation function familiar in Lagrangian mechanics. This leads to modes of relaxation which are used as normal co-ordinates to derive general expressions for operational tensors relating stress and strain. A large variety of phenomena involving interaction of diffusion, chemical reaction, heat transfer, mechanical deformation, etc., is included in this theory.

Biot, M. A. (1955) DEFORMATION OF VISCOELASTIC PLATES DERIVED FROM THERMODYNAMICS. Phys. Rev., 98, 1869-1870.

Differential equations are set up by which the displacements are determined as functions of the coordinates and the time. In some degree of approximation the equations are of the same form as the corresponding equations for elastic plates, time operators being substituted for constants. The reference in the title to thermodynamics means that certain approximations (conventional in irreversible thermodynamics) are made with respect to the rate of dissipation. No quantitative results are deduced from the differential equations; it is not stated to which materials the equations are applicable. For these reasons the use of the present note is limited.

Biot, M. A. (1956) VARIATIONAL AND LAGRANGIAN METHODS IN VISCOELASTICITY. Colloquium Madrid, Sept. 26-30, 1955, Springer Verlag, Berlin, 251-253.

Author develops, using Onsager's reciprocity relations, a very general formulation of relations between stress and strain in linear viscoelasticity in operational form. It is shown that a variational formulation of deformation and stress field problems leads to a generalization of Lagrange's equations. A formal correspondence between problems in viscoelasticity and elasticity theory is possible. A new approach to the dynamics of plates or shells for isotropic or anisotropic media is developed. This can also be used in the elastic theory of plates and shells when the effect of increasing thickness is taken into account. As an example, the theory is applied to determine the deflection of an isotropic viscoelastic plate. Two nonlinear integro-differential equations, when solved, yield the deflection.

Bishop, R.E.D.; see Goodier, J. N., and Bishop, R.E.D. (1951).

Blake, F. G., Jr. (1952) SPHERICAL WAVE PROPAGATION IN SOLID MEDIA. J. Acoust. Soc. Am., 24, 211-215.

The wave propagating from a radially oscillating spherical cavity in an infinite solid medium sees an acoustic radiation impedance which is a function of the Poisson's ratio of the medium as well as of the usual parameters. The radiation resistance has the same form as in a fluid medium, but the reactance is a negative or stiffness reactance, except at high frequencies in media of low rigidity.

Bland, D. R., and Lee, E. H. (1955) CALCULATION OF THE COMPLEX MODULUS OF LINEAR VISCOELASTIC MATERIALS FROM VIBRATING REED MEASUREMENTS. J. Appl. Phys., 26, 1497-1503.

Two methods of determining the variation of real and complex modulus with frequency from vibrating reed test results are detailed. One is based on measurements of the relative amplitude and phase lag of the motion of the free and driven ends of the reed, the other on amplitude resonance measurements only. The analysis is based on a general linear viscoelastic law, and takes into account the influence of the frequency dependent moduli of the material on the frequency and amplitude of the resonance peaks. This influence has not been correctly accounted for in previous analyses which have included the assumption that the material behaves according to a particular, simple viscoelastic law, which will in general not be borne out by the final results. The method is applied to a series of tests. For the material and frequency range used the imaginary part of the complex modulus was small compared with the real part, and the influence mentioned in the foregoing was small. A simpler method of analysis might thus be justified, but in other cases it will be necessary to carry out the complete analysis in order to obtain a satisfactory interpretation of test results.

Blokhintsev, D. I. (1956) ACOUSTICS OF A NONHOMOGENEOUS MOVING MEDIUM. NACA TM 1399, 194 pp.

Theoretical basis of the acoustics of a moving nonhomogeneous medium is considered in this report. Experiments that illustrate or confirm some of the theoretical explanations or derivation of these acoustics are also included.

Bohme, Werner; see Exner, Marie-Luise, and Bohme, Werner (1953).

Bordoni, P. G. (1942) ON THE MOTION OF AN ELASTIC MEMBRANE COUPLED TO AN ACOUSTIC SYSTEM. Ricerca Sci., 13, 820-827.

The equations of motion of a membrane coupled to an acoustic impedance are solved, and an analytic expression is given for the value of such an impedance that would render the membrane independent of the frequency. Physically this is possible only by reducing the amplitude for all frequencies, but practical solutions approximating the theoretical conditions are discussed.

Bordoni, P. G. (1951) ABSORPTION OF ULTRANSONIC WAVES IN SOLIDS. Atti Con. Internaz. Ultracust., 135-143. (In Italian)

Theoretical discussion is given for absorption of sound waves in solids. Author investigates the dependence of attenuation on thermal conductivity and on viscous losses at the interface of crystals and in the interior of crystals. Effect on attenuation of each of above variables is characterized by a respective relaxation time at which absorption is maximum. Author also discusses dependence of relaxation time on temperature, as well as dependence of attenuation constant on both frequency and temperature.

Bordoni, P. G., and Nuovo, M. (1957) LONGITUDINAL VIBRATION MEASUREMENTS IN THE MEGACYCLE RANGE MADE BY ELECTROSTATIC DRIVE AND FREQUENCY-MODULATION DETECTION. Acustica, 7, 1-7.

An apparatus is described which extends to the longitudinal vibrations of plates the electrostatic drive and frequency-modulation detection technique formerly used to measure the natural resonant frequencies of flexural, extensional, and torsional vibrations. The frequency range of the present equipment is about 20 times wider than those of all previous apparatus. Details are given of the frequency-modulation and detection circuits used, together with typical data upon their sensitivity and signal-to-noise ratio.

The behavior of the apparatus is checked in a practical case, for measuring the frequencies of the first eleven longitudinal modes, for an aluminum plate, in the range from 0.5 up to 5.5 Mc/s.

Borgnis, F. E. (1952) ACOUSTIC RADIATION PRESSURE OF PLANE-COMPRESSIONAL WAVES AT OBLIQUE INDICENCE. J. Acoust. Soc. Am., 24, 468-469.

The forces due to acoustic radiation in a beam of finite cross section in a nonviscous medium striking a plane reflector at oblique incidence are derived from simple mechanical considerations. The formulae are applied to a wedge-shaped vane. For a vane, the wings of which include an angle of 90 degrees, the force turns out to be quite independent of the coefficient of reflection at the boundary between vane and medium.

Borgnis, F. E. (1953) ACOUSTIC RADIATION PRESSURE OF PLANE COMPRESSIONAL WAVES. Revs. Modern Phys., 25, 653-664.

Both electromagnetic and acoustic waves exert forces of radiation upon an obstacle placed in the path of the wave, the forces being proportional to the mean energy density of the wave motion. The physical processes leading to these forces in a sound wave are quite complex because of the fact that the acoustic wave equation is not linear and that a beam of finite cross section is subject to effects caused by the surrounding medium. The approach used in this paper uses the momentum theorem. The expression for the radiation pressure is given both in Eulerian and Lagrangian coordinate systems.

Special consideration is given to liquids of constant compressibility, since in such media the processes involved can be dealt with mathematically in a simple manner. The general case of a plane reflector with arbitrary reflection coefficient is treated; the modus operandi of the force at the interface between liquid and obstacle is explained for some special cases, including the radiation forces on the interface between two non-miscible liquids.

Finally, a general relation is established between the energy density and the pressure caused by radiation falling normally upon a plane reflector, which, under certain assumptions, is valid in any fluid, and at any amplitude.

Bradfield, G. (1951) INTERNAL FRICTION OF SOLIDS. Nature, 167, 1021-1023.

A report on the contributions by various speakers at a meeting held in London, March 15, 1951. A summary of the causes and properties of the principal types of internal friction of solids is followed by accounts of several current theoretical and practical investigations on the subject, particularly on the internal friction due to the motion of dislocations.

Bradfield, G., and Levi, F. A. (1958) MEASUREMENT OF ELASTICITY AND ANELASTICITY OF SMALL DISKS BY AN INDUCTOR METHOD. Brit. J. Appl. Phys., 9, 13-16.

An instrument is described operating on the inductor principle to set a small disk into radial vibration so that one of its elastic constants can be determined from its frequencies of resonance. The method of testing also permits the internal friction to be measured as the ratio Q_m of the real to the imaginary component of the elastic compliance.

Breazeale, M. A., and Hiedemann, E. A. (1958) INVESTIGATION OF PROGRESSIVE ULTRASONIC WAVES BY LIGHT REFRACTION. J. Acoust. Soc. Am., 30, 751-756.

The optical method used by Loeber and Hiedemann for the study of stationary ultrasonic waves has been adapted to the study of progressive waves. Three methods are described by which one may determine the presence of distorted wave forms in liquids. Distorted wave forms caused by finite amplitude effects are shown to be present in liquids, and the increase of wave form distortion with distance is shown for water and carbon tetrachloride.

Brekhovskikh, L. (1948) REFLECTION OF SPHERICAL WAVES ON "WEAK" SEPARATING SURFACES. Zh. Tekh. Fiz., 18, 473-482. (In Russian)

The field of acoustic or radio waves from a point source above a plane separating surface is investigated for the special case in which the properties of the two media separated by the surface are not very different from one another. Limitations of the existing theories are shown.

Brekhovskikh, L. (1948) REFLECTION OF SPHERICAL WAVES ON THE PLANE SEPARATION OF TWO MEDIA. Zh. Tekh. Fiz., 18, 455-472. (In Russian)

A point source of acoustic or electromagnetic waves is assumed to be situated above the plane of separation of two media. The calculation is effected by expanding the general solution in power series in terms of $1/k_0R$. Formulae for practical calculation of the Hertz vector in the electromagnetic case, and the acoustic potential in the acoustic case, are obtained, and these are valid for any position of wave source and receiver, respectively, above the separating plane. A new type of "lateral" wave is described and shown to be important in a number of special cases. Detailed discussion of the solution deals further with the application of the methods of geometrical optics to the problem and shows its limitations.

Brekhovskikh, L. M. (1949) REFRACTION OF PLANE WAVES FROM LAYER-HETEROGENEOUS MEDIA. Zh. Tekh. Fiz., 19, 1126-1135. (In Russian)

Special feature of the theory is that it is based not on the wave equation but on the equations (of first order) for the refraction coefficient. Two methods of successive approximation are used permitting representation of the refraction coefficient in form of convergent series. An example illustrates how quickly the series converge.

Brekhovskikh, L. M., and Ivanov, I. D. (1955) CONCERNING ONE TYPE OF ATTENUATION OF WAVES PROPAGATING IN INHOMOGENEOUSLY-STRATIFIED MEDIA. (ONE PARTICULAR FORM

OF ATTENUATION IN WAVE PROPAGATION IN LAMELLAR NON-UNIFORM MEDIA). Sov. Phys.-Acous., 1, 23-31.

Analysis of propagation of waves in a layer, bounded on one end by an inhomogeneous medium, in which the velocity of wave propagation diminishes with increasing distance from the layer boundary. It is shown that under these conditions the wave propagation is subject to supplementary attenuation, due to the energy "soaked up" by the inhomogeneous medium. A complete theory is presented for this problem, and the magnitude of the attenuation is determined.

Brennan, J. N. (1957) The Penn State Bibliography on Shock and Shock Excited Vibrations, Vol. I. Technical Report No. 3, 343 pp.

This bibliography contains abstracts of 1168 technical papers on shock and shock excited vibrations. Information is included on theoretical and analytical methods, experimental methods and equipment, measurement and instruments, properties of materials, characteristics of structures, isolation and packaging, and miscellaneous. Also included are summaries of the abstracts on (1) Mathematical Methods for Investigating Dynamic Behavior of Structures Subjected to Impulsive Forces, (2) The Shock Spectrum Approach to Impact Problems, (3) Behavior of Materials Under Impulsive Loading, (4) Dynamic Behavior of Structures Under Impulsive Loading, (5) Impact Testing Devices, and (6) Instrumentation for Measuring Impulsive Forces and Motions. An author index, a subject index, and the details of the scope of the search may be found in the appendix. The abstracts are mainly of papers published in technical journals from 1938 to 1955.

Brillouin, J. (1950) TRANSIENT RADIATION FROM SOUND SOURCES AND CONNECTED PROBLEMS. Ann Telecommun., 5, 160-172; 179-194. (In French)

Mathematical. The problem of progressive waves and the coexistence of a stationary field in a medium is reviewed with a survey of the framing of such a problem mathematically. Special note is made of the difficulties in the representation of discontinuities. General formulae are developed expressing the flux, and the radiated and stationary energy densities: these are applied to examples. The discontinuities created at the front and the end of a wave-train are then created and the results applied to a sinusoidal oscillator. The behavior of a rigid sphere subjected to certain types of external forces is examined and the question of diffraction briefly treated with note of some practical consequence.

Brown, R. L.; see Fay, R. D., Brown, R. L., and Fortier, O. V. (1947).

Bueche, F. (1954) THE VISCOELASTIC PROPERTIES OF PLASTICS. J. Chem. Phys., 22, 603-609.

A general method has been devised to predict the viscoelastic behavior of plastics. A simplified model of the molecule is assumed and its general motion is treated by the method of normal coordinates. General equations have been developed such that when the manner of application of external forces to the molecule is known, the molecule's general behavior may be found in a convenient and straightforward fashion. This method has been used to obtain theoretical curves for the viscoelastic behavior of cross-linked polymers subjected to sinusoidal forces. Also, the similar problem for linear material has been solved together with the creep and stress relaxation problems. It is shown that the temperature-time superposition procedure of Ferry and Tobolsky has a firm theoretical basis. In general, the theoretical curves appear to agree with the limited experimental data available. The method is also applied to the case of dilute solutions, and comparison is made with the result obtained by Rouse using a different approach.

Bullen, K. E. (1953) An Introduction to the Theory of Seismology. Cambridge University Press.

Very good theoretical coverage of elastic wave propagation.
Ch. V. Surface Elastic Waves (Rayleigh, Love, other).
Ch. VI. Reflection and Refraction of Elastic Waves.

Burton, C. J., and Barnes, R. B. (1949) A VISUAL METHOD FOR DEMONSTRATING THE PATH OF ULTRASONIC WAVES THROUGH THIN PLATES OF MATERIAL. J. Appl. Phys., 20, 462-467.

A visual method for studying the path of ultrasonic waves through thin plates of material has been devised, and a set of photographs showing the complexity of ultrasonic reflection and transmission by metal plates has been obtained. An attempt has also been made to estimate the critical angles of total reflection for dilatation and shear waves by visual examination of the reflection of a supersonic beam. Using these data, Young's modulus and the shear modulus for 1/16-inch aluminum sheet have been determined, and the values are compared with those obtained using a previously described electrical method and with published data.

Burton, C. J.; see Barnes, R. Bowling, and Burton, C. J. (1949).

Burton, C. J.; see Schneider, W. C., and Burton, C. J. (1949).

Bycroft, G. N.; see Arnold, R. N., Bycroft, G. N., and Warburton, G. B. (1955).

Cahill, W. F.; see Abramowitz, M., and Cahill, W. F. (1955).

Caloi, P. (1946) RAYLEIGH WAVES IN AN INDEFINITE, ELASTIC, FIRMO-VISCOUS MEDIUM. Acta Pont. Acad. Sci., 10, 143-154. (In Italian)

There is a difference between the observed value of the ratio of horizontal and vertical components of surface waves and the value calculated on Rayleigh's theory. The theory is modified by introducing the idea of firmo-viscosity, and the discrepancy reduced.

Caloi, P. (1948) BEHAVIOR OF RAYLEIGH WAVES IN A SOLID-ELASTIC INFINITE MEDIUM. Ann. Geofis., 1, 550-567. (In Italian)

The propagation velocity of the waves, starting from infinity for zero period, falls rapidly to the value obtained for purely elastic media as the period increases. The fall is the steeper the greater the ratio μ/μ' (where μ is Lame's constant, μ' the internal damping factor of the volume unit). For waves with large periods the effect of internal damping is nearly zero and the medium behaves as a purely elastic one. Classical theory considers the Rayleigh waves as free, persistent and not subject to absorption by the medium, yet observation proves that strongest absorption occurs for the smallest periods, decreasing rapidly and reaching a value of $\sim e^{-0.0003}$ for periods $\sim$ 20 sec. The new theory proves that in a rigid-elastic medium with $\mu/\mu' = 50\ \text{sec}^{-1}$, this is the case.

Caloi, P. (1951) THE EFFECT OF INTERNAL FRICTION ON THE VELOCITY OF THE SUPERFICIAL SEISMIC WAVE WITH SHORT PERIOD. Ann. Geofis., 4, 469-473. (In Italian)

A brief note comparing theoretical and experimental velocities for Rayleigh waves in a visco-elastic medium. Theory predicts an infinite velocity for waves with zero period dropping rapidly to the value for an elastic medium for periods of a few seconds, and the experimental data is quite consistent with this.

Campbell, I. D. (1955) THE TRANSMISSION OF A PLANE WAVE BETWEEN PARALLEL PLATES. Acustica, 5, 298-302.

The transmission of a plane wave between infinite parallel plates is discussed theoretically, allowance being made for the effects of viscosity and thermal conduction. The use of an approximate method allows the attenuation and phase velocity to be deduced at all frequencies. Some experimental measurements are presented for comparison with the theory.

Canac, F. (1953) INTERFERENCE BETWEEN TWO ULTRASONIC BEAMS REFLECTED BY A PLANE WALL. CONDUCTION OF WAVES. Compt. Ren., 236, 360-362. (In French)

Employing methods of optical interferometry such as those of Lucas and Biquard, Debye and Sears, and Brillouin, the author has observed the phenomena when high frequency (λ = 1.4 cm) sound waves are reflected from a plane surface. Observations were made both by stroboscopic and by continuous illumination. In the former case the interference between incident and reflected waves forms a lozenge-type pattern, whilst in the latter case the pattern consists of dark and bright lines. If a second, smaller, reflector is placed near and parallel to the first, there is evidence that the sound proceeds in the channel thus formed. There is evidence that the velocity of propagation exceeds that of sound in free space.

Canac, F.; see Bergassoli, A., Canac, F., and Vogel, T. (1954).

Cooper, J. L. B. (1938) THE VIBRATIONS OF SYMMETRICAL PLATES AND MEMBRANES. J. Acoust. Soc. Am., 10, 68-73.

The mathematical theory of vibrating membranes or plates, which is usually applied to squares and rectangles may also be used for triangles, provided the equations are plotted on axes which are not rectangular. These triangles are then fitted together to produce many-sided symmetrical plates. Thus the Chladni patterns are found mathematically for polygonal membranes or plates. If one angle of the triangle is made very small, the plates are practically circular so that these equations also give the patterns on circular plates (approximately) for special cases. The triode valve oscillator which drives the plates is calibrated accurately so that the frequency of the plates is found at the time the patterns are formed. A table gives a comparison between the observed and calculated frequencies.

Cooper, J. L. B. (1947) THE PROPAGATION OF ELASTIC WAVES IN A ROD. Phil. Mag., 38, 1-22.

In this paper there is an examination of the types of vibration which can be generated by local actions applied to a rod initially at rest; and an investigation of the rate of propagation of an arbitrary disturbance; and an investigation of the disturbances which have, apparently, a phase velocity greater than the dilatational velocity. It is shown that the last does not occur. This paper also discusses longitudinal waves, using the exact equations of motion.

Courant, R., and Friedrichs, K. O. (1948) Supersonic Flow and Shock Waves. Interscience.

This book treats basic aspects of the dynamics of compressible fluids in mathematical form; it attempts to present a systematic theory of nonlinear wave propagation. The appendix to Part III (pp. 235-246) considers wave propagation in elastic-plastic material. Part III is on one-dimensional flow; part IV is on isentropic irrotational steady plane flow; and part VI is on flow in three dimensions.

Cramer, W. S. (1957) PROPAGATION OF STRESS WAVES IN RUBBER RODS. J. Poly. Sci., 26, 56-65.

A progressive wave technique has been used by several investigators to study the propagation of longitudinal stress waves in rubber rods or strips. The present paper describes the extension of this technique to include torsional and flexural waves and compares propagation data obtained for the various wave types from measurements on the same materials at the same frequencies and temperatures.

Cremer, L. (1942) THEORY OF SOUND DAMPING BY THIN WALLS. Akust. Z., 7, 81-104.

The damping for perpendicular incidence is calculated and compared with the result of measurements obtained with statistical distribution of angles of incidence. Mass and frequency are the main factors. The movement of the wall is considered as a forced bending oscillation. When the component of sound velocity along the surface of the wall = the speed of propagation of a free oscillation of the membrane, the pressure difference equals 0. This "coincidence effect" and its dependence on frequency is investigated, and the analogies between coincidence and resonance are discussed.

Cremer, L. (1949) "Sound-Insulation of Panels at Oblique Incidence." Report on the 1948 Summer Symposium of the Acoustical Group, Noise and Sound Transmission, Phys. Soc. (London), 23-26.

The influence of angle of incidence on measurements of the transmission loss through insulating panels is emphasized. The effect of resistance to bending becomes more important with oblique incidence and a correction is derived for the usual transmission loss formula for normal incidence. It is shown how the insulating properties may be improved by decreasing the stiffness of thin panels.

Cremer, L. (1955) THE TRANSMISSION IMPEDANCE OF A CYLINDRICAL SHELL. Acustica, 5, 245-256. (In German)

The transmission-impedance of a cylindrical shell is given by the mass-reactance of stiffness against bending, and by a third reactance due to the tension of the shell which is involved in deformation. This stiffness-reactance against tension depends on the incidence of the waves and is for a given direction inversely proportional to frequency. If the trace-velocity equals the velocity of longitudinal or of shearing waves, the tensional stiffness becomes infinite and therefore the transmission loss too. This happens near perpendicular incidence only. Excluding this region the tensional stiffness is proportional to $\sin^4 B$, where B means the angle between the plane of incidence and the plane perpendicular to the axis. For high frequencies the mass-reactance and the stiffness-reactance against bending may compensate each other as in the case of plane waves (coincidence effect). Here a similar compensation of the mass-reactance and stiffness-reactance against tension is possible at frequencies below the zero-mode frequency of the shell. Averaging over all directions of incidence, one obtains a flat frequency response of the transmission loss. For shells with small diameter compared to the wave-length, mainly axial motions are to be expected within the shell. Then the stiffness against tension will preponderate and the transmission loss will increase towards low frequencies.

Cremer, L. (1956) COMPUTATION OF STRUCTURE-BORNE SOUND PROPAGATION. Akust. Bei., 1, 59-66. (In German)

The different types of structure-borne sound waves occurring in an elastic continuum and in rods and plates are described. The longitudinal waves can be treated as wave-guides, but the flexural waves excite not only secondary waves, but also quasi-stationary near fields.

These fields make total transmission and total isolation in the cases of elastic layers and impeding masses possible. The paper furthermore deals with corners, transition from rod to plate, impact sound and its isolation by elastic coverings and floating floors.

Cremer, L., and Schwantke, G. (1957) ON THE PROBLEM OF RADIATION FROM BENDING WAVES. Akust. Bei., 1, 329-335. (In German)

To take into account the effect that the receiving enclosure has on the radiation of vibrating plates, an improved model is used in which the radiation into a rectangular enclosure open at one side is considered. The radiation is characterized by the normalized mean square value of the sound pressure, for planes parallel to the plate. Consideration of the near field leads to a distance dependence for frequencies below the cut-off frequency. The response shows two maxima, one on either side of the cut-off frequency f_g. As the number of half wavelengths that fit onto the plate increases, the principal maxima approach each other and the response tends asymptotically towards that obtained with an infinite plate. Poles due to enclosure resonances are avoided by introducing a finite wall impedance.

It is not possible to give a strict expression for the radiation using the quotient f/f_g only. Rather, as an additional parameter the mode of vibration of the plate is of major importance. From this it follows, however, that one and the same plate may show a variety of radiation characteristics, depending on the width of the plate and on the enclosure of which it forms a bounding surface.

Cunningham, J. R., and Ivey, D. G. (1956) DYNAMIC PROPERTIES OF VARIOUS RUBBERS AT HIGH FREQUENCIES. J. Appl. Phys., 27, 967-974.

Paper presents shear wave measurements on several rubbers, e.g., GR-S, Butyl, Hevea, Hycar and Paracril, as a function of temperature and frequency. From shear wave velocity and attenuation and the corresponding bulk wave data (reported previously), the dynamic shear, bulk, and Young's modulus data on the same materials give information over many decades of logarithmic frequency, and from this the distribution of relaxation times was determined.

Curry, B., Hsi, Eugene, Ambrose, J. S., and Wilcox, F. W. (1951) Supersonics or Ultrasonics Bibliography. Research Foundation, Oklahoma A and M.

Das Gupta, S. C. (1952) NOTE ON LOVE WAVES IN A HOMOGENEOUS CRUST LAID UPON HETEROGENEOUS MEDIUM. J. Appl. Phys., 23, 1276-1277.

The density and rigidity of the lower layer are assumed to be given by:

I $\rho = \rho' e^{pz}, \quad \mu = \mu' e^{pz}$

II $\rho = \rho'(1+z/\lambda), \quad \mu = \mu'(1+z/\lambda)^2$

Love waves with velocity c can exist if $= \mu'/\rho' > c^2 > \mu/\rho$

Das Gupta, S. C. (1953) NOTE ON LOVE WAVES IN A HOMOGENEOUS CRUST LAID UPON HETEROGENEOUS MEDIUM, II. Indian J. Theor. Phys., 1, 121-124.

It has been shown in this paper that propagation of Love waves is possible in a homogeneous crust lying on a heterogeneous medium in which both rigidity and density vary as $\cosh^2(z/\lambda)$, λ being a constant and z the depth below the surface of the substratum.

Das Gupta, S. C. (1956) PROPAGATION OF RAYLEIGH WAVES IN TRANSVERSELY ISOTROPIC MEDIUM IN THREE DIMENSIONS. Trans. Am. Geophys. Un., 36, 675-678.

It has been found that the frequency equation is the same as in two-dimensional case. It has been shown that in case of ordinary crystals, there is only one real root of the frequency equation which satisfies the necessary boundary conditions.

Davies, R. M. (1950) INTERNAL FRICTION OF SOLIDS. Some Recent Developments in Rheology, United Trade Press, London, 27-37.

Several methods of measurement are discussed. The more interesting and newer methods are those involving wave and pulse attenuation, the first being more suitable for high friction materials. Possible wave distortion is an objection to the second method. The Voigt and Boltzmann models for solids having internal friction are compared with actual observations. Friction of materials stressed at low levels is discussed in terms of relaxation frequencies.

Davies, R. M. (1953) STRESS WAVES IN SOLIDS. Appl. Mech. Rev., 6, 1-3.

This is a review article containing 99 references. It gives groups of references in the following areas:

- I Elastic Waves
  - A. Waves in an Infinite Medium
  - B. Waves in Semi-Infinite Medium
  - C. Two-Dimensional Problems
  - D. Bars and Beams
- II Viscoelastic Waves
- III Plastic Waves

Demishev, G. K. (1952) METHOD OF DETERMINING THE MECHANICAL PARAMETERS OF RUBBER-LIKE MATERIALS AT ACOUSTIC FREQUENCIES. Zh. Eksper. Teor. Fiz., 22, 617-623. (In Russian)

The method presented permits of determining the shear modulus and the corresponding tangent of the mechanical loss angle of elastomers at shear deformations produced at acoustic frequencies. It is based on the principle of a standing wave set up in the specimen. The set-up consists of a generator of sinusoidal acoustic waves, feeding the latter to a piezo-vibrator with 4 Seigneete crystals between which the band-shaped specimen is held, a frequency meter, phase-shifter and c.r.o. The phase difference between the vibrator and receiver, corresponding to the length of the acoustic wave in the specimen, and also the amplitude of the oscillations of the receiver may be determined from the form and dimensions of the Lissajous figures appearing on the oscillographic screen. The full theory of the method, based on the inhomogeneous 3rd order equation of a shear wave propagated through a viscous-elastic medium, is given and shown to yield the phase curves vs. specimen thickness in fractions of wavelength. A detailed description of the apparatus and test results conclude the paper.

Den Hartog, J. P. (1947) "Many Degrees of Freedom," (Chap. 4). Mechanical Vibrations, McGraw-Hill, New York, 155-209.

This chapter contains discussions on free and forced vibrations with and without damping, strings and organ pipes; longitudinal and torsional vibrations of uniform bars, Rayleigh's method, bending vibrations of uniform beams, beams of variable cross section, normal functions and their applications, Stodda's method for higher modes and rings, membrances and plates.

Deresiewicz, H. (1957) PLANE WAVES IN A THERMOELASTIC SOLID. J. Acoust. Soc. Am. 29, 204-209.

In an isotropic, thermoelastic solid, shear waves are unaltered by thermal effects. However, two distinct dilatational waves exist, both of which are dispersed and attenuated by the medium. One of the waves (denoted the E wave) is close in character to the pure elastic wave, the other wave (denoted the T wave) is similar in nature to the pure thermal wave.

The properties of the two dilatational motions are studied, and relations are given expressing the variation, in each, of phase velocity, amplitude attenuation and specific loss with impressed frequency. For the E wave the result is verified that this disturbance propagates at the adiabatic velocity at low frequencies and at the isothermal velocity at high frequencies. An explanation based on physical considerations is offered to account for this generally overlooked phenomenon. It is further found that the amplitude is attenuated exponentially as the square of the frequency at relatively low frequencies, but approaches a finite value as the frequency increases without limit. The specific loss reaches a maximum for the E wave, a minimum for the T wave, near the frequency whose period is equal to the relaxation time due to thermal currents. Finally, the ratios are computed of the amplitude of the displacement in each of the two modes of motion. Numerical work indicates that, for metals at room temperature, the effect of coupling between elastic and thermal motions is very small.

Dix, C. H. (1945) RAYLEIGH WAVES AND FREE SURFACE REFLECTIONS. Quart. Appl. Math., 3, 151-156.

Numerical and graphical results are given relating to the reflection of a plane compressional wave at a free surface. The results are of value in the seismic method of oil exploration, where Rayleigh waves are important.

Eckart, C. (1948) THEORY OF THE ANELASTIC FLUID. Revs. Modern Phys., 20, 232-235.

It is shown, by mathematic analysis, that in the case of an anelastic fluid, slow steady motions and the diffusion of vorticity obey the same laws as in the Stokes-Navier theory of a viscous fluid. Hysteresis is, however, exhibited by the response of density to pressure. This hysteresis vanishes for very low and very high frequencies. The compressibilities for these two limiting cases approach different real values. For intermediate values the compressibility is a complex number, corresponding to the hysteresis. The velocity of propagation is also a complex number which is a function of the frequency. The two roots of this function determine two relaxation times; one root is associated with the hysteresis, the other with viscosity.

Eckart, C. (1948) THE THERMODYNAMICS OF IRREVERSIBLE PROCESSES. IV. THE THEORY OF ELASTICITY AND ANELASTICITY. Phys. Rev., 73, 373-382.

A classical theory of anelasticity is outlined, after removing two traditional false assumptions: the principle of a constant relaxed (or standard) state; and the principle of macro-relaxibility, which is replaced by micro-relaxibility, analogous to Riemann differential geometry.

Eckart, Gottfried, and Lienard, Pierre. (1952) INCOMPLETE ANALOGY OF THE ELECTRICAL AND ACOUSTICAL CHARACTERISTIC IMPEDANCES AND THE RELATED CONSEQUENCES OF THE ECHO IN MANY STRATIFIED CONTINUOUS MEDIA. Acustica, 2, 157-161. (In French)

The characteristic acoustic impedance of a medium is defined by analogy with the corresponding quantity for electric waves. In the latter case, there is no internal reflection in a medium continuously stratified provided the characteristic impedance remains constant, but this is not true for sound waves, so that stratified atmosphere should reflect sound and produce echoes under all circumstances.

Edelman, S.; see McKinney, J. E., Edelman, S., and Marvin, R. S. (1956).

Eichler, E. G., and Lambert, R. F. (1957) ACOUSTIC (0,1) WAVE TRANSMISSION THROUGH THIN RECTANGULAR PLATES. Acustica, 7, 379-386.

Transmission loss measurements of thin, rectangular aluminum plates employing the (0,1) acoustic mode of a waveguide are described. Theoretical transmission loss formulas are derived for the limiting cases of small and large ratios of frequency to plate thickness. In the case of large ratios, a "mass law" formulation is obtained which exhibits an angular dependence characteristic of the (0,1) mode. Complete sound transmission predicted for angles near grazing is verified by the experimental results for all plates studied. Some discrepancies between theory and experiment for small ratios are discussed and an attempt is made to correct the calculations empirically. The discrepancies between theory and experiment are here attributed to internal plate dissipation and imperfect boundary clamping.

Eirich, F. R. (1956) Rheology Theory and Applications. Vol. I and II, 761 pp. and 591 pp., Academic Press, Inc.

In this book noted workers in rheology have pooled their knowledge and made it easily available in condensed form. The contributions, although self-contained, are interrelated. In Vol. I there are two introductory chapters, one from the physicochemical and the other from the physics and engineering angle, followed by five chapters on various phases of the deformations of solids. These are followed by four chapters on the basis of the rheology of disperse systems and one on acoustic responses of liquids.

Volume II opens with an integrated survey which will serve to link the fifteen chapters that deal with various fields and aspects of linear viscoelasticity. It continues with relaxation theory and three chapters on experimental techniques; then there follows the series of chapters on special types of materials or behavior, such as the relaxation of polymers, the rheology of elastomers, glasses, cellulose derivatives, and fibers; it includes also chapters on concrete and on seismic measurements.

Eisler, J. D.; see Evans, J. F., Hadley, C. F., Eisler, J. D., and Silverman, D. (1954).

Ernst, P. J. (1945) ULTRASONIC LENSES AND TRANSMISSION PLATES. J. Sci. Instr., 22, 238-243.

The author claims that solid lenses give the best results for ultrasonic work; as aluminum and glass have almost the same acoustic resistivity as quartz, lenses in these materials may be joined directly to the generating crystal. When there is a large difference in acoustic resistivity between two media, the loss due to back reflection at the discontinuity may be reduced by transmission plates, i.e., parallel-sided sheets of suitably chosen intermediate resistivities. A photograph is included, showing the focusing effect of a plastic lens.

Espinola, R. P., and Waterman, P. C. (1958) ULTRASONIC INTERFEROMETER FOR THE MEASUREMENT OF THE TEMPERATURE DEPENDENCE OF ELASTIC CONSTANTS. J. Appl. Phys., 29, 718.

An ultrasonic interferometer method for relatively precise measurement of changes in velocities in solids is described; fractional velocity changes as small as 5×10^{-6} can be detected by this method. Application of the interferometer to specimens in which the temperature is varied yields the temperature dependence of the appropriate adiabatic elastic stiffness constants. Some results are reported for steel, fused silica, and single crystals of KBr, KCl, and LiF.

Evans, J. F., Hadley, C. F., Eisler, J. D., and Silverman, D. (1954) A THREE-DIMENSIONAL SEISMIC WAVE MODEL WITH BOTH ELECTRICAL AND VISUAL OBSERVATION OF WAVES. Geophysics, 19, 220-236.

The short wavelengths required in a seismic model to give wave-front patterns geometrically similar to those in a large prototype (the earth) can only be obtained by using high-frequency sound waves. As sources and detectors of such high-frequency waves, piezoelectric crystals are used, primarily because under identical stimuli they are capable of almost perfect duplication. Such duplication is made use of in displaying on an oscilloscope stationary patterns which are characteristic of transient particle motion at a point in the model. Also, it has made possible the direct visual observation of transient wave fronts in transparent models, techniques for which are described, and sample photographs given. As an example of quantitative use of the described model techniques, the results are presented showing symmetric and anti-symmetric wave propagation in a free elastic plate. Good agreement is found between many features of the experimental record and theoretical predictions.

Ewing, W. Maurice, Jardetzky, Wenceslas S., and Press, Frank (1957) Elastic Waves in Layered Media, McGraw-Hill, New York.

Very good general coverage of wave propagation theory - general principles - fundamentals. Includes many references.

Exner, Marie-Luise, and Bohme, Werner. (1953). MEASUREMENT OF STRUCTURE-BORNE SOUND INSULATION USING FLEXURAL WAVES. Akust. Bei., 1, 104-110. (In German)

The first part of this work describes an apparatus for determining the sound insulation factor of flexural waves by measuring the reflected and the transmitted part of the wave.

In the second part results of these measurements are stated. The frequency dependency of sound insulation of thin elastic layers is discussed by means of a formula given by Cremer. With thicker layers resonance phenomena occur which, as in the case of longitudinal waves, reduce the insulation the more, the smaller the internal damping of the material is. The phase velocity of the insulation material is computed from the resonance frequencies, and its dependence on frequency is compared with Firestone's curve.

Exner, M. L., Guth, W., and Immer, F. (1954) INVESTIGATION OF THE ACOUSTIC BEHAVIOUR OF POWDERS UNDER SHEAR-WAVE TREATMENT. Acustica, 4, 350-358. (In German)

A vibrometer is described suitable for measuring the mechanical impedance in such a case in the range 100 to 4000 c/s. The acoustical properties of the medium are investigated from impedance curves, obtained under various conditions, characteristic of the structure. With the aid of a simple model for the structure, the meaning of the results obtained is elucidated. It appears that in sand under certain circumstances, just as in solid blocks of material, compressional as well as shear waves are set up. Only the latter are studied in this paper.

Fay, R. D. (1948) INTERACTIONS BETWEEN A PLATE AND A SOUND FIELD. J. Acoust. Soc. Am., 20, 620-625.

This paper deals with phenomena associated with the interactions between flexural vibrations in a plate and the sound field in an ambient fluid medium. An equation is developed in tractable form which determines the propagation function of the free and forced flexural waves which can exist under stated assumptions. It is found that the reaction of the fluid on the plate makes possible a wave which cannot exist in the free plate in steady state. For a steel plate in water, the potential effect of the additional wave is relatively great when the product of the frequency and plate thickness lies between 6 and 20 kilocycle-inches. Errata: J. Acoust. Soc. Am., 21, No. 3, May 1949, p. 272.

Fay, R. D. (1952) WAVES IN LIQUID-FILLED CYLINDERS, J. Acoust. Soc. Am., 24, 459-462.

If a system comprising a water column bounded by a steel cylindrical shell is driven at a fixed frequency, the pressure amplitude has been found to vary along the axis in a complicated manner. On the hypothesis that this phenomenon results from the excitation of two or more modes of vibration having different speeds of phase propagation, an investigation has been made of waves in liquid-filled cylindrical shells. It is shown that, in addition to the modes associated with the boundaries of high impedance, there is also a possible mode associated with each type of free wave in the shell. The phase velocities of several symmetrical free waves are calculated by an extension of the method employed by Love for solid cylinders. A comparison with measurements appears to confirm the hypothesis.

Fay, R. D. (1953) NOTES ON THE TRANSMISSION OF SOUND THROUGH PLATES. J. Acoust. Soc. Am., 25, 220-223.

A relatively tractable expression for the transmittivity of steel plates immersed in a fluid medium is formulated. Criteria for total transmission and total reflection are inherent in the expression.

An investigation of the discrepancies between calculated and observed transmittivity indicates a probability that the assumption of negligible losses associated with shear waves in steel is not tenable.

Fay, R. D. (1953) EFFECT OF LOSSES ON TRANSMITTIVITY OF PLATES. J. Acoust. Soc. Am., 25, 623-625.

The theory of the transmittivity of immersed plates is extended to include the effects of losses associated with shear waves. The loss is completed for the transmission maxima which occur for five modes of vibration and is compared with observations made at a fixed frequency of 1-1/2 megacycles. The general agreement is good but not within the experimental error for all of the five modes. The value of the loss factor, which was determined to give agreement in a simple case, is difficult to appraise without data at other frequencies.

Fay, R. D., Brown, R. L., and Fortier, O. V. (1947) MEASUREMENT OF ACOUSTIC IMPEDANCES OF SURFACES IN WATER. J. Acoust. Soc. Am., 19, 850-856.

An analytical and experimental investigation of the practicability of a water-filled acoustic impedance tube is described. It is shown that by proper choice of tube material and of diameter and wall thickness with respect to wavelength, a satisfactory tube for measuring the impedance of underwater acoustic materials can be built. The phase velocity of sound in the tube is nearly constant in the useful frequency range but less than the velocity of sound in free water, and the variation in sound pressure along a radius of the tube is frequency dependent. Both rigorous and approximate formulae are given for the phase velocity and radial pressure dependence. The formulae are checked experimentally.

Fay, R. D., and Fortier, O. V. (1951) TRANSMISSION OF SOUND THROUGH STEEL PLATES IMMERSED IN WATER. J. Acoust. Soc. Am., 23, 339-346.

The measured transmittivity of a steel plate in water is presented as a function of the angle of incidence and the product of frequency and plate thickness over wide ranges.

The normal velocity of the plate surface can attain an amplitude necessary for good transmission only by construction interference among internal reflections. It is shown that the ideal conditions can be met in a plate of finite width in only a few cases. In general, the conditions for a transmission maximum are the conditions for the existence of appropriate types of stable traveling waves in a plate of infinite extent; these conditions, however, are modified by edge effects. An apparent effect of this modification is to produce changes in the divergence of the transmitted beam and hence in the observed transmittivity.

Feher, K.; see Schoch, Arnold, and Feher, K. (1952).

Feher, K. (1946) MEASUREMENT OF THE VELOCITY DISTRIBUTION ON PLATES AND MEMBRANES. Akust. Bei., 1, 99-103. (In German)

The velocity distribution on flat plates and membranes has been determined by the help of its known relation to the directional pattern at long distances. The practicability of the method is demonstrated by some examples.

Ferry, J. D.; see Adler, F. T., Sawyer, W. M., and Ferry, J. D. (1949).

Finney, W. J. (1948) REFLECTION OF SOUND FROM SUBMERGED PLATES. J. Acoust. Soc. Am., 20, 626-637.

It has been found that an appreciable reflection occurs in the direction of the incidence. The magnitude of this "non-specular" reflection, together with the assorted transverse vibrations in the plate, has been studied experimentally as a function of frequency, plate dimensions, and angle of incidence. Significant non-specular reflection occurs from bounded plates between about one-quarter inch and two inches thick, when the product of the thickness in inches and frequency in kilocycles per second lies between about 20 and 60 in.-kc. Within this range, the angle of incidence for non-specular reflection η is described by the empirical relation $\sin \eta = 2.16/(bf)^{1/3}$. This relation has been found to apply also to 0.002 inch plates at 15 megacycles.

The results of the present study are in agreement with a theoretical analysis by Fay, and with the experimental results obtained by Sanders at frequencies of several megacycles.

Firestone, F. A., and Frederick, Julian R. (1946) REFINEMENTS IN SUPERSONIC REFLECTOSCOPY. POLARIZED SOUND. J. Acoust. Soc. Am., 18, 200-211.

One form of simple circuit for the generation of the short duration high frequency voltage trains used in the supersonic reflectoscope is shown. The required band width of the system, including the crystal, is discussed. Techniques for the radiation of longitudinal, shear, and Rayleigh waves are set forth.

Fletcher, W. P., and Gent, A. N. (1957) DYNAMIC SHEAR PROPERTIES OF SOME RUBBER-LIKE MATERIALS. Brit. J. Appl. Phys., 8, 194-201.

Measurements are described of the dynamic shear properties of a number of representative rubber-like materials, both vulcanized and unvulcanized, over a wide range of frequencies and temperatures. The major part of the transition from a rubber-like to a glass-like state has been investigated. Reduced values for the real component of the complex shear modulus and the ratio of the imaginary to the real part are presented, enabling the behavior of the materials studied to be evaluated for other frequency and temperature conditions.

Flugge, S. (1958) Encyclopedia of Physics, Volume VI, Elasticity and Plasticity, Springer-Verlag.

This volume includes the following major dividions: "The Classical Theory of Elasticity," by I. N. Sneddon; "Photoelasticity," by H. T. Jessop; "The Mathematical Theories of the Inelastic Continuum," by A. M. Freudenthal and H. Geiringer; "Rheology," by M. Reiner; "Fracture," by G. R. Irwin; and "Fatigue," by A. M. Freudenthal.

Fortier, O. V.; see Fay, R. D., Brown, R. L., and Fortier, O. V. (1947).

Fortier, O. V.; see Fay, R. D., and Fortier, O. V. (1951).

Fourth Symposium on Plasticity. (1953) Brown University, Providence, R. I.

Wave propagation in viscoelastic media, T. L. Alfrey, Dow Chemical Co., Midland, Michigan, U.S.A.

A nonlinear analysis of static characteristics in viscoelastic materials, J. K. Knowles, Massachusetts Institute of Technology, Cambridge, Massachusetts, U.S.A.

Propagation of transient waves in viscoelastic materials, E. H. Lee, Brown University, Providence, R. I., U.S.A.

Stress waves in imperfectly elastic solids, H. Kolsky, Imperial Chemical Industries, Ltd., Herts, England.

Fox, F. E., and Wallace, W. A. (1954) ABSORPTION OF FINITE AMPLITUDE SOUND WAVES. J. Acoust. Soc. Am., 26, 994-1006.

The coefficients of absorption of high intensity ultrasonic waves in liquids (CCl_4 and water) have been measured as a function of intensity.

Frankenfeld, K.; see Oberst, Hermann, Becker, G. W., and Frankenfeld, K. (1954).

Frederick, Julian R.; see Firestone, F. A., and Frederick, Julian R. (1946).

Friedlander, F. G. (1948) ON THE TOTAL REFLECTION OF PLANE WAVES. Quart. J. Mech. Appl. Math., 1, 376-384.

The reflection and refraction of transverse plane waves at an interface parallel to the direction of polarization is considered when the incidence exceeds the critical angle. It is shown that the solution of this problem depends on the determination of a plane harmonic function $h(\xi,\lambda)$ satisfying the condition

$$\left(\frac{\partial h}{\partial \xi}\right)_{\eta=0} - \lambda \left(\frac{\partial h}{\partial \eta}\right)_{\eta=0} = 2f'(\xi)$$

where λ is a known constant and $f'(\xi)$ a given function. By using the half plane analogue of Poisson's formula, $h(\xi,\eta)$ can be expressed in terms of $f'(\xi)$. The results show that the reflected and transmitted disturbances exist everywhere at all times even when the incident wave has a well-defined front, and that the transmitted disturbance due to an incident simple pulse is of the order of the reciprocal of the distance from the interface when this distance is large. It is pointed out that the same analysis can be applied to the treatment of the total reflection of electromagnetic waves of arbitrary shape. Finally, the propagation of waves of arbitrary shape over the surface of a semi-infinite elastic solid is considered and shown to be possible when the velocity of propagation is that of Rayleigh waves.

Friedrichs, K. O.; see Courant, R., and Friedrichs, K. O. (1948).

Fu, C. Y. (1947) STUDIES ON SEISMIC WAVES. III. PROPAGATION OF ELASTIC WAVES IN THE NEIGHBORHOOD OF A FREE BOUNDARY. Geophysics, 12, 57-71.

Continuous and spherical harmonic waves are generated at an internal point of the medium. By use of the classical method of Sommerfeld, the different modes of propagation near a free surface after the arrival of the waves are examined. From the approximate evaluations of the integrals, it is found that in addition to the ordinary types of body and surface waves, there are also inhomogeneous waves and surface waves which are not of the Rayleigh type. The amplitude factors of these latter waves vary inversely as the square instead of as the square root of the epicentral distance. Altogether, there are not less than five different types of waves, and they are obtained from integrations in the neighborhood of the singularities of the integrals.

Fusfeld, H. I. (1950) APPARATUS FOR RAPID MEASUREMENT OF INTERNAL FRICTION. Rev. Sci. Instr., 21, 612-616.

The apparatus described satisfies the conditions: (a) low induced stress amplitude to preclude any plastic flow of the specimen; (b) ability to install specimen within a few minutes after treatment; (c) rapidity of measurement, at a rate of 10 to 20 per minute; (d) accuracy of at least 1%. Longitudinal vibrations are induced by an eddy-current drive similar to one previously described in the literature, satisfying (a) and (b). Conditions (c) and (d) are obtained by measuring the decay time of free vibrations using vacuum tube trigger circuits and a counter chronograph. Satisfactory measurements can be made with push-button rapidity and simplicity.

Gast, T. (1955) (SPRING-DASHPOT) MODELS FOR THE VISCOELASTIC BEHAVIOUR OF HIGH-POLYMER MATERIALS. Z. angew. Phys., 7, 82-86. (In German)

These and their electrical analogues are discussed for tension shear and hysteresis experiments.

Gaulard, M. L. (1957) ON THE TRANSMISSION OF AN ULTRASONIC WAVE THROUGH AN INDEFINITELY STRATIFIED MATERIAL. Compt. Rend., 244, 2486-2488. (In French)

Theoretical expressions are deduced for plane wave propagation through a medium consisting of successive parallel slices of two different materials, the wave being normal to the boundaries. These give forbidden frequencies when the slice width is an integral number of half wavelengths.

Gazis, D. C. (1958) EXACT ANALYSIS OF THE PLANE-STRAIN VIBRATIONS OF THICK-WALLED HOLLOW CYLINDERS. J. Acoust. Soc. Am., 30, 786-794.

The plane-strain vibrations of a thick-walled hollow cylinder are investigated in the framework of the linear theory of elasticity. Approximate expressions for the frequencies of free modes are derived for moderately thick shells. The transition from the shell vibrations to the Pochhammer vibrations of a solid cylinder is investigated by means of a numerical solution of the frequency equation using an IBM 704 digital computer.

Gehman, S. D. (1947) DYNAMIC PROPERTIES OF ELASTOMERS. Rubber Chemistry and Technology, 30, Rubber Reviews for 1957, 1202-1250.

This is a review article, containing 54 references. It is very well written. Starts with fundamentals of viscoelasticity and goes on to review current work. Division titles are:

I. Introduction
II. Dynamic Properties and the Theory of Viscoelasticity
III. Methods for Measuring Dynamic Properties
IV. Nonlinearity in Dynamic Properties
V. Dynamic and Dielectric Properties
VI. Further Developments for the Field of Dynamic Properties
VII. Acknowledgments
VIII. References

Gemant, Andrew (1940) THE MEASUREMENT OF SOLID FRICTION OF PLASTICS. J. Appl. Phys., 11, 647-653.

In view of the increasing importance of synthetic plastic materials, a method is developed to measure their vibrational damping in a wide range of temperatures up to fairly high plasticity. The method and its results should be useful both from a physical and technical standpoint.

Gent, A. N.; see Fletcher, W. P., and Gent, A. N. (1957).

Gerjuoy, E. (1948) REFRACTION OF WAVES FROM A POINT SOURCE INTO A MEDIUM OF HIGHER VELOCITY. Phys. Rev., 73, 1442-1449.

A point source is placed in one medium, and the fields in a second medium, separated from the first by an infinite plane boundary, are calculated for the case that the wave velocity in the second medium exceeds that in the first medium. Absorption is neglected and the problem is solved both by ray methods and by evaluation, by the method of steepest descents, of an exact solution of the wave equation. Rays incident on the boundary at angles exceeding the critical angle are totally reflected; directly transmitted energy penetrates to all points in the second medium. At points in the second medium outside the critical angle, near the surface and far from the source, the directly transmitted fields are much smaller than the fields, exponentially decaying from the surface, which result from totally reflected rays. An experiment to measure quantitatively the penetration of the fields into the second medium in total reflection is easily performable for the case of sound waves penetrating from air into water.

Gerjuoy, E. (1953) TOTAL REFLECTION OF WAVES FROM A POINT SOURCE. Comm. Pure Appl. Math., 6, 73-91.

A mathematical analysis of the reflection of a pulse of sound from a harmonic point source in a nonabsorbing liquid at a plane boundary of indefinite extent, the nonabsorbing medium 2 beyond the interface having a smaller index than the source medium 1. Sound field medium 2 has been discussed previously by author. To obtain sound field in medium 1, the exact solution of the wave equation is evaluated in the complex plane by means of the method of steepest descents, extending the work of H. Ott [Ann. Physik, (Leipzig) 41, 6, 443, 466, July, 1942] and L. Brekhovskikh [Zh. Tekh. Fiz. USSR, 18, 455-472, Apr., 1948 (in Russian)]. A simple geometrical interpretation is given of the amplitude dependence of the head wave, sometimes observed in geophysical prospecting and in underwater propagation. Also studied is the contribution which a pole lying on the imaginary axis in the complex plane of integration may make to the field in medium 1.

The analysis is equally applicable to the total reflection of electromagnetic radiation from a dipole perpendicular to the interface.

Gigli, A. (1948) SOUND ABSORPTION AND TRANSMISSION MEASUREMENTS. J. Acoust. Soc. Am., 20, 839-845.

A report of research performed in the last 10 years in the field of architectural acoustics, with special reference to meaurements of sound absorption coefficients of materials and sound transmission losses of partitions. The absorption of sound by systems of resonators is given particular attention.

Gigon, J.; see Mayer G., and Gigon, J. (1955).

Ginzberg, V. L. (1955) CONCERNING THE GENERAL RELATIONSHIP BETWEEN ABSORPTION AND DISPERSION OF SOUND WAVES. Sov. Phys.-Acous., 1, 32-41.

The general relationship between dispersion and absorption of sound waves is discussed. The problem is first attacked as applied to propagation of electromagnetic waves, and previously known results are derived. Analogous equations are then obtained to relate the velocity and absorption coefficient of sound. The features that distinguish the acoustic case from the electromagnetic one are discussed.

Gogoladze, V. G. (1941) ON RAYLEIGH WAVES ON THE CONFINES OF TWO SOLID ELASTIC MEDIA. C. R. Acad. Sci. URSS, 33, 15-17.

Two semi-infinite elastic solids given by $y > 0$ and $y < 0$ have densities ρ_1, ρ_2 and elastic constants $\lambda_1 \mu_1$ and $\lambda_2 \mu_2$ respectively. Displacements in the two regions are given by means of the potentials $u_i = \partial\phi_1/\partial x + \partial\psi_1/\partial y$, $v_i = \partial\phi_i/\partial y - \partial\psi_i/\partial x$ where $i = 1$ for $y > 0$ and $i = 2$ for $y < 0$. The potentials ϕ_1, ψ_1, ϕ_2, ψ_2 satisfy the wave equations. Applying a theory of Soboleff and Smirnov, potentials of a special form are found and these lead to necessary and sufficient conditions for the existence of Rayleigh waves.

Goodier, J. N., and Bishop, R. E. D. (1952) A NOTE ON CRITICAL REFLECTIONS OF ELASTIC WAVES AT FREE SURFACES. J. Appl. Phys., 23, 124-126.

The wave motion in an elastic solid given by the theory of reflection at a free surface is evanescent for certain conditions—a P (plane irrotational) wave at grazing incidence and also an SV (plane equivolunal) wave at grazing incidence. It is shown that by the application of suitable limiting processes, wave motions can be obtained for these critical circumstances. The relation of these motions to the noncritical motions is analogous to the relation of critically damped to noncritically damped vibrations.

Goodier, J. N.; see Timoshenko, S., and Goodier, J. N. (1951).

Goos, F., and Hanchen, H. (1947) A NEW AND FUNDAMENTAL EXPERIMENT ON TOTAL REFLECTION. Ann. Physik, 1, 333-346. (In German)

In the case of total reflection the reflection does not take place sharply at the interface of the two media, but there is a penetration of the wave into the rarer medium, which should result in a lateral displacement of the reflected beam. In the experiment described, multiple reflections of a beam of light occur, part of the beam falling on a silvered glass surface and part on a glass-air interface. As many as 74 such reflections take place, rendering the relative lateral displacement of the two parts of the beam subject to accurate measurement. The measurements lead to an empirical value of a constant in the theoretical expression for the displacement of the reflected beam.

Gorelik, A. G., and Zverev, V. A. (1955) ON THE PROBLEM OF MUTUAL INTERACTION BETWEEN SOUND WAVES. Sov. Phys.-Acous., 1, 353-357.

The paper shows the possibility of utilizing a method which is analogous to the I. L. Bershtein method (1) for detecting and investigating the interaction between acoustic waves in liquids. This method makes it possible not only to detect the presence of the very small modulation which is caused by the interaction of the soundwaves, but also to determine the nature of this modulation (amplitude modulation, phase modulation). Control experiments are performed which verify the fact that the modulation is caused by interaction between acoustic waves.

Gosels, K. (1956) RADIATION BEHAVIOR OF WALLS. Akust. Bei., 1, 94-98. (In German)

It is found by theoretical considerations that normal radiation behavior of plates occurs for $\lambda_B > \lambda_L$, and abnormally small radiation for $\lambda_B < \lambda_L$. In the first case the behavior of a plate excited by flexural waves is almost equivalent to a vibrating piston and, whenever the dimensions of the plate exceed λ_B, neither the internal damping nor the dimensions have any influence in this case. In the range of abnormal radiation, however, these parameters, primarily the dimensions of the plate, are of great importance. The decrease in radiation amounts 10 to 20 db. The calculation from the vibration amplitudes of the walls and ceilings of the sound radiated into air is quite possible for thick walls with a low limiting frequency, but difficulties arise in the case of thin walls because there sometimes exists a mixture of free and forced vibrations with different wave lengths for a given frequency.

Gotz, J. (1943) THE PASSAGE OF SOUND THROUGH METAL PLATES IMMERSED IN FLUIDS, WHEN THE WAVES ARE PLANE AND ARE INCIDENT OBLIQUELY. Akust. Z., 8, 145-168. (In German)

I. The origin of sound transmission problems and their use in the testing of materials.
   1. Rules of use and the attempt of the solution of the problems.
   2. The meaning of sound transmission problems by the detection of flaws in plates. Description of the measuring apparatus.
   3. Aim of the work.

II. The transmission of plane sound waves through plane-parallel free partitions.
   1. The problem.
   2. The theory of Rayleigh for media free from shearing stress.
   3. The theory of Reissner and the work of the Zurich Group.
   4. The sound damping by simple free partitions in room and building acoustics. The coincidence of bending waves.
   5. The attempt to use the theory of the coincidence of bending waves in the transmission of sound through metal plates in a liquid.
   6. Attempt the exhibition of vibrating plates as bending waves under consideration of the rotational inertia and the shearing deformation.
   7. Determination of the bending wave decrement through treatment of the problems as two-dimensional wave problems.
   8. The sound permeability by the incident angle within the angle of total reflection. The thickness resonance.
   9. Construction of thickness resonance by layers of partitions free from shearing stress as coincidence.
   10. Agreement of Reissner's theory with the coincidence theory by solid free partitions.

III. Attempt with the arrangement described under I.
   1. The maximum sound decrement.
   2. The progress of the tangential wave outside the defined sound ray.
   3. Summary.

The diagrams in this paper include photographs and schematic drawings describing the experimental apparatus as well as sketches of the sound transmission through the partition. Curves are given from Sander's work on brass foil. Both the measured and the calculated values for the bending wave decrement are given for a brass plate. Apparatus and curves are pictured on the determination of the sound permeability angle dependence. A few curves are given on the propagation of tangential waves in a solid plate beyond the stimulated region. Velocities of different conditions appear in table form.

Graham, F. H. (1942) MEASUREMENTS OF SOUND TRANSMISSION THROUGH SINGLE AND DOUBLE PLATES. OSRD Report No. 829.

This report covers measurements on the transmission of sound through single and double plates. The purpose of the tests was to obtain an efficient method of sound transmission through a ship's hull and to provide a means whereby echo-ranging projectors may be used at greater depths. The tests consisted in measuring the response of a projector and a standard hydrophone with and without the plates in the sound path.

Greenspon, J. E.; see Kirchman, E. J., and Greenspon, J. E. (1957).

Groen, P. (1948) INTERNAL WAVES IN CERTAIN TYPES OF DENSITY DISTRIBUTION. Nature, 161, 92.

Gross, B. (1950) FRICTIONAL LOSS IN VISCOELASTIC SUBSTANCES. J. Appl. Phys., 21, 185.

This communication deals with an extension of a theory developed in two previous papers on linear viscoelastic behavior. It introduces a frictional mechanism, which appears to contribute only to the imaginary part of the complex elastic modulus, in addition to the relaxation mechanism contributing to imaginary as well as to real part. Frictional force is assumed to depend linearly on rate of deformation. Its effect should, therefore, be observable at high frequencies.

Gross, B. (1953) Mathematical Structure of the Theories of Viscoelasticity. Paris: Hermann et Cie (Actualites Scientifiques et Industrielles), 74 pp.

The first of a series of monographs on "Rheology" from the Brazilian National Institute of Technology, comprising a systematic discussion of the relations between stress and strain that represent the most general type of viscoelastic behavior consistent with the principle of superposition. A complete duality between stress and strain is emphasized throughout. The distribution function of relaxation times, the relaxation function, and the complex modulus function for periodic strains are related with the distribution function of retardation times, the creep function, and the complex compliance function. Exact formulae suitable for numerical calculations are derived. Bibliography.

Gubanov, I. A. (1947) ELEMENTARY DEFORMATIONS OF ELASTO-VISCOUS BODIES. Zh. Tekh. Fiz., 17, 475-490. (In Russian)

The hydrodynamics of viscous fluids on the one hand and the theory of elasticity on the other are regarded as the extremes of the general case of the elasto-viscous material. For the latter, both the shear modulus and the coefficient of viscosity must be considered. The principles of the mechanics of such bodies were developed by Y. I. Frenkel ("Kinetic Theory of Fluids," published by Acad. of

Sci., USSR, 1945, Chap. 4). The corresponding equations can be obtained by substituting for the shear modulus G in elastic theory the operator

$$\frac{\eta \frac{d}{dt}}{1 + \tau \frac{d}{dt}} ,$$

where η is the coefficient of viscosity, and $\tau = \eta/G$ is the reaction time. On this basis the cases of elastic shear, torsion, and tension are generalized in this paper for elasto-viscous material. The elasto-viscous properties appear only in periodic or nonstationary regimes. Under stationary conditions simple viscous behavior is obtained.

The following cases are treated in detail: (1) shear in an infinite layer of finite thickness under (a) imposed displacements, (b) imposed forces, (c) tangential impact; (2) torsion of a cylindrical rod for (a) and (b) above; (3) uniform tension for (a) and (b) above.

The general equations take account of inertia effects. It is shown, however, that in most cases the magnitude of these effects is negligible, making simplifications possible. Numerical illustrations apply the theory to the behavior of a soil layer under shear, and to that of heated glass in various forming processes. It is stated that practical applications of this method are of interest in the field of polymers, plastics, and glasses, and in geology, astrophysics, and the investigation of motion in highly viscous media.

Guillet, L. (1948) "Internal Friction." Report on the Conference on Strength of Solids, 116-118. Phys. Soc. (London).

The results of experiments on internal friction by measurements of logarithmic decrements of the vibrations of pure metals, solid solutions, intermetallic compounds and phases. Internal friction less in all cases where the lattice is irregular or disordered than in the ordered state. This is true also for the case of the "ordered" β-phase and the "disordered" ν-phase.

Guth, E.; see Ivey, D. G., Mrowca, B. A., and Guth, E. (1949).

Guth, W.; see Exner, M. L., Guth, W., and Immer, F. (1954).

Hadley, C. F.; see Evans, J. F., Hadley, C. F., Eisler, J. D., and Silverman, D. (1954).

Hanchen, H.; see Goos, F., and Hanchen, H. (1947).

Hardtwig, E. (1947) ON THE THEORY OF RAYLEIGH WAVES WITH GIVEN INITIAL CONDITIONS. Z. angew. Math. Mech., 25/27, 1-13. (In German)

The differential equations of motion of a "nearly elastic" medium (that is, one in which the stress tensor contains viscous terms linear in the velocity, as well as elastic terms linear in the displacement) are applied to a body filling a half space, bounded by a plane. The condition for the existence of Rayleigh waves is found to be that the viscous constants are proportional to the elastic ones, and in the ensuing work the usual assumption for the earth's crust, the equality of the Lame constants, is made.

Solutions are obtained in two and three dimensions (in the latter case in cylindrical co-ordinates) for the surface displacements due to an initial surface distribution of normal displacement and velocity. The integrals are simplified by the assumption that the viscous constants are very small, and in the case of the elastic medium well-known formulas of wave theory are recovered.

Harris, C. M., and Molloy, C. T. (1952) THE THEORY OF SOUND ABSORPTIVE MATERIALS. J. Acoust. Soc. Am., 24, 1-7.

Presents a review of the status of the theory of sound-absorbing materials. The basic concept of absorption coefficient, as well as the relation between absorption coefficient and acoustical impedance, is discussed. Other topics considered are sound propagation in homogeneous isotropic media, perforated panels, suspended absorbers and resonant absorbers.

Hart, S. D.; see Osborne, M. F. M., and Hart, S. D. (1945).

Hart, S. D.; see Osborne, M. F. M., and Hart, S. D. (1946).

Haskell, N. A. (1953) THE DISPERSION OF SURFACE WAVES ON MULTILAYERED MEDIA. Bull. Seism. Soc. Amer., 43, 17-34.

Author discusses propagation of plane waves in a multilayered medium. Employing a matrix formalism for expressions for displacements, stresses, and boundary conditions in the medium, an arranged form of dispersion function of phase velocities is obtained which is so general that it can describe characters of Rayleigh waves, Stoneley waves, and others, according to assumptions on structures of layered medium. Love wave and fluid coupled wave are also discussed.

Numerical examples are shown of dispersion of Rayleigh wave in two- or three-layered medium, and comparison is made with seismological data.

Hatfield, P. (1952) AN ULTRASONIC PHASE LAG METHOD FOR MEASURING THE THICKNESS OF RUBBER. Brit. J. Appl. Phys., 3, 326-328.

A method for measuring the thickness when only one surface is available is described. This method, working at 50 kc/s frequency, was chosen because at this frequency ultrasonic absorption losses in rubber are low. The method was developed to measure thickness of rubber in the range 5-20 mm with an accuracy of ± 1 mm.

Hatfield, P. (1954) THE DESIGN OF LOW FREQUENCY ULTRASONIC TRANSDUCER HOUSINGS. Acustica, 4, 193-195.

Paper given at the Congress of the International Commission of Acoustics, Netherlands, 1953. Ultrasonic techniques have been developed for detecting internal voids and measuring the thickness of rubber products. Low frequency ultrasonic waves from 50 to 500 kc/s have been used because of the relatively high absorption of ultrasonic waves in rubber. This paper gives practical details of transducers and their associated water-tight housings, including suitable rubbers for acoustically matching the transducer into a liquid medium, and a simple electrical network for electrically matching the transducer output into an amplifier. It also describes a transmitting and receiving crystal mounted in a common housing for use when only one surface is available.

Heaps, H. S. (1957) REFLECTION OF PLANE WAVES OF SOUND FROM A SINUSOIDAL SURFACE. J. Appl. Phys., 28, 815-818.

When a plane wave of sound is incident upon a sinusoidal surface, part of the reflected radiation consists of undamped plane waves that travel away from the boundary. Under the assumption that no other reflected radiation is present the amplitudes of the plane waves are chosen to minimize the mean square value of the surface pressure. The amplitudes so obtained agree with the experimental results of LaCasce and Tamarkin. Except in the case of the specularly reflected wave the agreement is better than that obtained in previous analyses.

Helberg, H. W. (1955) THE PROPAGATION OF SOUND IN A NARROW, LIQUID-FILLED TUBE. Acustica, 5, 267-268. (In German)

The absorption and velocity of sound waves in rigid tubes filled with liquid are calculated for the transition region between the Rayleigh and the Helmholtz approximations.

Heller, G. S. (1953) REFLECTION OF ACOUSTIC WAVES FROM AN INHOMOGENEOUS FLUID MEDIUM. J. Acoust. Soc. Am., 24, 1104-1106.

Paper gives an approximate method of calculating the reflection coefficient of plane waves for oblique incidence in the case of a homogeneous fluid medium separated by a plane interface from a nonhomogeneous medium. The method used is the Wentzel-Kramers-Brillouin asymptotic solution of the differential equation. A complete account of the theory on which this method is based is given by Jeffreys, Proc. Lond. Math. Soc., 23, 428, 1924. Author compares his approximate results with the exact results in the case in which the wave velocity in the second medium is exponential, for which he derives an exact solution in terms of Hankel functions. Good agreement is obtained - 5% overall - with better agreement for grazing and normal incidence. It is likely that the method will be reliable for fields of exponential type.

Herrey, E.M.J. (1955) EXPERIMENTAL STUDIES ON ACOUSTIC RADIATION PRESSURE. J. Acoust. Soc. Am., 27, 891-896.

An apparatus is described which allows one to measure the normal and shearing component of the force of radiation pressure exerted by an ultrasonic beam through water on an intercepting disk.

Herrmann, G. (1956) THE INFLUENCE OF INITIAL STRESS ON THE DYNAMIC BEHAVIOUR OF ELASTIC AND VISCOELASTIC PLATES. Publ. Int. Assn. Bridge Struct. Engng., 16, 255-294.

Author first derives from Biot's general three-dimensional theory of elasticity of a body under initial stress the equations of motion of an initially stressed plate, which imply Saint-Venant equations of a plate as a special case. For this purpose proper assumptions are introduced as to displacements, and Hamilton's principle is used. Necessary further simplifications are pointed out. The equations of motion are solved for the problem of vibrations of a viscoelastic rectangular plate simply supported along all four edges and subjected to initial uniformly distributed uniaxial thrust. Neglecting the damping, the additional effect of the weight of the plate and that of a free edge is discussed. Particularly, the influence of the aspect ratio of the plate on the deflections and on the frequencies of vibration is analyzed, and the connection to the stability problem of the plate is worked out.

Hibbard, F. H.; see Mason, W. P., and Hibbard, F. H. (1948).

Hickman, J. S., Risty, D. E., and Stewart, E. S. (1957) PROPERTIES OF SANDWICH-TYPE STRUCTURES AS ACOUSTIC WINDOWS. J. Acoust. Soc. Am., 29, 858-864.

The acoustic transmission of a sandwich consisting of a pair of plane parallel solid plates immersed in a liquid has been investigated theoretically and experimentally. Not only the dilatational waves, but also the shear waves are considered.

Hiedemann, E. (1947) MECHANICAL PROPERTIES OF SOLIDS. IV. WAVE PROPAGATION IN SOLIDS, ULTRASONICS. "Physics of Solids, I." FIAT Rev. German Sci. (Off. Mil. Govt. Germany), 154-178. (In German)

Many experimental results are recorded for the propagation of sound and supersonic waves in solids of many types, and for specimens of varying shapes and sizes. The use of a supersonic lens is described and photographs of sound waves in certain materials are given. The principles are applied in flaw detection by supersonic waves.

Hiedemann, E. A.; see Breazeale, M. A., and Hiedemann, E. A. (1958).

Hines, C. O. (1953) REFLECTION OF WAVES FROM VARYING MEDIA. Quart. Appl. Math., 11, 9-31.

Formulas are found for the coefficient of reflection from varying media of a type encountered in physics. These are applied approximately for some general classes of media, and exactly for some specific cases. Many media which would normally be expected to be highly reflecting are shown to be completely transparent to certain waves at least and, in some cases, to a whole spectrum of waves. The results are considered both for electro-magnetic (or other classical) waves and for mass waves.

Holden, A. N. (1951) LONGITUDINAL MODES OF ELASTIC WAVES IN ISOTROPIC CYLINDERS AND SLABS. Bell System Tech. J., 30, 956-969.

The general properties of the longitudinal modes in cylinders and slabs are developed with the aid of the close formal analogy between the dispersion equations for the two cases.

Hopkins, I. L. (1958) STRESS RELAXATION OR CREEP OF LINEAR VISCOELASTIC SUBSTANCES UNDER VARYING TEMPERATURE. J. Poly. Sci., 28, 631-633.

Tobolsky and Andrews, Leaderman, Ferry and associates, and Williams have shown that the effect of a change of temperature on a material whose mechanical properties are characterizable by a distribution of relaxation or retardation times is to multiply all relaxation or retardation times by a factor variously known as $\kappa(T)^5$ or $a_T{}^3$. This factor depends upon the reference temperature, T_o, and the other temperature, T. In work so far published, the temperature has been held constant for the duration of a test. The object of this letter is to show some effects of varying the temperature during the test.

Howes, E. T., Tejada-Flores, L. H. and Randolph, L. (1953) SEISMIC MODEL STUDY. J. Acoust. Soc. Am., 25, 915-921.

A method has been developed for studying seismic sound pulses in reduced scale models which simulate geophysical seismic exploration methods. Use is made of a tank of water for transmission of the acoustic wave from a source to a faulted limestone stratum and return to a pressure-sensitive receiver. Results obtained demonstrating the geometric aspects of the propagation, reflection, refraction, and diffraction of sound pulses are described and illustrated on accompanying plates.

Hsi, Eugene; see Curry, B., Hsi, Eugene, Ambrose, J. S., and Wilcox, F. W. (1951).

Hudimac, A. A. (1957) RAY THEORY SOLUTION FOR THE SOUND INTENSITY IN WATER DUE TO A POINT SOURCE ABOVE IT. J. Acoust. Soc. Am., 29, 916-917.

The sound intensity in the water due to a point source above it has been determined by the ray theory. For a given height of source and depth of point of observation, the intensity and lateral range are given by a pair of parametric equations in terms of the angle of incidence. An example is given for which iso-intensity lines are plotted. A striking feature is the way in which intensity increases appreciably with depth (except directly below the source).

Hughes, D. S., and Kelly, J. L. (1953) SECOND-ORDER ELASTIC DEFORMATION OF SOLIDS. Phys. Rev., 92, 1145-1149.

Expressions for the velocities of elastic waves in stressed solids are derived using Murnaghan's theory of finite deformations and third-order terms in the energy. For isotropic materials, in addition to the Lame constants λ and μ, three additional constants, l, m, and n are required to describe the material. By measuring the transmission time of elastic pulses through the material, the velocities of longitudinal and shear waves are determined as a function of applied stress. By subjecting the material to hydrostatic pressure as well as simple compression, it is found that seven functions of the three constants l, m, and n can be measured and thus numerical values calculated. Results are given for polystyrene, iron, and Pyrex glass.

Hunt, F. V. (1955) NOTES ON THE EXACT EQUATIONS GOVERNING THE PROPAGATION OF SOUND IN FLUIDS. J. Acoust. Soc. Am., 27, 1019-1039.

The assumptions underlying the exact equations of motion for a thermoviscous fluid are reviewed and the complete equations are given, for reference convenience, in both tensor and vector form. The first- and second-order acoustic equations are then exhibited and used to obtain the source terms that account for the generation or vorticity and streaming. In order to preserve a broad base from which to make the approximations appropriate under various circumstances, all terms are retained explicitly, including those arising from any functional dependence of the viscosity and thermal coefficient on the state variables.

The difference between spatial and material coordinate systems is carefully drawn, and conversion transforms are derived rigorously and their use illustrated. The general properties of finite-amplitude waves are demonstrated by including the second-order terms in a plane wave solution of the exact wave equation in material coordinates, with special concern for the effects of large amplitude on speed of propagation and on wave form distortion.

Sound absorption and dispersion measures for a viscous conducting fluid are analyzed in terms of Truesdell's recent exact solution of the first-order secular equation. These differ characteristically from the corresponding measures predicted for pure relaxation in a two-fluid mixture. It is concluded that a complete and adequate theory of sound absorption and dispersion will need to take into account both relaxation and visco-thermal phenomena as well as their interaction, and until such a general theory is available, the exact theory of visco-thermal effects - instead of the crude linear approximation commonly, but inappropriately, called "classical" - should be used in computing the "excess" absorption and dispersion to be accounted for by relaxation processes.

The exact solutions of the secular equation permit a new evaluation, in series form, of the characteristic acoustic impedance of a thermoviscous medium. The notes conclude with a revised account of the spectral character of thermal noise in the acoustic medium, based on the quantum hypothesis and a merger of the concepts of architectural acoustics and specific heat theory.

Hurst, D. G. (1935) TRANSMISSION OF SOUND BY A SERIES OF EQUIDISTANT PARTITIONS. Can. J. Research, 12, 398-407.

The transmission of normally incident waves through a series of similar equally spaced partitions has been calculated for the cases of infinite partitions and of circular partitions. The transmission characteristics depend on the solution of simultaneous linear difference equations for the velocity potentials. The array of partitions possesses interesting properties as a filter, and to illustrate these, the change in intensity levels due to glass partitions is calculated numerically for 1, 2, 5, and 10 partitions.

Immer, F.; see Exner, M. L., Guth, W., and Immer, F. (1954).

Ingard, U. (1951) ON THE REFLECTION OF A SPHERICAL SOUND WAVE FROM AN INFINITE PLANE. J. Acoust. Soc. Am., 23, 329-335.

The reflection of a spherical sound wave from a wall with the boundary conditions expressed in terms of a normal impedance independent of the angle of incidence is treated. It is shown that the integral for the reflected wave can be evaluated exactly in closed form under certain conditions. The solution given for an arbitrary normal impedance involves a slight approximation of the integral. The reflected wave is brought into a form such that it can be considered as originating from an "image source" having a certain amplitude and phase. Graphs for determining this amplitude and phase are given in terms of a "Numerical Distance," which depends on the normal impedance and the position of the field point. Pressure distributions around point sources for different wall impedances are shown. The limitations in simulating plane wave conditions at a boundary and the corresponding effect on free-field methods of measuring acoustic impedance are discussed.

Ingard, U. (1954) TRANSMISSION OF SOUND THROUGH A STRETCHED MEMBRANE. J. Acoust. Soc. Am., 26, 99-101.

The problem of sound transmission through a membrane stretched across a duct is analyzed rigorously. The integral equation for the velocity distribution of the membrane is set up and studied in the special case of a circular cylindrical tube. Equivalent circuits for the membrane are shown for the frequencies around the resonances and the anti-resonances of the membrane. High transmission loss is commonly associated with a large mass, but it is clear that it can also be obtained with very little mass if stiffness rather than mass provides the high impedance.

Irmay, S. (1954) DYNAMIC BEHAVIOUR OF LINEAR RHEOLOGICAL BODIES UNDER PERIODIC STRESSES. Quart. J. Mech. Appl. Math., 7, 399-409.

The simpler linear rheological bodies - such as the elastic and Kelvin's solids, Maxwell's and Newton's viscous fluids - obey a generalized linear differential equation with constant coefficients between the strain and stress deviators and their time rates. The various coefficients are correlated to the asymptotic rigidity or static elastic modulus G, elastic firmness or dynamic modulus H, solid viscosity μ, times of relaxation R and of lagging or retardation L, and the endosity η. Expressing the time and stress in non-dimensional forms, a universal equation is obtained, dependent on a single non-dimensional parameter, the "time factor" $\tau = R/L = G/H$. This defines a principle of similitude for all bodies of identical τ. The mechanical and thermodynamic study of periodic, impulsive, and transient stresses leads towards a new classification of the linear bodies, based on the value of τ: (a) The exothermal or dissipative bodies ($\tau < 1$) are less rigid than firm, less strained than elastic solids, dissipate energy in a cycle. They warm up adiabatically; here belong also Maxwell's elastico-viscous fluids and Kelvin's firmo-viscous solids ($\tau = 0$); (b) The endous solids ($\tau > 1$) are more rigid than firm, more strained than elastic solids, may show a "negative" dissipation in a cycle, which is compensated by internal structural changes. This is not in contradiction with the second law of thermodynamics and may explain the fatigue of such solids; (c) The homothermal solids ($\tau = 1$) are as rigid as firm, show no apparent dissipation in a cycle. A particular case is that of elastic solids. The stress-strain diagram under periodic stresses tends towards an ellipse, which shows accommodation of the body. The smaller axis passes through a maximum for a critical frequency, and the body has two independent elastic moduli—a static and a dynamic one. These facts were experimentally confirmed for certain plastics.

Isakovich, M. A. (1956) THE SCATTERING AND RADIATION OF WAVES BY STATISTICALLY NON-UNIFORM AND STATISTICALLY OSCILLATORY SURFACES. Sov. Phys.-Acous., 2, 149-153.

The Kirchoff principle is applied to the scattering of waves at a plane surface having a statistically distributed reflection coefficient and to the radiation from a statistically oscillating surface.

Isakovich, M. A. (1956) THE UTILIZATION OF LAYERS THAT ELIMINATE THE FORMATION OF TRANSVERSE WAVES WHEN A LONGITUDINAL WAVE IS REFLECTED FROM THE BOUNDARY OF A SOLID BODY. Sov. Phys.-Acous., 2, 154-158.

The paper poses and solves the problem of the suppression of transverse waves which arise when sound is reflected in solid bodies; the solution is accomplished by means of a solid layer which is deposited upon the surface of the solid body.

Isakovich, M. S.; see Ageeva, N. S., Zhukov, I. P., Isakovich, M. S., Sosedova, A. L., and Sukharevsii, Yu. M. (1952).

Ishida, Y.; see Takahashi, I., and Ishida, Y. (1953).

Ivanov, I. D.; see Brekhovskikh, L. M., and Ivanov, I. D. (1955).

Ivey, D. G., Mrowca, B. A., and Guth, E. (1949) PROPAGATION OF ULTRASONIC BULK WAVES IN HIGH POLYMERS. J. Appl. Phys., 20, 486-492.

The propagation of supersonic waves in bulk rubbers has been studied from 40 kc/s to 10 Mc/s and from -60°C to 60°C. The wave velocity was found to increase with decreasing temp., leveling off both at high and low temps., and was found to increase slightly with frequency. Peaks in attenuation as a function of either temp. or frequency were observed, the peaks occurring at lower temps. for lower frequencies. The peaks for butyl, a high loss rubber, are broader and higher than those of GR-S and Hevea, which are lower loss rubbers. The results are in qualitative agreement with data obtained by strip methods at audio-frequencies. However, for bulk waves the real and imaginary parts of two elastic constants, the bulk and shear moduli, determine wave velocity and attenuation; hence, independent measurements of shear wave properties are necessary to evaluate these constants. A 3-constant theory is discussed assuming a shear viscosity only, so that an effective modulus $\kappa + 4\mu/3$ is obtained, where κ and μ are the bulk and shear moduli. Relaxation times of the order 10^{-6} to 10^{-8} sec are indicated. Approximate values of the dynamic Young's modulus are obtained from the effective modulus by assuming that the high-frequency dispersion is due to the appearance of a "crystalline" shear elasticity. These results are correlated with low-frequency data, and the dynamic Young's modulus and the loss factor are plotted. The loss factor exhibits a maximum in the dispersion region. Results are plotted in the range from 1 c/s to 10^7 c/s, which covers a wider range of frequency than earlier investigation. The necessary distribution of relaxation times is discussed.

Ivey, D. G.; see Cunningham, J. R., and Ivey, D. G. (1956).

Jacobs, R. B.; see Bancroft, Dennison, and Jacobs, R. B. (1938).

Jardetzky, Wenceslas S.; see Ewing, W. Maurice, Jardetzky, Wenceslas S., and Press, Frank (1957).

Jobert, N. (1955) EFFECT OF THE EARTH'S CURVATURE ON LOVE WAVE. Ann Geophys., 11, 1-48. (In French)

A sudden displacement is considered, at a point inside an elastic spherical layer, surrounding an elastic homogeneous sphere of different properties; the motion at a point of the surface, due to the Love waves, is calculated and compared to the motion at the surface of a plane layer, covering an elastic half-space. Owing to the curvature of the surface, the long-period waves are more dispersed, and the beginning of the train of waves is stretched forward; the first long-period waves arrive with a velocity greater than that of the SH waves in the underlying medium, and the amplitude of the subsequent motion grows more slowly with time.

Jones, R. C. (1946) THE DRIVING-POINT IMPEDANCE OF AN INFINITE SOLID PLATE. J. Acoust. Soc. Am., 17, 334-336.

In the design of mechanical filters whose function is to prevent the transmission of vibration from one structure to another, it is necessary to know the impedances of the structures between which the filter is to be connected. In many of the cases which arise in practice, the impedance may be estimated from a knowledge of the driving-point impedance of an infinite plate. The expression $8ph^2v$ is obtained for connection to a constant-thickness plate at a single point, where p is the density, h is the thickness of the plate, and v is a velocity approximately equal to the velocity of shear waves in the material. This is equal, except for a constant factor, to the impedance of a mass equal to the mass of a disc cut from the plate whose radius is the mean proportional of the thickness and the wavelength which corresponds to v. The results are exemplified by applying them to a steel plate.

Junger, M. C. (1952) VIBRATIONS OF ELASTIC SHELLS IN A FLUID MEDIUM AND THE ASSOCIATED RADIATION OF SOUND. J. Appl. Mech., 19, 439-445.

This is a study of the vibrations of thin elastic shells freely suspended in a compressible fluid medium. The effect of the fluid reaction on the dynamic characteristics and, in particular, on the natural frequencies is investigated for cylindrical and spherical shells. The dynamic configuration of such shells undergoing forced vibration and the associated radiation of sound are determined. The problem is analyzed by means of the classical methods of the theory of mechanical vibrations; the Lagrange equations for the system are derived, the fluid reaction being introduced in the form of generalized forces. From the boundary condition that the normal shell deflection be equal to the normal fluid-particle displacement at the shell surface, and introducing the concept of acoustic impedance, it is shown that the fluid reaction is equivalent to an accession to the inertia of the shell and to a damping force. Numerical examples show that the effect of the fluid reaction on the dynamic characteristics of a shell may be of such magnitude as to render valueless calculations neglecting it.

Junger, M. C., and Rosato, F. J. (1954) THE PROPAGATION OF ELASTIC WAVES IN THIN-WALLED CYLINDRICAL SHELLS. J. Acoust. Soc. Am., 26, 709-713.

The propagation of axially symmetric elastic waves in the walls of cylindrical shells is studied by means of a theory which takes into account both membrane and flexural stresses.

Junger, M. C., and Smith, P. W., Jr. (1955) CONCERNING THE ARTICLE BY A. BERGASSOLI, F. CANAC, AND T. VOGEL, "THE TRANSMISSION OF SOUND BY SPHERICAL SHELLS." Acustica, 5, 47-48.

Kaminir, G. I., and Tartakovskii, B. D. (1956) EXPERIMENTAL STUDY OF ULTRASONIC TRANSITION LAYERS. Sov. Phys.-Acous., 2, 159-165.

The work deals with the acoustic analogue of "blooming" in optics. It is shown that a single layer can increase the coefficient of sound penetrability of an Al plate in water up to 99% and for steel up to 92%. The use of a double transition layer (as in optics) makes it possible to broaden the band of acoustic penetrability. Experimental work is described using frequencies of 0.5-2 Mc/s. Test surfaces were plane, cylindrical, and spherical. Best results were obtained for layers of thickness $\lambda/4$. Layers of other metals, plastics, or paint were used.

Kammerer, A. (1950) THE VISCOSITY AND INTERNAL FRICTION OF SOLIDS. Compt. Rend., 231, 1285. (In French)

If the elastic modulus decreases more rapidly with temperature than the viscosity, then it is shown that the damping of torsional oscillations increases with temperature.

Kane, T. R. (1957) REFLECTION OF DILATATIONAL WAVES AT THE EDGE OF A PLATE. J. Appl. Mech., 24, 219-227.

The reflection of straight-crested dilatational waves at the edge of a semi-infinite plate is studied in terms of a two-dimensional plate theory and in terms of the theory of generalized plane stress. It is found that, in general, a dilatational wave propagated toward the edge at an arbitrary angle of incidence gives rise to three reflected waves; namely, two dilatational waves and a shear wave. A number of special cases are investigated in detail.

Kanter, I.; see Lee, E. H., and Kanter, I. (1953)

Karnovskii, M. I. (1949) WORK OF SOVIET ACOUSTICAL ENGINEERS IN THE STUDY OF DIRECTIONAL PROPERTIES OF TRANSMITTERS AND RECEIVERS. Izv. Akad. Nauk, SSSR, Ser. Fiz., 13, 698-709.

Enumeration of results obtained in the investigation of the directionality of various geometrical forms of sound transmitting and receiving surfaces.

Kastner, S.; see Altenburg, K., and Kastner, S. (1953).

Kastner, Siegfried (1956) THE REFLECTION AND TRANSMISSION OF A PLANE SOUND WAVE INCIDENT AT ANY ANGLE ON A LAYERED VISCOELASTIC MEDIUM I. Ann. Physik, 18, 190-219. (In German)

The propagation of a sound wave through an infinite viscoelastic medium is discussed theoretically. The treatment is then extended, using a matrix notation, to a system of n parallel plane layers of viscoelastic material; from the chain matrix of the system, expressions are derived for the reflected and transmitted waves as a function of the incident wave.

Kastner, Siegfried (1956) THE REFLECTION AND TRANSMISSION OF A PLANE SOUND WAVE INCIDENT AT ANY ANGLE ON A LAYER-SYSTEM VISCOELASTIC MEDIUM II. Ann. Physik, 19, 102-115. (In German)

The reflection and transmission of plane waves through a layered system of viscoelastic material is discussed. Four different arrangements of material in which either both compression and shear waves appear or only compression waves are propagated are considered theoretically.

Kastner, Siegfried, and Schlosser, E. (1957) PHENOMENOLOGICAL THEORY OF VISCO-ELASTICITY. Kolloid-Zeit., 152, 116-121.

Basic relations of linear scalar relaxation theory.

Kawashima, S. (1941) SOUND-PREVENTION MECHANISM OF NON-POROUS MATERIALS, II. J. Acoust. Soc. Am., 12, 327-331.

The problem of sound prevention from the architectural standpoint was experimentally investigated, and agreement with the theory checked. The formulae of David for the transmission loss in platelike materials and in thin flexible materials were verified experimentally. Formulae are derived giving the transmission loss, and the maximum value of the transmission loss, for an elastically built-in wall of which the thickness is comparable with the exciting wavelength.

Keller, H. B.; see Keller, J. B., and Keller, H. B. (1948)

Keller, J. B.; see Primakoff, Henry, and Keller, J. B. (1947).

Keller, J. B. (1955) REFLECTION AND TRANSMISSION OF SOUND BY A MOVING MEDIUM. J. Acoust. Soc. Am., 27, 1044-1047.

The reflection and transmission of sound by a moving medium are investigated theoretically and the reflection and transmission coefficients are determined. These coefficients are found to depend only upon that component of the velocity of the medium which lies in the plane of incidence. The reflection coefficient increases with the velocity of the moving medium until a velocity is reached at which total reflection occurs. Total reflection persists until a still higher velocity is reached above which the reflection coefficient decreases as the velocity increases.

Keller, Joseph B. (1957) ACOUSTIC TORQUES AND FORCES ON DISKS. J. Acoust. Soc. Am., 29, 1085-1091.

The time-average forces and torques exerted by a plane sound wave upon fixed rigid disks of various shapes are calculated. Results are given for disks bounded by smooth closed convex curves. These results are then specialized to ellipses and circles. Results are also given for infinitely long thin strips. The results are all valid for ka large, where $k = 2\pi/\lambda$, λ being the wavelength and a being a typical dimension of the disk. The oscillatory behavior of the torque as a function of ka and the occurrence of numerous equilibrium positions are interesting consequences of these calculations.

Keller, J. B., and Keller, H. B. (1948) REFLECTION AND TRANSMISSION OF SOUND BY A SPHERICAL SHELL. J. Acoust. Soc. Am., 20, 310-313.

A periodic point source in medium 1 is at the center of a spherical shell of medium 2 which is surrounded by medium 3. The densities, sound speeds, and shell radii are arbitrary. An exact, explicit expression for the sound pressure is obtained. If the shell radii become infinite but the thickness remains constant, and if media 1 and 3 are the same, the solution reduces to that of Rayleigh for plane waves normally incident on a flat plate. If the shell radii become infinite and if media 2 and 3 are the same, the solution yields the acoustic Fresnel formulae for normal incidence of a plane wave on a plane interface between two half-infinite media. For finite radii, with media 1 and 3 identical and the shell thickness small compared to a wavelength, a simpler form for the solution is obtained. This solution agrees with an earlier approximate solution for the sound fields reflected and transmitted by a thin shell of any shape, when their result is specialized to the present case.

Kelly, J. L.; see Hughes, D. S., and Kelly, J. L. (1953).

Kennard, E. H. (1953) THE NEW APPROACH TO SHELL THEORY: CIRCULAR CYLINDERS. J. Appl. Mech., 20, 33-40.

Taking Epstun's basic work on elastic vibrations in plates and shells, the author proceeds to construct expressions for the distributions of stress and displacements. From these, stress resultants are calculated. The principal effects of external load on the faces of the shell are included, and the validity of the approximation and practical applications of the results are discussed.

Kennedy, A. J. (1952) PLASTICITY OF MATERIALS. Nature, 170, 875-877.

A report on the conference of the British Society of Rheology held in September, 1952. The papers presented were concerned, in the main, with (a) instrumentation and (b) interpretation of data. The problems of measurements on rubber, putty, plastics, clays, paper, and gels were discussed under (a), with (b) devoted to an examination of creep phenomena in metals. It would appear that whilst instrument design is tending to become more specialist (to a particular material), the treatment of the basic rheological properties is being successfully extended to a more general range of solids, both metallic and non-metallic in nature.

Kepes, A. (1949) A NEW APPARATUS FOR THE MEASUREMENT OF THE ELASTIC MODULUS AND INTERNAL FRICTION IN SOLIDS. Trans. Instr. Meas. Conf., Stockholm, 136-138. (In French)

A theoretical examination leads to a method in which the specimen is fixed rigidly at one end and a force applied to the free end. The deflection is measured in terms of amplitude and frequency. Methods of measurement are considered and examples given.

Kharkevich, A. A. (1949) NON-STATIONARY (ACOUSTIC) RADIATION OF A SEMI-SURFACE. Zh. Tekh. Fiz., 19, 833-838. (In Russian)

Mathematical. The acoustic radiation emitted by a semi-surface is analyzed, particularly with regard to phenomena occurring near the edge of the semi-surface and to the reaction of the medium.

Kharkevich, A. A. (1950) EQUATIONS OF ACOUSTICAL TRANSMISSION SYSTEM. Dokl. Akad. Nauk SSSR, 72, 285-287. (In Russian)

The behavior of acoustically interacting surface is dealt with on the basis of consideration of mean pressures arising at the radiating surface. In certain applications the equations derived are shown by examples to be simpler than the classical method using the wave equation.

Kiely, J. P.; see Morgan, G. W., and Kiely, J. P. (1956).

Kimball, A. L. (1936) THEORY OF TRANSMISSION OF PLANE SOUND WAVES THROUGH MULTIPLE PARTITIONS. J. Acoust. Soc. Am., 7, 222-224.

Transmission through ideal infinite plane partitions by plane waves. The partitions are flexible (no stiffness, only mass), and there is elastic coupling only from the air between the partitions, which are perfect reflectors. The distance between the partitions and their thickness is less than the wavelength. No sound absorption is considered—the purpose of the analysis is to ascertain the transmission losses apart from damping effects.

Kirby, P. L. (1953) INTERNAL FRICTION IN GLASS. J. Soc. Glass Technol., 37, 7T-26T.

Relationships between internal friction or damping capacity and delayed elastic effects are discussed, both effects being related to a quantity denoting the relaxation ratio of an anelastic process. The connection between damping factors for oscillatory and aperiodic stress-time phenomena is considered. Suggestions are made concerning the probable relationships between the relaxation ratios (and hence internal friction peaks in the acoustic spectrum) corresponding to different types of elastic deformation. The physical causes of anelasticity in glass are considered, including the effects of inhomogeneity, thermal diffusivity, ionic mobility, and effective configuration temperature. The result of which is to suggest reasons for the surprisingly small difference in the time order of elastic after-effects at room temperature and those in the transformation range.

Kirchman, E. J., and Greenspon, J. E. (1957) NONLINEAR RESPONSE OF AIRCRAFT PANELS IN ACOUSTIC NOISE. J. Acoust. Soc. Am., 29, 854-857.

This paper considers the response of thin elastic plates to sinusoidal acoustic excitation. A theoretical method for obtaining the dynamic deflection and stress in the nonlinear region is given. The theory is compared with test results, showing rather good agreement. The application of the theory to the design of panels to withstand acoustic fatigue is discussed in the latter part of the paper.

Kneser, H. O., and Voelz, K. (1953) EXPLANATION OF THE INTERNAL DAMPING OF SOLIDS BY SHEAR-VISCOSITY AND PRESSURE-VISCOSITY. Ann. Physik, 11, 377-382. (In German)

Some results of measurements point to the advisability of introducing a coefficient of the shear viscosity, independent of frequency, and a coefficient of volume viscosity. These coefficients might enable the damping to be compared for different forms of vibration. Volume viscosity for metals is probably zero.

Knopoff, Leon (1954) ON THE DISSIPATIVE VISCOELASTIC CONSTANTS OF HIGHER ORDER. J. Acoust. Soc. Am., 26, 183-186.

The limitations imposed upon the usual elastic and viscoelastic constants are reinvestigated.

Knopoff, Leon (1958) SURFACE MOTIONS OF A THICK PLATE. J. Appl. Phys., 29, 661-670.

The motion of a thick elastic plate, infinite in two dimensions and bounded by air on the two parallel faces, has been studied. The plate is excited at a point on one face, as in Lamb's problem, by a force impulsive in time, and directed normal to the surface.

Knudsen, J. R. (1954) THE EFFECTS OF VISCOSITY AND HEAT CONDUCTIVITY ON THE TRANSMISSION OF PLANE SOUND PULSES. J. Acoust. Soc. Am., 26, 51-57.

The dissipative effects of viscosity and heat conductivity are studied here in connection with the flow of a compressible fluid in a parallel channel or tube. Two kinds of waves or pulses are considered and the distortion from the customary square wave calculated. An observer at a fixed point on the channel and two traveling with the wave are seen to give information as to the order of decay or dissipation of the wave with increasing time.

Kolsky, H. (1953) Stress Waves in Solids. Oxford, Clarendon Press.

Part I: treats the propagation of stress waves in perfectly elastic solids, and the theory is developed as a mathematical consequence of Hooke's law and the equations of motion. The only difference between individual solids in this treatment results from differences in the values of their elastic constants and densities. Recent experimental work concerned with the verification of the theory is described.

Part II: concerned with the propagation of stress waves through solids which are not perfectly elastic. The measurement of internal friction and the nature of the various dissipative processes which cause it are discussed first. A review of experimental work on the measurement of dynamic elastic properties is then given. Finally, the theory of plastic waves and shock waves is outlined and some of the fracture phenomena produced by large stress pulses are described.

Kolsky, H. (1956) SOME ASPECTS OF THE MECHANICAL TESTING OF NON-METALLIC SOLIDS. Brit. J. Appl. Phys., Suppl. No. 6, S1-S4.

The difficulties encountered in measuring the elastic properties of rubbers, plastics, and fibrous materials are considered, and tests on the mechanical strength of glass-like materials are discussed.

Koppe, H. (1948) ON RAYLEIGH WAVES AT THE INTERFACE OF TWO BODIES. Z. angew. Math. Mech., 28, 355-360. (In German with Russian summary)

The author applies the Rayleigh wave theory to boundary waves between two media. The first case he considers is that of two semi-infinite isotropic elastic solids in welded contact. The irrational equation derived for the velocity of boundary waves between the two solids in terms of the elastic constants and the transverse wave velocities in the two media is obtained on the assumption that a displacement potential exists for motions parallel to the interface, and that amplitudes normal to the interface fall off exponentially with distance from the interface in both media. Solving numerically for the case of equality of the two Lame constants, the author finds that boundary waves exist only if the ratio of the rigidity in the acoustically less dense medium to that in the denser medium lies between 3 and 0, and the boundary velocity lies between the velocity of Rayleigh waves and transverse waves in the denser medium. The second case the author considers is that of waves of a fluid in contact with a solid. He concludes that boundary waves can always exist and that they travel more slowly than the corresponding Rayleigh waves. (There are a few minor typographical errors, such as subscript z in place of x in the last term of Equation (2) on page 356, and $\rho = 1/3$ instead of $g = 1/3$ in line 6 on page 359.)

Kraichnan, R. H. (1957) NOISE TRANSMISSION FROM BOUNDARY LAYER PRESSURE FLUCTUATIONS. J. Acoust. Soc. Am., 29, 65-80.

A theoretical study is made of noise spectra radiated by the vibration of thin, stiff, flat plates under the action of turbulent boundary layer pressure fluctuations. The transmitted radiation investigated arises from the streamwise convection of quasi-static pressure fluctuations by the steady flow and is critically influenced by the dispersive character of transverse wave propagation in the plates. At moderate subsonic Mach numbers and typical parameter values the total transmitted power varies approximately as the fifth power of Mach number, for sufficiently thin boundary layers. At lower Mach numbers the dependence may be flatter and near certain transonic velocities should be steeper. The dominant transmitted frequencies increase with Mach number, varying, under certain conditions, as Mach number squared. Plate parameters which importantly influence sound transmission included mass/unit area, size of independent plate sections, stiffness, and damping factors for the various vibrational modes. For sufficiently thin boundary layers, the transmitted spectrum shape is essentially independent of boundary layer thickness, but the total transmitted power varies approximately as the fourth power of the thickness. For thicker boundary layers, the dependence is flatter and the Mach number dependence is also flattened. Several possible procedures for reducing the noise transmission are mentioned briefly.

Kretschmer, S. I., and Rschevkin, S. N. (1938) TOTAL REFLECTION OF SUPERSONIC WAVES. Acad. Sci., URSS, 20, 17-20.

It is recalled that in the case of total reflection of a sound wave at the boundary of two media, partial penetration of the sound into the second medium takes place. The nature of the waves in the second medium is discussed mathematically and it is concluded that waves travel parallel to the surface of the separation, describing in amplitude as the distance from this surface is increased. The more the angle of incidence exceeds the critical angle, the more rapidly the amplitude decreases with penetration into the second medium. Total reflection of supersonic waves at a vaseline oil-salt solution interface is studied experimentally, photographs being shown which confirm the above conclusions.

Kroupa, F. (1955) PLANE DEFORMATION IN THE NON-LINEAR THEORY OF ELASTICITY. Czech. J. Phys., 5, 18-29.

A definition and discussion is presented, with reference to rubber. From the fundamental equations given, a special case is studied for rotational symmetry, and the torsional damper is solved according to the non-linear static theory of elasticity.

Kruger, M. (1943) THE THEORY OF THE SPHERICAL WAVE EXCITED AT FINITE DISTANCE FROM THE PLANE OF SEPARATION OF TWO MEDIA OF FINITE REFRACTIVE INDEX. Z. Phys., 121, 377-437.

For a source of radiation of spherical waves situated in one medium at a finite distance from the boundary layer of a second, exact asymptotic solutions are derived of the potential function in both media for finite complex and the real indices of refraction. The results are for distances large in relation to the wavelengths. Weyl's method of transforming complex double integrals is used in the solution of the problem.

Kuhl, I. W. (1954) POSSIBLE ERRORS IN TRANSMISSION LOSS MEASUREMENTS AT LOW FREQUENCIES. Akust. Bei., 2, 611-614.

Four possible errors are discussed. Three of them are explained by measurements and can be avoided by proved methods.

Kuvshinskii, E. V. (1951) EQUATIONS OF MOTION OF AN INCOMPRESSIBLE ELASTO-VISCOUS MEDIUM. Zh. Eksper. Teor. Fiz., 21, 88-92. (In Russian)

On the basis of two equations expressing the rheological laws of an incompressible elasto-viscous medium (Reyner-Ten lectures on theoretical rheology) derived according to Maxwell's hypothesis, equations are derived for the motion of such a medium. An analysis is made of cases where these equations can be simplified. The analysis shows that for small stresses, where only the linear rheological law applies, the elasticity of the medium manifests its characteristic form only for unsteady processes. In the case of steady flow, with certain reservations, the elasto-viscous medium is displaced according to the laws of the hydrodynamics of viscous liquids.

Kynch, G. J. (1957) THE FUNDAMENTAL MODES OF VIBRATION OF UNIFORM BEAMS FOR MEDIUM WAVELENGTHS. Brit. J. Appl. Phys., 8, 64-73.

The Rayleigh-Ritz method is used to determine approximate forms for the dispersion curves of a vibrating infinite beam of arbitrary shape, using the exact elasticity equations. The method is also used to investigate the relations between the different types of vibration. The results for flexural vibrations confirm the Timoshenko equation for most beams and include corrections for thin strips. Dispersion curves are obtained for longitudinal-type vibration which show the variation with shape and the change in classification of the modes when the symmetry of the cross section is altered. When the wavelength ∅ is of the order of magnitude of the perimeter, the usual longitudinal mode is replaced as the fundamental mode by a new mode.

Lamb, G. L., Jr. (1957) ON THE TRANSMISSION OF A SPHERICAL SOUND WAVE THROUGH A STRETCHED MEMBRANE. J. Acoust. Soc. Am., 29, 1091-1095.

The transmission of a spherical sound wave through a homogeneous stretched membrane of infinite extent is investigated theoretically. An integral representation of the transmitted sound field is initially derived. The path of integration is then transformed into the complex plane and the integration carried out in an approximate manner by the method of stationary phase. The transmitted sound field is found to be composed of two parts, an outgoing spherical wave modified by an amplitude factor containing angular dependence and a surface wave. The surface wave, which results from the free flexural vibration of the membrane itself, exhibits an interesting "zone of silence" in the transmitted sound field.

Lamb, Horace (1917) ON WAVES IN AN ELASTIC PLATE. Proc. Roy. Soc. (London), 93, 114-128.

An examination of the problem of two-dimensional waves in a solid bounded by parallel planes.

The theory of surface (Rayleigh) waves has been extended by H. Lamb to the case of a solid body bounded by two parallel planes.

Lamb, J. (1952) THE BEHAVIOUR OF ULTRASONICS IN LIQUIDS. Research, 5, 553-560.

The paper describes the results of recent research work connected with the properties which liquids exhibit to ultrasonic waves. Particular attention is given to the measurement and interpretation of relaxation effects in pure liquids, electrolytes, and polymer liquids. Emphasis is placed on the physical interpretation of these processes and the influence which they have on the propagation of a sound wave. A description is given of two new methods of measurement, namely, the high-frequency pulse technique and the low-frequency reverberation method. (Bibliography, 49 items)

Lambert, R. F.; see Eichler, E. G., and Lambert, R. F. (1957)

Laslett, L. J. (1956) ON THE ELECTROMAGNETIC ANALOGY TO SOUND PROPAGATION. J. Acoust. Soc. Am., 28, 724.

Refers to a paper by R. H. Kraichnan, who has drawn attention to an interesting correspondence between the paths of sound rays in fluids undergoing shear flow and the trajectories of charged particles in magnetic field. To establish the analogy it is assumed (i) the eddy size to be large compared with the sound wavelength and (ii) the velocity of the fluid flow to be small in comparison with the velocity of sound. Use is made of the Hamilton-Jacobi theory of particle dynamics and of the associated principles of Fermat and of least action. Extending Kraichnan's analysis, the author indicates how sound rays are influenced by the fluid motion.

Lawhead, R. B., and Rudnick, I. (1951) ACOUSTIC WAVE PROPAGATION ALONG A CONSTANT NORMAL IMPEDANCE BOUNDARY. J. Acoust. Soc. Am., 23, 546-549.

An expression is obtained for the amplitude and phase of an acoustic wave above a boundary due to a point source on or near a boundary which exhibits a constant normal specific acoustic impedance. This is shown to be a special case of the solution for an isotropic medium with constant characteristic acoustic impedance; specifically, the case is one in which the ratio of the propagation constant in the upper medium to that in the lower approaches 0. A material which obeyed a constant normal impedance boundary condition was constructed from ordinary drinking straws. Measurements of amplitude and phase as a function of receiver position along and above the boundary showed good agreement with theory. The nature of the approximations involved in the solution are discussed and it is shown to be an adequate representation of the sound field for distances greater than one wavelength from the source.

Lawhead, R. B., and Rudnick, I. (1951) MEASUREMENTS OF AN ACOUSTIC WAVE PROPAGATED ALONG A BOUNDARY. J. Acoust. Soc. Am., 23, 541-545.

The sound field of a point source located at a plane boundary was measured with respect to both its amplitude and phase characteristics. This was done for a very high impedance boundary and one composed of material which is relatively absorbing. The fields were calculated, the calculations for the latter material being based on measured values of impedance and propagation constant, and found to be in good agreement with those measured.

Lax, M. (1944) THE EFFECT OF RADIATION ON THE VIBRATIONS OF A CIRCULAR DIAPHRAGM. J. Acoust. Soc. Am., 16, 5-13.

The vibrations of a clamped circular plate in an infinite baffle with a fluid on one side are solved in terms of the radiation impedances associated with the normal modes of a plate vibrating in a vacuum. The influence of the fluid on the motion of the plate depends on the dimensions of the plate and the relative densities of fluid and plate. The procedure may be applied to plates with nodal diameters, membranes, and strings.

Ledinegg, E., and Urban, P. (1953) THE DETERMINATION OF THE ELASTIC CONSTANTS OF ISOTROPIC RIGID BODIES BY ULTRASOUND. Acta Phys. Austriaca, 8, 16-27. (In German)

This is a theoretical paper giving the equations for determining the elastic constants of an isotropic body from measurements of the resonant frequencies for propagation of ultrasound in the body. A two-layer cavity resonator is employed consisting of a cylindrical resonator with test specimens in the form of rods or plates, and the elastic constants are determined from measurements on both horizontal and axial layers. Approximate formulae are deduced for very thin rods and plates and found to agree with those obtained in earlier work.

Lee, E. H.; see Bland, D. R., and Lee, E. H. (1955)

Lee, E. H. (1956) STRESS ANALYSIS IN VISCOELASTIC MATERIALS. J. Appl. Phys., 27, 665-672.

Linearly viscoelastic materials are considered. This is the simplest group of materials which exhibits the general stress-strain characteristics found in polymers and plastics. Three basic aspects are considered: measurement of material properties, determination from these of the operator equations between stress and strain or equivalent of the viscoelastic model, and use of this in the theoretical analysis of stress distributions. Quasi-static analysis, in which inertia forces are negligible, is treated quite generally. The wave problems which arise when inertia effects are included are restricted to one-dimensional space variations. A series of typical solutions of these types is discussed.

Lee, E. H., and Kanter, I. (1953) WAVE PROPAGATION IN FINITE RODS OF VISCOELASTIC MATERIAL. J. Appl. Phys., 24, 1115-1122.

The paper is concerned in the main with a Maxwell material which corresponds to a model having a spring and dashpot in series. The equation for longitudinal wave propagation in rods is shown to be equivalent to the telegraph equation, and solutions of transient wave problems are treated briefly in the Appendix, using the Laplace transform technique. Impact on a semi-infinite rod is considered in detail in the report. A method of superposition of images is discussed to use this solution to solve boundary value problems for finite rods. The resulting stress distributions are discussed and contrasted with those for an elastic rod. The natural grouping of problems is discussed according to the relative magnitude of the duration of interest, the relaxation time, and the wave traverse time. The influence of the idealization involved in the Maxwell model is briefly touched upon.

Lengyel, Bela (1951) A NOTE ON REFLECTION AND TRANSMISSION. J. Appl. Phys., 22, 263-264.

Consideration of the quantities characterizing wave propagation through the interface of two media or through a transmission line containing obstacles is given.

LeRolland, P. (1948) ON A NEW METHOD OF DETERMINING THE DISSIPATION OF ENERGY BY INTERNAL FRICTION IN SOLIDS. Compt. Rend., 227, 37-39. (In French)

Describes a method in which the specimen is subjected to forced vibrations by two identical oscillating systems. The theory shows that measurement of the decrement when they are (1) in phase, (2) in antiphase, together with a count of the number of oscillations, N, between "stationary points" executed by one system starting from rest, the other being set in motion, is all that is required. Pendulums were used as the systems in the case discussed, the results showing that the difference of the two decrements is inversely proportional to N for the same material, as indicated by theory.

LeRolland, P., and Plenard, E. (1956) THE RELATIVE DISSIPATION OF ENERGY PER CYCLE OF DEFORMATION AT LOW FREQUENCY CONSIDERED AS A SPECIFIC PROPERTY OF MATTER. Compt. Rend., 243, 1488-1490. (In French)

Vibration experiments with Plexiglas, which has a high damping capacity, show that the relative dissipation of energy per cycle $k(=\Delta w/w)$ is sensibly constant, irrespective of the amplitude and frequency of the vibration and of the dimensions of the test specimen. For materials such as brass, k tends towards a constant value (within about 10%), for small amplitudes of vibration. It is concluded that k can be used as a specific property of a material, subject to the limitation that, in metals, the amplitude of vibration is sufficiently small.

Letherisch, W., and Pelzer, H. (1950) THE MEASUREMENT OF THE COEFFICIENT OF INTERNAL FRICTION OF SOLID RODS BY A RESONANCE METHOD. Brit. J. Appl. Phys., 1, 18-22.

A theory is given and an expression derived relating amplitude of vibration with frequency for a rod subjected to alternating mechanical stress. The coefficient of internal friction of the material can be deduced, providing the internal friction is small, as for example, with metals. With plastics the internal friction is larger, so that a correction must be applied which can be expressed in the form $\eta/E = (\delta f/2\pi f^2)(1+2\delta f/f)$. The physical basis from which the fundamental equations are derived is discussed, and the relation between longitudinal and tangential viscosity is deduced. An expression has also been derived which enables the volume viscosity to be determined should experiments show its existence.

Levi, F. (1949) A GENERALIZATION OF THE STRESS-STRAIN RELATION IN VISCOUS ELASTIC SOLIDS. Ricerca Sci., 19, 368-373.

A model of a viscous-elastic solid is suggested in which the substance is assumed to be homogeneous as far as external forces are concerned, while, to determine the stress-strain relation in any fibre, the fibre is considered to be made up both of longitudinal elastic elements and a number of viscous-elastic ones, uniformly distributed in the section. For the latter it is further assumed that if ϵ_0 is the viscous deformation under unit stress and ϵ that under any stress σ, $d\epsilon/dt = \sigma^{d\epsilon_0/dt}$.

Levi, F., and Nath, N. S. (1938) TRANSMISSION OF SUPERSONIC WAVES THROUGH A RIGID SHEET. Helv. Phys. Acta, 11, 408-431. (In German)

Following a paper of Reissner, the transmission of waves through a rigid sheet immersed in a fluid is analyzed and Reissner's general results are confirmed, although a different method is used. Total reflection is also dealt with.

Levi, F. A.; see Bradfield, G., and Levi, F. A. (1958).

Liebermann, Leonard (1956) ON THE PRESSURE DEPENDENCE OF SOUND ABSORPTION IN LIQUIDS. J. Acoust. Soc. Am., 28, 1253-1255.

The discussion gives the theory of the effect of pressure on the bulk viscosity of an idealized liquid. The theoretical behavior is compared with acoustical observations in water.

Lienard, P. (1946) STUDY OF A RESONANCE METHOD FOR MEASURING THE TRANSMISSION OF ACOUSTIC VIBRATIONS THROUGH A PARTITION AND THEIR REFLECTION. Compt. Rend., 223, 889-891. (In French)

An experimental method for measuring the reflection and transmission coefficients is described and the theory is given. From measurements made on 115 samples of very different materials for the partition, it is evident that the acoustic properties of a material are functions not only of its physical properties but of external conditions, e.g., mode of support in the case of the partition. The experiments were carried out with sound of frequency 250 c/s.

Lienard, P. (1946) VARIATION OF THE ACOUSTIC PROPERTIES OF MATERIALS WITH THE MODE OF USE. Compt. Rend., 223, 1107-1110. (In French)

A continuation of previous work. The vibration of a partition depends on such factors as the porosity, density, and elasticity of the material composing the partition, and on the impedance of the space behind the partition, etc. These are discussed, and experimental results are given showing how widely the transmission and reflection coefficients of a given partition may vary under different conditions.

Lienard, Pierre; see Eckart, Gottfried, and Lienard, Pierre (1952).

Lin, T. C., and Morgan, G. W. (1956) WAVE PROPAGATION THROUGH FLUID CONTAINED IN A CYLINDRICAL, ELASTIC SHELL. J. Acoust. Soc. Am., 28, 1165-1176.

A study is presented of the wave propagation of axisymmetric waves through compressible inviscid fluid contained in a cylindrical, elastic shell. The dependence of the phase velocity as a function of frequency on four dimensionless parameters of the system is discussed and illustrated graphically.

Lindh, G. (1955) THE TRANSMISSION AND REFLECTION OF AN EXPONENTIAL SHOCK WAVE IMPINGING ON A HOMOGENEOUS ELASTIC PLATE IMMERSED IN A LIQUID. Acustica, 5, 257-262.

By means of a Laplace transform it has been possible to characterize satisfactorily, from a physical point of view, the reflection and transmission of a plane exponential wave with normal incidence to an elastic plate immersed in a liquid. Furthermore, the waves travelling inside the plate have been considered. It was then found that the transmitted as well as the reflected wave may be represented by a discontinuous function with a finite jump at times corresponding to twice the plate thickness. The theoretical results have been verified experimentally by studying the change of the exponential pressure-time curve produced by an underwater explosion in the case of reflection at, and transmission through a concrete plate immersed in water. Tests have also been made with a combination of different plates, and the agreement between theory and experiment seems to be satisfactory.

Lindsay, R. B. (1938) FILTRATION OF SOUND. J. Appl. Phys., 9, 612-622.

The author reviews the theory of infinite acoustic filters and then proceeds to describe a general theory of transmission through a medium in which there are periodic changes in its properties. The theory is adapted to filters containing a finite number of elements, and the calculated transmission characteristics of low-pass and high-pass filters are compared with the results of experiment. Good agreement is obtained. The calculations are extended to cover the case of a filter connected to a finite line, e.g., an acoustic filter connected to a tube of finite length. The formula obtained does not allow of simple deductions being made unless special values are assumed for the resonance of the terminating line. Certain special cases are dealt with, however.

Lindsay, R. B. (1939) FILTRATION OF OBLIQUE ELASTIC WAVES IN STRATIFIED MEDIA. J. Acoust. Soc. Am., 10, 178-183.

Previous work has been done on the problem of the transmission of plane compressional elastic waves normally through a stratified medium consisting of alternate plane parallel layers of two different substances. Such a structure acts as a low-pass elastic wave filter. The present paper extends the analysis to the case of oblique transmission. This proves to be comparatively simple when the layer substances are both fluid. The transmission and attenuation (i.e. reflection) bands are found to depend on the angle of obliquity in a characteristic way. When one of the layer substances is solid, the problem is more difficult. Account must here be taken of the fact that compressional waves in the fluid layers give rise to both dilatational and shear waves in the solid layers. The result is somewhat more complicated than in the previous case, but the structure still turns out to be a low-pass elastic wave filter for angles of obliquity less than the critical angle. As before, the transmission and reflection bands are a function of an angle. In the special case in which the thickness of the solid layers is small compared with that of the fluid layers one obtains the elastic wave analogue of the Bragg reflection law for X-rays, that is, one gets reflection approximately for the wavelengths $\lambda_n = 2l/n \sin \Theta$, where l is the distance between successive solid layers and n is integral.

Lindsay, R. B. (1941) ELASTIC-WAVE FILTRATION IN NON-HOMOGENEOUS MEDIA. J. Acoust. Soc. Am., 12, 378-382.

Previous work has indicated that when harmonic compressional waves pass through a stratified medium consisting of a series of alternating layers of 2 different substances which may be either fluid or solid, the medium acts as an acoustic filter with alternate transmission and attenuation frequency bands. This analysis of the transmission characteristics of the medium was based on the assumption that the transition in acoustical properties (i.e. density and sound velocity) from each layer to the next is abrupt and effectively discontinuous. The purpose of the present investigation is to examine the consequences of assuming that the transition in question is a gradual one. The interesting theoretical result is that for a gradual transition in which there are no discontinuous changes in either the acoustical properties or their gradients, the stratified medium passes all frequencies. In order to assure attenuation for a gradual transition one must assume at least discontinuity in the acoustical parameters.

Lindsay, R. B.; see Smyth, J. B., and Lindsay, R. B. (1944).

Lomnitz, C. (1957) LINEAR DISSIPATION IN SOLIDS. J. Appl. Phys., 28, 201-205.

In solid materials the properties of transient creep, internal friction, and dispersion can be correlated on the basis of a linear theory, if the strains are small throughout. The theory, first given by Bottzmann, is developed in some detail.

London, A. (1949) TRANSMISSION OF REVERBERANT SOUND THROUGH SINGLE WALLS. J. Res. Nat. Bur. Stand., 42, 605-615.

The transmission of reverberant sound through homogeneous single walls has been investigated theoretically and experimentally. Random incidence sound-transmission measurements were made on homogeneous walls of aluminum, plywood, and plasterboard.

London, A. (1949) "Transmission of Reverberant Sound Through Single Walls." Report on the 1948 Summer Symposium of the Acoustics Group. Noise and Sound Transmission, 1948, Phys. Soc. (London), 194-200.

Random incidence sound-transmission measurements were made on homogeneous walls of Al, plywood, and plasterboard. The results were found to be in satisfactory agreement with a modified version of a theoretical treatment first given by Cremer which postulates that the wall impedance has a resistive component in addition to its mass reactance and a stiffness reactance resulting from the occurrence of flexural waves. 2 of the 3 parameters which are required to predict the transmission loss, namely resistance and critical flexure frequency, the third one being mass, are evaluated from the experimental data in such a way as to obtain the best fit between the theoretical and experimental results.

London, A. (1950) TRANSMISSION OF REVERBERANT SOUND THROUGH DOUBLE WALLS. J. Res. Nat. Bur. Stand., 44, 77-88.

London, A. (1950) TRANSMISSION OF REVERBERANT SOUND THROUGH DOUBLE WALLS. J. Acoust. Soc. Am., 22, 270-279.

Present paper is an extension of a previous one on the transmission of reverberant sound through single walls. Author considers the transmission of sound through two identical mechanically uncoupled walls having a fixed spacing. The problem is treated both theoretically and experimentally. It is show that the problem is determinate if only the impedance of a single wall and the spacing are known. As in the case of single walls, the concept of a single normal impedance is not valid. Furthermore, a wall cannot be characterized as a mass reactance; the effects of resistance (viscous damping) and flexural waves play important roles.

The attenuation of sound by walls is materially reduced if there is any solid mechanical coupling between them. When coupling is by air alone, even small spacings can produce significant increases over a single wall. Insertion of absorbent material in the airspace produces large improvements in attenuation when the walls are relatively light, but produces little effect if the walls are heavy. Finally, a nonabsorbent cellular structure having no cell walls in a direction normal to the wall faces does not improve the attenuation of sound.

Longman, I. M.; see Pekeris, C. L., and Longman, I. M. (1958).

Loschner, G. (1956) THE INTERNAL FRICTION OF METALS. Technik, 11, 289-300. (In German)

The internal friction is represented as a result of the relation between elongation and stress. It is shown that stress and elongation depend to some extent on time (anelasticity). Another facotr in this connection is dynamic hysteresis, which is a special case of relaxation, a general property of linear systems. Relaxation is the property tending to re-establish the equilibrium of a system after an interval of time. This means, in the present case, that deformation is determined not only by the instaneous external forces but also by the variation of the forces. These effects can be approximated by an exponential function. Static hysteresis appears in the materials which do not have any noticeable relaxation properties and is independent of the frequency. The causes of internal friction are internal structural rearrangements, including thermoelastic effects, and the transmission of vibration from grain to grain to the case of polycrystalline metals. Other causes are an interaction between the conductivity electrons and the elastic lattice vibrations. This has not been determined experimentally, but was calculated for certain cases. In ferromagnetic materials there are magneto-elastic effects producing magneto-strictive non-elastic elongation, which causes mechanical vibrations to be damped. The stress-induced ordering of atoms in the metal lattice is different from the equilibrium distribution, and the tendency of the metal to re-establish the equilibrium condition by means of irreversible processes causes internal friction. The grain-boundary viscosity has anelastic effects, also dislocation and plastic flow due to cold working and phase transformation in conjunction with a dimensional change. The following methods are employed to measure internal friction: the phase angle is measured to determine the damping effect, the hysteresis loop is recorded directly, the area of the loop is a measure of internal friction. The loop is recorded for up to 50 c/s by mechanical methods and for higher frequencies by means of the cathode-ray oscillograph. This method can be employed only if the internal friction is very high. In other cases, internal friction is measured by comparing forced vibrations and decaying vibrations. The following methods are employed for converting electrical vibrations and mechanical ones, and vice versa: electrostatic, eddy current, electro-magnetic, piezo-electric, etc. 183 refs.

Love, E. R. (1956) LINEAR SUPERPOSITION IN VISCO-ELASTICITY AND THEORIES OF DELAYED EFFECTS. Austral. J. Phys., 9, 1-12.

Writers on elastic after-working or "viscoelasticity" have given a formula expressing the stress-history as an integral involving the strain-history linearly.

If this is to be based directly on experiment, linear superposition is a necessary physical datum; but it is not sufficient, and examples are given to demonstrate this. Necessary and sufficient conditions are established in this paper, and expressed in physical as well as in mathematical terms; they may admit physical verification in some degree. Histories both with and without beginning are considered.

Lucas, R. (1950) ON THE RADIATION PRESSURE OF SPHERICAL WAVES. Compt. Rend., 230, 2004-2006. (In French)

Most investigations of radiation pressure due to sound waves have hitherto been concerned with plane progressive waves and stationary waves. Unlike these cases, with spherical waves near a small pulsation source the density of the kinetic energy is greater than the density of potential energy. It is shown that the radiation pressure for spherical waves $\delta_p = W_p \times (1 + 3d \log B/d \log \rho)$ (where W_p is the mean density of potential energy, V is the velocity of sound and ρ the density of the medium). The numerical factor 3, characterizing the problem of spherical symmetry, is significant, for it is here that the result differs from Brillouin's result for plane stationary waves in which this factor is unity. The difference is in effect very small, for in all practical cases $d \log V/d \log \rho$ is insignificant and $\delta_p = W_p$ in all cases.

Lucas, R. (1951) ON RADIATION PRESSURES OF SOUND WAVES. Atti Con. Internaz. Ultracust., 1950, 236-247. (In French)

An international congress on the applications of ultrasonics (in physics, engineering, biology, and medicine) was held in Rome in 1950. Present paper was presented under the first of these subjects. Following the approach initiated by Brillouin and Fubini (for bibliography see J. Acoust. Soc. Amer. 22, 3, p 318, May, 1950, and 24, 5, p 468, Sept, 1952), author studies acoustic radiation pressure by placing emphasis on its tensorial character. He analyzes the radiation pressure exerted by a plane progressive wave on its source, on a perfectly absorptive surface, and on a partially reflective surface (he suggests a device, based on the analysis of this case, for measuring the reflectivity of a surface); he then derives the pressure of a spherical progressive wave on its source and of spherical standing waves, confined between two concentric spherical surfaces, on the outer surface. He finds that radiation pressures exerted by progressive and standing waves involve, respectively, the density of the kinetic and potential energy densities.

Lyamshev, L. M. (1954) REFLECTION OF SOUND BY A THIN PLATE IN WATER. (translated from Russian by M. D. Friedman, 572 Calif. St., Newtonville, Mass., 4pp) Dokl. Akad. Nauk SSSR, 99, 719-721.

Observations using high-frequency pulse technique are described briefly. Reflections in a direction anti-parallel to the obliquely incident ray are found at two critical angles, corresponding, respectively, to flexural and to compressional waves in the plate. The latter case is presented as new; related transmission data are not cited or discussed.

Lyamshev, L. M. (1955) DIFFRACTION OF SOUND UPON A THIN BOUNDED PLATE IN LIQUID. Sov. Phys.-Acous., 1, 145-151.

The paper examines the problem involved in the diffraction of sound upon a thin bounded plate in liquid; the analysis takes into account the longitudinal and flexural vibrations of the plate.

It is shown that at certain angles of incidence the passage of the sound through the plate is observed, as well as intense scattering in a direction opposite to the direction of the incident wave (this constitutes so-called non-mirrorlike reflection). The paper is entirely theoretical.

Lyamshev, L. M. (1956) NONSPECULAR REFLECTION OF SOUND FROM THIN BOUNDED PLATES SUBMERGED IN A LIQUID. Acta Phys. Hungar., 6, 33-65. (In Russian)

Discovery is made of a nonspecular ultrasonic reflection from thin finite plates under water, occurring at considerably smaller angles of incidence than that due to coincidence effect in bending. Precise measurements made in the Fraunhofer zone of reflection, using metal plates up to 1.1 mm thick and up to 6 x 6 cm, with megacycle sound waves, show this phenomenon to occur when the phase velocity of the incident waves along the plate is equal to the speed of longitudinal waves in the plate. A detailed theoretical analysis is made of sound diffraction, taking into account this plate response. The theory appears to describe the observed results satisfactorily.

Lyamshev, L. M. (1956) NON-MIRRORLIKE REFLECTION OF SOUND BY A THIN CYLINDRICAL SHELL. Sov. Phys.-Acous., 2, 198-203.

By using the axially symmetric vibrations of a thin cylindrical shell as an example, it is shown that the non-mirrorlike reflection of sound from a bounded cylindrical shell is dependent on the vibrations of the shell which are excited by the external field.

Lyamshev, L. M., and Rudakov, S. N. (1956) REFLECTION OF SOUND BY THICK FINITE PLATES IN A LIQUID. Sov. Phys.-Acous., 2, 242-244.

Thick plates of steel, brass and aluminum were used whose thickness was comparable with, or greater than, the wavelength in them of the longitudinal waves used. They were suspended in water. A quartz pulse generator (f = 1 Mc/s, pulse repetition frequency = 200/sec 1 μsec pulses) also acted as receiver. Rotating the plates about a vertical axis enabled reflection polar diagrams (three are given) to be plotted. The number of non-specular reflections found increases with increase of thickness of the plate and with increase of frequency.

Lyon, R. H. (1955) RESPONSE OF AN ELASTIC PLATE TO LOCALIZED DRIVING FORCES. J. Acoust. Soc. Am., 27, 259-265.

The vibration of an infinite elastic plate when driven by a localized driving force is studied theoretically. The dilatation and shear potentials are expressed as Fourier integrals, the boundary conditions are applied, and the integrals evaluated by the calculus of residues. It is found that the motion of the plate may be represented by a discrete sum of nonorthogonal eigenmodes. These modes represent two types of waves: propagated and attenuated. The former are obtained from previous work on coincidence transmission. The latter are calculated by a graphical method, and presented in such a manner that they tie in continuously with the propagated modes. Certain unresolved features of the problem are discussed. One previous application of the theoretical results is disclosed.

Lyons, W. J. (1953) VISCOELASTIC PROPERTIES AS FUNCTIONS OF THE DISTRIBUTION OF ACTIVATION ENERGIES. J. Appl. Phys., 24, 217-221.

1. Assuming that the elementary molecular deformation process conforms to the Maxwell model, and that the molecular elastic force G_i and the viscous force η_i are functions (of unspecified forms) of the free energy of activation F*, the following expressions for the dynamic modulus G_d and dynamic viscosity (internal friction) η_d are obtained:

$$G_d = \frac{1}{A}\int_0^\infty \frac{\omega_i{}^2\tau_i{}^2G_i\phi(F^*)}{\omega_i{}^2\tau_i{}^2+1}\,dF^*$$

and

$$\eta_d = \frac{1}{A}\int_0^\infty \frac{\eta_i\phi(F^*)}{\omega_i{}^2\tau_i{}^2+1}\,dF^* \quad ,$$

where A = area of a sample, $\tau_i = G_i/\eta_i$, ω = vibration frequency, and ϕ (F*)dF* = the number of elementary processes having activation energies lying between F* and F* + dF*.

2. By employing an expression relating the relaxation time τ_i with F* for the elementary process, and adopting the so-called "box" distribution of relaxation times, the following explicit form for the distribution, of activation energies is deduced: ϕ = const $(1/kTF^* - 1/F^{*2})$, where k = Boltzmann's constant and T = the absolute temperature. When the box distribution, as represented by

this explicit form for ϕ, is introduced into the foregoing expressions for G_d and η_d, the integrated results are found to predict temperature and frequency dependencies which are in gratifying agreement with experiment.

Lyons, W. J. (1955) STATISTICO-MECHANICAL THEORY OF DEFORMATION INVOLVING THE ACTIVATED STATE. Am. J. Phys., 23, 268-275.

The theory of deformation in matter which has been constructed by Eyring, his co-workers, and former pupils as an adaptation of the chemical reaction-rate theory is, in the present article, reviewed on the basis of concepts falling in the domain of physics in the more restricted sense. The theory of the physical phenomena of deformation, elasticity and flow is developed directly from statistico-mechanical fundamentals, without the introduction of concepts of chemical kinetics. Application of the basic theory to deformation in crystalline solids, as well as polymeric materials, is treated in some detail, and finally the work of numerous investigators who have contributed to the theory is briefly recounted.

McKinney, J. E., Edelman, S., and Marvin, R. S. (1956) APPARATUS FOR THE DIRECT DETERMINATION OF THE DYNAMIC BULK MODULUS. J. Appl. Phys., 27, 425-431.

An apparatus has been developed for the direct measurement of the real and imaginary parts of the dynamic bulk modulus of solid and liquid materials over the frequency range of 50 to 10,000 c/s. Piezoelectric crystals serving as driver and detector, together with the sample and a confining liquid, are contained in a cavity small compared with the wavelength of sound at these frequencies. Static pressure is superposed to eliminate the effect of small air bubbles. The complex compliances of the sample, confining liquid, and the cavity, are additive in this region, where the compliance is pure dilatation. The dynamic compliances of several natural rubber-sulphur mixtures were obtained in a preliminary evaluation of the behavior of the apparatus.

$$Z = \frac{p}{V} = \frac{-j}{c\omega} = \frac{-j}{\left(\frac{V}{\beta *}\right)\omega} = \frac{-j}{V\omega}(\beta' + j\beta'')$$

$$= \underbrace{\frac{\beta''}{V\omega}}_{R} - \underbrace{\frac{j\beta'}{V\omega}}_{-X}$$

McSkimin, H. J.; see Mason, W. P., and McSkimin, H. J. (1948).

McSkimin, H. J. (1956) PROPAGATION OF LONGITUDINAL WAVES AND SHEAR WAVES IN CYLINDRICAL RODS AT HIGH FREQUENCIES. J. Acoust. Soc. Am., 28, 484-494.

Exact steady-state solutions for both longitudinal waves and shear waves travelling in isotropic rods of circular cross-section are analyzed. Numerical examples are described for rods of large diameter to wavelength ratio. The effect of mode conversion on the propagation of short duration longitudinal wave trains is considered; and an approximate expression for the resulting loss is developed. Experimental results for 10-25Mc/s longitudinal and shear waves in fused silica rods of 1.13 cm radius are described.

McSkimin, H. J. (1956) WAVE PROPAGATION AND THE MEASUREMENT OF THE ELASTIC PROPERTIES OF LIQUIDS AND SOLIDS. J. Acoust. Soc. Am., 28, 1228-1232.

Diffraction effects as encountered in the measurement of acoustic attenuation at high frequencies are discussed with particular reference to low-loss materials. The propagation of short wave trains in cylindrical rods is considered in some detail. For longitudinal waves, losses resulting from mode conversion at the boundary are analyzed. First mode shear waves are also considered.

Mahly, H., and Trosch, A. (1947) SHEARING VIBRATIONS OF SQUARE PLATES. Helv. Phys. Acta, 20, 253-255. (In German)

The function containing the elastic moduli in the formula for the frequency of shearing vibrations of a square plate is evaluated. Theoretical results are in agreement with experiment.

Maidanik, G., and Westervelt, P. J. (1957) ACOUSTICAL RADIATION PRESSURE DUE TO INCIDENT PLANE PROGRESSIVE WAVES ON SPHERICAL OBJECTS. J. Acoust. Soc. Am., 29, 936-940.

The expression for the force exerted on a "rigid" sphere by a plane progressive wave is computed by making use of the momentum formulation. The expression is general in the sense that it allows for variation of the density of the sphere relative to that of the surrounding medium, as well as for a wide range of ka (k = wave number, a = radius of sphere). The numerical calculations are confined to the range ka $\leq$ 10.

Makinson, K. R. (1952) TRANSMISSION OF ULTRASONIC WAVES THROUGH A THIN SOLID PLATE AT THE CRITICAL ANGLE FOR THE DILATATIONAL WAVE. J. Acoust. Soc. Am., 24, 202-206.

The transmission, through an isotropic solid plate immersed in a liquid, of ultrasonic waves incident at the critical angle for total reflection of the dilatational wave, is examined experimentally and theoretically. It has previously been held that total reflection does not occur at this angle when the thickness of the solid is less than or comparable with the wavelength of the dilatational wave in it. It is now shown that, owing to interference between the dilatational and rotational waves, total reflection does occur at or very near this angle for a considerable range of thickness in this region. It is therefore possible to use the total reflection method for the determination of the dilatational velocity in a solid even when only thin specimens of the solid are available.

Makinson, K. R. (1953) TRANSMISSION OF SOUND THROUGH PLATES. J. Acoust. Soc. Am., 25, 1202.

Fay's treatment of the theoretical problem of the transmission of sound through a solid plate immersed in a fluid is used to deduce an additional criterion for total reflection, and some comments are made on the criteria for total transmission.

Mandel, J. (1951) THE DEFORMATION OF VISCOELASTIC SOLIDS. Compt. Rend., 233, 1003-1005.

Mandel, J. (1955) ON VISCOELASTIC BODIES BEHAVING LINEARLY. Compt. Rend., 241, 1910-1912. (In French)

In an extension of the theory of elasticity to viscoelastic bodies, retaining the principle of superposition, a modulus is replaced by a relaxation function (of time), and a reciprocal modulus by a flow function. The functions are related through their Carson (or Laplace) transforms.

Mandel, J. (1956) ON VISCOELASTIC BODIES BEHAVING LINEARLY . Compt. Rend., 242, 2803-2805. (In French)

An application of the method reported in Compt. Rend., 241, 1910-1912 (1955) made to the theory of propagation of stress discontinuities and sinusoidal elastic waves.

Mann-Nachbar, P. (1957) THE INTERACTION OF AN ACOUSTIC WAVE AND AN ELASTIC SPERICAL SHELL. Quart. Appl. Math., 15, 83-93.

The effect of the impact of a plane pressure wave on an elastic spherical shell is considered, taking into account both the incident and diffracted waves.

An infinite series (mode) solution is used and numerical results are obtained for the case of a steel shell in water. This is a theoretical paper. The shell is considered to possess perfect elasticity. The acoustic wave is of the ordinary, small signal, nondissipative type. The acoustic wave causes the shell to vibrate, thus acting as a scatterer, and to some extent, a radiator.

Martinek, J., and Yeh, G. C. K. (1955) SOUND SCATTERING AND TRANSMISSION BY THIN ELASTIC RECTANGULAR PLATES. Quart. J. Mech. Appl. Math., 8, 179-190.

The work of Vogel on an ideal elastic plate simply supported in an infinite baffle is extended in two ways: (1) the incident wave (although separable into Cartesian coordinates) need not be plane; (2) the fluid media on opposite sides of the plate may be different. The incident wave excites forced vibrations of the plate, and the resulting scattered wave is expressed in terms of the constants of the plate and the media. The plate (composed of material which is isotropic, devoid of damping, and which obeys Hooke's law) is treated essentially as a plane in relating the normal velocity and excess pressure at its surface to those of the assumed sound field; the media it separates are specified by the small amplitude wave equations. The excess pressure of the field is then taken as the inhomogeneous term of the fourth-order equation for the transverse deflections of the plate, and the corresponding Lagrange equations are used to determine the motion. Expressions are given for the normalized time-averaged transmitted energy, the energy absorbed by the plate, and for the reaction forces at the plate supports.

Martinek, J.; see Yeh, G. C. K., and Martinek, J. (1956).

Martner, J. G.; see Arnold, J. S., and Martner, J. G. (1958).

Marvin, R. S.; see McKinney, J. E., Edelman, S., and Marvin, R. S. (1956).

Mason, W. P. (1950) Piezoelectric Crystals and Their Application to Ultrasonics. Van Nostrand Co., Inc., New York.

Ch. XV, p. 390 - Properties of Solids and Their Measurement by Ultrasonic Waves. P. 399 - section on measurement of the properties of a solid by measuring the transmission loss through a solid at various angles of incidence. Presents experimental data for lucite and hicar rubber and compares with theory of Reissner for perfect elasticity of plate.

Mason, W. P. (1956) PHYSICAL ACOUSTICS AND THE PROPERTIES OF SOLIDS. J. Acoust. Soc. Am., 28, 1197-1206.

Considerations of four techniques of physical acoustics used to determine the properties of solids.

Mason, W. P. (1958) Physical Acoustics and the Properties of Solids. D. Van Nostrand Co., Inc., New York.

This book is divided into two parts. The first part deals with types, generators, and practical applications of waves in solids, and the second part deals with analysis of the sources of dissipation and elastic dispersion in solids. It contains chapters on properties of solids and polymer liquids, low and high amplitude waves in solids, and an appendix on stress and strain and applied electric and magnetic fields in transducer materials.

Mason, W. P., and Hibbard, F. H. (1948) ABSORBING MEDIA FOR UNDERWATER SOUND MEASURING TANKS AND BAFFLES. J. Acoust. Soc. Am., 20, 476-482.

By using absorbing walls surrounding a small body of water, measuring tanks have been produced which will determine the directional properties of underwater sound instruments down to a level of 25 db below the direct beam. These absorbing media are constructed by inserting fine mesh screen or packed copper wadding in a viscous liquid such as castor oil and result in an enhanced viscous action which is nearly independent of the frequency above 10 kc/s. A six-inch wall can reduce the reflections by 20 db. Tanks using such absorbing media were used for testing transducers at the manufacturing plant and were used for determining the approximate characteristics of small-sized instruments. Absorbing media were also used in the sound transparent dome housing the transducer and in the back of the QJB transducers.

Mason, W. P., and McSkimin, H. J. (1948) ENERGY LOSSES OF SOUND WAVES IN METALS DUE TO SCATTERING AND DIFFUSION. J. Appl. Phys., 19, 940-946.

When high-frequency longitudinal and transverse sound waves are sent through a multicrystalline rod of metal, attenuation losses result because of scattering and diffusion of sound waves by the grains. When the grain size is less than one-third of the wavelength, these losses are due to Rayleigh 4th-power law scattering and are proportional to the grain volume. The scattering factor depends on the anisotropy of the elastic constants. Two different factors are obtained, one for shear waves and one for longitudinal waves. These factors have been evaluated for cubic and hexagonal metals. From the measured elastic constants the only metals with a low loss are Al, Mg and W. The calculations indicate that the losses for Al and Mg are about equal for longitudinal waves, but for shear waves Mg has a very low shear loss. It has been found experimentally that Mg has nearly as low a loss as fused quartz. Experiments with higher frequencies show that when the wavelength is 1/3 of the grain size or less, the transmission process becomes a diffusion process similar to the propagation of a heat wave. The grain sizes determine the mean free path, and the loss becomes infinite $(\text{grain diam.})^{-1}$. An approximate formula for diffusion losses has been obtained which closely agrees with the experimental values.

Matschinski, M. (1954) WAVE PROPAGATION IN AN IMPERFECT ELASTIC MEDIUM. Compt. Rend., 238, 203-205. (In French)

Author discusses change of shape of a stress wave. This may be due to either dispersion or attenuation. He considers how this is related to hysteresis loops and suggests that different parts of a periodic disturbance will, in general, correspond to different values of effective elastic modulus and hence will be propagated with different velocities. Author does not give details of how these effects can be treated in practice.

An approximate method is given for determining the change in waveform and the absorption due to the imperfect elasticity of the medium (plasticity is excluded).

Mawardi, O. K. (1954) THE STATIONARY BEHAVIOR OF ACOUSTIC IMPEDANCES. J. Acoust. Soc. Am., 26, 101.

A mathematical note on the question of finding the conditions which will make an acoustical impedance Z, referred to a surface S, stationary with respect to first-order variations in acoustic pressure p and particle velocity q. The results are applicable only to plane waves.

Mayer, G., and Gigon, J. (1955) MEASUREMENT OF THE ELASTIC CONSTANTS OF SOLIDS BY MEANS OF ULTRASONICS. J. phys. radium, 16, 704-716. (In French)

A hot platinum wire vibrates in an electric field fed from an oscillator operating in the megacycle range and thus produces a beam of ultrasound. This beam falls upon an end face of a beam of the material to be studied and sets up longitudinal vibrations. The beam is supported at the two nodes, and a microphone placed against the end remote from the source is used to detect when the beam is vibrating in resonance, the frequency of the source being adjusted to give this condition. The modulus of elasticity of the material is computed from the dimensions of the beam and the frequency giving resonance, corrections being applied if necessary when the cross-section of the beam is large compared with its length. Poisson's ratio is computed from the frequency of the fundamental vibration of the beam and that of the second harmonic. The internal damping of the material is also determined from formulae given in the paper.

Meecham, W. C.; see Proud, J. M., Tamarkin, P., and Meecham, W. C. (1957).

Meixner, J. (1954) THERMODYNAMICAL EXTENSION OF THE THEORY OF AFTER-EFFECTS (VISCOELASTICITY). Z. Phys., 139, 30-43. (In German)

The laws for the eleastic after-effects, including those of entropy and temperature after-effects, are formulated within the range of validity of Boltzmann's principle of superposition. The extension leads to a characterization of the effects by a 7 x 7 matrix whose symmetry is proved by a generalization of Onsager's principle of reciprocity. The elastic matrix obtained by a Laplace transformation has a positive quadratic form when regarded as a function of p = iw (w = ang. freq.). From this follows a close analogy between 2-pole electric networks and the phenomenon of after-effects, with the possibility of representing the latter by the former. Finally it is shown how relaxation theory and the so-called dynamical equations of state can be incorporated in the general thermodynamical theory.

Mercier, R. (1953) CONTRIBUTION TO THE STUDY OF SURFACE AND INTERFACIAL WAVES. Helv. Phys. Acta, 26, 317-328. (In French)

The velocity potential for cylindrical waves on the surface of a liquid of infinite depth and zero viscosity is derived in terms of Hankel functions. Expressions for the velocity and phase of the waves are obtained, and an experimental method for determining the phase at different distances from the source, and hence the surface tension, is briefly described. Similar results for waves at the surface of separation of two immiscible liquids of different density are given.

Meyer, Erwin (1947) Sound Absorption and Sound Absorbers in Water. (Dynamic Properties of Rubber and Rubberlike Substances in the Acoustic Frequency Region) Volume I. Bureau of Ships, Wash., D. C., 519 pp (NavShips 900, 164). (tr. by Mongan, C. E., Jr.)

Contents:
Chapter I. Sound propagation and sound absorption in water, by Eugen Skudrzyk.
Chapter II. Sound absorption by gas bubbles, by Erwin Meyer and Eugen Skudrzyk.
Chapter III. Dynamic properties of rubber and rubberlike substances over large

frequency range, by Walter Kuhl and Erwin Meyer.

Chapter IV. Physics of rib sound absorbers, by Erwin Meyer and Konrad Tamm.

Chapter V. Introduction to the physics and technology of resonance sound-absorbers for underwater sound, by Erwin Meyer and Herman Oberst.

Chapter VIII. Sound soft walls and tubes, by Walter Kuhl and Konrad Tamm.

Chapter IX. Testing procedure for water sound absorber with one-dimensional sound propagation, by Walter Kuhl, Herman Oberst, and Eugen Skudrzyk.

Chapter X. Test procedure for underwater sound absorbers with two-dimensional sound propagation (Sound propagation in shallow water layer) by Konrad Tamm.

Chapter XI. Testing procedure for underwater sound absorbers with three-dimensional sound propagation, by Walter Kuhl.

Meyer, E. (1956) SURVEY ON SOUND TRANSMISSION IN A BODY BY MODELS. Akust. Bei., 1, 51-58. (In German)

After a short survey over the different wave forms in solids and the experimental methods for the investigation of the propagation of structure-borne sound in models, the following subjects are treated: Measurements of sound velocity and damping of flexural waves; propagation of flexural waves around corners; effect of soft intermediate layers; input impedance of plates for excitation at one point; radiation of plates excited to flexural vibrations.

Mifsud, J. F.; see Nolle, A. W., and Mifsud, J. F. (1953).

Mikhailov, G. D. (1953) INTERACTION OF ULTRASONIC WAVES IN LIQUIDS. Dokl. Akad. Nauk SSSR, 89, 663-664. (In Russian)

Sum and difference frequencies have been produced by heterodyning wave systems from two separate quartz ultrasound generators, placed at right angles to one another in a liquid. The rate of decay of the amplitude of both frequencies (sum and difference) with distance is the same, confirming Helmholtz's theory that the amplitude of such waves is proportional to the product of the component amplitudes.

Miki, H.; see Nishihara, T., and Miki, H. (1951).

Miles, John (1944) THE REFLECTION OF SOUND DUE TO A CHANGE IN CROSS SECTION OF A CIRCULAR TUBE. J. Acoust. Soc. Am., 16, 14-19.

The reflection and transmission coefficients due to a change in cross section of a circular tube are determined by calculating the exact pressure distribution in the vicinity of the discontinuity. The fluid medium in the tube is assumed to be ideal in the sense that the pressure distribution satisfies the wave equation. In contrast to the simpler theory which assumes a tube which is small compared to the wavelength, this theory is subjected only to the assumption of an ideal fluid.

Miles, J. W. (1954) ON NONSPECULAR REFLECTION AT A ROUGH SURFACE. J. Acoust. Soc. Am., 26, 191-199.

The reflection of a plane wave at a rough interface separating two fluid media is examined in the approximation of "small roughness," such that second-order terms in the magnitude of the roughness is harmonic, while asymptotic results are obtained for arbitrary distributions. The analysis deals principally with an incident wave that is harmonic in time, but the problem of the reflection of a pulse from a perfectly reflecting, sinusoidal boundary is solved. It is found that such a boundary acts as a band-pass filter of the nonspecular components of the reflected wave. Outside of this pass band the reflection is not only specular but distortionless. Rather less generality is possible when the boundary is not perfectly reflecting, but the pass band is found to be independent of the properties of the reflecting medium.

Miles, J. W. (1954) DISPERSIVE REFLECTION AT THE INTERFACE BETWEEN IDEAL AND VISCOUS MEDIA. J. Acoust. Soc. Am., 26, 1015-1018.

The effects of viscosity and heat conduction (in the reflecting medium) in producing dispersive reflection of a plane wave at the plane interface separating two media are investigated.

Miller, G. F., and Pursey, H. (1954) THE FIELD AND RADIATION IMPEDANCE OF MECHANICAL RADIATORS ON THE FREE SURFACE OF A SEMI-INFINITE ISOTROPIC SOLID. Proc. Roy. Soc. A, 223, 521-541.

Definite integral representations are obtained for the field at an arbitrary point in a semi-infinite solid, due to stress on the free surface, which vary sinusoidally with time. From these integrals, asymptotic expressions have been obtained for the field at infinity in the solid, and polar diagrams showing the variation of field strength with direction are given. Integrals are also found for the mean displacement over the externally stresses region of the surface, and these have been evaluated numerically in a number of cases to obtain the radiation impedance of the sources represented by such stress systems.

Miller, L. N. (1947) MEASUREMENT CONDITIONS INFLUENCING THE FRONT-TO-BACK DISCRIMINATION OF AN UNDERWATER HYDROPHONE. J. Acoust. Soc. Am., 19, 59-62.

Molloy, C. T.; see Harris, C. M., and Molloy, C. T. (1952).

Mooney, M. (1951) SECONDARY STRESSES IN VISCOELASTIC FLOW. J. Colloid Sci. 6, 96-107.

Theoretical equations are developed for secondary stresses in a shearing viscoelastic fluid. The theory assumes that the elastic stresses developed by the continuous shear also relax continuously in accordance with Maxwell's relaxation theory of viscosity. The steady-state strains are analyzed by the theory of superelasticity. The final equations predict pressure effects to be expected in rotating viscometers of cylindrical, plate, and conical forms. In the absence of thixotropy in the test liquid, the secondary stresses are quadratic in the angular velocity. Thixotropy leads to more complicated equations and permits agreement with more complex experimental results.

Morgan, G. W., and Kiely, J. P. (1956) WAVE PROPAGATION IN A VISCOUS LIQUID CONTAINED IN A FLEXIBLE TUBE. J. Acoust. Soc. Am., 26, 323-328.

A theoretical investigation of the propagation of pressure waves through liquid-filled flexible tubes is presented.

Morgan, G. W.; see Lin, T. C., and Morgan, G. W. (1956).

Mowry, S. C.; see Nolle, A. W., and Mowry, S. C. (1948).

Mrowca, B. A.; see Ivey, D. G., Mrowca, B. A., and Guth, E. (1949).

Muncey, R. W.; see Nickson, A. F. B., and Muncey, R. W. (1953).

Murnaghan, F. D. (1951) Finite Deformation of an Elastic Solid. John Wiley and Sons, New York.

This book treats the problem of the deformation of an elastic solid without making the assumption of the classical infinitesimal or linear theory of elasticity that the squares of the strain components are negligible. The importance of non-isotropic media is emphasized, and the fact that applied stress can make non-isotropic a medium which is isotropic when free from stress is pointed out. The final chapter applies the theory to the problem of the deformation of spherical shells and circular tubes under extreme external and internal pressures. (Matrices used extensively.)

Muskat, M. (1938) REFLECTION OF PLANE WAVE PULSES FROM PLANE PARALLEL PLATES. J. Appl. Phys., 9, 275-278.

A wave theory analysis is given for the reflection of wave pulses from plates, which heretofore has been treated by means of geometrical optics. The general theorem is proved that if the reflection coefficient for a harmonic wave system is exactly periodic in the frequency of the waves, the reflections from the plate due to an incident pulse will consist of a series of wave trains exactly the same form as the incident pulse. This theorem may be applied to electromagnetic waves polarized in and normal to the plane of incidence, longitudinal waves in fluid media, and transverse waves polarized normal to the plane of incidence in general elastic media, when absorptive and dispersive effects can be neglected.

Naake, H. J., and Tamm, K. (1958) SOUND PROPAGATION IN PLATES AND RODS OF RUBBER-ELASTIC MATERIALS. Acustica, 8, 65-76.

The known results for the propagation of sound in plates with Poisson's constant $\sigma = 0.5$ (liquids) and $\sigma = 0.7$ (rubber). The dispersion curves are easily understandable because of the large difference between the velocities of transverse and longitudinal waves occurring at this value of σ.

Measurements of the propagation of elastic waves in rods of rubber with square cross-section in the frequency range 0.1 to 300 kc/s are reported. The amplitude is measured as a function of distance by partly submerging the rod into a water filled vessel within which a hydrophone is arranged.

The results with respect to phase velocity and attenuation can be explained in terms of the propagation of extensional waves at low frequencies and compressional waves at high frequencies separated by a range with high attenuation.

Nash, W. A. (1954) Bibliography on Shells and Shell-Like Structures. David W. Taylor Model Basin Report 863, 62 pp.

Nath, N. S. N.; see Levi, F., and Nath, N. S. N. (1938).

Nealy, John; see Press, Frank, and Nealy, John (1957).

Newlands, M. (1950) RAYLEIGH WAVES IN A TWO-LAYER HETEROGENEOUS MEDIUM. Monthly Notes Roy. Astr. Soc., Geophys. Suppl., 6, 109-124.

A method is developed for the solution of the equations for Rayleigh waves in a semi-infinite incompressible medium in which a crust of rigidity varying linearly with depth lies on top of a uniform elastic medium of great depth. The method is extended to deal with compressible media and in both cases is applied to a model earth.

Newlands, M. (1952) THE DISTURBANCE DUE TO A LINE SOURCE IN A SEMI-INFINITE ELASTIC MEDIUM WITH A SINGLE SURFACE LAYER. Trans. Roy. Soc. (London), A, 245, 213-308.

An investigation is made of the disturbance created by a cylindrical pulse (of P- and S-type) emitted from a line source in a surface layer of elastic materials overlying a semi-infinite medium of different elastic constants and density. An exact formal description of the motion is obtained in terms of a succession of pulses; the double integrals corresponding to each are evaluated by approximate methods. It is found that at a remote point (at or near the surface) there should be felt pulses corresponding to travel by each one of the minimum-time-paths predicted by the ray theory, and, in addition, a whole series of diffraction effects. Ray-path pulses are of the same type as the initial pulse, showing the same "jerk" in the displacements (or in the rate-of-change of these); diffraction pulses are in general "blunt," but certain of them become sharper as the surface is approached until, at the surface, they become part of a minimum-time-path disturbance. The apparent S- and Sg-anomalies are considered in the light of these results. At a certain range interference between pulses becomes important, and at very great range the dispersive Rayleigh wave-train becomes the dominant feature. A further study of the propagation of free Rayleigh waves shows that an infinite number of modes of vibration are possible. The degree to which each is excited and the resultant motion is determined; the importance of the Airy phases is demonstrated. The pulse representation has a natural extension to systems of any number of layers; before the corresponding interference pattern at great range can be determined it will be essential to extend our knowledge of the dispersion of free surface waves to such multilayered systems.

Newlands, Margery (1954) LAMB'S PROBLEM WITH INTERNAL DISSIPATION, I. J. Acoust. Soc. Am., 26, 434-448

A theoretical investigation is made of the response of an elastic half-space to a vertical impulse at the surface. Dissipative properties are incorporated in the medium and dissipation coefficients λ', μ', varying as the nth power of the frequency are assumed. These lead to dispersion and absorption. The response may be described by components of the three distinct types, P-, S-, and R-. Each is observed at the surface as a train r/α, r/β, and r/γ, respectively, where α, β, and γ are the velocities of propagation of P-, S-, and R-waves in nondissipative media, and r is the focal range. These phases are discussed in detail; their "amplitude" and "span" are defined, and the variations of each of these quantities and their ratios with r, density ρ, and the material constants are derived. A schematic determination of λ and μ (the elastic constants), n, λ', and μ' from experimental data is outlined.

Nickson, A. F. B., and Muncey, R. W. (1953) ACOUSTIC IMPEDANCE MEASUREMENT BY THE TRANSMISSION-CHARACTERISTIC METHOD Acustica, 3, 192-198.

The transmission-characteristic method has been developed to the stage where it is an accurate, simple, and versatile method. The most suitable chamber dimensions are derived, construction of chambers is described, and the impedance of a selected material at various angles of incidence is given for a wide range of frequencies.

Nishihara, T., and Miki, H. (1951) EXPERIMENTAL STUDIES ON THE INTERNAL FRICTION IN SOLIDS. Tech. Rep. Engng. Res. Inst. Kyoto Univ., 1, 1-18.

A dashpot, spring and friction element model is proposed and investigated in some detail. The log decrement is calculated, and its dependence on frequency is compared with the experimental results obtained on cold drawn brass and 0.8% carbon steel. Both drawn and quenched samples of the latter were tested before and after annealing at various temperatures. These results are also compared with Zener's thermoelastic theory. Some details of the experiments are given; the log decrement was determined from a photographic record of the amplitude of transverse vibrations of freely suspended specimens.

Nodtvedt, Henrik (1954) AN ACOUSTIC WAVE GUIDE LENS FOR USE IN LIQUIDS. Norwegian Defence Research Establishment, 12 p., No. 3.

It is shown, theoretically and by measurements, that a plate medium consisting of parallel plates made of resilient material, for instance sorbo rubber, behaves like a high-pass filter for sound waves in liquids. Based on the variation of phase velocities in this kind of medium, a lens with a refractive index of 0.6 and with a focal length of 40 cm is constructed for use at 30 Kc/s. Measurements of the directive properties of this lens are carried out.

NOISE AND SOUND TRANSMISSION. Report of the 1948 Summer Symposium of the Acoustics Group, The Physical Society, London (1949).

A collection of papers from this symposium. Several of these pertinent papers are abstracted separately.

Nolle, A. W. (1947) ACOUSTIC DETERMINATION OF THE PHYSICAL CONSTANTS OF RUBBER-LIKE MATERIALS. J. Acoust. Soc. Am., 19, 194-201.

The necessary relations for computing Young's modulus and the associated viscosity coefficient from acoustic data are presented. An experimental method is described which has been used to measure the sound phase velocity and attenuation of longitudinal waves in thin narrow samples in the frequency range from 1 to 26 kilocycles.

Nolle, A. W. (1950) DYNAMIC MECHANICAL PROPERTIES OF RUBBER-LIKE MATERIALS. J. Poly. Sci., 5, 1-54.

The purpose of this paper is to present data concerning the dynamic mechanical behavior of rubber-like materials and to interpret these data insofar as possible. The data were obtained by five experimental methods previously described. In addition, certain data are obtained at a frequency of 15 megacycles by measuring the velocity and attenuation of bulk waves in rubber.

Nolle, A. W., and Mifsud, J. F. (1953) ULTRASONIC-WAVE STUDY OF SWOLLEN BUNA-N RUBBER. J. Appl. Phys., 24, 5-14.

The velocity and attenuation of ultrasonic waves are measured as a function of temperature in specimens of a Buna-N vulcanizate swollen to various degrees with methyl ethyl ketone. The frequencies are 2, 5 and 10 Mc/s. The experimental method consists of determining the insertion loss and the time delay due to insertion of a flat sample in the liquid acoustic medium of a pulse-reflection apparatus; an improved technique of observation, in which phase delay as well as envelope delay is examined, leads to more precise time data than previous applications of the method. As solvent content of the specimen increases, the position of the maximum of attenuation with respect to temperature moves to lower temperatures, and the height of the attenuation peak is reduced. It is shown that the height of the attenuation peak, when corrections are made for temperature effects according to the mechanisms of rubberlike elasticity, is proportional to the mass of polymer per unit volume in the swollen specimen; moreover, the temperature of maximum attenuation is a linear function of the ratio, for the swollen specimen, of mass of solvent to mass of polymer. The latter finding indicates, if the concept of energy of activation is applicable, that the reduction of activation energy is proportional to the number of solvent molecules associated with each polymeric "chain segment." The paper contains auxiliary data on dimensional and volumetric aspects of swelling and swelling rate.

Nolle, A. W., and Mowry, S. C. (1948) MEASUREMENT OF ULTRASONIC BULK-WAVE PROPAGATION IN HIGH POLYMERS. J. Acoust. Soc. Am., 20, 432-439.

The velocity and attenuation of bulk waves (longitudinal waves of dilatation) in solid samples of high polymers are measured by an acoustic pulse technique in the frequency range 10 to 30 mc/s. An ultrasonic pulse of about 2μsec duration is transmitted by a crystal into the liquid contained in a tank about 5 cm long, and returns as an echo to the crystal transducer. The velocity of bulk waves in the polymeric materials is found from the change in echo arrival time which occurs when a flat sample is introduced into the sound path, and the attenuation is found from the reduction of echo intensity. Measurements for several rubbers and plastics are reported over various portions of the temperature range -60°C to 100°C. The attenuation generally shows at least one maximum with respect to temperature in this range. Maximum attenuation values for various rubbers at 10 mc range from 200 to 400 db/cm.

Nolle, A. W., and Sieck, P. W. (1952) LONGITUDINAL AND TRANSVERSE ULTRASONIC WAVES IN A SYNTHETIC RUBBER. J. Appl. Phys., 23, 888-893.

Velocity and attenuation of both transverse and longitudinal ultrasonic waves are measured in a buna-N vulcanizate at 2, 5, and 10 Mc/s, over a range of temperatures. The method involves use of solid transmission media to conduct pulsed signals into a thin flat specimen. Values of the bulk modulus and of the complex shear modulus are computed from the measurements. It is found that longitudinal-wave losses in this particular synthetic rubber are substantially accounted for by the relaxation phenomena measured in shear, but this conclusion is subject to considerable quantitative uncertainty arising from experimental errors estimated to be as large as 5% for longitudinal-wave acoustic data and 10% for transverse-wave acoustic data. It is found that below approximately -25°C the shear-modulus loss tangent becomes relatively independent of temperature and frequency in the present range.

Nowick, A. A. (1953) "Internal Friction in Metals." Progress in Metal Physics, 4, 1-70.

First a phenomenological description of the general features of non-elastic deformation, which includes, as special cases, anelasticity, static hysteresis, and amplitude dependent internal friction, is given. Then the various experimental methods to measure internal friction are reviewed. The rest of the chapter is devoted to the physical origins of internal friction.

Nowick, A. A. (1954) INTERNAL FRICTION AND DYNAMIC MODULUS OF COLD-WORKED METALS. J. Appl. Phys., 25, 1129-1134.

The complexities of the internal friction and dynamic modulus of metals in the cold-worked condition may be understood reasonably well by separation of the phenomena into the following three distinct effects: (1) the "non-linear" effect, characterized by strong amplitude dependence, frequency independence and its disappearance after severe deformation; (2) the Koster effect, which shows rapid recovery after deformation, at temperatures well below the recrystallization temperature; (3) the "viscosity" effect, characterized by strong frequency and temperature dependence. The origin of each of these effects is briefly discussed from the point of view of dislocation theory.

Nuovo, M.; see Bordoni, P. G., and Nuovo, M. (1957).

Oberst, Hermann (1956) MATERIALS WITH VERY HIGH INNER DAMPING. Akust. Bei., 1, 144-153. (In German)

Materials of high inner damping are useful for diminishing the propagation of disturbing noise via solid structures. They may be used as building materials, as damping layers on metallic structures, as spring elements for vibration isolation or structure-borne sound insulation, etc. Extremely high internal losses can be obtained with high polymers (rubber and plastics), if use is made of the elastic dispersion which is due to molecular relaxation processes occurring in the viscoelastic range of the materials. The dispersion ranges in which the absorption has a maximum value can be systematically shifted to the desired frequencies and temperatures if the mixtures of which the materials consist are suitably chosen. Damping materials which are in technical use as adhesive layers on metal sheet structures have been adjusted in this way. The vibration damping of the metal sheets which is obtained with sufficiently thick layers is comparable to the inner damping of soft cork, and it can be shown that it will scarcely be possible to attain an essentially higher damping efficiency.

Oberst, Hermann, Becker, G. W., and Frankenfeld, K. (1954) DAMPING THE VIBRATIONS OF THIN SHEET METAL. II. Akust. Bei., 1, 433-434. (In German)

A paper having the same title as the present one appeared in this journal nearly one year ago. Since then progress has been made in the development of the materials having high internal energy losses, which are used for damping the vibrations of thin sheet metal. The technique for measuring the dynamical properties of those materials has been completed. The advances made are described in the present paper. The possibility of comparing different damping substances is discussed. It is shown how a maximum of damping efficiency in the desired ranges of frequency and temperature can systematically be obtained in the case of plasticized high polymers mixed with appropriate inorganic filling materials. Finally problems of the practical applications of the damping mixtures are discussed.

Oestreicher, H. L. (1951) FIELD AND IMPEDANCE OF AN OSCILLATING SPHERE IN A VISCOELASTIC MEDIUM WITH AN APPLICATION TO BIO PHYSICS. J. Acoust. Soc. Am., 23, 707-714.

With an application to human tissue in view, a theoretical analysis of the behavior of mechanical vibrations in a medium with elastic, viscous and relaxational properties is made. For this purpose, the equations of wave motion in a viscoelastic medium are discussed in general and solved for two problems, which are significant for the propagation and transfer of vibrational energy: (1) energy propagation and absorption in plane waves, (2) field and impedance of an oscillating sphere. The results show that the energy is propagated in two kinds of waves, the relative intensities of which change strongly with frequency: transverse waves, owing to the shear elasticity and viscosity, and compression (acoustical) waves, owing to the volume compressibility of the medium. A more detailed treatment is then accomplished for human muscle tissue by inserting the approximate values of its elastic constants into the general formulae, thus explaining the behavior in a frequency range from 0 up to several hundred kc/s.

Officer, C. B., Jr. (1951) NORMAL MODE PROPAGATION IN THREE-LAYERED LIQUID HALF-SPACE BY RAY THEORY. Geophysics, 16, 207-212.

The fundamental integral for normal mode propagation in a 3-liquid layered half-space is derived by multiple reflections, and the physical significance of the characteristic equation is discussed.

O'Neil, H. T. (1949) REFLECTION AND REFRACTION OF PLANE SHEAR WAVES IN VISCO-ELASTIC MEDIA. Phys. Rev., 75, 928-935.

The shear elasticity and viscosity of liquids have been measured at ultrasonic frequencies by utilizing plane shear waves in an elastic solid and measuring the reflection loss and phase shift caused by reflection at a plane interface of the solid and a liquid. The first measurements of this type involved normal incidence. In a recent modification of the method, oblique incidence results in an enhanced effect. This paper derives the theoretical relations between the constants of the two media, and the complex reflection coefficient and the angle of incidence. The theory describes some of the general properties of reflected and refracted shear waves in isotropic viscoelastic media.

Ormestad, K. (1950) ON SOUND ABSORPTION BY VIBRATING PLATES. K. Norske Vidensk. Selsk. Forhandl., 23, 3-6.

Formulae are derived for the impedance of a system comprising a vibrating plate fixed at the edges and closing an airspace. It is shown how the absorption and selectivity of such a system used for sound absorption in rooms can be influenced by matching the friction of the system to the specific acoustic resistance of the air, and the use of rock-wool or cotton-wool in the airspace is suggested.

Osborne, M. F. M., and Hart, S. D. (1945) TRANSMISSION, REFLECTION, AND GUIDING OF AN EXPONENTIAL PULSE BY A STEEL PLATE IN WATER, I. THEORY. J. Acoust. Soc. Am., 16, 1-18.

The problem of the interaction of an underwater explosion wave with a steel plate is discussed, particularly those aspects in which the plate can be considered as an elastic, 2-dimensional wave-guide. The phase velocities of the more important modes of the plate are evaluated as functions of the frequency. They are used to derive the properties of the precursor, an oscillation which precedes the explosion wave as it travels along the plate. The results of the theory are compared with experiment. The methods are applicable to the evaluation of the phase velocities of the modes of an electromagnetic-wave guide. The propagation of a transient, such as an explosion wave, down a wave guide, presents the mathematical problem of the evaluation of a contour integral of a function of a complex variable defined implicitly. No rigorous solution as yet exists.

Osborne, M. F. M., and Hart, S. D. (1946) TRANSMISSION, REFLECTION, AND GUIDING OF AN EXPONENTIAL PULSE BY A STEEL PLATE IN WATER. J. Acoust. Soc. Am. (Naval Research Lab. Repts.: S-2564 and S-2564-814270 PB 17570 and 16085), 18, 170-184.

In this paper are given the results of an experimental study of the interaction of an explosion wave with a water-backed steel plate. Data are given showing the dependence of the transmitted and reflected waves on the angle of incidence, and of the diffracted wave on position behind the plate. The plate acts as a filter, removing the high frequencies from the transmitted wave and the low frequencies from the reflected wave. The reflected wave is approximately constant in shape or time scale, with varying angle of incidence. Its amplitude has a broad maximum at normal incidence. In addition to the reflected, transmitted, and diffracted waves, waves can travel along the plate, in which case the plate acts as a wave guide. As a consequence of the dispersion of the guided waves, a precursor precedes the explosion wave as it travels along the plate. The dependence of the frequency, length and amplitude of this precursor upon orientation of the plate, position and time has been determined.

Pachner, J. (1949) PRESSURE DISTRIBUTION IN THE ACOUSTICAL FIELD EXCITED BY A VIBRATING PLATE. J. Acoust. Soc. Am., 21, 617-624.

Pressure distribution in the acoustical field excited by a vibrating circular plate clamped at the edge in an infinite wall is calculated for the points the distance of which from the center of the plate is > 10-20 times its radius. For completeness a short survey of the theory of forced vibrations of plates is also given.

Paranjape, B. V. (1953) ON THE THEORY OF INTERNAL FRICTION IN METALS. Proc. Phys. Soc. (London), 66, 572-575.

The absorption and emission of vibrational quanta by the conduction electrons in metals lead to a contribution $\pi^2 \nu F \sigma / K_0 (10^{-3})$ to the internal friction per cycle independent of frequency. This holds only for longitudinal vibrations whose wavelength is sufficiently small compared with the dimensions of the sample. In the above, ν is the number of free electrons per atom; σ/K_0 is twice the ratio of the velocity of sound to that of the fastest electron and is of the order 10^{-3}. F is a constant of the order unity; its exact value can be found from the temperature coefficient of the electrical resistivity at high temperatures.

Parker, J. G. (1956) REFLECTION OF PLANE SOUND WAVES FROM AN IRREGULAR SURFACE. J. Acoust. Soc. Am., 28, 672.

A plane sound wave is assumed to be incident upon an irregular pressure release surface $Z = \zeta(x,y)$. The solution for the reflected field is regarded as a superposition of plane waves having an amplitude spectrum $A(k_1,k_2)$. Next, the Fourier transform $G(x,y)$ of $A(k_1,k_2)$ is introduced and subjected to the boundary condition of ζ. This leads to an integral equation for $G(x,y)$ that cannot readily be solved. However, if one causes $G(x,y)$ to depend exponentially on a function $u(x,y)$, then a differential equation may be derived from this integral equation, the solution of which gives an approximate form of $u(x,y)$; the degree of approximation involved depends on the smallness of ζ.

This method is applied to the problem of sound scattering from a one-dimensional sinusoidally corrugated surface, and the results are compared with the experimental measurements of LaCasce and Tamarkin and also with the results of a theory due to Rayleigh. This comparison shows the predictions of the theory presented here to be as good as the Rayleigh theory in all cases and closer in the majority of cases.

Parker, John G. (1957) REFLECTION OF PLANE SOUND WAVES FROM A SINUSOIDAL SURFACE. J. Acoust. Soc. Am., 29, 377-380.

The problem of calculating the specular component of the sound field reflected from a sinusoidal pressure release surface is discussed. The incident field is assumed to be plane and directed normally to the surface. Basically, the problem consists of obtaining the solution to a nonlinear differential equation derived in an earlier paper. This was done numerically and the results from two differently formed surfaces. In one case agreement between calculated and measured values is quite good, while in the second case there is considerable discrepancy. A possible explanation of this discrepancy is given.

Pasler, M. (1944) THEORY OF THERMAL DAMPING IN SOLID MATTER. Z. Phys., 122, 357-386.

"Thermal damping" is the damping of mechanical oscillations by internal friction. The equation of motion is derived, using Hamilton's principle, but the thermal energy due to the deformation is included in the expression for the elastic potential energy of the oscillation system. The equation of motion has an additional term representing "thermal damping," and the logarithmic decrement is defined as measure of "thermal damping." The general theory is developed and applied to calculate "thermal damping" for rods, plates, spheres, and cylinders subjected to oscillations.

Pattinson, J. R. (1954) AN APPARATUS FOR THE ACCURATE MEASUREMENT OF INTERNAL FRICTION. Rev. Sci. Instr., 25, 490-496.

An electronic instrument has been developed for the measurement of internal friction to a high level of accuracy. The device is actuated by an input signal consisting of a voltage-time decay waveform, with the necessary condition that the decay should follow an exponential law. The operation is both automatic and rapid so that the apparatus is suitable for investigating changes in damping when a given dependent parameter is varied.

Paul, David I. (1957) ACOUSTICAL RADIATION FROM A POINT SOURCE IN THE PRESENCE OF TWO MEDIA. J. Acoust. Soc. Am., 29, 1102-1109.

Two semi-infinite isotropic media (porous or nonporous) are separated by a plane interface. A simple point source of sound is imbedded in either of the media. Expressions for the resultant wave function are obtained by the method of steepest descents as modified by Banos and Wesley. In particular, two different asymptotic solutions are presented. The first solution is valid in the vicinity of the interface. The expansions, calculated out to three terms, yield the wave solution as a continuous function of the parameters of the two media and the space coordinates for horizontal ranges beginning at small distances from the source and extending to infinity. It is shown that a surface wave exists and that this wave gradually disappears when the horizontal range becomes sufficiently large. The second solution consists of a simple three-term asymptotic expansion valid in the vicinity of the vertical axis. The mathematical treatment uses a new path of integration not used in the literature of this problem.

Pearson, J., and Rinehart, J. S. (1953) SURFACE MOTION ASSOCIATED WITH OBLIQUELY INCIDENT ELASTIC WAVES. J. Acoust. Soc. Am., 25, 217-219.

Well-known laws which govern the reflection of elastic waves that strike free surfaces obliquely are used to deduce particle motion at the free surface of a body. The surface particle motion is presented in the form of diagrams and graphs for the case of an incident longitudinal wave. Considerations indicate that, for oblique incidence, the particle motion at the surface will not, in general, be perpendicular to the surface but will depend on the angle of incidence and the Poisson's ratio of the material. The data are expected to be of value in the solution of problems connected with impulsively loaded bodies such as metal-explosive systems.

Pekeris, C. L., and Longman, I. M. (1958) RAY-THEORY SOLUTION OF THE PROBLEM OF PROPAGATION OF EXPLOSIVE SOUND IN A LAYERED LIQUID. J. Acoust. Soc. Am., 30, 323-328.

The problem of propagation of explosive sound in a layered liquid is formulated operationally, and an exact solution is derived based on ray theory. The contribution of each ray at a given time is expressed by a single definite integral taken over a fixed finite range. With the aid of an electronic computer the pressure-field was evaluated both for the case of a slow-speed bottom and for the case of a high-speed bottom. It was found that for a Heaviside unit pulse and a high-speed bottom the pressure becomes logarithmically infinite at the time of arrival of the totally reflected wave. For a high-speed bottom, the pressure pulse at large ranges, as computed by the ray theory, exhibits the well-known features, first observed by Ewing and Worzel and later deduced from the normal-mode theory, of a long-period ground-wave followed by a high-frequency dispersive water-wave. We have found, furthermore, that at large ranges sufficient accuracy can be obtained by retaining only the contributions from a group of the last arriving quadruplets of rays. With this approximation it becomes feasible to use ray theory for the evaluation of the pressure field even at large ranges.

Pelzer, H.; see Letherisch, W., and Pelzer, H. (1950).

Pendse, C. G. (1948) ON THE ANALYSIS OF A SMALL ARBITRARY DISTURBANCE IN A HOMOGENEOUS ISOTROPIC ELASTIC SOLID. Phil. Mag., 39, 826-827.

The equations of motion are derived and the chief special types of motion are discussed. It is pointed out that when the motion is arbitrary (i.e., neither of the 2 basic types, wholly irrotational or wholly equivoluminal) it consists of 2 distinct parts, depending on equations similar to those for the basic types but involving different physical quantities. The analysis shows that in seismology there can be waves which are neither longitudinal nor transverse; conditions under which these may exist are pointed out.

Peutz, V. M. A. (1954) SOME FUNDAMENTAL MEASUREMENTS ON SINGLE AND DOUBLE PLATE STRUCTURES. Acustica, 4, 281-284.

Paper given at the Congress of the International Commission of Acoustics, Netherlands, 1953. Measurements on the transmission loss of plates of wood, lead, rubber, and aluminum in a reverberant sound field are discussed. In agreement with the results of London et al. a rather high insulation is found for the low frequencies. The transmission loss of a double wall is compared with that of the corresponding single wall.

Peutz, V. M. A. (1955) CONCERNING THE ARTICLE BY I. W. KUHL, "POSSIBLE ERRORS IN TRANSMISSION LOSS MEASUREMENTS AT LOW FREQUENCIES, I." Acustica, 5, 46-47.

Pickett, Gerald (1945) FLEXURAL VIBRATION OF UNRESTRAINED CYLINDERS AND DISKS. J. Appl. Phys., 16, 820-831.

Solutions are given for the free flexural vibration of a cylinder vibrating as a rod would vibrate, and for the free flexural vibration of a disk vibrating as a circular plate would vibrate. The solutions are based on the mathematical theory of elasticity. Curves are given showing the correction factors which, when applied to the elementary solutions, will give results in agreement with those obtained by means of the more rigorous solutions given here.

Pieruschka, E. (1951) DERIVATION OF FUNDAMENTAL EQUATIONS FOR THE DEFORMATION OF A VISCOELASTIC MEDIUM AND THEIR APPLICATION TO WAVE PROPAGATION. Ing.-Arch., 19, 271-281. (In German)

Author gives a Cartesian tensor analysis of the deformation of a viscoelastic medium. Wave propagation is discussed in Maxwell-Fromm and Hookean materials and in Newtonian fluids.

Pisent, G.; see Barducci, I., and Pisent, G. (1957).

Plenard, E.; see LeRolland, P., and Plenard, E. (1956).

Post, E. J. (1953) RADIATION PRESSURE AND DISPERSION. J. Acoust. Soc. Am., 25, 55-60.

Starts with a brief discussion of the two components of acoustical radiation pressure in contrast with the single component obtained for electro-magnetic radiation in vacuum. The two components of acoustical radiation pressure are correlated in a simple manner with the two distinct interaction possibilities of the obstacle and the medium, i.e., interaction with the wave motion only or interaction with the wave motion as well as with the medium itself. This picture appears to be consistent with the earlier conclusions of Brillouin and Richter. Afterwards the result is generalized for dispersive media. It is shown that the component which is usually slated to be independent of the equation of state in the existing non-dispersive theories should contain the time parameters of the equation of state in the form of a multiplying factor group, velocity over phase velocity. The present paper stresses the basic concepts rather than mathematical detail and concludes with an extensive bibliography and commentary.

Postma, G. W. (1955) WAVE PROPAGATION IN A STRATIFIED MEDIUM. Geophysics, 20, 780-806.

A periodic structure consisting of alternating plane, parallel, isotropic, and homogeneous elastic layers can be replaced by a homogeneous, transversely isotropic material as far as its gross-scale elastic behavior is concerned. The five elastic moduli of the equivalent transversely isotropic medium are accordingly expressed in terms of the elastic properties and the ratio of the thicknesses of the individual isotropic layers. Imposing the condition that the Lame constants in the isotropic layers are positive, a number of inequalities are derived, showing limitations of the values the five elastic constants of the anisotropic medium can assume. The wave equation is derived from the stress-strain relations and the equation of motion. It is shown that there are in general three characteristic velocities, all functions of the direction of the propagation. A graphical procedure is given for the derivation of these characteristic velocities from the five elastic moduli and the average density of the medium. A few numerical examples are presented in which the graphical procedure is applied. Examples are given of cases which are likely to be encountered in nature, as well as of cases which emphasize the peculiarities which may occur for a physically possible, but less likely, choice of properties of the constitutent isotropic layers. The concept of a wave surface is briefly discussed. It is indicated that one branch of a wave surface may have cusps. Finally a few remarks are made on the possible application of this theory to actual field problems.

Press, Frank; see Ewing, W. Maurice, Jardetzky, Wenceslas, S. and Press, Frank (1957).

Press, Frank, and Nealy, John (1957) ABSORPTION OF RAYLEIGH WAVES IN LOW-LOSS MEDIA. J. Appl. Phys., 28, 1323-1325.

An expression is derived for media characterized by internal dissipation parameter $1/Q << 1$ relating the Rayleigh wave absorption coefficient to compressional and shear wave absorption coefficients with the elastic velocities as parameters.

Primakoff, H. (1944) THE ACOUSTIC PROPERTIES OF DOMES, I. OSRD 3159, Columbia University, Division of War Research, Underwater Sound Reference Laboratories, 350 Fifth Ave., NYC.

For the purpose of providing material of possible assistance in setting up specifications for domes, a critical study is made of existing information both of an experimental and theoretical nature.

In this Part I, the various reports issued by the Underwater Sound Reference Laboratories covering dome tests are evaluated and analyzed theoretically. The detailed theoretical discussion of the acoustic performance of domes, based on the recent fundamental mathematical work performed by the NDRC Applied Mathematics Panel, will be presented in Part II of this study.

As a result of the discussion, it is possible to devise simple approximate relations covering the acoustic performance of domes as a function of:

a. Wall thickness of the dome.
b. Properties of the material used, especially its density.
c. Frequency and directivity of the enclosed transducer.
d. Size of the dome relative to that of the transducer; position of transducer in dome.
e. Shape of the dome.

Requirements to be fulfilled in dome design, based on formulae allowing prediction of the magnitude of dome transmission loss and of dome reflections, are also given.

Primakoff, H. (1944) THE ACOUSTIC PROPERTIES OF DOMES, II. OSRD 3372, Columbia University, Division of War Research, Underwater Sound Reference Laboratories, 350 Fifth Ave., NYC.

In this Part II of the report there are given the theoretical derivations of the formulae for the transmission loss and specular reflection introduced by domes. The formulae themselves have been extensively discussed and compared with experiment in Part I of this study.

In this Part II, the total sound field pressure of a dome-enclosed transducer P is found explicitly by transforming the wave equation satisfied by P into an inhomogeneous integral equation. The integral equation for P is solved by a method of series expansion in powers of h, the dome wall thickness, yielding successively the "undisturbed" sound field p, and the "first, second, ..., m'th, ... order disturbed" sound fields hp_1, h^2p, ... , h^mp_m, ... In terms of these,

$$P = p + \sum_{m=1}^{\infty} h^m p_m \quad .$$

All the h^mp_m can be expressed in terms of hp_1, which in turn is given as a superposition in the form of an integral over the dome surface, of secondary wavelets with amplitudes proportional to p. This basic integral for hp_1 in terms of p was first obtained by a "limiting" boundary value method in the recent fundamental mathematical work of the NDRC Applied Mathematics Panel.

The integral giving hp_1 in terms of p is explicitly evaluated in all regions of interest. With hp_1 available, P and, consequently, the magnitudes of transmission loss and specular reflection, are found. The angular bredth of the specularly reflected beam is determined. The change in rediation impedance of the transducer due to the dome is estimated and found to be small. A brief discussion is given of domes of special shape, and of the effect of domes on echo-ranging in the vertical plane. Finally, the various physical and mathematical approximations made are discussed and justified.

Primakoff, Henry, and Keller, Joseph B. (1947) REFLECTION AND TRANSMISSION OF SOUND BY THIN CURVED SHELLS. J. Acoust. Soc. Am., 19, 820-832.

In this paper the reflection and transmission of sound by thin curved shells, as well as several related problems, are treated mathematically. First one derives an inhomogeneous integral equation for the sound field in an infinite medium containing a thin curved shell of different material. The solution of the integral equation is then reduced, approximately, to the evaluation of a surface integral not too different from that obtained in the usual Kirchhoff diffraction theory. The integral is evaluated approximately and gives expressions for the pressure waves reflected from and transmitted through a thin curved shell. The reflection and transmission coefficients of the shell are obtained from these expressions. It is found that the reflection coefficient can be expressed as the product of a geometrical factor, a phase-cancellation factor, and a reflectivity factor. When the reflection problem for a rigid obstacle is solved with the aid of the assumptions of the Kirchhoff diffraction theory, the reflection coefficient thus obtained is the product of the geometrical and phase factors of the previous solution. The geometrical factor alone is obtained as the reflection coefficient when the reflection problem is solved exactly by geometrical acoustics. The agreement among the various solutions may be considered as a partial justification for the Kirchhoff theory as well as for geometrical acoustics.

The Kirchhoff method is also applied to the problem of refraction at a curved surface. From the solutions of the reflection and refraction problems, the laws of reflection and refraction for curved surfaces are obtained. In addition, the mirror and lens laws, the conditions for point images, and the change of phase at a focus are obtained.

Pritchard, Robert L. (1951) DIRECTIVITY OF ACOUSTIC LINEAR POINT ARRAYS. ONR TM 21, Acoustics Research Laboratory, Dept. of Engineering Sciences and Applied Physics, Harvard University, Cambridge, Mass.

This research deals with a theoretical study of linear arrays of acoustic point elements, with particular emphasis on the broadside array. A systematic method is presented for analyzing the directive properties of arrays with non-uniform excitation of the elements. Steering of the directivity pattern, including the equal-minor-lobe type, is discussed. An improved method of estimating the beam width and a new method of computing the directivity factor to a very good approximation are described. Another type of optimum directivity pattern, different from the equal-minor-lobe type described in an earlier report, has been obtained by requiring that the directivity index be a maximum. For element spacings less than a half-wave-length, these patterns become super-directive. In an effort to evaluate the practicability of using such super-directive arrays, expressions have been derived for the sound-transmission efficiency of the array and for the electric power available in sound reception. The performance of ideal arrays under non-steady-state excitation is also discussed.

Proud, J. M., Jr., Tamarkin, P., and Meecham, W. C. (1957) REFLECTION OF SOUND FROM A SURFACE OF SAW-TOOTH PROFILE. J. Appl. Phys., 28, 1298-1301.

A variational method is used to calculate the energy diffracted into the various orders produced when a plane acoustic wave is incident on a periodic, pressure-release surface of saw-tooth shape. The results of companion experiments performed with a cork-covered surface, using techniques of underwater sound, are also presented. The relative energies reflected in various orders are plotted as a function of the ratio of acoustic wavelength to spatial period of the surface for a range of angles of incidence. Theory and experiment agree within 10% for all angles of incidence examined and for a large part of the frequency range covered.

Pursey, H.; see Miller, G. F., and Pursey, H. (1954).

Pursey, H., and Pyatt, E.C. (1954) AN IMPROVED METHOD OF MEASURING DYNAMIC ELASTIC CONSTANTS, USING ELECTROSTATIC DRIVE AND FREQUENCY-MODULATION DETECTION. J. Sci. Instr., 31, 248-250.

Apparatus is described for the measurement of the natural longitudinal resonant frequencies of metal bar specimens.

Pyatt, E. C.; see Pursey, H., and Pyatt, E. C. (1954).

Radok, J. R. M. (1957) VISCOELASTIC STRESS ANALYSIS. Quart. Appl. Math., 15, 198-202.

E. H. Lee has discussed the use of Laplace transform techniques in the analysis of quasi-static problems of linear viscoelasticity. In any particular case, Lee's methods involve the concept of an associated elastic problem (whose solution is supposed known) that corresponds formally to the Laplace transform of the viscoelastic problem. The application is therefore restricted to the general class of problems with boundary conditions admitting this operation. The purpose of the present paper is to show that this restriction may be avoided through more general analysis.

Author shows that the elastic and viscoelastic solutions of a given boundary-value problem are related to each other through functional equations for the quantities specifying the solutions. If the elastic solution of the boundary-value problem is known, then these functional equations are given by expressing the elastic constant in this solution in terms of the differential time-operators in the general, isotropic, visocelastic, stress-strain law. In many cases, these functional equations are ordinary differential equations in time whose solutions for the given initial conditions make up a viscoelastic solution satisfying the same boundary conditions as the elastic solution. If these functional equations are solved by the use of Laplace transform techniques, then the later stages of obtaining the viscoelastic solution coincide with Lee's methods. However, the establishment of the independence of the use of Laplace transform techniques from the associated elastic problem considerably widens the range of application of these techniques.

Raes, A. C. (1954) MEASUREMENTS OF COEFFICIENTS OF REFLECTION IN AMPLITUDE AND PHASE. Acustica, 4, 123-125. (In French)

Paper given at the Congress of the International Commission of Acoustics, Netherlands, 1953. A description is given of three methods which proved to be useful in architectural acoustics. The main principle is to separate the incident and the reflected waves in time and space so that they can be measured independently of each other. Calculations are thus reduced to a minimum. (1) Acoustical transmission line tests. Convenient to test small samples under normal incidence. Allows great operational speed. A direct reading reflection coefficient meter is described. (2) Free room tests. Designed to test absorbing materials, including vibrating panels and curtains, in situ and without touching them, under normal incidence. (3) Oblique incidence tests. Development of the preceding case.

Raes, A. C. (1955) A TENTATIVE METHOD FOR THE MEASUREMENT OF SOUND TRANSMISSION LOSSES IN UNFINISHED BUILDINGS. J. Acoust. Soc. Am., 27, 98-102.

The method attempts to measure the transmission loss of any wall independently of the surrounding elements of the building. The extreme case of a wall without any surrounding elements, i.e., the first wall in a building under construction, is included in the problem.

Ramer, L. G.; see Sabine, P. E., and Ramer, L. G. (1938).

Randolph, L.; see Howes, E. T., Tejada-Flores, L. H., and Randolph, L. (1953).

Rayleigh, John Strutt (1895) ON WAVES PROPAGATED ALONG THE PLANE SURFACE OF AN ELASTIC SOLID. Proc. Lon. Math. Soc., 17, 4-11.

The behavior of waves upon the free surface of an infinite homogeneous isotropic elastic solid is investigated in this paper. These waves are confined to a superficial region, the only disturbance being found within a distance comparable to the wavelength. (Rayleigh Waves).

Rayleigh, John Strutt, (1894) "Vibrations of Membranes" (Chap. IX), "Vibrations of Plates" (Chap. X), "Curved Plates or Shells" (Chap. XI), "Vibrations of Solid Bodies" (Chap. XXII), Theory of Sound, Dover, New York, 306-432.

A lengthy treatise dealing with what was known on these subjects before 1894.

Reissner, E. (1946) ON VIBRATIONS OF SHALLOW SPHERICAL SHELLS. J. Appl. Phys., 17, 1038-1042.

Reissner, E. (1954) ON AXI-SYMMETRICAL VIBRATIONS OF CIRCULAR PLATES OF UNIFORM THICKNESS; INCLUDING THE EFFECTS OF TRANSVERSE SHEAR DEFORMATION AND ROTARY INERTIA. J. Acoust. Soc. Am., 26, 252-253.

Starting from the differential equations for axi-symmetrical transverse vibrations of homogeneous plates, it is shown how the solution may be expressed in terms of Bessel functions. When transverse shear deformation and rotary inertia are neglected, the solution reduces to that of Kirchhoff.

Reissner, E. (1955) ON TRANSVERSE VIBRATIONS OF THIN, SHALLOW ELASTIC SHELLS. Quart. Appl. Math., 13, 169-176.

Author had previously shown (J. Boston Soc. Civ. Engrs., Aprl. 55) that the differential equations of the theory of shallow shells as formulated by Marguerre could be expressed as system of two simultaneous equations for an Airy stress function F and the transverse displacement w. He notes that this system may be extended to include vibratory motion if, retaining only the transverse inertia term, the longitudinal inertia terms are neglected. In order to justify the omission of these terms, author carries out an order-of-magnitude analysis whereby he establishes the conditions for the validity of these simplified equations. To illustrate his results, author determines the frequencies of transverse vibrations of a paraboloidal shell with a simply supported rectangular boundary.

Reissner, H. (1938) TRANSMISSION OF COMPRESSION WAVES THROUGH A SOLID PLATE IMMERSED IN A FLUID. Helv. Phys. Acta, 11, 140-155. (In German)

Assuming plane compression waves falling on a parallel-sided plate in which there is no internal friction, the author deduces an expression for the transmission, i.e., the ratio of the squares of the amplitudes of the incident and emergent waves. This expression is a function of the angle of incidence, the angles of refraction in the plate, the wave lengths, and the velocities of both compression and torsional waves in the plate. It is useful in determining the elastic constants of the plate. Its possible value in the theory of sound insulation of walls is pointed out.

Renault, L. (1939) TRANSMISSION OF SOUND THROUGH SINGLE AND DOUBLE SHEETS OF PLATE GLASS. Rev. Acoust., 8, 12-46.

The author calculates the attenuation of sound produced by glass sheets mechanically insulated, rigid, subjected to elastic constraint and presenting no internal absorbing surface. The attenuation is, for a single sheet, proportional to the logarithms of the surface density of the glass and the frequency of the sound. For a double sheet it is, in general, less for low frequencies and greater for high frequencies than the attenuation for the single sheet of the same mass. In the second part of the paper the results of much experimental work on several kinds of glass are given; these follow the theory more closely, the lighter the glass and the lower the frequency of the sound.

Richardson, E. G. (1953) Technical Aspects of Sound, Vol. I. Amsterdam: Elsevier Pub. Co., 544 pp.

The text is divided into six divisions written by experts on the various fields: (1) acoustic measurements and materials; (2) acoustics of buildings; (3) noise; (4) speech and hearing; (5) sound reproduction; (6) analysis and synthesis of sound, design and performance of musical instruments.

Richardson, E. G. (1954) ACOUSTIC METHODS OF MEASURING RELAXATION SPECTRA IN SOLIDS. Acustica, 4, 537-543.

Methods of measuring (1) decrement, (2) breadth of resonance peak, (3) loss angle by observations at (a) varying frequencies, (b) varying temperatures. Propagation of (a) transverse, (b) torsional, (c) longitudinal waves in lengthy specimens, at infrasonic, audio, and ultrasonic frequencies. Sorting out imaginary and real parts of propagation constants. Prediction of relaxation spectra. Explanation in terms of viscoelastic models.

Richardson, E. G. (1957) Technical Aspects of Sound, Vol. II. Amsterdam: Elsevier Pub. Co., 412 pp.

This is a continuation of Volume I covering ultrasonics, their applications, and including underwater propagation. The first chapter is on propagation of sound in the atmosphere and the sea. The rest of the book is in divisions: (1) Ultrasonic transducers and applications, (2) Underwater acoustics, (3) Aircraft noise, with a chapter on Underwater propulsion noise.

Richardson, E. G. (1957) Relaxation Spectrometry. North-Holland Publishing Company, Amsterdam.

This is a review of experimental aspects of the mechanical properties of matter as revealed by acoustic relaxation studies. After a general introduction to methods of description of mechanical properties of matter the author systematically covers experimental work from infrasonic to ultrasonic frequency ranges. Dielectric relaxation is also discussed.

Rimskii-Korsakov, A. V. (1951) ON SOUND RADIATION FROM A PLATE IN COMPLEX TYPES OF VIBRATIONS. Zh. Tekh. Fiz., 21, 970-985.

A method is presented for evaluating sound radiation at frequencies above the fundamental from a plate subjected to a sinusoidal force of constant amplitude. The method is applied to a simplified piano sounding board.

Rinehart, J. S.; see Pearson, J., and Rinehart, J. S. (1953).

Risty, D. E.; see Hickman, J. S., Risty, D. E., and Stewart, E. S. (1957).

Roark, R. J. (1943) "Beams; Flexure of Straight and Curved Bars," (Chap. 8), "Flat Plates," (Chap. 10), Formulas for Stress and Strain, McGraw-Hill, New York, 90-162, 186-223.

This book gives formulas for various cases under each topic. It makes little effort to derive them, including a large bibliography instead.

Robertson, J. M., and Yorgiadis, A. J. (1946) INTERNAL FRICTION IN ENGINEERING MATERIALS. J. Appl. Mech., 13, 173-182.

A comprehensive review of previous work on internal friction is followed by some experimental measurements on various metallic and plastic materials. It is concluded that, in a cyclic phenomenon, damping capacity is independent of the frequency, but is proportional to the square of stress amplitude. A good bibliography is provided.

Robey, D. H. (1955) ON THE CONTRIBUTION OF A CONTAINED VISCOUS LIQUID TO THE ACOUSTIC IMPEDANCE OF A RADIALLY VIBRATING TUBE. J. Acoust. Soc. Am., 27, 22-25.

The impedance presented to the inside surface of a hollow, liquid-filled, radial cylinder of finite length has been determined theoretically. It was assumed

that the liquid was retained by pressure release caps or one pressure release cap and one rigid cap at each end. For a loss-free liquid it is shown that the reactance presented to the cylinder wall becomes infinite whenever the liquid has a longitudinal or coupled radial resonance.

A sizeable resistance may appear when a viscous liquid is used. This is because the geometry of the arrangement is ideal for creating large shear losses. Exceptions to this occur for high frequencies where the wavelength is small in comparison to the cylinder length.

Rogers, Robert (1939) THE ABSORPTION OF SOUND BY VIBRATING PLATES BACKED WITH AN AIR SPACE. J. Acoust. Soc. Am., 10, 280-287.

The purpose of the rigorous theory presented here is:

1. To exhibit the dependence of the sound absorptivity on frequency and the various physical characteristics of the material.
2. To show how the physical characteristics may be varied to give a high absorptivity over a band of frequencies taken anywhere in the audible range and to show how this band width may be varied.
3. To present a method for attacking the problem of a vibrating system coupled to a reverberating space.

Rosato, F. J.; see Junger, M. C., and Rosato, F. J. (1954).

Roscoe, R. (1950) MECHANICAL MODELS FOR THE REPRESENTATION OF VISCOELASTIC PROPERTIES. Brit. J. Appl. Phys., 1, 171-173.

Author shows that any spring-dashpot model is equivalent to a two-terminal electrical network containing resistors and capacitors. He quotes a theorem of Cauer (Arch. f. Elect. 17, p. 355, 1926) that any complex network is equivalent to either of two "canonic" forms. He gives a simple example, but does not indicate a general procedure for effecting this simplification.

Rschevkin, S. N.; see Kretschmer, S. I., and Rschevkin, S. N. (1938).

Rudakov, S. N.; see Lyamshev, L. M., and Rudakov, S. N. (1956).

Rudnick, I. (1945) THE PROPAGATION OF AN ACOUSTIC WAVE ALONG A BOUNDARY. J. Acoust. Soc. Am., 19, 348-356.

The sound field of a point source near the boundary of two media cannot be obtained by an acoustic-ray approach. In fact, such an approach, which utilizes the reflection coefficient for plane waves, leads to completely contradictory results at grazing incidence. A more rigorous solution is obtained, the procedure followed being exactly similar to that initiated by Sommerfeld to derive the electromagnetic field of a vertical dipole situated near a conducting plane. The solution shows that when the boundary medium has a high real specific acoustic impedance, non-zero fields are obtained at all points along the boundary. For bounding media adequately described by simple porosity theory, the acoustic pressure at the boundary proportional to $1/(\text{distance})^2$ and $1/(\text{frequency})^2$, at reasonably large distances and low frequencies. There appear to be decreased phase velocities along the boundary. Some calculations of the sound pressure as a function of height above a Quietone surface show, among other things, the presence of a minimum occurring some distance above the boundary. At large distances from the source there are very large decreases in amplitude as the receiver height is increased in the region above this minimum. Errata: J. Acoust. Soc. Am., 20, p. 149, March, 1948.

Rudnick, I.; see Lawhead, R. B., and Rudnick, I. (1951).

Rudnick, I.; see Lawhead, R. B., and Rudnick, I. (1951).

Rytov, S. M. (1956) THE ACOUSTIC PROPERTIES OF A THIN-LAYERED MEDIUM. Sov. Phys.-Acous., 2, 67-80.

A medium which consists of alternating layers of two isotropic substances behaves, for the case where the wave-field alters only slightly within the thickness of a separate layer, as if it were homogeneous but anisotropic. The anisotropy corresponds with that of a crystal of hexagonal symmetry. Expressions are obtained for the effective elastic constants of the crystal as a function of the parameters of both substances and the layer thickness. The cases are examined of alternate layers of two solid substances and of one solid and one liquid substance. Since their properties can be varied (anisotropy of velocities of propagation and absorption both for compression and displacement waves), layered materials possess a practical interest for sound and vibration insulators.

Rzhanizyn, A. R. (1946) THE STRAINING OF CONSTRUCTIONS CONSISTING OF ELASTICO-VISCOUS ELEMENTS. C. R. Acad. Sci. URSS, 52, 25-28.

A material is said to be elastico-viscous when the relation between the strain, ϵ, and the stress, σ, is expressed by $nH\,\dot{\epsilon} + E\,\epsilon = \sigma + n\dot{\sigma}$, where H is the instantaneous modulus of elasticity, E the final modulus, and n the relaxation time. Most building materials satisfy this relation. The problem of an elastico-viscous rod losing stability under compression is studied. Formulae for the max. deflection are obtained when the compressive force < its critical value. The equations of vibration of an amplitude of forced vibrations are obtained.

Sabine, P. E., and Ramer, L. G. (1938) ABSORPTION EFFECTS IN SOUND TRANSMISSION MEASUREMENTS. J. Acoust. Soc. Am., 10, 102-104.

Transmission loss measurements entail the determination of the ratio between the sound energy density on the source side near the partition and the average sound energy density in the receiving room, together with a knowledge of the total equivalent absorption of the receiving room. It is the purpose of the present paper to show that the value of the transmission loss for a given partition is independent of a_2, the total equivalent absorption of the receiving room.

Sanders, F. H. (1939) TRANSMISSION OF SOUND THROUGH THIN PLATES. Can. J. Research, 17, 179-193.

The transmission of high frequency sound through plates of brass and nickel has been studied for angles of incidence ranging from 0 to 70 degrees, using effective plate thicknesses varying from 1/20 of a wavelength to one wavelength. In addition to strong transmissions in the regions below the normal critical angle, very sharp and intense transmission maxima are observed at angles of incidence greatly in excess of the critical angle. These transmission maxima fall within three clearly defined angular regions: (i) angles between zero and the critical angle for longitudinal waves, (ii) angles between the critical angle for longitudinal waves and the critical angle for transverse waves; (iii) angles above the critical angle for transverse waves. In regions (i) and (ii) the data are in satisfactory agreement with a recent theory advanced by Reissner, and good values of the elastic constants are obtained. By an extension of Lamb's theory for flexural vibrations in bars the results in region (iii) can be interpreted.

Sawyer, W. M.; see Adler, F. T., Sawyer, W. M., and Ferry, J. D. (1949).

Schlosser, E.; see Kastner, Siegfried, and Schlosser, E. (1957).

Schneider, W. C., and Burton, C. J. (1949) DETERMINATION OF THE ELASTIC CONSTANTS OF SOLIDS BY ULTRASONIC METHODS. J. Appl. Phys., 20, 48.

The application of ultrasonic methods to the determination of the elastic constants of solids is considered in some detail. It is shown that a rotating plate technique in which ultrasonic transmission is plotted as a function of the angle of incidence of the waves allows determination of the velocities of dilatation and shear waves in the plate. From these data, Poisson's ratio and the mechanical moduli may be determined. Details of an apparatus for making such measurements are given. The elastic constants of several metals have been measured with this equipment, and the values obtained are shown to be in agreement with previous published data. In addition, measurements of a number of thermoplastic and thermo-setting resins have been made successfully. It has been found that in the case of Melmac Resin 26-8B there is no variation in the elastic constants as a function of cure time.

Schoch, A. (1950) SOUND REFLECTION, SOUND REFRACTION, AND SOUND DIFFRACTION. Berlin, Springer-Verlag, Ergeb. exakt. Naturwiss., 23, 127-234.

This monograph is a valuable addition to the literature of the theory of sound waves of small amplitude, either in a gas or in an elastic solid. The scope of the work is best indicated by the titles of the chapters, viz,: (I) Introduction; (II) Foundations of the theory; (III) Reflection and refraction of a plane wave at a plane boundary surface; (IV) Free boundary-layer waves along a plane boundary surface; (V) Reflection and refraction of nonplane waves at a plane boundary surface; (VI) Waves in plates; (VII) Layered media; (VIII) Curved boundary surfaces and diffraction phenomena; (IX) Bibliography. The bibliography should prove most useful, as it contains 144 references, nearly half of them to work done since 1945. While the work is essentially mathematical, it contains many beautiful photographs of experiments illustrating the theory.

Schoch, Arnold (1950) THE TRANSMISSION OF ULTRASOUND THROUGH PLATES. Nuovo Cim., 7, 302-306. (In German)

The transmission by a plate of plane parallel ultrasonic vibration depends on the frequency, the thickness of the plate, and the angle of incidence. Maximum transmission occurs when the velocity with which the wave fronts cut the plate equals the phase velocity of any type of wave which can be set up in the plate. Schlieren photographs show how the transmission varies with plate thickness and angle of incidence. Small damping by the plate gives a strong and broader beam of waves on the rear side of the plate. When very good transmission through the plate occurs, the schlieren photographs show that the reflected wave on the front face disappears.

Schoch, Arnold (1951) PROPAGATION OF ULTRASONIC WAVES THROUGH PLATES. Atti Con. Internaz. Ultracust. 1950, 302-306. (In German)

Schoch, Arnold (1952) THE TRANSMISSION OF WAVES THROUGH PLATES. Acustica, 2, 1-17. (In German)

The theory of transmission of sound—plane waves and laterally bounded beams—through plates is given in a form which reveals the connection with the free waves in plates. Cremer's interpretation of total transmission as "coincidence" of the incident wave with a free wave in the plate, certain exceptions from that representation, and the influence of the finite cross section beam are discussed. The conclusions have been examined experimentally on aluminum plates by ultrasonic waves.

Schoch, Arnold (1952) TRANSVERSE DISLOCATION OF TOTALLY REFLECTED WAVES BY ULTRASONIC WAVES. Acustica, 2, 18-19. (In German)

A beam of sound undergoes a relatively large lateral displacement at reflection from a solid surface, if such an angle of incidence is chosen that a Rayleigh wave is excited in the solid medium.

Schoch, Arnold (1953) REMARKS ON THE CONCEPT OF ACOUSTIC ENERGY. Acustica, 3, 181-184.

The conventional expressions for acoustic energy—recently found not to be correct in a strict sense—are shown to have characteristic properties by which their use in acoustics can be justified satisfactorily.

Schoch, A. (1954) THE INFLUENCE OF THE LATERAL BOUNDARY ON THE SOUND TRANSMISSION OF SIMPLE WALLS. Acustica, 4, 289-290. (In German)

Paper given at the congress of the International Commission of Acoustics, Netherlands, 1953. The transmission of sound through a plate with finite dimensions has been treated theoretically. The result does not explain the abnormally high values of sound insulation measured on lightweight partitions at low frequencies.

Schoch, Arnold, and Feher, K. (1952) THE MECHANISM OF SOUND TRANSMISSION THROUGH SINGLE LEAF PARTITIONS, INVESTIGATED USING SMALL SCALE MODELS. Acustica, 2, 189-204.

The paper presents: 1. A qualitative theoretical discussion of sound transmission with regard to the finite area of partitions, 2. A technique of measuring the transmission of sound through partitions by means of small scale models, on the basis of the similarity law relating linear dimensions and frequency,

3. Measurements on homogeneous plates—representing single leaf partitions—with plane waves at varying angle of incidence as well as with diffuse (reverberant) sound. The results show the importance of the "coincidence effect" and the existence of additional "transmitted" waves caused by effects of the boundaries.

Scholte, J. G. (1942) ON SURFACE WAVES IN A STRATIFIED MEDIUM. Proc. K. Ned. Akad. Wet., 45, 380-388, 449-456, 516-523.

Comprehensive theoretical study of the whole problem of all possible types of such waves: (1) If the incident wave, propagated in the underlying medium, is transverse and vibrates perpendicular to the plane of incidence, 4 transverse waves will occur: a reflected wave in this medium as well as a refracted and reflected wave in the layer. (2) If it is longitudinal or transverse, vibrating in the plane of incidence, 7 waves occur: longitudinal and transverse reflected waves in the subjacent medium, as well as longitudinal and transverse refracted and reflected waves in the layer. The boundary conditions are derived. For an amplitude of the incident wave equal to zero, the equations of (1) lead to the Love wave-system, of (2) to the generalized Rayleigh-and-Stoneley-waves. A new special case is obtained for the density of the underlying medium being equal to zero, which leads to the wave equation of an isolated layer, the properties of which are studied. The values of the material constants for which a generalized Rayleigh and Stoneley wave-system can exist are determined, also the general shape of the dispersion curves, representing the wave-velocity as a function of the wavelength.

Scholte, J. G. (1947) ON RAYLEIGH WAVES IN VISCOELASTIC MEDIA. Physica, 13, 245-251.

The Rayleigh movement possible in a viscoelastic medium is investigated theoretically by an examination of the plane wave-systems which can exist in an infinite and in a semi-infinite body. It appears that the theory of Hardtwig is partly erroneous and that his conception of a Rayleigh wave-system is too narrow.

Scholte, J. G. (1948) ON THE LARGE DISPLACEMENTS COMMONLY REGARDED AS CAUSED BY LOVE-WAVES AND SIMILAR DISPERSIVE SURFACE-WAVES. Proc. K. Ned. Akad. Wet., 51, 969-976.

Previous work is extended to waves reflected at an interface, and an expression obtained for the disturbance due to the Stoneley wave shows that this may be a major factor in the ocean movement caused by a shock in the subjacent medium. Other surface waves can be formed by the interference of several reflected waves if the primary impulse is not of too short duration.

Schreuer, E. (1953) THE INTERNAL DAMPING OF AN INITIALLY STRESSED MEDIUM. Z. Naturforsch, 8a, 322-328. (In German)

The chief advantage of the underwater spark is that it gives a pressure impulse of high intensity and short duration. The equipment developed by the German Hydrographic Institute is described and illustrated with an echo record from the sea bed (fine sand and mud; reflection factor 5 - 10%) 35 m below. The reflection factor can be increased by using a parabolic reflector behind the spark source.

Schwantke, G.; see Cremer, L., and Schwantke, G. (1957).

Schwarzl, F. (1951) APPROXIMATION METHODS IN THE THEORY OF VISCOELASTIC BEHAVIOR, I. Physica, 17, 830-840.

Using Alfrey's approximation method a complete system of approximate equations is obtained. By differentiation of the creep curve resp. the relaxation curve, the retardation spectrum resp. the relaxation spectrum can be found without using the elasticity modulus. The creep curve and the relaxation curve are reciprocal and yield unity on multiplication. The relaxation curve is a continuation of the real part of the complex elasticity modulus so that these two curves can be considered as two branches of the "generalized relaxation curve." In the same way the creep curve without flow yields, together with the real part of the compliance, the "generalized creep curve." The spectra can be obtained from the generalized curves by differentiation, a formalism which may be transferred into the logarithmic time scale. (Chapter 6.)

Schwarzl, F. (1951) APPROXIMATION METHODS IN THE THEORY OF VISCOELASTIC BEHAVIOR, II. Physica, 17, 923-929. (In German)

The approximation system of viscoelastic theory is completed by an approximation equation for the calculation of spectra from the imaginary components of the complex compliance and modulus (damping); the spectra multiplied by t are obtained by differentiation of $E_2(\omega)/\omega$ with respect to t. Finally, the entire approximation system is checked on the Maxwell and Kelvin element. The most important results are: The creep curve without flow is parallel to the real part of the compliance and runs somewhat above the latter. The relaxation curve is parallel to the real part of the modulus and runs somewhat below the latter.

Schwarzl, F.; see Staverman, A. J., and Schwarzl, F. (1952).

Schwarzl, F. (1958) FORCED BENDING AND EXTENSIONAL VIBRATIONS OF A TWO-LAYER COMPOUND LINEAR VISCOELASTIC BEAM. Acustica, 8, 164-172.

A theoretical study of a rectangular beam consisting of two layers of different viscoelastic materials. Considers the superposition of bending vibrations and longitudinal tensile vibrations. Damping and energy dissipation are discussed.

Scott, E. J. (1954) WAVE PROPAGATION IN A VISCOELASTIC MEDIUM. Quart. Appl. Math., 12, 300-306.

Paper considers propagation of longitudinal waves through a material the mechanical behavior of which can be represented by a series of Maxwell units joined in parallel. The case of an infinite slab, one face of which is suddenly accelerated to a constant velocity, is treated and the form of the general solution obtained by use of suitable Laplace transforms. The special case of a model consisting of two Maxwell units joined in parallel is then solved in detail and the results plotted of displacement-time and velocity-time curves for different layers in the slab.

Sentis, A. (1955) ON A THEORY OF THE VISCOELASTICITY OF MATERIALS. Compt. Rend., 241, 729-730.

Stress-strain relations are proposed, to take account of delayed elasticity, flow, internal friction, etc., which differ from those of classical elasticity theory only by an additional factor $(1 + \tau^{d}/dT)$ operating on all the strain terms, where τ is a constant coefficient.

Sharma, R. L. (1957) DEPENDENCE OF THE FREQUENCY SPECTRUM OF A CIRCULAR DISK ON POISSON'S RATIO. J. Appl. Mech., 24, 53.

The results of computations of frequencies of axially symmetric flexural vibrations of circular disks are given for an intermediate frequency range and for several values of Poisson's ratio.

Sherwood, J. W. C. (1958) ELASTIC WAVE PROPAGATION IN A SEMI-INFINITE SOLID MEDIUM. Proc. Phys. Soc. (London), 71, 207-219.

A simple physical picture is given of plane waves possessing complex angles of propagation. Their utility is illustrated by studying continuous sinusoidal wave propagation parallel to the unstressed plane boundary of a semi-infinite, homogeneous and isotropic solid medium, the Rayleigh and head waves being particular features of the investigation. A novel study of the field due to an impulsive force acting at a line in the surface of a semi-infinite medium indicates a general method of solving important transient propagation problems encountered in seismology. The equivalent problem of an impulsive force acting at the edge and in the plane of a semi-infinite thin sheet has been simulated experimentally by detonating small explosive charges at the edge of an aluminum sheet. The displacements detected by a condenser microphone technique are in excellent agreement with the theoretical determinations.

Shil'krut, D. I. (1956) VELOCITY OF PROPAGATION OF ELASTIC WAVES IN NOT QUITE ELASTIC MEDIA (SIGNAL VELOCITY). Dokl. Akad. Nauk SSSR, 106, 58-60. (In Russian)

Theoretical discussion of the relation between the velocity of the wavefront and of the signal in a dispersive viscoelastic medium.

Sieck, P. W.; see Nolle, A. W., and Sieck, P. W. (1952).

Silverman, D.; see Evans, J. F., Hadley, C. F., Eisler, J. D. and Silvervan, D. (1954).

Skudrzyk, E. (1949) THE INTERNAL FRICTION AND MATERIAL LOSS OF A SOLID BODY, I. GENERAL THEORY. Ing.-Arch., 3, 356-373. (In German)

The fundamental elastic equations for the deformation of solids are derived and the elastic after-effects as well as elastic long distant effects (temperature equalizations between compressed and extended portions of a material) are discussed. It is shown that frictional losses can only be taken into account if an infinite number of constants depending on the material are considered. Harmonic motion, however, reduces the number of constants to two. In that case, the frictional constants can even be considered imaginary parts of the elastic constants. The damping of mechanical vibrations depends on the characteristics of the two frictional constants; only the low frequencies frequently seem to make an exception owing to the predominance of hysteresis effects. In case of harmonic motion the losses can be taken into account in an exact manner by using complex elastic constants and a complex Poisson's number m. The relations between the different loss factors are derived and tabulated as a function of two primitive constants.

Skudrzyk, E. (1952) INTERNAL FRICTION AND ELASTIC PROPERTIES OF SOLID, LIQUID, AND GASEOUS BODIES, II. Ing.-Arch., 6, 157-196. (In German)

Under the conception of internal friction we usually comprise all those phenomena which lead to an irreversible generation of heat from mechanical energy.

Internal friction is thus caused by simple relaxation phenomena, thermic effects, complicated elastic lags, mechanical hysteresis, and plastic flow. The various components of internal friction as determined by simple vibration measurement give a fair insight into the mechanical properties and physical structure of the material.

Skudrzyk, E. (1954) Foundations of Acoustics. Vienna, Springer-Verlag, 1084 pp. (In German)

This monumental work is much too modestly described as foundations of acoustics. It is, in fact, a complete and up-to-date treatise, covering the whole field of acoustics and ultrasonics, with emphasis on the theoretical aspects. There is indeed no part of physical acoustics which is not dealt with and, in addition, chapters are devoted to hearing and to musical acoustics. Each section terminates with a bibliography, and the complete book has a copious subject index and a list of the symbols currently employed.

Besides the subjects conventionally - though often less thoroughly - treated in handbooks of this type, the following less usual subjects are included: wave equations in cylindrical coordinates; applications of Huyghens' principle to sound; scattering radiation from arrays of sources; coupled systems and coupled vibrations; theory of noise; thermal damping effects; underwater propagation; waves of large amplitude.

The treatment is predominantly mathematical, and the analysis is clearly set out with frequent reference to analogous problems in other branches of physics, such as one would expect from a writer of the experience which Prof. Skudryzk brings both research and teaching. Book is to be highly recommended.

Smith, P. W., Jr. (1955) PHASE VELOCITIES AND DISPLACEMENT CHARACTERISTICS OF FREE WAVES IN A THIN CYLINCRICAL SHELL. J. Acoust. Soc. Am., 27, 1065-1072.

Results are presented giving values of the phase velocities and the relative magnitudes of the components of displacement of all possible free waves in the wall of a thin, elastic, cylindrical shell. Three classes of waves are identified and their natures are discussed as frequency is varied continuously. The vibrations are interpreted not only as standing waves and waves progressing the axial direction, but also as fully free waves travelling in a helical direction in the wall of the cylinder.

Smith, P. W., Jr.; see Junger, M. C., and Smith, P. W., Jr. (1955).

Smith, P. W., Jr. (1957) SOUND TRANSMISSION THROUGH THIN CYLINDRICAL SHELLS. J. Acoust. Soc. Am., 29, 721-729.

An analysis is presented of the impedance presented by a thin cylindrical elastic shell to a pressure or normal stress as a function of the axial wavelength and the angular dependence of the forces. Results of the computation are presented graphically. This information is then used to compute a measure of the sound transmitted through the shell immersed in air for various particular cases. The theory of the scattering and absorption of waves incident upon the cylinder at angles other than normal is developed for this purpose. The results and their implications are discussed in detail.

Smyth, J. B., and Lindsay, R. B. (1944) SUPERSONIC TRANSMISSION AT OBLIQUE INCIDENCE THROUGH A SOLID PLATE IN WATER. J. Acoust. Soc. Am., 16, 20-25.

The selective transmission of oblique supersonic waves through a solid plate immersed in water is studied theoretically and experimentally over a frequency range from 1.0 to 3.0 megacycles. Three cases are considered: transmission for angles of incidence less than the critical angles for both dilatational and shear waves, transmission for angles of incidence between the two critical angles, and transmission for angles of incidence greater than both critical angles. In the frequency region studied, good agreement is found between the measured transmission, using the torsion disk method, and the theoretical values. Particular interest attaches to the third case. Study is also made of the supersonic transmission through a stratified medium consisting of a set of solid plates immersed in water. The acoustical Bragg law is investigated and verified experimentally.

Sokolovski, V. V. (1948) PROPAGATION OF CYLINDRICAL DISPLACEMENT WAVES IN AN ELASTO-VISCO-PLASTIC MEDIUM. Dokl. Akad. Nauk SSSR, 60, 1325-1328. (In Russian)

The investigation is based on the assumptions of the Hohenemser-Prager theory, and the case of axial symmetry about the z-axis of the cylindrical co-ordinates r, θ, z is considered. Waves on whose front the stress components $\tau_{r\theta}$ and deformations $\gamma_{r\theta}$ and the velocity v_0 suffer discontinuities represent shock waves. The characteristic equations of the wave system are of the hyperbolic type and have to be supplemented by the kinematic and dynamic compatibility condition applying to the wave front. The dependent variables of the system of equations as well as the original constants are suitably transformed and substituted by a corresponding number of dimensionless parameters which converts the original equations into a system of comparatively simple first order equations, solvable by quadratures. This formal method has to be supplemented by a graphical procedure when it is required to describe the actual propagation process of the displacement waves and to find stress and deformation components as well as velocities. Where numerical results are wanted, these are conveniently found by difference equations.

Sosedova, A. L.; see Ageeva, N. S., Zhukov, I. P., Isakovich, M. S., Sosedova, A. L., and Sukharevsii, Yu. M. (1952).

Southwell, R. V. (1941) Theory of Elasticity, Oxford University Press, Oxford.

This is a text designed to prepare the reader for the works of Love and Rayleigh. The propagation of stress is discussed on pp. 345-355.

Staverman, A. J., and Schwarzl, F. (1952) NON-EQUILIBRIUM THERMODYNAMICS OF VISCOELASTIC BEHAVIOUR. Proc. K. Ned. Akad. Wet. B, 55, 486-492.

Linear viscoelastic behavior is described as resulting from an arbitrary number of molecular processes proceeding in a sample which is subjected to viscoelastic deformations. Describing the course of the molecular processes by a set of quantities, ζ_i, indicating the degree of progress of the processes, and applying non-equilibrium thermodynamics, one can construct a set of molecular processes which behave independently in a relaxation experiment. From this description the physical meaning of the relaxation spectrum becomes clear at once: the intensity of the spectrum at a certain frequency is a measure for the contribution of the independent molecular process of that frequency to the elasticity moduli at very short times. Boltzmann's superposition principle can be derived from these thermodynamical considerations without further assumption. The course of free energy in viscoelastic deformations is shown to be in accordance with the results obtained with models.

Stenzel, H. (1943) THE SONIC FIELD OF A RADIATOR IN A LAYER OF MEDIUM WITH ACOUSTICALLY "SOFT," OR ACOUSTICALLY "HARD" BOUNDARY. Ann. Physik, 43, 1-31. (In German)

The general formulae for the radiation and reflection and the sonic field of an acoustic radiator when placed in a layer of medium bounded by two absorptive or reflective planes is deduced. The sonic field in the vicinity of the radiator source is calculated for large and small thickness of the medium layer. The reflected and radiated power in a medium with an upper absorptive boundary and a lower reflective boundary is studied. Numerical examples are included.

Stenzel, H. (1952) THE ACOUSTIC RADIATION OF THE RECTANGULAR PISTON MEMBRANE. Acustica, 2, 263-281. (In German)

General formulae are obtained for calculating the sound field immediately in front of a vibrating membrane. The vicinal sound field is calculated by graphical integration and illustrated by many diagrams. The general formulae for the radiation impedance are derived; and finally its two components are calculated and graphically constructed for different ratios of the sides of the rectangle (a:b = 1:1, a:b = 2:1, a:b = 5:1, a:b = 10:1).

Stewart, E. S.; see Hickman, J. S., Risty, D. E., and Stewart, E. S. (1957).

Stoneley, R. (1924) ELASTIC WAVES AT THE SURFACE OF SEPARATION OF TWO SOLIDS. Proc. Roy. Soc. (London), 106, 416-429.

This paper deals with wave motion that is greatest at the surface of separation of two media.

(Considers problem of elastic waves at the surface of separation of two solid media. Waves analogous to Rayleigh waves will propagate. Also considers Love waves in an internal stratum, bounded on both sides by material of other elastic properties.)

Stoneley, R. (1954) RAYLEIGH WAVES IN A MEDIUM WITH TWO SURFACE LAYERS, I. Monthly Notes Roy. Astr. Soc. Geophys. Suppl., 6, 610-615.

The period equation is obtained in the form of a determinant of the tenth order. If the length of Rayleigh waves propagating in this layered half-space is very small, the determinant reduces to the product of three determinants. They then yield period equations for very short Rayleigh waves along the free surface as well as for similar waves along the two interfaces.

Sveklo, V. A. (1948) PLANE WAVES AND RAYLEIGH WAVES IN AN ANISOTROPIC MEDIUM. Dokl. Akad. Nauk SSSR, 59, 871-874. (In Russian)

For the system of the two partial equations with constant coefficients

$$\sum a_{\alpha\beta}^{pq} u_{\alpha\beta}^{q} = u_{tt}^{p} \quad p, q, \alpha, \beta, = 1, 2,$$

the solution

$$u^p = \sum \int^{\Omega k} A_k^{p} (t)\, w_k (t)\, dt \quad k = 1, 2, 3, 4$$

is stated. Here the w's are arbitrary, A_k^1, A_k^2 are a set of minors of the determinant

$$\Big| \sum_{\alpha,\beta} a_{\alpha\beta}^{pq} m_\alpha m_\beta - \delta^{pq} \ell^2 \Big| ,$$

where δ^{pq} is Kronecker's symbol, and ℓ, m_1, m_2 are chosen to annul the determinant. Ω is any function of t, x_1, x_2 constant on the characteristic planes $\ell t + m_1 x_1 + m_2 x_2$ = const., of which there are four families. This solution generalizes the familiar plane waves. It is applied to determine, in a nonisotropic medium, the reflection of a plane wave from a plane, free face. The analog of the Rayleigh function and waves is thereby discovered.

Sukharevsii, Yu. M.; see Ageeva, N. S., Zhukov, I. P., Isakovich, M. S., Sosedova, A. L., and Sukharevsii, Yu. M. (1952).

Tahsin, S. I. (1957) PROPAGATION OF A SOUND PULSE IN A MEDIUM WITH A COMPLEX ELASTIC MODULUS. Proceedings of the Iraqi Scientific Societies, Vol. I, 1-9.

A complex propagation constant is assumed with properties leading to relaxation phenomena. Two approximate methods are used to evaluate the integrals in the regions of no anomaly. The manner of the pulse build-up is established. It is found that a sonic pulse in a relaxing medium builds up exponentially at first and later assumes its oscillatory property.

Takahashi, I., and Ishida, Y. (1953) DETERMINATION OF ULTRASONIC SOUND VELOCITIES AND ELASTIC CONSTANTS OF SOLID. Mem. Coll., Sci. Univ. Kyoto A, 27, 47-54.

An experimental arrangement is described for recording changes in the intensity of an ultrasonic beam transmitted through water when solid plates of different thickness immersed in the water are rotated. From these results, by applying the theoretical work of Rayleigh and Reissner, the velocities of the longitudinal and transverse waves in the solid can be deduced and hence the elastic constants of the solid. Data are given for Al; in general, they do not agree with other recent determinations, such as those of Schneider and Burton.

Tamarkin, P.; see Proud, J. M., Jr., Tamarkin, P., and Meecham, W. C. (1957).

Tamm, K. (1956) MEASURING APPARATUS FOR SOUND IN A BODY. Akust. Bei., 1, 189-195. (In German)

The author gives at first a general survey of the methods of representing the vibratory state of solids by means of the spatial and temporal distributions of the velocity and of stress or dilatation respectively. Devices for the measurement of dilatation and amplitude, velocity and acceleration and their properties (absolute sensitivity, frequency response, directional selectivity, constancy with respect to time), as well as methods for the absolute, are described which permit determination of the vibration behavior under well defined states of excitation, also some combined systems which can be used as impedance meters.

Tamm, K.; see Naake, H. J., and Tamm, K. (1958).

Tartakovskii, B. D. (1950) ON THE THEORY OF THE PROPAGATION OF PLANE WAVES IN HOMOGENEOUS LAYERS. Dokl. Akad. Nauk SSSR (N.S.), 71, 465-468. (In Russian)

Calculation of the coefficients of reflection and refraction of plane waves in passage through n homogeneous plane layers reduces to the solution of a system of algebraic equations of order 2 (n + 1). These equations are obtained by putting the expressions for the wave potentials in the boundary conditions. The various resistances to passage of the waves are specified, as well as layer thickness. Author investigates the case of acoustic waves in liquid layers, characterized by their densities, velocities of propagation of acoustic waves, and thicknesses. He constructs the determinants of the system and seeks the simplest ways for the calculations. For two particular cases, calculations are made completely.

Tartakovskii, B. D. (1950) SOUND TRANSMISSION LAYERS. Dokl. Akad. Nauk SSSR, 75, 29-32. (In Russian)

The article works out algebraically and diagrammatically a solution to the problem of rendering the boundaries of different media fully conductive. An examination of the method of propagation of plane waves through similar layers leads to a study of the conditions under which sound energy is transmitted, without loss, through the boundary separating two different media, between which the sound transmission layers are situated. The formulae can be rendered fully conductive by a combination of layers consisting of materials the applicability of which can be tested by means of a graph in which coordinates are placed on a logarithmic scale. Graphs are also given illustrating energy conductivity calculation for a given case, and the dependence of conductivity upon angle of incidence. Ernst's conclusions as to the behavior of certain layers independently of the law of distribution of their wave-resistances are incidentally judged to be erroneous.

Tartakovskii, B. D. (1951) ON THE TRANSMISSION OF SOUND WAVES ACROSS BOUNDARIES OF SOLID AND LIQUID MEDIA. Zh. Tekh. Fiz., 21, 1194-1201. (In Russian)

Theoretical. Using a method similar to the classical treatment of plane sound-wave transmission across a plane solid-to-solid interface, a detailed examination is made of the special case when, for one of the media, the Lame const $\mu = 0$ (characteristic of the liquid state). Expressions for the energy transmission and reflection coefficients are derived for (a) a sound wave in a liquid incident upon a solid boundary; (b) a sound wave in a solid incident upon a liquid; (c) propagation of a sound wave through a solid plate immersed in a liquid. Values of these coefficients are presented graphically for case (a) over the range of Poisson's ratio = 0.2 to 0.5, covering all angles of incidence from normal to grazing.

Tartakovskii, B. D.; see Kaminir, G. I., and Tartakovskii, B. D. (1956).

Tchen, C. M. (1956) INTERFACIAL WAVES IN VISCOELASTIC MEDIA. J. Appl. Phys., 27, 431-434.

The stability of waves on the interface of two superposed semi-infinite layers of incompressible media is studied. The two uniform layers are of differnet densities and different viscoelastic properties. Gravity, Taylor acceleration, and surface tension are taken into consideration. The main problems considered are the dispersion, decay and growth of waves, and the formation of a hydrodynamical foundation for the cohesive action of elasticity.

Tejada-Flores, L. H.; see Howes, E. T., Tejada-Flores, L. H., and Randolph, L. (1953).

ter Haar, D. (1950) A PHENOMENOLOGICAL THEORY OF VISCOELASTIC BEHAVIOUR, I and II. Physica, 16, 719-737, 738-752.

I. Recently Sips (J. Poly. Sci., 5, 69, 1950) has studied the behavior of viscoelastic substances, starting from a well-defined model, consisting of parallel Maxwell elements. The present series of papers applies Sips' method to a number of simplified models, and discusses for these models the relationship between various methods of measurement.

II. The general theory is applied to experimental results. The influence of the finite period of stretching prior to a relaxation or creep experiment and the physical meaning of the relaxation spectrum function $N(\nu)$ are discussed. An approximate method for obtaining a rough impression of the relaxation spectrum from relaxation experiments is described and compared with the approximate method proposed by Alfrey. Relaxation spectra from experimental data of various authors are determined and various methods of exactly obtaining the relaxation spectrum compared. The yield value and the question of non-linear elements and the phenomenon of the glass-transition region are discussed.

ter Haar, D. (1950) A PHENOMENOLOGICAL THEORY OF VISCOELASTIC BEHAVIOR, III. Physica, 16, 839-850.

The first two papers dealt with the behavior of viscoelastic materials under static experiments. The present paper discusses periodic phenomena. At each frequency, the material otherwise described by a relaxation frequency spectrum $N(\nu)$ can be described by an equivalent Kelvin element, the modulus $E_1(\omega)$ and viscosity $\eta(\omega)$ of which are completely determined by $N(\nu)$ and depend on the frequency. It is also possible to give an equivalent Maxwell element. Various methods are described to determine from the complex modulus $E(\omega)$ $[= E_1(\omega) + i\omega\eta\ (\omega)]$ the spectrum $N(\nu)$. The determination of $E_1(\omega)$ and $E_2(\omega)$ $[= \omega\eta(\omega)]$ from the resonance curves observed in experiments with vibrating bars is discussed, and also the propagation of waves through a viscoelastic medium, a phenomenon which can be used to determine $E_1(\omega)$ and $E_2(\omega)$ for high frequencies.

Thomas, Dan. A. (1958) CHARACTERISTIC IMPEDANCES FOR FLEXURE WAVES IN THIN PLATES. J. Acoust. Soc. Am., 30, 220.

Boundary conditions are applied to the general solution of the thin-plate wave equation to obtain the solution for outgoing flexure waves in an infinite plate. This solution is used to obtain expressions for a bending moment characteristic impedance and a shear force characteristic impedance. Graphs of these impedances are presented.

Thomson, W. T. (1950) TRANSMISSION OF ELASTIC WAVES THROUGH A STRATIFIED SOLID MEDIUM. J. Appl. Phys., 21, 89-93.

The transmission of a plane elastic wave at oblique incidence through a stratified solid medium consisting of any number of parallel plates of different material and thickness is studied theoretically. The matrix method is used to systematize the analysis and to present the equations in a form suitable for computation.

Thomson, W. T. (1950) THE EQUIVALENT CIRCUIT FOR THE TRANSMISSION OF PLANE ELASTIC WAVES THROUGH A PLATE AT OBLIQUE INCIDENCE. J. Appl. Phys., 21, 1215-1217.

Equations are developed for the transmission of a plane elastic wave through a plate at oblique incidence with unequal fluid medium on each side of the plate. The plate transmitting both the dilatation and shear wave is reduced to a simple equivalent circuit with impedances which are functions of the incidence angle.

Tiffen, R. (1956) DILATATIONAL AND DISTORTIONAL VIBRATIONS OF SEMI-INFINITE SOLIDS AND PLATES. Mathematika, 3, 153-163.

This paper shows that, in the presence of a free plane boundary, special types of purely dilatational and purely distortional vibrations are possible with the presence of Rayleigh waves. Excluding the use of Rayleigh waves, there is only one stable form of distortional plane wave with the displacement vector always parallel to the free surface.

Equations of vibrations of an infinite flat plate are derived with Fourier transform method. In general, it is not possible to consider dilatational and distortional waves separately, except one stable form with displacement vector parallel to the free surfaces.

Timoshenko, S. (1928) "Vibration of Elastic Bodies" (Chap. IV), Vibration Problems in Engineering. Van Nostrand, New York, 199-326.

This contains the theory of vibration of elastic bodies. The problems considered are: the longitudinal, torsional and lateral vibrations of prismatical bars; the vibrations of bars of variable cross section; the vibrations of bridges, turbine blades and ship hulls; the theory of vibration of circular rings, membranes, plates and turbine disks.

Timoshenko, S., and Goodier, J. N. (1951) "The Propagation of Waves in Elastic Solid Media" (Chap. 15), Theory of Elasticity. McGraw-Hill, New York, 438-459.

The following problems are discussed: longitudinal waves in prismatical bars, longitudinal impact of bars, waves of dilatation and waves of distortion in isotropic elastic media, plane waves, and the propagation of waves over the surface of an elastic solid body.

Tolstoy, Ivan, and Usdin, Eugene (1957) WAVE PROPAGATION IN ELASTIC PLATES: LOW AND HIGH MODE DISPERSION. J. Acoust. Soc. Am., 29, 37-42.

This is an analysis of dispersive properties of elastic plates in vacuo. For low modes there exists conclusive experimental verification of these properties. Model studies show prominent arrivals having the proper spectra and velocities for group velocity maxima and minima corresponding to several symmetric and anti-symmetric modes. In addition, detailed calculations based upon exact formulas predict some new and as yet unconfirmed properties of plates, e.g., negative phase velocities. New results concerning high modes of propagation are also displayed. These modes are of considerable theoretical interest since they belong to the transition region between the domains of validity of the wave and ray theories.

Torikai, Y. (1953) TRANSMISSION OF ULTRASONIC WAVES THROUGH A PLANE PLATE MADE OF VISCOELASTIC MATERIAL IMMERSED IN A LIQUID MEDIUM. J. Phys. Soc. Japan, 8, 234-242.

The absorptive properties of the solid medium which have been neglected in previous theory are considered. The resulting expression for the transmission is of the same form as in the case of a non-absorptive plate, but the propagation constants of the waves are replaced by complex quantities in the expression. It is shown that when the absorption by the plate is appreciable, the more simple formula can be applied and the formula agrees well with the experimental result. As a note on Srivastava's papers, it is explained that the velocity of rotational waves obtained from the apparent critical angle for rotational waves is always larger than the real value on account of the absorptive property of the solid medium.

Trosch, A.; see Mahly, H., and Trosch, A. (1947).

Tyutekin, V. V. (1955) A METHOD OF MEASURING THE MECHANICAL PARAMETERS OF RUBBER AT SONIC AND ULTRASONIC FREQUENCIES. Sov. Phys. Acoust., 1, 370-373.

The paper describes a method for determining the mechanical parameters over a continuous frequency band. The elastic modulus and loss coefficient can be measured for shear strains over a frequency range 4-50 kc/s.

Urban, P.; see Ledinegg, E., and Urban, P. (1953).

Usdin, Eugene; see Tolstoy, Ivan, and Usdin, Eugene (1957).

Van Oort, W. P. (1952) A METHOD FOR THE MEASUREMENT OF DYNAMIC MECHANICAL PROPERTIES OF SMALL SAMPLES OF PLASTIC MATERIAL. Trans. Instr. Meas. Conf., 267-276.

A method is described for determining the damping and dynamic modulus of elasticity at different frequencies, when only a few grams of a viscoelastic material are available. A steel strip, covered on one side or on both sides with a thin layer of the material under investigation, is simply supported at two points and set in transverse oscillation electrically; the variation of amplitude with frequency of the applied sinusoidal stress is then observed. The method is suitable for soft solids, as little as 0.4 g may suffice for the determinations.

Verma, G. S. (1955) DETERMINATION OF ELASTIC CONSTANTS OF SOLIDS BY ULTRASONIC DIFFRACTION METHODS. Nature, 176, 27-28.

Debye-Sears equipment for observing ultrasonic diffraction patterns is used for detecting the two critical angles of internal reflection when a thin plate of polycrystalline material is rotated about a vertical axis in the beam of a quartz transducer. Expressions are given for relating the critical angles and the elastic constants of the plate material, and a table gives data for Al, Ag, Ni, Zn, brass, steel and glass.

Voelz, K.; see Kneser, H. O., and Voelz, K. (1953).

Vogel, T. (1946, 1947) VIBRATION OF A METAL PANEL IN A SOUND FIELD. J. phys. radium, 7, 193-201; 2, 502-516. (In French)

The transparency of a vibrating metal panel (in an infinite wall) in a uniform sound field is discussed theoretically. An approximate expression for the transparency is deduced at exciting frequencies widely different from the fundamental resonance frequency of the panel. An experimental method of measuring the acoustic transparency of panels of different dimensions is described. The results obtained agree well with the author's theoretical formulae, but disagree notably from the values deduced from Davis's theory, especially for panels of small dimensions.

The second reference is a continuation of the first.

Vogel, T. (1947) SOUND TRANSPARENCY OF ELASTIC PANELS COVERED BY POROUS MATERIAL. J. phys. radium, 8, 151-154. (In French)

Earlier theoretical results obtained for elastic plates either isolated or separated by an air space are extended to heterogeneous systems comprising an elastic support with a porous covering such as felt. Upper and lower limits of the acoustic transparency of these systems are calculated, and the experimental results are shown to lie, in general, between these limits.

Vogel, T. (1947) STUDY, TO THE SECOND APPROXIMATION, OF THE ACOUSTIC TRANSPARENCY OF A RECTANGULAR PANEL. Ann. Phys. (Paris), 2, 502-516. (In French)

Vogel, T. (1948) ON VIBRATIONS OF CERTAIN ELASTIC SYSTEMS IN A SOUND FIELD. Publ. Sci. Minist. Air (France), 209, 79 pp. (In French)

A study of the acoustical transmission coefficient for a wall or partition. For this coefficient, the author coins the optically inspired term "transparency." He derives an analytic expression for it in terms of air density, sound velocity, and particle velocity on each side of the partition. For a single rectangular plate type of partition the force acting on the surface is given in terms of air density, sound velocity, incident particle velocity, and plate velocity. Using the characteristic shape functions, the Lagrangian equations of motion of the plate in generalized coordinate are obtained. Thence, the required energy ratio is determined. The transmission coefficient so found is given in terms of an infinite series. A method is developed to approximate the coefficient by a finite inequality. Using Bessel functions, the coefficient for a circular plate is then determined. Next, the problem of oblique incidence is studied. The problem of double-walled partitions for normal incidence is treated in detail. There is considerable discussion of the air "coupling." Porous walls are treated briefly, as well as vibrations of finite amplitude. The results of an extensive experimental investigation are given for single bare plates with and without stiffeners, double walls with air between the plates with felt, asbestos and glass wool affixed to the surfaces. Reasonably good agreement is shown between experimental and theoretical sound-level reductions which are shown in a series of curves plotted on frequencies as abscissae.

Vogel, T. (1949) "On the Transmission of Sound by Elastic Panels." Report on the 1948 Summer Symposium of the Acoustics Group. Noise and Sound Transmission, Phys. Soc. (London), 16-21.

The problem has been investigated with a view to its application to sound insulation of aircraft. The transparence is deduced theoretically of a rectangular plate supported at the edges and of two such plates separated by a thin layer of air. The transparence of a plate coated with a porous layer is also considered An automatic recording method for measuring transparence ratios is described, and results are given which show fair agreement with the theory.

Vogel, T. (1950) VIBRATIONS OF CLOSED SPACES WITH DEFORMABLE ELASTIC WALLS. J. phys. radium, 11, 627-632. (In French)

Hypotheses in the simple geometric theory of the acoustics of closed spaces are shown to be at variance with the wave equation in the case where a velocity potential exists. These are explained using hypotheses analogous to those used in linear elastic theory, the velocity potential being expressed as a series.

Vogel, T.; see Bergassoli, A., Canac, F., and Vogel, T. (1954).

Voit, S. S. (1953) TRANSITION OF SPHERICAL SOUND WAVES FROM A MOVING MEDIUM INTO ANOTHER MEDIUM MOVING AT A DIFFERENT SPEED AND HAVING DIFFERING CHARACTERISTICS. Dokl. Akad. Nauk SSSR, 92, 491-493. (In Russian)

Two semi-infinite fluid media having different acoustic properties are contiguous at the horizontal plane $z = 0$ and move parallel to this plane at velocities different in magnitude and direction. A point source of harmonic waves is located in the upper medium at $z = h$. Author develops integral equations for the acoustic potentials of direct and reflected waves in upper medium and refracted waves in lower medium.

Wallace, W. A.; see Fox, F. E., and Wallace, W. A. (1954).

Waller, M. D. (1949) VIBRATIONS OF FREE RECTANGULAR PLATES. Proc. Phys. Soc. (London), B, 62, 277-285.

Records are given of the normal vibrating modes and frequencies of free rectangular plates between the limiting shapes of the bar and the square. The nodal systems, which in general consist of straight lines parallel to the sides, are, from considerations of symmetry, divided into 4 classes. Combined modes, for which the nodal patterns are less simple, are not uncommon. The constituent modes belong to the same class, but their uncombined periods may be appreciably different. The combination of modes belonging to different classes is extremely rare, the uncombined periods differing very little in frequency. As the mirror symmetry of the nodal design is lost in such combinations, it may be questioned whether they are ideally possible even for modes of exactly equal period.

Waller, M. D. (1952) VIBRATIONS OF FREE PLATES: LINE SYMMETRY; CORRESPONDING MODES. Proc. Roy. Soc. (London) A, 211, 265-276.

The normal modes of vibration of a plate with m lines of symmetry may be divided into 2f classes, where f denotes the number of factors of m. The normal vibration patterns of a plate may be arranged on a diagram in which all classes of symmetry recur in every two rows (or one row for the circular plate) and in every m columns. The normal modes of vibration of plates correspond with one another. That is to say; every vibration pattern on one plate has a counterpart on every other plate. The principle of corresponding vibrations can be extended to plates of irregular shape. Combined vibrations must also conform to the symmetry of the plate.

Waller, M. D. (1953) CONCERNING COMBINED AND DEGENERATE VIBRATIONS OF PLATES. Acustica, 3, 370-374.

The distinction between "combined single" and "combined normal" vibrations of elastic plates is discussed, and also the two uses which are made of the latter term. The modes of vibration with equal characteristic frequencies of square and regular triangular plates do not combine because they belong to different classes of symmetry. All the possible vibrations of a plate of geometrical shape must be "mechanically balanced" about one or more lines of symmetry, and the additional "degenerate" vibrations which are predicted by the mathematical theory are impossible. A "coupling of symmetry" which has been observed with rectangular plates is described.

Waller, M. D. (1954) CRITICAL REVIEW OF EARLIER CHLADNI FIGURES. Acustica, 4, 677-680.

Walther, H.; see Wegel, R. L., and Walther, H. (1935).

Walti, A.; see Bar, R., and Walti, A. (1934).

Walti, Albin (1938) SUPERSONIC MEASUREMENT OF ELASTIC CONSTANTS OF SOLIDS. Helv. Phys. Acta, 11, 113-139. (In German)

An improved experimental arrangement is described for finding Poisson's ratio, Young's modulus, and the torsion modulus of an isotropic solid: refer to Bar and Walti, Helv. Phys. Acta, 7, 1934, 658-661.

Wang, Chi-Teh (1953) "Bending and Buckling of Thin Plates" (Chap. 11), "Theory of Thin Shells and Curved Plates" (Chap. 12), Applied Elasticity. McGraw-Hill, New York, 276-352.

The geometry is discussed and then the differential equations are set up. Boundary conditions are considered and several problems are worked out. These include: buckling, bending and stretching of circular and rectangular plates and the membrane theory of surface of revolution shells.

Warburton, G. B.; see Arnold, R. N., Bycroft, G. N., and Warburton, G. B. (1955).

Waterhouse, R. V. (1954) TRANSMISSION OF REVERBERANT SOUND THROUGH WALLS. Acustica, 4, 290-293.

Paper given at the Congress of the International Commission of Acoustics, Netherlands, 1953. Further computations of London's expression for the transmission loss, TL, of double walls revealed significant differences between the computed results and experimental data, both at discrete frequencies, and as regards the functional dependence of the loss on frequency. To establish more precisely this frequency dependence, particularly in the region of the "coincidence effect," more refined measurements were made giving TL as a continuous function of frequency. Some results are presented.

Waterman, P. C.; see Espinola, R. P., and Waterman, P. C. (1958).

Wegel, R. L., and Walther, H. (1935) INTERNAL DISSIPATION IN SOLIDS FOR SMALL CYCLIC STRAINS. Physics (J. Appl. Phys.), 6, 141-157.

This paper represents the results of investigations of dissipation of energy in vibrating solids, mostly metals, by means of longitudinal and torsional vibrations of cylindrical rods.

Weinstein, A. (1949) ON SURFACE WAVES. Can. J. Math., 1, 271-278.

Various mathematical aspects of the linearized theory of surface waves are discussed, including the three methods now available: (1) the eigenvalue method, (2) the method of reduction, (3) the method of singular integral equations. It is shown that (2) and (3) may be combined to give more complete results than obtained previously. As an illustration the problem of waves in an ocean of infinite depth is considered. The ocean is bounded on one side by a vertical cliff, and the wave crests are not assumed to be parallel to the shore line.

Weinstein, M. S. (1952) ON THE FAILURE OF PLANE WAVE THEORY TO PREDICT THE REFLECTION OF A NARROW ULTRASONIC BEAM. J. Acoust. Soc. Am., 24, 284-287.

In past studies of the interaction of an ultrasonic beam with a solid plate immersed in water, the general practice has been to assume that a narrow radiation pattern is a sufficiently close approximation to a plane wave to permit the use of plane wave theory to predict the results. Reflection measurements made in water with a three-degree radiation pattern at a frequency of 3.35 Mc/s, using both air-backed Al slab to approximate a semi-infinite medium, indicate that under certain conditions this assumption is not valid. Experimentally, the excess pressure of the reflected wave is considerably lower than that predicted by plane wave theory when the angle of incidence is such that the change of phase of the wave upon reflection varies greatly with a small change in the angle of incidence. It is apparent that at these angles of incidence a divergent beam which is several degrees wide cannot be used to approximate a plane wave. The nature of the phenomenon indicates that it should be of equal importance in the study of transmission phenomena.

Welkowitz, W. (1956) DIRECTIONAL CIRCULAR ARRAYS OF POINT SOURCES. J. Acoust. Soc. Am., 28, 362-366.

Linear arrays of acoustic and electromagnetic point sources suffer from certain drawbacks: In a plane through the array they produce a bidirectional rather than a unidirectional pattern. Also, the main lobe width of the optimum pattern varies as the beam is rotated electrically. Circular point source arrays are free from these drawbacks. Author develops theory of circular arrays. The effect of diameter and number of sources is illustrated quantitatively.

Westervelt, P. J. (1951) THE THEORY OF STEADY FORCES CAUSED BY SOUND WAVES. J. Acoust. Soc. Am., 23, 312-315.

A general expression is derived for the force owing to radiation pressure acting on an object of any shape and having an arbitrary normal boundary impedance. It is shown that boundary layer losses may lead to forces that are several orders of magnitude greater than the forces owing to classical radiation pressure. Steady forces arising from an asymmetric wave form are compared with the other forces. A sound wave, consisting of equal parts of fundamental and second harmonic components, can cause forces 10 or more orders of magnitude greater than forces owing to radiation pressure to be exerted on small particles.

Westervelt, P. J. (1957) ACOUSTIC RADIATION PRESSURE. J. Acoust. Soc. Am. 29, 26-29.

An expression obtained (1951) by the author for the radiation force on a scattering obstacle with arbitrary normal impedance is now shown to be valid for any scattering obstacle. The derivation of the final expression for the force in terms of the asymptotic scattering function for the obstacle in the field of an incident plane wave is accomplished by taking into account the interaction of the incident wave with the scattered wave. Thus the former assumption of a perfectly collimated beam (1951) is avoided by considering the incident plane wave to be of infinite extent. The result for the force in the direction of the incident wave is

$$F_{11} = C_0^{-1} \{\text{power scattered + power absorbed} - \int \Gamma_s \cos \Theta \, dA\} ,$$

where C_0 is the velocity of sound, Γ_s is the magnitude of the mean scattered intensity, Θ is the angle formed between the incident and scattered waves. This is the same result as that obtained in 1951.

The expression given in 1951 for the force perpendicular to the incident wave is correct only for an object which scatters in a restricted way. The correct general expression for the perpendicular component of the force is $F_{\perp} = - C_0^{-1} \int \Gamma_s \cos \beta \, dA$ in which β is the angle formed between $F_{\perp}$ and Γ_s.

Westervelt, P. J.; see Maidanik, G., and Westervelt, P. J. (1957).

Westphal, Wolfgang (1954) FLEXURAL WAVES IN A PLATE AND SOUND RADIATION. Akust. Bei., 2, 603-610. (In German)

The relation between the flexural waves on a plate and the sound radiation as well as the directional distribution of the radiation have been studied both theoretically and experimentally. The radiation is characterized by the "radiation coefficient" s following Gosele. Above the critical frequency of the plates this coefficient is about one. Below the critical frequency, s decreases with decreasing frequency, however, in the case of vibrations forced by airborne sound less than for "free" flexural waves. The slope of decrease depends on the dimensions and the damping of the plates. By means of the radiation coefficient s, which is roughly known, one can estimate the sound energy radiated from the plate, after having measured the amplitude of the flexural vibrations. With that it is possible to determine directly the flanking transmission in building acoustics.

White, J. E., and Angona, F. A. (1955) ELASTIC WAVE VELOCITIES IN LAMINATED MEDIA. J. Acoust. Soc. Am., 27, 310-317.

The velocities of elastic waves in a laminated medium have been determined by calculating the effective elastic parameters and the effective density. The procedure is to assume the medium to be in static equilibrium and exposed to certain stresses. The stresses are of such a nature as to generate strains similar to those which would exist during the passage of an elastic wave through the medium. From the application of Hooke's law, an effective stiffness constant for the medium is obtained. The ratio of this effective stiffness to the effective density is the square of the velocity of the elastic wave. For a medium consisting of layers of two materials with the same density but with a velocity contrast of two, the velocity of compressional waves traveling parallel to the layering is 20% higher than the velocity of the same wave traveling perpendicular to the layers. The SH shear wave has a velocity which is 25% higher than the SV shear wave for the same laminated medium.

Wilcox, F. W.; see Curry, B., Hsi, Eugene, Ambrose, J. S., and Wilcox, F. W. (1951).

Willms, W. (1954) ON THE CONCEPT OF ACOUSTIC IMPEDANCE. Akust. Bei., 1, 427-432. (In German)

After some considerations of the concept of acoustic impedance the author gives a characterization of the transmission properties of "acoustic elements" by means of a matrix, and in connection considers therewith the basic equations of the acoustic field by analogy with the undulatory and transmission theory. A three-dimensional admittance vector is introduced. By the definition of a "Poynting vector" it is possible to give a more exact formulation of the acoustic flux and expressions for a surface impedance and the impedance of a complete system. Finally the author points out, by means of an example, that there exist fundamental differences between the acoustic and electric field.

Wood, D. S. (1952) ON LONGITUDINAL PLANE WAVES OF ELASTIC-PLASTIC STRAIN IN SOLIDS. J. Appl. Mech., 19, 521-525.

A theoretical description is given for the propagation of longitudinal plane waves of large lateral extent in solids, for waves of plastic as well as elastic strain. The importance of the hydrostatic compressibility in determining the nature of the waves is brought out. The results are illustrated by a computation of the velocities of propagation of such waves in 24S-T aluminum alloy, and by a computation of the propagation of a pressure pulse of short duration through a flat plate. The later results illustrate the attenuation and change in shape of the pressure pulse during its propagation. The effects of the pressure dependence of the compressibility, the temperature changes accompanying compression, and the time and rate dependence of the mechanical properties upon the propagation of such waves are discussed qualitatively.

Work, G. A.; see Beranek, L. L., and Work, G. A. (1949).

Yeh, G. C. K.; see Martinek, J., and Yeh, G. C. K. (1955).

Yeh, G. C. K., and Martinek, J. (1956) FORCED VIBRATION OF A CLAMPED RECTANGULAR PLATE IN FLUID MEDIA. Akust. Bei., 1, 104-108.

Forced vibration of a thin rectangular plate clamped in a rigid infinite baffle is analyzed. The plate is assumed to separate two different fluid media, and the vibration is excited by a simple plane wave of high frequency (as compared with $c/2\sqrt{ab\pi}$) normally incident from one side of the plate. Using the characteristic shape functions, the Lagrange equations of motion of the plate are set up in generalized coordinates. The solutions of the equations render series expressions for the plate deflection and an energy transmission coefficient. Certain numerical results are given.

Yorgiadis, A. J.; see Robertson, J. M., and Yorgiadis, A. J. (1946).

Young, J. E. (1954) TRANSMISSION OF SOUND THROUGH THIN ELASTIC PLATES. J. Acoust. Soc. Am., 26, 485-492.

The transmission of sound through thin elastic plates set in a plane infinite baffle or an infinite duct is discussed in some detail. A two-dimensional configuration is considered in both instances. The problems then are the transmission through a strip set in an infinite baffle and transmission through a plate set in a duct supporting lowest mode of propagation.

These systems make it possible to indicate in a formal manner how the boundary conditions affect transmission. The notion of bending impedance is used as a means of categorizing the mounting conditions.

Experimental investigations of the transmission through circular plates in ducts of the same cross section were carried out. It is shown that the transmission loss varies with the manner in which the plates are mounted. The conditions under which this behavior is predictable are discussed.

Young, J. E. (1955) PROPAGATION OF SOUND IN THIN ELASTIC SHELLS. J. Acoust. Soc. Am., 27, 1061-1064.

A wave theoretical analysis of symmetric mode propagation in a medium confined by a cylindrical elastic shell is carried out.

Zatzkis, H. (1953) THE SOUND FIELD OF A MOVING SOURCE. J. Acoust. Soc. Am., 25, 897-898.

An infinite series is developed which gives the sound field of an extended moving source which is an oblate spheroid, flattened in direction of motion with numerical eccentricity equal to Mach number. The first term of the series agrees with the point source solution established previously.

Zener, C. (1947) MECHANICAL BEHAVIOR OF HIGH DAMPING METALS. J. Appl. Phys., 18, 1022-1025.

The relation between the various measures of internal friction are independent of the precise mechanism of the dissipation of energy when the internal friction is small, but not when it is large. In this paper the relation between the two measures most commonly used, logarithmic decrement and tangent of the angle with which strain lags behind stress, is deduced for all levels of internal friction in the important case in which the dissipation of energy is due to a relaxation process having a single time of relaxation. The conditions are further derived under which a specimen of such a metal will not vibrate, but returns periodically to its equilibrium configuration.

Zhukov, I. P.; see Ageeva, N. S., Zhukov, I. P., Isakovich, M. S., Sosedova, A. L., and Sukharevsii, Yu. M. (1952).

Zverev, V. A.; see Gorelik, A. G., and Zverev, V. A. (1955).

Zvolinsky, N. V. (1947) PLANE WAVES IN AN ELASTIC SEMI-SPACE COVERED WITH A LIQUID LAYER. C. R. Acad. Sci. URSS, 56, 19-22.

General solutions are obtained for this two-dimensional problem with a non-viscous fluid. Potentials of the form f(t + Θ x, y) are assumed, where x and y are measured parallel and perpendicular to the interface, respectively. (1/Θ) is a constant > the velocity of transverse waves in the solid, which, in turn, is assumed > the velocity of waves through the liquid.

Zvolinsky, N. V. (1948) PROPAGATION OF A DISTURBANCE FROM A POINT IMPULSE IN AN ELASTIC SEMISPACE COVERED WITH A LAYER OF FLUID. Dokl. Akad. Nauk SSSR, 59, 1081-1084. (In Russian)

The solid homogeneous and isotropic semispace $y > 0$ is separated from an ideal liquid by a surface $y = 0$. The initial impulse is axial about the line $x = 0$, $y = y_0 > 0$, and expansive. The pressure is constant at the fluid surface, the shear stresses are zero at the interface, and the normal stresses are equal there. The three potentials for the fluid flow and the longitudinal and transversal wave motion of the solid are chosen as the unknowns, and the boundary and initial conditions stated.

The author uses his earlier results (Dokl. Akad. Nauk SSSR, 1947, Vol. 56, No. 1) yielding three families of plane waves each depending on a parameter Θ, and integrates them with respect to Θ in the complex plane to obtain the solutions. These quadratures are replaced by approximate expressions. The same method is stated to work for an initial central rotational impulse.

APPENDIX A

List of Abbreviations

Acta Phys. Austriaca	Acta Physica Austriaca
Acta Phys. Hungar.	Acta Physica Hungarica
Acta Pont. Akad. Sci	Acta Pontificia Akademia Scienitiarim
Acustica	Acustica
Akust. Bei.	Akustische Beihefte
Akust. Z.	Akustische Zeitschrift
Am.J. Phys.	American Journal of Physics
Ann. Geofis.	Annali di Geofisica
Ann. Physik	Annalen der Physik
Ann. Phys. (Paris)	Annales de Physique
Ann. Telecommun.	Annales de Telecommunication
Appl. Mech. Rev.	Applied Mechanics Reviews
Atti Con. Internaz. Ultracust.	Atti Convegno Internazionale-Supplement No. 2, Nuovo Cimento-Ultracustica
Austral. J. Phys.	Australian Journal of Physics
Bell System Tech. J.	Bell System Technical Journal
Brit. J. Appl. Phys.	British Journal of Applied Physics
Bull. Seism. Soc. Amer.	Bulletin of the Seismological Society of America
C. R. Acad. Sci. URSS	Comptes Rendus de l'Academie de Science de l'URSS
Can. J. Math.	Canadian Journal of Mathematics
Can. J. Research	Canadian Journal of Research
Comm. Pure Appl. Math.	Communications on Pure and Applied Mathematics
Compt. Rend.	Comptes Rendus Hebromadaires des Seances de l'Academie des Sciences
Czech. J. Phys.	Czechoslovak Journal of Physics
Dokl. Akad. Nauk SSSR	Doklady Akademii Nauk SSSR
Ergeb. exakt. Naturwiss.	Ergebnisse der exakten Naturwissenschaften
FIAT Rev. German Sci. (Off. Mil. Govt. Germany)	FIAT Review of German Science (Office of the Military Government of Germany
Geophysics	Geophysics
Helv. Phys. Acta	Helvetica Physica Acta

Indian J. Theor. Phys.	Indian Journal of Physics and Proceedings of the Indian Association for the Cultivation of Science
Ing.-Arch.	Ingenieur-Archiv
Izv. Akad. Nauk, SSSR, Ser. Fiz.	Izvestiya Akademii Nauk, SSSR Seriya Fizicheskaya
J. Acoust. Soc. Am.	Journal of the Acoustical Society of America
J. Appl. Mech.	Journal of Applied Mechanics
J Appl. Phys.	Journal of Applied Physics
J. Assn. Comp. Machy.	Journal of the Association for Computing Machinery
J. Chem. Phys.	Journal of Chemical Physics
J. Colloid Sci.	Journal of Colloid Science
J. phys. radium	Journal de physique et le radium
J. Phys. Soc. Japan	Journal of the Physical Society of Japan
J. Poly. Sci.	Journal of Polymer Science
J. Res. Nat. Bur. Stand.	Journal of Research of the National Bureau of Standards
J. Sci. Instr.	Journal of Scientific Instruments
J. Soc. Glass Technol.	Journal of the Society of Glass Technology
K. Norske Vidensk. Selsk. Forhandl.	Kongehige Norske Videnskabers Selskabs Forhandlinger
Kolloid-Zeit.	Kolloid-Zeitschrift
Mathematika	Mathematika
Mem. Coll. Sci., Univ. Kyoto	Memoirs of the College of Science, University of Kyoto
Monthly Notes Roy. Astr. Soc., Geophys. Suppl.	Monthly Notes of the Royal Astronomy Society, Geophysics Supplement
NACA	National Advisory Committee for Aeronautics
Nature	Nature
Nuovo Cim.	Il Nuovo Cimento
ONR	Office of Naval Research
OSRD	Office of Scientific Research and Development
Phil. Mag.	Philosophical Magazine
Phys. Rev.	Physical Review
Physica	Physica
Proc. Cambridge Phil. Soc.	Proceedings of the Cambridge Philosophical Society
Proc. K. Ned. Akad. Wet.	Proceedings, Koninklijke Nederlandsche Akademie van Wetenschappen

Proc. Lon. Math. Soc.	Proceedings of the London Mathematical Society
Proc. Phys. Soc. (London)	Proceedings of the Physical Society of London
Proc. Roy. Soc. (London)	Proceedings of the Royal Society of London
Publ. Int. Assn. Bridge Struct. Engng.	Publications of the International Association for Bridge and Structural Engineering
Publ. Sci. Minist. Air (France)	Publications Scientifiques et Techniques du Ministere de l'Air
Quart. Appl. Math.	Quarterly of Applied Mathematics
Quart. J. Mech. Appl. Math.	Quarterly Journal of Mechanics and Applied Mathematics
Research	Research
Rev. acoust.	Review d'acoustique
Rev. Sci. Instr.	Review of Scientific Instruments
Revs. Modern Phys.	Reviews of Modern Physics
Ricerca Sci.	La Ricerca Scientifica
Sov. Phys.-Acous.	Soviet Physics-Acoustics (AIP translation)
Tech. Rep. Engng. Res. Inst. Kyoto Univ.	Technical Reports of the Engineering Research Institute of Kyoto University
Technik	Technik
Trans. Am. Geophys. Un.	Transactions of the American Geophysical Union
Trans. Instr. Meas. Conf.	Transactions of the Instrument and Measurements Conference
Trans. Roy. Soc. (London)	Philosophical Transactions of the Royal Society of London
Z. angew. Math. Mech.	Zeitschrift fur angewandte Mathematik und Mechanik
Z. angew. Math. Phys.	Zeitschrift fur angewandte Mathematik und Physik
Z. angew. Phys.	Zeitschrift fur angewandte Physki
Z. Naturforsch.	Zeitschrift fur Naturforschung
Z. Phys.	Zeitschrift fur Physik
Zh. Eksper. Teor. Fiz.	Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki
Zh. Tekh. Fiz.	Zhurnal Tekhnicheskoi Fiziki

APPENDIX B

Temporal Distribution of Abstracts

In the process of forming this bibliography the variation in rate of publication of relevant work has been quite evident. The following figure shows the distribution in the time interval 1935 through 1957 of the references cited, each symbol (/) representing one reference.

Shown in the figure are the total number of references as well as the distribution by the five major divisions of the bibliography. The circled symbols (∅) are for references in publications originating in the U.S.S.R. Of the remainder of the references, approximately one-half are from U.S. publications. The figure does show a general increase in published activity in recent years. This increase is not due to a single advance that has served to dictate the direction of future work, but rather appears to be about evenly distributed in the several approaches to the problem.

NUMBER OF REFERENCES

Year	Total	A	B	C	D	E
1957	`//////////////////////////////////`	`////`	`////////////////`	`//////`	`/////`	`////`
1956	`///////////////////////////////ØØØØØØØØØØ`	`///ØØØØØØ`	`//////////ØØØ`	`///////////`	`////Ø`	`/`
1955	`//////////////////////////////ØØØØØØØ`	`////ØØ`	`///////////ØØØ`	`////////ØØ`	`////////`	
1954	`///////////////////////////////////Ø`	`//////Ø`	`/////////////`	`/////////////`	`///`	`//`
1953	`////////////////////////////////////ØØØ`	`///////Ø`	`//////////////ØØ`	`//////////`	`//////`	`/////`
1952	`/////////////////////////ØØ`	`////`	`///////`	`///////ØØ`	`////`	`/`
1951	`//////////////////////ØØØ`	`//Ø`	`//////////////`	`//////Ø`	`Ø`	`///`
1950	`//////////////////////ØØØ`	`//////ØØ`	`/////Ø`	`/////////`	`/`	
1949	`////////////////////ØØ`	`/////`	`////ØØ`	`////`	`//`	
1948	`///////////////////ØØØØØØ`	`/////////Ø`	`/////ØØØØØ`	`/////`	`/`	`////`
1947	`////////////////////ØØ`	`////`	`////////ØØ`	`////`	`/`	`//`
1946	`/////////Ø`	`///`	`//`	`/Ø`	`//`	
1945	`/////`	`//`	`/`	`/`	`/`	`/`
1944	`////////`	`///`	`/`	`///`	`/`	
1943	`///`	`/`	`//`			`/`
1942	`////`	`//`	`/`		`/`	
1941	`//Ø`	`/`	`/Ø`			`/`
1940	`//`		`/`	`/`		
1939	`////`	`//`	`/`		`/`	
1938	`//////////Ø`	`////`	`//Ø`	`//`	`/`	
1937						
1936	`/`		`/`			
1935	`///`	`/`	`/`	`/`		

/ = One reference
Ø = U.S.S.R reference

A. References on Transmission Through Plates
B. References on Wave Propagation
C. References on Properties of Materials
D. References on Vibrating Surfaces and Plates
E. General References

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AD Accession No.

The University of Michigan, Willow Run Laboratories, Ann Arbor Michigan

A Bibliography on Propagation of Sound Through Plates, G. B. Thurston and R. Stern

Report No. 2784-1-S, February, 1959, 167 pp., 4 illus., Project 2784 [Contract Nonr-1224(24)] UNCLASSIFIED

This report is a bibliography on propagation of sound through plates. The abstracted material is organized in accordance with a detailed subject outline having five major topics: Transmission Through Plates; Wave Propagation; Properties of Materials; Vibrating Surfaces and Plates; General References. Literature surveyed is principally in the period from 1929 to 1958. Approximately 450 abstracts are given.

Primary Field: Physics

Secondary Fields: Detection; Astronomy, Geophysics, and Geography

1. Acoustics
2. Acoustic Detection
3. Seismology
4. Contract No. Nonr-1224(24)

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A Bibliography on Propagation of Sound Through Plates, G. B. Thurston and R. Stern

Report No. 2784-1-S, February, 1959, 167 pp., 4 illus., Project 2784 [Contract Nonr-1224(24)] UNCLASSIFIED

This report is a bibliography on propagation of sound through plates. The abstracted material is organized in accordance with a detailed subject outline having five major topics: Transmission Through Plates; Wave Propagation; Properties of Materials; Vibrating Surfaces and Plates; General References. Literature surveyed is principally in the period from 1929 to 1958. Approximately 450 abstracts are given.

Primary Field: Physics

Secondary Fields: Detection; Astronomy, Geophysics, and Geography

1. Acoustics
2. Acoustic Detection
3. Seismology
4. Contract No. Nonr-1224(24)