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Report of VESIAC

A BIBLIOGRAPHY OF SEISMOLOGY FOR THE VELA UNIFORM PROGRAM

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Ann Arbor, Michigan

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PREFACE

VESIAC, the VELA Seismic Information Analysis Center, is an information collection, analysis, and dissemination facility established at the Institute of Science and Technology of The University of Michigan. The contract is sponsored by the Advanced Research Projects Agency under the Office of the Secretary of Defense.

The purpose of VESIAC is to analyse the research information related to the VELA UNIFORM Program of Project VELA and to function as a central facility for this information. The facility will serve all authorized recipients of VELA UNIFORM research information by issuing subject bibliographies with abstracts, annotated bibliographies, and special reports as required. In addition, VESIAC will periodically summarize the progress of the research being conducted.

VESIAC is under the technical direction of the Acoustics and Seismics Laboratory of the Institute. In its operation VESIAC draws upon members of this laboratory and other members of the Institute and University.

CONTENTS

A BIBLIOGRAPHY OF SEISMOLOGY FOR THE VELA UNIFORM PROGRAM

ABSTRACT

Nearly 600 publications on seismology and underground explosion detection are cited in this bibliography. A listing of authors and titles is arranged by subjects. The subject headings used represent the main study areas of interest to the VELA UNIFORM Program of the Advanced Research Projects Agency. All available abstracts for the publications cited are given.

1
INTRODUCTION

The extensive research efforts of organizations in the VELA UNIFORM Program have created a need for a bibliography of research information on underground explosion detection. The areas of prime importance to the VELA UNIFORM Program are seismology and underground explosion detection.

Because of the brief time that the VELA UNIFORM Program has been in existence, only a small amount of literature has been published by the program contractors. However, there is a vast quantity of literature related to the underground explosion detection problem available from other sources. This material constitutes the major portion of the bibliography. Both technical and semi-technical literature in seismology and underground explosions, as well as a few theoretical papers on hydrodynamics and fluid mechanics, have been included. Foreign literature was cited when translated abstracts were available.

The following standard references were reviewed:

ASTIA Technical Abstracts Bulletin	1947 . . . present
AEC Nuclear Science Abstracts	1947 . . . present
Geophysical Abstracts	1940 . . . present
Geoscience Abstracts	1959 . . . present
Bibliography of Seismology	1929 . . . 1958

In addition, a comprehensive literature search was conducted in The University of Michigan Libraries. Material was obtained also from The Office of Technical Services, The Library of Congress, and The ASTIA Regional Library at Dayton, Ohio.

The bibliography is divided into two general sections. Section 4 contains an Author-Title Listing by Subjects; Section 5 contains Abstracts of publications cited; both listings are arranged alphabetically by author names. Works with multiple authors are listed under each author's name, but the abstract is entered only under the first named author. Works with no author credit are listed alphabetically under the name of the corporate author.

A companion volume of classified material is being prepared and will receive a separate distribution in compliance with existing security regulations.

The classified and unclassified bibliographies will be revised periodically.

Additions or corrections to the bibliography will be appreciated. Please write:

VESIAC
Institute of Science and Technology
The University of Michigan
Box 618
Ann Arbor, Michigan

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DIRECTIONS for EFFECTIVE USE

The bibliography will be most effective if users follow these directions:

1. Consult the subject outline in Section 3 to find areas of interest.

2. Next, refer to Section 4, where the subject outline is repeated, with the author and title of each article listed under the appropriate subject heading.

3. Turn to Section 5, where the abstracts of articles are arranged alphabetically according to author. (Some publications have been cited for which no abstract was available.)

4. Refer to Appendix A for those publications sponsored by the VELA UNIFORM Program.

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SUBJECT-OUTLINE — VELA UNIFORM PROGRAM

I. Research in Seismology

1. Seismic Source Mechanisms
   a. Earthquakes
   b. Explosions[1]
   c. Seismic Noise
   d. Other Artificial Devices (oscillators, weight drops, etc.)
2. Seismic Wave Propagation
   a. Theoretical
   b. Observational
   c. Models
3. Seismic Propagation Paths
   a. U. S. Crustal Structure
   b. Foreign Crustal Structure
   c. Mantle and Core
   d. Geophysical Constants (Seismic velocity, rock density, etc.)
4. Seismic Signal Detection
   a. Surface
   b. Array
   c. Deepwell
   d. Underwater
   e. Special Purpose
5. Seismic Data
   a. Processing
   b. Analysis
6. General Studies

II. Research in Electromagnetic Signals from Underground Disturbances

1. Source Mechanisms
2. Model Studies

[1]A great number of entries in this bibliography report on seismic phenomena resulting from an explosion. However, to list the reports of every study which uses an explosion energy source under Section I.1.b, "Explosions," would prove unwieldy and less informative than the more discriminative listing chosen. In this grouping, only those articles which are specifically source studies, e.g., energy transfer (coupling and decoupling), cavity formation, plastic zone studies, explosion thermodynamics, etc., are listed under I.1.b.

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AUTHOR-TITLE LISTING by SUBJECTS

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DENOYER,J., "Determination of the Energy in Body and Surface Waves (Part II)."

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d. Other Artificial Devices (oscillators, weight drops, etc.)

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2. Seismic Wave Propagation

a. Theoretical

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ADAMS

5
ABSTRACTS

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A series of paired explosions in a salt mine near Winnfield, La., was conducted to test a theory by A. L. Latter concerning seismic decoupling by underground cavities. The theory predicted a decoupling of 132. Free-field and surface measurements from an explosion in either a 6-foot- or a 15-foot-radius spherical cavity were compared with similar measurements from a completely tamped explosion of equal size. Shot sizes were from 20 lb up to a ton. Surface measurements were made out to 100 km and covered the frequency range from 0.05 to 100 cps. The experiment confirmed that decoupling does occur. For explosions that produce an average cavity pressure up to one-fifth and possibly more of the lithostatic overburden pressure, seismic waves were decoupled by more than 100, i.e., two orders of magnitude. Even for explosions producing an average cavity pressure of six times the lithostatic overburden pressure, the seismic waves were decoupled by 20—more than a full order of magnitude. Minimum decoupling factors as a function of frequency are presented.

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A device that permits direct input of seismic traces into electronic digital computers is described. Examples of its use and its several merits are presented. The device makes feasible numerical analysis of data recorded in analog form on photographic film or paper.

ADAMS, W. M., and CARDER, D. S., "Seismic Decoupling for Explosions in Spherical Cavities," U. of Calif., Livermore. UCRL Report (1960).

A series of paired explosions in a salt mine near Winnfield, La., was conducted to test a theory concerning seismic decoupling by underground cavities. The theory predicted a decoupling of about 100. Free-field and surface measurements from an explosion in either a 6 or 15-foot radius spherical cavity were compared with similar measurements from a completely tamped explosion. Shot sizes were from 20 lb up to a few tons. Surface measurements were made out to 100 km and covered the frequency range from 0.05 to 100 cycles. The experiment confirmed that decoupling does occur. The actual decoupling factor as a function of frequency is presented and compared with the theory.

ADAMS, W. M., FLANDERS, P. L., PERRET, W. R., PRESTON, R. G., and SACHS, D. C., "Summary Report of Strong-Motion Measurements—Underground Nuclear Detonations," U. of Calif., Livermore, Lawrence Radiation Lab.; Stanford Research Inst., Menlo Park, Calif.; and Sandia Corp., Albuquerque, N. Mex. Report on Project 26.0 of Operation Hardtack, Phase II (1960).

Subsurface and surface motion measurements were made on six underground nuclear detonations in the Oak Springs tuff of Nevada Test Site on Operation Hardtack II: Shots Mars (~13 tons), Tamalpais (~72

tons), Neptune (~90 tons), Logan (~5 kt), Evans (~55 tons), and Blanca (~19 kt). Free-field peak radial acceleration decreased as the inverse third or fourth power of slant range, as for Rainier. Particle velocities attenuated at a rate between the inverse square and inverse cube. Maximum radial and tangential subsurface stress varied as the inverse cube of radial range. Observed peak strain suggested attenuation at a rate between inverse cube and inverse square of range. Maximum upheaval at Blanca surface zero was about 25.5 feet; ~ 2.5 feet at 750 feet radial range; and 1.5 feet at 910 feet. Reed gage spectra indicated a shift of maximum energy to lower frequencies with increasing ground range. All components of surface acceleration followed an empirical equation of the form $A(g) = 3.2 \times 10^6 W^{0.7}(kt)R^{-2}(feet)$. All components of surface displacement did not follow a comparable relationship. Displacement is more precisely predicted than acceleration. The velocity of the tuff was determined to be 6200 fps, with velocity of the underlying dolomite 11,700 fps. The crust at Nevada Test Site has a velocity of 6.58 km/sec and a thickness of ~30 km. The top of the mantle has a velocity of 8.08 km/sec and dips eastward.

ADAMS, W. M., and SWIFT, L. M., "The Effect of Shotpoint Medium on Seismic Coupling," U. of Calif., Livermore. UCRL Rept. No. 6059 (1961).

Experiments on the coupling of seismic waves to the surrounding medium have been conducted in volcanic tuff at the Nevada Test Site, and in halite in the Winnfield Salt Dome near Winnfield, La. The coupling effect is defined as the ratio of a tuff velocity potential to a halite velocity potential. Velocity measurements within 400 feet of the explosions indicate that 3 to 4 times more elastic energy is propagated in the tuff than in the halite. There is some indication that in the tuff, the amount of energy transmitted elastically is dependent upon the lithostatic overburden pressure. Increasing the tuff overburden by a factor of about 5 almost quadrupled the energy propagated elastically.

ADLUNG, A., "Seismische Beobechtungen bet Kammesprengungen [Seismic Observations of Chamber Blasts]," Gerlands Beitr. Geophys. Band 65, pp. 1-10 (1955).

Seismic records from 23 chamber blasts in Saxony, Thuringia, and northern Czechoslovakia in 1951-1954, are analyzed. Although the times of origin are not precisely known, travel-time curves can be established for four profiles. The velocities thus obtained fall within the range determined by other methods, except for that of the "gabbro" layer, which is higher. A slight transfer of energy away from the Harz and a decrease in travel-time to the right of the Elbe were noted. The necessity for a plan of systematic observations of chamber blasts is indicated.

AIR FORCE CAMBRIDGE RESEARCH LABORATORIES, Handbook of Geophysics, U. S. Air Force, Cambridge Research Laboratories (1960).

AIR FORCE TECHNICAL APPLICATIONS CENTER (Staff), "The Relative Seismicity of the U.S.S.R., U.S.A., and U.K.," Air Force Technical Applications Center. Special Report of AFTAC.

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Seismicity on the basis of the number of earthquakes is tabulated for several time intervals for the geographic regions under control of the U.S.S.R., U.S.A., and U.K. All the data used are taken from published material, and comparisons of the three regions considered indicate that the seismicity of the U.S.S.R., U.S.A., and U.K. are roughly the same when long enough time periods are taken.

AKADEMIIA NAUK S.S.S.R. VESTNIK, "Seismic Observations During Experimental Explosions" [in Russian], Izvest. Akad. Nauk S.S.S.R., V. 17, n. 4, pp. 91-92 (1947).

Records of seismic observatories constitute valuable material for the study of the earth's crust, but many related questions can be studied better by experimenting with artificial earthquakes. A real earthquake can never be as accurately or as completely observed as an earthquake produced artificially. Many unknown factors which confuse the final conclusions can be completely eliminated in an experimental installation.

An artificial earthquake was produced and studied in detail in January 1947 when 260 tons of dynamite were exploded in the Azerbaydzhan S.S.R. in the Caucasus. Ten high-precision seismographs were installed at distances ranging from 3 to 214 kilometers from the shot point, all equipped with radio receivers and special wiring for timing. The results of these experiments are considered valuable for the elucidation of many questions on local and regional geology.

AKI, K., "Further Study of the Mechanism of Circum-Pacific Earthquakes from Rayleigh Waves," Calif. Inst. of Technology. CIT Contribution No. 992.

Source functions of three earthquakes in the Western Pacific were obtained from Rayleigh waves at I.G.Y. stations over the world. These were interpreted in a manner outlined previously. It was found that the pattern of the source at the source is quadrant for all three earthquakes. One of the two nodal lines was found to be nearly parallel to the trend of the seismic zone for each of these earthquakes. If this nodal line is taken as the actual Fault, the slip direction is found to be parallel for all of them. The results from the recent Chilean shocks also support the hypothesis that right-hand strike-slip prevails along the Circum-Pacific earthquake belt.

ALESHIN, E., "Seismological Notes," Bull. Seism. Soc. Am., V. 50, n. 1, pp. 153-161 (1960).

This article tabulates data pertaining to nuclear explosions in Nevada (Operation Hardtack) during 1958. Approximately 70 natural earthquakes throughout the world were also briefly reported including an eyewitness account in the epicentral region of the 1959 western Nevada quake at the Black Mountain microwave site. Also included are the particulars for the larger after-shocks of the Hebgen Lake, Montana, earthquake. Dates covered are from June 23, 1959 to Oct. 15, 1959.

ALIVERTI, G., and SOLAINI, L., "Sulla velocita di propagazione delle onde sismiche su brevi percorsi superficiali [The Velocity of Propagation of Seismic Waves Over Short Distances]," Riv. geofis. appl., V. 11, n. 1, pp. 3-13 (1950).

Records of several bomb explosions at distances ranging from a few kilometers to more than 24 km recorded on the Pavia Geophysical Obser-

vatory seismographs during the war showed extremely low velocities of propagation of longitudinal and transverse waves. A seismic investigation was made over a profile about 1600 meters long in the vicinity of the observatory. The aim of the observations was to measure the interval of time necessary for the arrival of seismic waves, to determine the velocity of propagation of these waves and their path, to determine the depth of penetration and to study the sharpness of the seismograms. Western Geophysical Company geophones with a natural frequency of 8 cps and the damping coefficient of 0.61 were placed at an average distance of 100 meters apart, and the depth of the shot holes was 2 meters. A velocity of 0.55 km/sec was found in a surface layer which had a thickness of only four meters, presumably equal to the depth of the water table. Two deeper layers had velocities of 1.58 and 1.65 km/sec. The velocity in the second layer was tentatively computed increasing according to the equation $v = 1580 + 0.73\ z$ m/sec, z being the depth in meters.

The depth of penetration of the seismic waves was estimated as 150 meters. The thickness of the upper very low velocity layer may vary with the seasons of the year, depending on the precipitation of the preceding weeks.

ALLEN, D. C. See Adams, W. M. (2).

ALLEN, H. J., PACK, D. H., et al., "Fundamental Investigation of Air Blast and Ground Shock, " Technical Rept. No. 2 on Contract DA 04-495-ORD-674 (1957).

A report is made of the investigation of damage and noise caused by air blast and ground shock. The investigation includes (1) study of the variables and conditions affecting the propagation of air and ground shock waves over long distances, (2) examination of systems used to forecast the strength of a blast wave from a given explosive charge at long distances from the charge center, and (3) examination of the effect of air and ground blast waves on various types of structures. A brief outline of the instrumentation is presented (AD 135121). Air Shock is discussed, and analytical calculations are made. The results of the tests are summarized. A study is presented of the propagation of waves in ground. Several experimental shots were made to check the theoretical results. The effect of earth cover on sound intensity is explained. The general conclusions drawn from the results state that (1) disturbances caused by propagation of shocks through ground are insignificant compared to those created by shock travelling through air; (2) 95 to 99% of complaints have their origin in the psychological reaction of individuals as a result of auditory impressions; and (3) weather conditions affect air waves to a great degree. (See also AD 111 550, AD 121 791.)

ALSOP, L. E., SUTTON, G. H., and EWING, M., "Free Oscillations of the Earth Observed on Strain and Pendulum Seismographs," J. Geophys. Res., V. 66, n. 2 (1961).

Spectral analyses of seismograms of the great Chilean earthquake of May 22, 1960, from a newly installed strain seismograph at Ogdensburg, New Jersey, and from pendulum seismographs at Palisades, New York, have revealed spectral peaks corresponding to fundamental spheroidal modes 2 to 34, fundamental torsional modes 2 to 9, and the first overtone of the second spheroidal mode. Other peaks, some of which may be over-

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tones, occur in the spectra but are not yet identified. Amplitudes of some observed spectral peaks vary radically between two time intervals on the same record. The peaks do not decrease in amplitude according to any simple law, and, rarely, an increase in amplitude with time is observed, indicating the apparent acquisition of energy in the mode between the time intervals. The periods of the graver modes of oscillation, both spheroidal and torsional, are in agreement with the theoretical values of Alterman, Jarosch, and Pekeris. The periods of the fundamental spheroidal oscillations between 250 and 500 seconds have been determined very accurately. These periods show excellent agreement with theoretical values calculated by Bolt and Dorman for a mantle with velocities according to the Gutenberg model and densities according to the Bullen model A. Also, phase velocities obtained from these periods are in agreement with Rayleigh wave phase velocities observed directly from the same earthquake by Brune, Nafe, and Alsop. Good agreement is also observed between torsional periods and theoretical values of Sato, Landisman, and Ewing, based on velocities of Jeffreys and densities of Bullen model A.

ALTERMAN, Z., JAROSCH, H., and PEKERIS, C. L., "Propagation of Rayleigh Waves in the Earth," Weizmann Institute, Dept. Applied Mathematics, Rehovoth, Israel. Report (1961).

The propagation of Rayleigh waves is investigated in the whole range of periods T from about 10 seconds up to 1 hour. Three methods are necessary to cover this range of periods effectively. The standard flat earth method, with neglect of gravity, gives values for phase velocity U up to T=250 seconds. The flattening of the earth method, with neglect of gravity, has accuracy limits of 1% for C and U at 300 and 400, respectively; inclusion of gravity effects does not alter the limits. For $T > 300$ ($n < 25$) the period of T(n) of free oscillation of the earth as a function of the order of the spherical harmonic n must be determined; this involves solution of a system of differential equations of the 6th order in which gravitational effects are included. Using these three methods, C(T) and U(T) are evaluated for Bullen's model B, the Jeffreys-Bullen model as modified by Dorman, Ewing, and Oliver, and the Gutenberg model. Results substantiate conclusions that the observed Rayleigh wave data provide evidence in support of Gutenberg's low velocity layer. The few observed Rayleigh group velocities between T=400 and 600 are substantially lower than the theoretical values for all three models.

AMES, E. S. See Murphey, B. F.; Thornbrough, A. D., et al.

ANDERSON, D. C., and PORZEL, F. B., "Close-in Time-of-Arrival Measurements for Yield of Underground Rainier Shot," Illinois Inst. of Technology, Armour Research Foundation, Chicago. Report on Project 25.1 of Operation Plumbbob (1959).

An investigation was continued on the hydrodynamic variables which contribute to an understanding of the phenomenology of underground explosions. Measurements were made of the total energy released and energy partition at various interfaces following the detonation of Rainier Burst. Theoretical background is discussed and test procedures are described.

ANDERSON, D. L., "Elastic Wave Propagation in Layered Anisotropic Media," Calif. Inst. of Technology. CIT Contribution No. 1036.

This is an analysis of the dispersive properties of transversely isotropic media. Such anisotropy is exhibited by hexagonal crystals, sediments, planar igneous bodies, ice sheets and rolled metal sheets where the unique axis is perpendicular to the direction of surface wave propagation and the other axes are distributed randomly in the plane of the layers. Period equations are derived for Rayleigh, Stoneley, and Love-type waves, and comparisons are made, in certain cases, with ray theoretical and plane stress solutions. Anisotropy can have quite a pronounced effect on both the range of existence and the shape of the dispersion curves and can lead to an apparent discrepancy between Love and Rayleigh wave data. Attention is focused in this initial paper on a single solid layer in vacuo (i.e., a free plate) and a solid layer in contact with a fluid halfspace. The single layer solutions can be generalized to n-layer media by the use of Haskell matrices.

ANDREWS, A. B., "Photomechanical Wave Analyzer for Seismic Wave Analysis," Pennsylvania State University, University Park. Technical Rept. No. 4 on Contract N6-onr-26918.

A photomechanical wave analyzer which can be used to perform rapid Fourier harmonic analyses of seismic waves is described in this report. This instrument provides a convenient method of studying the frequency content of seismic pulses.

The procedure followed is to:

1. Transfer the original oscillographic record onto a film suitable for use with the photomechanical reproducer.
2. Use the reproducer to transform the wave-form into an electrical signal.
3. Analyze the electrical signal using an electrical wave analyzing device.

The analyzer described has an accuracy of 5% or better of the fundamental amplitude for individual components. The average error for various wave-forms with respect to the fundamental amplitude for the harmonics measured is about 3% of the fundamental frequency. The complete analysis takes about one-half hour. The analyzer can resolve seismic pulses into Fourier frequency components in the range from two to several hundred cps.

ANDREWS, F. See Gutenberg, B.

ANDREWS, T. J., BRYANT, E. J., LORRAIN, P. H., and MASICH, N. M., "Transient Ground Mechanical Effects from HE and Nuclear Explosions," Ballistic Research Labs., Aberdeen Proving Ground, Md. Report on Project 1.2a-2 of Operation Jangle (1952).

Ground accelerations and pressures resulting from a surface nuclear detonation at a scaled charged height of 0.024, from an underground burst at a scaled burial depth of 0.135, and from two underground HE detonations of different weights at a scaled burial depth of 0.15, were determined

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as functions of a reduced distance. The maximum horizontal and vertical ground accelerations were of approximately the same magnitude for each of the detonations. Some correlation between the laws of attenuation of ground accelerations was found to exist between the underground nuclear detonation and the underground HE explosion of 40,000 lb. A comparison of the data from the three shots indicated that ground pressure data from small charges may not be accurately applied to nuclear charges by scaling laws now in use. Maximum ground pressures occuring from the detonation of nuclear charges described in this report were primarily due to air blast effects on the ground surface. The apparatus used (accelerometers and pressure gages) is described.

ANSTEY, N. A., "A Note on the Seismic Pulse Recorded from a Mine Explosion," Geophys. Prosp., V. 4, n. 6, pp. 433-437 (1958).

A seismogram is reproduced that shows clearly the shape of the pulse from a mine explosion. It was recorded fortuitously at the end of a poor record in the course of a normal reflection survey, against a background of wind noise only. Although this was not a controlled experiment, it does show that under practical field conditions—a stratified earth, an oblique path, a weathered layer—the pulse form does not become hopelessly complicated but retains considerable similarity to the simple theoretical form. Therefore, theoretical studies confined to a homogeneous earth hold real promise of giving concrete help to the exploration seismologist in years to come, and it may be that many improvements of interpretation techniques can be made on the basis of present knowledge of pulse shape.

ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES (Staff), "Ground Motion Measurements," Army Engineer Research and Development Laboratories, Fort Belvoir, Va. Report on Project 26.3 of Operation Hardtack, Phase II (1959).

Measurements were made of strong ground motion occurring in the medium surrounding the Evans event of Operation Hardtack Phase II. Due to the low yield of the Evans device no usable records were obtained from the event. A preliminary analysis is given of measurements of strain and acceleration made on the Tamalpais event in an effort to improve the instrumentation for Evans. A tentative correlation of data on accelerations and strains from contained underground explosions in the Oak Springs tuff indicates that the effectiveness of Tamalpais in causing ground motion was less than 10% of that expected on the basis of cube root scaling from a 1-ton, fully stemmed HE model test.

ARONS, A. B., "Underwater Explosion Shock Wave Parameters at Large Distance from the Charge," J. Acous. Soc. Am., V. 26, n. 3, pp. 343-346 (1953).

ARONS, A. B., and YENNIE, D. R., "Energy Partition in Underwater Explosion Phenomena," Rev. Modern Phys., V. 20, n. 3, pp. 519-536 (1948).

Pressure-time curves, continuous from initial shock-wave incidence through the second bubble pulse, are examined in the light of acoustic theory. Calculations of impulse and of reversible and irreversible energy flux are made for the various phases of the phenomenon. An estimate has been made of the amount of energy dissipation associated with the propa-

gation of the shock front. A tabulation of the energy partition is included, and it is shown that substantial quantities of energy are radiated or dissipated by mechanisms other than those taken into account in this discussion.

ASANO, S., "On the Accuracy of Hypocenter Determination," Bull. Earthquake Research Inst., Tokyo Univ., V. 32, pt. 4, pp. 371-380 (1954). V. 33, pt. 2, pp. 199-206 (1955).

Methods of determining the focus of an earthquake were evaluated by applying them to the data from three explosions, including the 2nd and 3rd Isibuti explosions (see Geophys. Abs. 151, 118, 119). From an assumed approximate epicenter and travel-time curve, a least-squares adjustment was made to determine the epicenter, velocity, origin time, and depth. The first two were relatively well determined in all cases, but the origin-time and depth seem to be sensitive to the nature of the superficial layer (uniform structure was assumed).

ASANO, S., "On the Accuracy of Hypocenter Determination III" [in Japanese with English abstract], Bull. Earthquake Research Inst., Tokyo Univ., V. 37, pt. 2, pp. 337-345 (1959).

Seismic waves generated by detonation of 156 tons of explosives, in connection with construction of the Mihoro dam in central Japan, were recorded at about 10 Japanese observatories. Although the recorded amplitude was small and the onset of initial motion not clear except at Matsushiro, an attempt was made to determine focal quantities by the least-squares method. The results are tabulated. The position of the epicenter was determined within 0.1^{o}; the determination of velocity was fairly good, but that of origin time was not very accurate. Giving weight to the Matsushiro observation improved the accuracy of the results, especially with respect to origin time. S-wave velocity was determined as 3.34 km/sec.

ASANO, S., DEN, N., MIKUMO, T., SHIMA, E., and USAMI, T., "On the Travel-Times of S-Waves, Derived from the Explosion Seismic Observations," Bull. Earthquake Research Inst., Tokyo Univ., V. 37, pt. 2, pp. 279-306 (1959).

Shocks from 11 large blasts, set off for engineering purposes in the Tohohu and Kwanto areas in Japan, and from 2 other explosions for research purposes have been observed. The arrival times of the late phases, particularly the S phases, are considered in this paper. Data are tabulated, giving names of explosions, names of stations at which recorded, epicentral distances, S-wave arrival times, degree of accuracy of readings, and S-wave travel times. Velocities of 3.04 and 3.36 km/sec were derived near the Kamaisi Mine, 3.06 and 3.57 km/sec in the Tohoku area, and 3.63 km/sec in the Kwanto area; these are taken to be S-waves. The depths of the discontinuities calculated from these velocities are fairly consistent with those calculated from P waves, although the S-wave velocities used in the calculations were mean values. Information about Sn is insufficient because of the scarcity of data from distant observations. Various V_P/V_S values are also calculated and compared in a table with results for western Transvaal, the Canadian Shield, and western Australia.

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ASANO, S. See also Matuzawa, T.

ATOMIC ENERGY COMMISSION (Staff), "Background Information on the U.S. Seismic Research Program with Reference to Mississippi," Atomic Energy Commission. AEC Special Report (1961).

This paper includes general non-technical material on purposes of Project Vela, recommendations, and preliminary data on selection of a Mississippi site for detonations.

AUBERGER, M., and RINEHART, J. S., "Ultrasonic Velocity and Attenuation of Longitudinal Waves in Rocks," Colorado School of Mines Research Foundation, Inc., Golden, Colo. Report (1960).

Hughes' pulse technique for measuring longitudinal velocities was adapted and extended to measure attenuation of longitudinal waves at frequencies of 250 to 100 kcs. Data for velocity and attenuation in eight different rocks (three granites, one porphyry, two sandstones, one limestone, and one marble) are given at eight frequencies. The values of attenuation measured were found much higher than for metals and plastics in the same range. All curves of attenuation as a function of frequency show one or more peaks, none of the curves indicating a marked law of increase or decrease of attenuation with frequency. In one granite, in the limestone, and in the marble, successive peaks occur at harmonic frequencies. A comparison between the wavelengths for which the peaks occur and the grain size of the rocks shows a good agreement for the coarse-grained rocks between the frequencies of occurrence of the peaks and the resonance frequencies of the largest crystals of the rocks, indicating a very large effect of the frictional boundary losses on attenuation when the wavelength approaches the grain size of the rock.

BACIGALUPI, C. M., "Large Scale Excavation with Nuclear Explosives," U. of Calif., Livermore. UCRI Rept. No. 5457.

BAILEY, L. F. See Carder, D. S.

BAKHSHIAN, F. A., "Spherical Wave Motion in an Elasto-Plastic Medium Caused by an Explosion" [in Russian], Prikladniya Matemat. Mekhan., V. 12, n. 3, pp. 281-286 (1948).

The author analyzes the problem of the spherical wave generated in an elasto-plastic medium of given properties by an explosion taking place in a spherical cavity. This explosion creates a pressure varying so that the deformation either increases or remains constant but never recedes. At any moment a certain sphere around the point of explosion encloses the points whose displacements are plastic; beyond this sphere they are elastic. Equations of wave motions for either of these regions can be written if the mechanical properties of the medium are known. Using the kinematic and dynamic conditions of continuity for the sphere separating the two regions, the integration of the established differential equations becomes feasible and gives the velocity of the propagating wave front and the stresses at these points.

BANERJI, S. K., and MANOHAR, M. D., "On the Artificial Vibrations of Ground," Indian J. Phys., V. 8, n. 2, pp. 95-121 (1933).

BARNES, D. See Finos, S.

BARON, M. L., BLEICH, H. L., and WEIDLINGER, P., "Theoretical Studies on Ground Shock Phenomena," The MITRE Corporation. Rept. No. SR-19 (1960).

This report contains technical material concerned with the theory of wave propagation in solids with special application to ground shock phenomena. The theoretical background is presented for investigations concerned with the behavior of deep underground hard command posts when subjected to nuclear attack. Free-field effects and diffraction phenomena are described for regions relatively free of thermodynamic effects and large displacements.

BARTELS, J., "Wissenschaftliche Ergebnisse der geophysikalischen Beobachtungen der Sprengung auf Helgoland [Scientific Findings from the Geophysical Observations of the Helgoland Explosion]," Geol. Jahrb. Band 64, pp. 201-203 (1950).

Carefully organized observations during the Helgoland explosion on April 18, 1947, have clarified many questions concerning the structure of the earth's crust to a depth of 40 or 50 km. Seismic waves, produced by this explosion and accurately recorded, penetrated the ground deeper than ever before, attaining a velocity of about 8 km/sec. The mechanical energy involved in seismic waves by this explosion is calculated as equal to 10^{17} ergs, whereas the total thermal energy of the explosives used was about 1.3×10^{20} ergs. The similar explosion produced by an atomic bomb on Bikini evolved a mechanical effect equal to about 10^{19} ergs, comparable with a natural earthquake of 5.5 magnitude.

BATH, M., "Seismic Exploration of the Earth's Crust. Recent Developments," Geol. Foren. i Stockholm Forh., V. 80, pp. 291-308 (1958).

This is a review of recent developments in the seismic exploration of the earth's crust. Crustal structure can be determined from the records of near earthquakes and controlled explosions, from surface wave dispersion (both group velocity and phase velocity methods), and from channel waves. The boundaries between continents and oceans are of particular interest; here properties vary over short distances, hence, investigations are more difficult and must be made in more detail.

BEAUFILS, Y., "Etude des ondes superficielles dans les enregiatrements seismographiques des explosions de Champagne, octobre 1952 [Study of the Surface Waves in the Seismograph Records of the Champagne Explosions, October 1952]," Bur. Cen. Seism. Intnat'l. Publ., Ser. A, Travaux sci., n. 19, pp. 339-343 (1956).

Surface waves from the Champagne, France, explosions of 1952 were particularly well registered on the Mintrop seismographs. Comparison of the three components shows four distinct phases. First to appear are very regular L-waves with constant period (about 0.3 second at 24 km), polarized in the plane of propagation. A little before the end of the first phase, Love waves (Q) appear on the transverse component with an apparent period that is large at first, then decreases rapidly. Then follows a brief M train of large amplitude on all three components. Immediately following these are Rayleigh waves (R) of large period (0.5 to 0.9 second),

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polarized in the plane of propagation, whose amplitude decreases gradually. Love-wave dispersion is normal and indicates a velocity decreasing from 1.7 to 1.1 km/sec as the period decreases from 0.40 to 0.30 second. Rayleigh-wave dispersion is normal for short periods, anomalous for large; velocity decreases from 1.0 to 0.7 km/sec as period increases from 0.3 to 0.9 second. L-waves with periods of 0.2 to 0.4 second are superimposed on the shorter-period Rayleigh waves so that dispersion curves of the two are confused. The anomalous dispersion of the Rayleigh waves is attributed to a subjacent low-velocity layer. It is concluded from study of the phase velocities that the surface waves are formed at some distance from the origin and thus with some retardation.

BEAUFILS, Y., BERNARD, P., COULOMB, J., DUCLAUX, R., LABROUSTE, Y., RICHARD, H., PETERSCHMITT, E., ROTHE, J.-P., and UTZMANN, R., "Enregistrement des ondes seismiques provoquees par de grosses explosions. I - Camargue 1949. [Recording of Seismic Waves Generated by Large Explosions. I - Camargue 1949]," Bur. Cen. Seism. Intnat'l Publ., Ser. A, Travaux sci., n. 19, pp. 325-326 (1956).

About 60 records were obtained, at distances varying from 1.7 to 26 km, from explosions in Camargue, France, in 1949. Five P phases were encountered at relatively shallow depth (about 2000 meters); comparison with the gravity map shows that the seismic profile crosses the axis of the anticline. A velocity of 6.0 km/sec corresponds to the Paleozic basement. Four phases appear to represent S waves, and a train of surface waves with an apparent velocity of 500 m/sec is identified as Rayleigh waves.

BEAUFILS, Y., COULOMB, J., GENESLAY, R., JOBERT, G., LABROUSTE, Y., PETERSCHMITT, E., and ROTHE, J.-P., "Enregistrement des ondes seismiques provoquies par de grosses explosions. II - Champagne 1952 [Recording of Seismic Waves Generated by Large Explosions. II - Champagne 1952]," Bur. Cen. Seism. Intnat'l. Publ., Ser. A, Travaux sci., n. 19, pp. 327-329 (1956).

Fifty-two records were obtained from 11 explosions in Champagne, France, in 1952. In the first three explosions the stations were situated to the east of the shot point at distances between 1.6 and 25 km, in the rest they were arranged en echelon between 1.3 and 70 km to the west. Six P-phases were identified. The Paleozoic basement with a velocity of 6.0 km/sec was found to be somewhat deeper than at Camargue. Three S-phases were recognized, and surface waves with a velocity of 0.9 km/sec are interpreted as Rayleigh waves. Arrivals at 10 seconds at three stations were presumably deep reflections indicating a crustal thickness of 30 km.

BEAUFILS, Y. See also Labrouste, Y.

BEBB, A. H., "Under-Water Explosion Measurements from Small Charges at Short Ranges," Phil. Trans. Roy. Soc. London, Series A, (Mathematical and Physical Sciences), V. 244, n. 879, pp. 153-175 (1951).

BECK, G., "The Penetration of a Wave into a Potential Barrier," Centro Brasileiro de Pesquisas Fisicas. Report (1960).

The distortion of a wave pulse reflected by a potential step of finite height is determined and given, in a simple case, in closed form. It shows that part of the signal energy becomes temporarily stored inside the potential barrier before it becomes reflected.

BENDINELLI , R. A. See Polatty, J. M., et al. (2).

BENIOFF, H., "New Long-Period Waves Recorded with a Strain Seismograph," Science, V. 122, n. 3175, p. 873, (1955).

BENIOFF, H., "Suggestions for Standards of Noise, Amplitude, and Spectrum," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 12 (1959).

Seismic noise exhibits a continuous spectrum with superposed bright lines or bands corresponding to microseism frequencies. Both the continuous spectrum and the microseism bands vary in amplitude and frequency with time and from place to place. The seismic amplitude spectrum should be measured with appropriate frequency resolution over a frequency range from about 20 millicycles per second to 10 cps at several sites and for 3 components. Determinations of average spectrum levels for minimum, average, and maximum noise conditions should be made for each site, and measurement of other noise characteristics, such as spatial coherence, and type of distribution, are desirable. To obtain the ratio of signal to noise, measurements of the amplitude spectrums in 3 components of the initial P-waves and surface of earthquakes and underground blasts at different distances from the source and at different observing sites are necessary.

BENIOFF, H., "Improved Seismographs," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 13 (1959).

Suggested improvements for short period seismographs and for surface wave seismographs for improved detection and identification of earthquake and blast waves are discussed. Development of such seismographs must be coordinated with information on the spectrums of signals and noise not now available.

BENIOFF, H., EWING, M., and PRESS, F., "Note on 'Sound Waves in the Atmosphere Generated by a Small Earthquake'," Calif. Inst. of Technology and Lamont Geological Observatory. CIT Tech. Rept. No. 13 (1951).

Sound waves from the Imperial Valley earthquake of January 24, 1951, are interpreted as the result of coupling between Rayleigh waves crossing the valley and the atmosphere. An order-of-magnitude calculation based on the theory of air-coupled Rayleigh waves satisfactorily explains the duration, travel-time, period, and path of the sounds.

BEN-MENAHEM

BEN-MENAHEM, A., "Radiation of Seismic Surface-Waves from Simple Models of Fault Planes. Part I: Rayleigh Waves," Calif. Inst. of Technology. CIT Contribution No. 995.

This paper investigates the effect of the finiteness of the seismic focus on the Rayleigh-wave pattern. Starting with a previously solved internal harmonic concentrated force, a faultplane is realized by moving this source along a line and integrating the Rayleigh-pole contribution across a finite rectangle with arbitrary strike and dip. Displacements are evaluated for long ranges and expressions are obtained for strike-slip and dip-slip fault types. Attention is mainly focused on a dipole-type motion of a vertical strike-slip model for which displacement has been actually computed and the results transformed into the time domain. A considerable deviation exists from the point dipole pattern when the rupture velocity is above the Rayleigh-speed and when the length is of the order of the fault-dimensions. Also, azimuthal distribution of amplitudes in that range depends strongly on the dimensions of the source.

The energy radiated in the direction of motion highly exceeds the amount radiated in the opposite direction. Formulas are given for theoretical seismograms in dispersive media which, by comparison with real seismograms, may lead to an estimation of the source-dimensions and the rupture speed.

BEN-MENAHEM, A., "Radiation of Seismic Surface Waves from Simple Models of Fault Planes. Part II: SH waves (with Application to the G-Wave)," Calif. Inst. of Technology. CIT Contribution No. 995.

The effect of finiteness of the seismic focus on the SH wave radiation pattern is investigated in this report. Starting with a harmonic horizontal point source, situated in a homogeneous half space, the exact solution for the surface displacements is found. A fault plane is then realized by moving this source along a line with finite speed and integrating the Love-pole's contribution across a finite rectangle in the layer. Displacements are evaluated for long ranges, and expressions are obtained for strike-slip and dip-slip fault types. The theory is then applied to the G-wave pattern, for which the results are also transformed into the time domain. It is also demonstrated how this theory may lead to an estimate of source parameters such as fault length and rupture velocity from amplitudes ratio of G or R waves recorded at a single station.

BEN-MENAHEM, A. See also Press, F.

BENNETT, W. P., ANDERSON, A. L., and SMITH, B. L., "Cavity Definition, Radiation, and Temperature Distributions Resulting from the Logan Event." U. of Calif. Radiation Laboratory, Mercury, Nev. Report (1960).

Following the detonation of the Logan event on October 15, 1958, an exploratory drift was driven to within 160 feet of ground zero to recover experimental apparatus. Several postshot diagnostic holes were drilled through the zone of effects to obtain temperature and radiation data. The data obtained were used to define the cavity and the thermal distribution in the media surrounding ground zero. The following are presented: a graphical representation of drill-hole temperature and radiation; and isothermal diagram of the area surrounding ground zero; a cavity-definition

diagram from which cavity radii and scaling factors were derived; and blast effects encountered during the postshot excavation of the original access drift.

BENNETT, W. P. See also Olsen, J. L., et al.

BERG, J. W., "Effect of Stemming on the Energy Content of Explosion-Generated Seismic Pulses," Pennsylvania State University, University Park, Mineral Industries Experiment Station. Technical Rept. No. 3 of Project C-12 on U.S. Navy Contract N6-onr-26918 (1954).

BERG, J. W., and COOK, K. L., "Ground-Motion Measurements near Quarry Blasts at Promontory Point, Utah," Bull. Seism. Soc. Am., V. 49, n. 4, pp. 391-397 (1959).

Ground amplitudes and accelerations are presented for distances of 8000, 22,000, 43,700, and 72,200 feet from 3 quarry blasts each of more than 1,000,000 lb of explosives that were detonated at Promontory Point, Utah. The equation

$$\log D_m = 1.52 \cdot \log x + 4.51$$

where (D_m = maximum total displacement amplitude in inches, x = distance from source in feet) fits the data of maximum total displacement vs. distance for those distances. Maximum vertical acceleration vs. distance for the same distances is given by the equation

$$\log A_m = 2.55 \cdot \log x + 10.68$$

where A_m = maximum vertical acceleration in fps^2 and x = distance from source in feet.

BERG, J. W., et al., "Seismic Investigation of Crustal Structure in the Eastern Part of the Basin and Range Province," Bull. Seism. Soc. Am., V. 50, n. 4, pp. 511-535 (1960).

Results of seismic studies are presented of nine quarry blasts, ranging in size from 50,000 to 2,138,000 lb of explosives, at Promontory and Lakeside, Utah, during 1956 to 1959, and also of the Rainier and Blanca nuclear explosions near Mercury, Nevada. Seismic waves from blasts were recorded at 17 temporary stations to a distance of about 280 km and 15 permanent seismograph stations to a distance of about 1009 km. Time-distance graphs were plotted using first and later arrivals at all of the stations. Depths to refracting horizons were computed using refraction equations for horizontal layers having constant velocities.

From the travel-time curves, conclusions are drawn concerning the structure of the crust in the Utah-Nevada region. Warping of the crustal layers below the mountains is discussed.

BERNARD, P., "Interpretation des ondes seismiques des explosions des Rochilles (aout-septembre 1956). [Interpretation of the Seismic Waves from the Rochilles Explosions (August-September 1956)]," Acad. Sci., Paris Compt. rend., tome 243, n. 25, pp. 2115-2118 (1956).

The direct, reflected, transverse, Rayleigh, and air waves resulting from a series of explosions at Rochilles, France, were identified from seismic records obtained at four stations: Val-des-Pres, August 25;

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Allemont-en-Olsans, August 27; Villard-de-Lans, August 31 and September 4; and Vienne (Isere), September 6, 1956. Calculations were made of the depth of the Mohorovicic discontinuity using a velocity of 5.95 km/sec range from 35.9 to 39.2 km. Transverse wave reflections indicate a depth of about 17.3 km for the Conrad discontinuity. On two of the days, with wind disturbance at a minimum, a direct wave, apparently partly aerial and partly seismic, was observed, analogous to T waves at the ocean bottom.

BERNARD, P. See also Beaufils, Y., et al.

BERRYMAN, A. R., "A Geophone Instrumentation System for Detecting and Recording Natural or Artificial Earth Vibrations and Shock Waves," Navord Rept. No. 4968 (1955).

This report describes a geophone instrumentation system capable of extremely high sensitivity and used to detect and record various natural or artificial earth vibrations, shock waves, or other disturbances. The system is useful for detecting surface, underwater, or underground missile warhead functioning. It has been successful in recording very weak artificial disturbances in granite mountainous areas, in sandy desert areas, and with special geophone pickups on the ocean floor.

BERZON, I. S., "On Changes in the Dominant Frequencies of Seismic Waves with Increased Distance from the Source of Vibration," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz. n. 1, pp 3-22 (1956).

The character of the dominant seismic-wave frequency changes with the distance from the source of vibration, and the effects of absorption properties in concrete media are discussed. A possibility of step-wise changes in prevailing frequencies of straight, reflected, and refractory waves expanding into an absorption media are demonstrated. Explosion spectra effects, seismograph installation conditions, and the selection of a specific seismograph suitable to receive the wave dominant frequencies and their changes with distance are discussed.

BIRCH, F., "Internal Constitution of the Earth; Physics of the Interior," Trans. Am. Geophys. Union, V. 41, n. 2. pp. 173-176 (1960).

A bibliography is presented to serve as an index of activity during 1957-60, mainly in the United States, concerning the internal constitution of the earth. Items are listed under the following headings: books; seismology; equation of state (experimental); equation of state (theoretical); polymorphism, phase changes; melting curves (experimental); melting curves (theoretical); radiation, radiative transfer, conductivity, temperature distributions; geochemistry, heat production, and heat flow.

BIRKENHAUER, H. F. (S. J.), "An Analysis of Displacements Caused by Quarry Blasts," Report of Contract DA 33-019-ORD-2452 (1957).

Based on analyses of blasts and the variability presented in the results, a statistical method is presented to test the data from a group of blasts for the presence of variables other than charge weight and distance. Essentially, the method distinguishes whether the displacements vary because of chance or because of other causes which should be controlled by the blaster. If the variation is the result of chance, the limits within which

the values can be expected to fall in the future can be assigned, and this assurance can be expressed as a probability. If the variation is caused by other factors, the method indicates where to look for them. This procedure can be extended to analyze the data from other types of explosions so as to estimate the limits within which the measured displacement, or velocity, or acceleration will lie in the future.

BIRKENHAUER, H. F. (S. J.), "Seismic Waves from the Lakewood-Cleveland Sewer Explosion of September 10, 1953," Earthquake Notes, V. 26, no. 3-4, pp. 21-22 (1955).

BIRKENHAUER, H. F. (S. J.), and STUDER, M. V., "Correlation Between Displacement and Acceleration from Blasting," Earthquake Notes, V. 30, n. 9, pp. 35-36.

This paper contains information on the mathematical correlation of displacement and acceleration from quarry blasts. A statistical method is used to derive a formula for the coefficient of correlation.

BLACKFORD, M. E. See Ryall, A. S.

BLAIK, M., and CLAY, C. S., "Detection in the Ground of Sound from a Source in Shallow Water," Hudson Laboratories Tech. Rept. No. 76 (1959).

The propagation of single-frequency seismic waves in the ground from a sound source in shallow water has been studied. Frequencies were studied in the interval from 10 to 150 cps. The experiments were made in an area in which the geological section consists of 1900 feet of unconsolidated sediments over basement. The amplitude and relative phase of the seismic waves were observed at many depths down to basement. The effect of horizontal source to detector distance was studied. Portions of these data will be presented along with some discussion of their significance.

BLAIR, B. E., and DUVALL, W. I., "Evaluation of Gages for Measuring Displacement, Velocity, and Acceleration of Seismic Pulses," Dept. of Interior, Rept. of Investigations No. 5073 (1954).

This evaluation was conducted to determine the reliability of various accelerometers, velocity gages, and a displacement meter when measuring seismic pulses generated in rock by the detonation of explosive charges.

The procedure was as follows:

(a) Instruments for measuring displacement, velocity, and acceleration were mounted on the rock surface at distances of 26 to 1000 feet from the shot.
(b) Single charges from 6.25 to 100 lb of Hercomite B were detonated with primacord in holes 4 1/2 inches wide and 20 feet deep, stemmed with shale cutting.
(c) Seismic records were obtained for 10 shots in Pierre Shale, and 2 shots in Niobrara Chalk.

The gages employed were:

(1) A Leet displacement meter
(2) MB velocity gages
(3) Statham, General Electric, and Golton Accelerometers

BLEICH

The conclusions were:

(1) The General Electric, Golton, and Statham accelerometers gave good inter- and intra-group reproducibility. The MB velocity gages showed good intra-group reproducibility.
(2) The agreement between the derived (differentiated and/or integrated) and the directly observed records established that the gage records are true representations of the particle motion of the rock.
(3) The experimental data agree with scaling laws developed by dimensional analysis.
(4) The propagation laws for peak amplitudes of displacement, velocity, and acceleration are independent of gage type.

BLEICH, H. L. See Baron, M. L., et al.

BLUM, V. J. See Macelwane, J. B., et al.

BOLT, B. A., "The Revision of Earthquake Epicentres, Focal Depths, and Origin-Times using a High-Speed Computer," Geophys. J. Roy. Astron. Soc., V. 3, n. 4 (1960).

A program for an automatic computer has been developed to revise rapidly provisional foci and origin-times of normal and deep-focus earthquakes. For each earthquake, up to 300 equations of condition found from P, pP, and PKP observations are solved by least squares to give a correction to the trial location. Special attention is given to the weighting of observations and factors affecting convergence.

Features of the program are that the theoretical travel-time tables are stored in complete form, and after each iteration a list of stations with corresponding distances, azimuths, and residuals as well as the root-mean-square error, is printed. Applications to a 1954 hydrogen bomb explosion and a number of earthquakes are described. The results suggest that the program may be useful to research organizations requiring either regular or special location of epicentres.

BOLT, B. A., DOYLE, H. A., and SUTTON, D. J., "Seismic Observations from the 1956 Explosions in Australia," Geophys. J. Roy. Astron. Soc., V. 1, n. 2, pp. 135-145 (1958).

Both P and S phases from the four 1956 British atomic explosions at Maralinga in South Australia, were observed at field stations set up along the Trans-Australian railway for $0.4^{o} < \Delta < 11^{o}$, and on a Benioff seismograph located near Adelaide at 8^{o}. The travel times indicate a Pn velocity of 8.21 ± 0.005 km/sec and an Sn velocity of 4.75 ± 0.01 km/sec. There is also evidence for P and S phases traveling near the surface with velocities of 6.03 ± 0.009 km/sec and 3.55 ± 0.04 km/sec, respectively. No onsets corresponding to paths through intermediate layers were observed. The observations can best be explained by a single crustal layer having constant seismic velocities. This hypothesis gives a crustal thickness of 32 km for P and 39 km for S. These results agree with those of Hodgson for the Canadian shield (see Geophys. Abs. 157-117) and of Willmore, Hales, and Gane for the western Transvaal (see Geophys. Abs. 148-13340), suggesting that the old continental shields are seismically very similar.

BRENNER, J. L. See Swift, L. M., et al.

BRINKLEY, S. R., Jr., and KIRKWOOD, J. G., "Theory of the Propagation of Shock Waves from Infinite Cylinders of Explosive," Phys. Rev., V. 72, n. 11, pp. 1109-1113 (1947).

BRINKLEY, S. R., Jr. See also Kirkwood, J. G.

BRODE, H. L., "Cavity Explosion Calculations for the Cowboy Program," The RAND Corporation. Rept. No. RM-2624-AEC (1960).

A series of calculations was made for the purpose of predicting the behavior of tamped and decoupled HE shots in salt cavities. The calculations correspond to the actual sizes and charge weights tested and apply to cavity explosions in a 12 foot and a 30 foot diameter sphere. Wall response was not included.

The equation-of-state of air is given, and some discussion of the equation-of-state for the explosive gases and of the detonation details is included. Comparisons are made with some of the wall-pressure measurements. Details of the hydrodynamics in the cavity during an explosion are illustrated in an appendix.

It was found that, in addition to charge weight and cavity size, the density of the explosive, the nature of the detonation, and the amount of air present influence the results.

BROWN, H. See Johnson, G. W.

BRUNE, J., EWING, M. N., and KUO, J., "Group and Phase Velocities for Rayleigh Waves of Period Greater Than 380 Seconds," Science, V. 133, p. 757 (1961).

Recent theoretical and experimental investigations of the period of free spheroidal oscillation of the earth have shown good agreement. These data are used to determine group and phase velocities for Rayleigh waves of period greater than 380 seconds. The velocities so obtained are compared with those determined from analysis of progressive waves. It is concluded that group and phase velocities determined by either of the two methods are in agreement.

BRUNE, J. N., OLIVER, J., "Seismic Noise of the Earth's Surface," Lamont Geological Observatory. Contribution No. 388 (1959).

BRYANT, E. J. See Andrews, T. J., et al.

BUDENSTEIN, D. See Howell, B. F., Jr.

BULLARD, E. C., "Explosions in Germany," British Association for the Advancement of Science. Report (1947).

BULLEN, K. E., "The Bikini Bomb and the Seismology of the Pacific Region," Nature, V. 161, n. 4080, p. 62, (1948).

BULLEN, K. E., "Some Trends in Modern Seismology," Sci. Prog., V. 43, n. 170, pp. 211-227 (1955).

A summary of knowledge of the internal structure of the earth based on the contributions of seismology, especially such recent studies as those of blasts, surveys at sea, surface waves, more precise velocity determinations, and the magnitude and energy of earthquakes.

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BULLEN, K. E. and BURKE-GAFFNEY, T. N., "Evidence Relating to the Earth's Inner Core from Hydrogen Bomb Explosions in 1954," Nature, V. 180, n. 4575, pp. 49-50 (1957).

Stations in the distance range of 137° to 142° recorded wave movement from the bombs as much as 12 seconds before the expected arrival times as well as larger phases that agreed within 2 seconds with the expected arrival times of PKIKP. The early waves correspond to diffracted waves and supplement proof that PKIKP is not a diffracted wave but one due to the inner core.

BUNE, V. I., and KON'KOV, A. A., "Testing of the Mechanical Seismographs CMP-II [SMR-II] in Order to Evaluate the Dimensions of a Seismically Dangerous Zone during a Massive Explosion," Trudy Inst. Seys., Akad. Nauk Tadzhik S.S.S.R., V. 71, pp. 47-58 (1957).

Data are presented on the disturbance of the ground close to an explosion of 1800 tons of ammonite. Characteristic of the records are the relatively large periods (0.14 - 0.45 second) at distances of 600 to 1200 meters from the shot point; these had not been recorded from earlier explosions. According to tentative data, the radius of the seismic danger zone is twice as large as was expected from the empirical formulas, which take into account only the weight of the charge and the character of the ground.

BUNKER, C. M., DIMENT, W. H., and WILMARTH, V. R., "Distribution of Gamma Radioactivity, Radioactive Glass, and Temperature Surrounding the Site of the Rainier Underground Nuclear Explosion, Nevada," U.S. Geological Survey, Geological Survey Research. USGS Prof. Paper No. 400-B (1960).

Radiometric measurements indicate that most of the gamma radioactivity produced by the Rainier underground nuclear explosion is contained in glass formed by the explosion. Maxima of radio active glass concentration and temperature occur in a bowl-shaped zone below the explosion point. One year after the explosion, much of the explosion energy remained in the form of heat around the explosion point.

BURKE-GAFFNEY, T. N., and BULLEN, K. E., "Seismological and Related Aspects of the 1954 Hydrogen Bomb Explosions," Australian J. Phys., V. 10, n. 1, pp. 130-136 (1957).

Seismic waves from hydrogen bomb explosions in the Pacific in 1954 were recorded at stations at distances of 33.7° to 140.6°. The origin times (in Greenwich mean time) have been determined as: February 28, 18:45:0; March 26, 18:30:0; April 25, 18:10:0; and May 4, 18:10:0. If these surmised times and the assumed source point are correct, the data show that seismic travel time from Bikini in all azimuths should be reduced by 1 to 2 seconds or more from the Jeffreys-Bullen travel times. If these origin times are used, there is no discrepancy between velocities of air waves from these blasts and those from the Krakatoa eruption and the fall of the Siberian meteor, as indicated by Yamamoto.

BURKE-GAFFNEY, T. N., and BULLEN, K. E., "On the Seismological Aspects of the 1954 Hydrogen Bomb Explosions,"Australian J. Phys., V. 2, n. 3, pp. 318-321 (1958).

A re-examination of tentative conclusions drawn from analysis of seismic records of the four 1954 hydrogen bomb explosions (see Geophys. Abs. 169-73, 170-208, 173-238) made in the light of source data recently released by the United States Atomic Energy Commission, leads to the conclusions that earlier computed origin times for the four explosions were correct within 0.0, 0.4, 0.7, and 0.1 seconds, respectively, and that the Jeffreys-Bullen P-tables need a correction of -2.2 to +1.0 seconds for surface epicenters in the mid-Pacific and recordings of continental stations. The analysis also confirms the fact that the difference between P travel times from Bikini to Australia and from Bikini to the United States is not much more than 1/2 second; does not alter previous inferences on velocities of air waves from explosions; and confirms the arrival of diffracted PKP waves in front of the 142^{o} caustic, at times significantly earlier than PKIKP waves.

BURKE-GAFFNEY, T. N. See also Bullen, K. E.

BYCROFT, G. N., "The Magnification Caused by Partial Resonance of the Foundation of a Ground Vibration Detector," Trans. Am. Geophys. Union, V. 38, n. 6, pp. 928-930 (1957).

BYERLY, P., "The Seismic Waves from the Port Chicago Explosion," Bull. Seism. Soc. Am., V. 36, pp. 331-348 (1946).

Seismograms of the Port Chicago blast are studied and lead to the conclusion that an average layering for California is 3 km of rock of speed 5.0 km/sec for P waves, overlying a layer 11 km thick of speed 5.6 km/sec, which in turn overlies a medium of speed 7.7 km/sec. No waves which traversed the mantle were observed. The root of the southern Sierra Nevada blocks the 7.7 km/sec wave even as it blocks the 8.0 km/sec.

Energy in the blast is considered.

BYERLY, P., "Seismological Problems which Nuclear Explosions May Solve," U. of Calif., Berkeley, Lawrence Radiation Laboratory. Report.

Controlled nuclear explosions have much to offer to seismology in the way of interpretation of the earth's structure, in improving the location of earthquake foci, and in the correlation of wave motion with damage.

BYERLY, P., and DYK, K., "Richmond Quarry Blast of September 12, 1931, and the Surface Layering of the Earth in the Region of Berkeley," Bull. Seism. Soc. Am., V. 22, n. 1, pp. 50-55 (1932).

BYERLY, P., STEWART, S. W., and ROLLER, J. C., "Seismic Measurements by the U.S. Geological Survey during the Pre-Gnome High-Explosives Tests near Carlsbad, New Mexico: Final Report," U.S. Geol. Survey, Trace Elements Investigation Rept. No. 761, 40 p. (1960).

The U.S. Geological Survey monitored 3 high-explosive test shots at the Gnome site during the pre-Gnome experiments and monitored routine blasting in the potash mine of the Duval Sulphur and Potash Company.

Analysis of the data leads to the conclusion that the motion in the potash mines near Carlsbad from a shot of 9 kt of TNT at the Gnome

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site, 46,000 feet from the nearest potash mine, would not exceed:

displacement:	0.1	- 0.2 cm
velocity:	1.5	- 3 cm/sec @ 2 cps
	2.5	- 5 cm/sec @ 4 cps
acceleration:	0.02	- 0.04 g @ 2 cps
	0.06	- 0.12 g @ 4 cps

These particle velocities and accelerations are less than those recorded at a distance of 90 feet from a routine 75-lb dynamite blast in a potash mine.

BYERLY, P., and WILSON, J. T., "The Richmond Quarry Blast of August 16, 1934," paper presented at the Thirty-Fourth Annual Meeting of the Cordilleran Society of the Geological Society of America (1935).

CAIRD, R. S. See Fowler, C. M., et al.

CALESS, T. W., "Compendium of Contract Information in the VELA UNIFORM Program," Inst. of Science and Technology, U. of Mich., Report on Contract No. SD-78 (1961).

This report gathers together and presents contract information on the VELA UNIFORM Program. The tasks specified for this program are defined, and individual contract details of an informative nature are given. The report also includes indexes arranged according to research subject headings, names of contracting agencies, and names of governmental and non-governmental individuals responsible for the research.

CALIFORNIA, UNIVERSITY OF, "Proceedings of the Second Plowshare Symposium, May 13-15, 1959, San Francisco, California. Part I. Phenomenology of Underground Nuclear Explosions," U. of Calif., Livermore, Lawrence Radiation Laboratory, and San Francisco Operations Office of Atomic Energy Commission. Report No. 2 of Contract W-405-eng-48 on Plowshare Series (1959).

The main topics covered at this symposium were: underground explosion phenomenology, excavation with nuclear explosives, power and isotope recovery studies, industrial applications, and scientific experiments.

CAMPBELL, D. C., "Some HE Tests and Observations on Craters and Base Surges," Armed Forces Special Weapons Project, Washington, D. C. Report of Project 1(9)-3 of Operation Jangle (1951).

Ten HE shots were conducted in the Upper Yucca Flat and Frenchman Flat areas in order to obtain data for predictions concerning the phenomena to be studied during Operation Jangle. The HE data indicated that for the Jangle surface burst a base surge would be unlikely, and the maximum altitude of the cloud would be 12,000 feet. The data also indicated that the Jangle underground burst would have considerable throw-out at the base of plume, and the base surge, if any, would be small. Since the crater diameter is a readily scaled parameter for underground TNT explosions, then the immediate observation of the underground crater diameter would be a simple method for determining the equivalent TNT yield of the nuclear weapon. Estimated dimensions of the craters and lips of the Jangle S and U bursts are given.

CANADIAN GEOPHYSICAL BULLETIN (Staff), "Annual Report of the Associate Committee on Geodesy and Geophysics, National Research Council of Canada," Can. Geophys. Bull., V. 11, 57 p. (1958).

The current geophysical research of Canadian government and private agencies is reviewed by several persons. The Dominion Observatory made four regional gravity surveys, extensive pendulum surveys, isostatic studies and laboratory work with pendulums and with vibration gravimeters. Seismologic work included instrument development, field studies of explosions off Vancouver Island, crustal thickness studies in Alberta, and detection of nuclear tests. Activity in age determinations and radioactivities of rocks is reviewed briefly. Airborne magnetometer surveys by the Canadian Geological Survey have been extended over water in the attempt to relate the geology of Newfoundland to that of the mainland. Paleomagnetism is being studied by the Geological Survey and by the University of Western Ontario.

CARDER, D. S., "Travel Times in the Lake Mead Region, Arizona and Nevada," Earthquake Notes, V. 20, n. 1, p. 8 (1958).

Using data from the explosion of 4000 lb of TNT near Boulder City, Nevada, the velocity of P waves below 3 km was found to be 6.38 km/sec and the corresponding S wave velocity 3.75 km/sec. At depths less than 3 km the P wave velocity is about 3 km/sec.

CARDER, D. S., "Seismic Investigation of Large Explosions," J. CGS, n. 1, pp. 71-73 (1948).

CARDER, D. S., and BAILEY, L. F., "Seismic Wave Travel Times from Nuclear Explosions," Bull. Seism. Soc. Am., V. 48, n. 4, pp. 377-398 (1958).

Seismograph records from nuclear explosions in Nevada and in the Pacific have been analyzed. The Nevada explosions were well recorded to distances of 6.5° (450 miles) and weakly recorded as far as 17.5° and even as far as 34°. The Pacific explosions were recorded in all parts of the world, with regional data necessarily meager.

The Nevada data indicate a crustal thickness of 35 km in that area, with velocities of 6.1 km/sec in the crust and 8.0 to 8.2 km/sec beneath it; no uniform crustal layering is indicated. The crust beneath the proving grounds and central California, possibly extending beneath the Owens Valley, is thickened probably to 70 to 75 km. A discontinuity is suggested at 160 to 185 km.

Pacific travel times out to 14° are 4 to 8 seconds earlier than similar continental data, partly because of a thinner crust (17 km or less) under the atolls and partly because velocities in the top of the mantle are closer to 8.15 km/sec than to 8.0 km/sec. A fairly sharp discontinuity is indicated at 19°. Travel times from Pacific sources to North America follow the Jeffreys-Bullen and Gutenberg curves for surface foci except they are about 2 seconds earlier on the continent, and Arctic and Pacific basin data are about 2 seconds earlier still. The core reflection, PcP, shows a strong variation in amplitude, with slight changes in distance, at two points where sufficient data were available.

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CARDER, D. S., and CLOUD, W. K., "Surface Motion from Large Underground Explosions," J. Geophys. Research, V. 64, n. 10, pp. 1471-1487 (1959).

Seismic effects of several underground nuclear explosions were measured in terms of ground surface motion by suitable seismographs from 1200 feet to nearly 10 miles from the source and with teleseismic instruments at great distances. Prior to the Rainier explosion (a 1.7-kt nuclear shot detonated 900 feet underground) empirical formulas were developed which predicted ground effects from the Rainier shot and several of the larger Hardtack II shots with fair accuracy, but with certain limitations. The limitations were (1) that at distances greater than a few thousand feet, observed displacements were somewhat larger than the formula; (2) that frequencies of ground waves did not exceed 20 cps; and (3) that the source conditions and material were in fair duplication. Ground amplitudes on deep alluvium were, as expected, more than twice the amplitudes at nearly the same distance on rock. Velocity response spectrums of one of the shots have been made and reproduced. The magnitude of the Rainier shot was about 4.0, based on the assumption that the source was contained in a volume of rock comparable to that of an earthquake having the same magnitude. Local travel time data indicate that the subbasement rock associated with a speed of about 6.2 km/sec is about 3600 feet beneath the shot points area.

CARDER, D. S., CLOUD, W. K., PEARCE, T. H., and MURPHY, L. M., "Surface Motions from a Series of Underground Nuclear Tests," U.S. Coast and Geodetic Survey, Washington, D. C. USCGS Rept. of Operation Hardtack (1959).

Ground effects resulting from Blanca, Logan, Evans, Tamalpais, and Mars events of the Hardtack Phase II underground explosions were measured by strong motion and teleseismic seismographs out to distances of nearly 100 miles. In addition, many temporary seismographs were operated by a number of organizations to distances of nearly 2400 miles, and routine seismographs continued to operate on a worldwide basis. Some of the results are given in this report. For safety purposes, predictions of ground effects, using formulas derived by the U. S. Coast and Geodetic Survey from pre-Rainier HE tests and modified slightly as a result of the Rainier tests, hold true with reasonable accuracy.

CARDER, D. S., and MICKEY, W. V., "Seismic Ground Effects from Coupled and Decoupled Shots in Salt," Final Report of Project Cowboy (1960). [Includes Appendix A: "Long Period Seismic Program," by POMEROY, P. W., and OLIVER, J.]

The ratio of transient earth particle displacements resulting from the detonation of high explosives in a tamped bore hole (coupled) to detonations in a spherical cavity (uncoupled) in salt, varied from about 20 for the scaled ratio of Shots 15/14 to 180 for Shots 11/10 at a distance of 22,100 feet from the source. Transient earth particle displacements (A_μ), measured in microns, varied with the yield (Y) in pounds from $Y^{0.73}$ to $Y^{1.16}$. The distance (D) in feet varied with the earth particle displacements from $D^{-2.1}$ to $D^{-3.5}$ for the recorded seismic waves. Observed frequencies varied from about 2 to 120 cps. The diverse seis-

mograph recording systems were sensitive to frequencies from less than 1 to 100 cps. Detector-to-source distances ranged from 761 to 323,830 feet, with readable energy for the 1000-lb tamped shots received to 88,100 feet, and the 1900-lb sphere shot to 44,700 feet.

CARDER, D. S., MURPHY, L. M., CLOUD, W. K., and PEARCE, T. H., "Operation Pre-Gnome. Seismic Data from Natural Phenomena and High-Explosive Tests Near Carlsbad, New Mexico," U.S. Coast and Geodetic Survey, Washington, D.C. USCGS Report (1960).

The extrapolation equations formulated prior to the Rainier Shot predicted with reasonable accuracy low-frequency displacements in potash mines and at points near the Pre-Gnome explosions (Carlsbad, New Mex. area). The equations did not predict high accelerations associated with high-frequency ground waves resulting from these explosions. Accelerations and displacement of ground motion were found to vary directly as the first power of the weight of the explosives. Both accelerations at the surface and ground amplitudes from blasts in a mine were found to attenuate as the square of the distance. Seismic wave speeds in the salt were observed to be about 14,000 fps.

CARDER, D. S., et al., "Operation Hardtack II Surface Motions from Underground Explosions," U.S. Coast and Geodetic Survey. USCGS Report (1960).

The purpose of Operation Hardtack II was to determine the seismic effects of underground explosions. Ground surface accelerations and displacements were recorded at several sites in the range 2000 to 50,000 feet with strong-motion and teleseismic seismographs. Previously derived formulas for predicting ground effects are shown to hold with reasonable accuracy. Low-frequency ground displacements in the distant ranges are indicated to attenuate as the first power of distance. Based on ground effects, the Blanca shot is equivalent to an earthquake of magnitude 4.8.

CARDER, D. S., et al., "Operation Pre-Gnome, Seismic Data from Natural Phenomena and High-Explosive Tests Near Carlsbad, New Mexico," U.S. Coast and Geodetic Survey. USCGS Report (1960).

The Pre-Gnome explosions consisted of 180-, 750-, and 6200-lb high-explosive charges. These explosions were contained and were fired in salt. Seismometers were placed to cover a distance range from ground zero (slant distance 1200 feet) to a distance of 99,840 feet from ground zero. Some records were obtained in mines below the surface. Waves with frequencies of about 1 cps showed amplitudes and accelerations that corresponded with predicted values from relationships found from explosions in bedded tuff. Frequencies at least as high as 30 cps were observed. These high frequencies were not predicted by results from explosions in bedded tuff.

CARDER, D. S., et al., "Surface Motion from an Underground Explosion," Atomic Energy Commission. AEC Rept. No. WT-1530 (1958).

Surface motion from an underground 1.7 kt nuclear explosion (Rainier) was measured at ten stations located at radial ranges of 1200

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to 45,000 feet, and records from seven teleseismic stations located 100 to 300 miles from the source were borrowed for study of intermediate range and remote seismic effects.

Empirical formulas are given for acceleration and amplitude attenuation. A Gutenberg-Richter magnitude of 4.6 for Rainier was calculated from seismograph records as for natural earthquakes. Seismic energy attenuation was quite rapid near the shot point; accelerations normally recorded 60 miles from such a quake were confined to 3 miles around the source.

Rainier's elastic wave signature was recognized at several remote stations as distant as Alaska.

CARDER, D. S. See also Adams, W. M.

CARPENTER, E. W. See Wright J. K., et al.

CAUGHEY, T. K., and HUDSON, D. E., "An Electric Analog Type Response Spectrum Analyzer for Earthquake Excitation Studies," Office of Naval Research. Technical Rept. No. 6 of Contract N6-onr-244 (1954).

This report is written to:

(1) Describe briefly the general design considerations behind the development of the response spectrum analyzer,
(2) Serve as a manual of operations for users of the device,
(3) Provide circuit details and instrument arrangements to serve as a maintenance and checking guide.

Electric analog techniques are used to design a response spectrum analyzer for earthquake excitation studies. The results obtained with the function-generator spectrum-analyzer system for a half-sine wave pulse are compared with mathematically obtained exact answers for a zero damping case. The accuracy of the system is shown to be satisfactory.

CHAPELLE, W. See Wilson, J. T., et al.

CHASZEYKA, M. A., and PORZEL, F. B., "Study of Blast Effects in Soil," Illinois Inst. of Technology, Chicago. Report No. 5 of ARF Project No. D119 (1958).

The pressures generated by a nuclear detonation on the walls of the chamber in which it is detonated are estimated by employing equations-of-state for air, reflection theory and extrapolation of the blast wave pressure-distance curve in the surrounding soil to higher pressures. The effect on the blast wave of increasing the air space surrounding the charge is to increase the available blast wave energy at large distances. Effect of partial confinement on a nuclear detonation by a chamber and adjoining tunnel is evaluated by determining the relative rate of energy propagation into soil and air in the chamber, and then combining these results with the correlation of the propagation of shock waves from a spherical nuclear detonation in air with the propagation of a plane shock wave in the tunnel. The conclusion derived from this evaluation is that the length of unstemmed straight tunnel required to reduce the peak pressure to indestructive levels from a nuclear detonation of the kiloton size inside a tunnel, is too large to be practical. The propagation of a blast wave from a one kiloton nuclear detonation in a spherical chamber of one

meter radius in reddish rhyolite tuff is analyzed. The results are compared with a similar analysis on white rhyolite tuff. These rhyolite tuffs are volcanic rocks of different physical characteristics and are found in the Nevada Test Site Area. The reddish tuff has a density of 1.9 gm/cm^3, the white tuff density is 1.7 gm/cm^3. The comparison illustrates the relative effect of soil properties on blast wave attenuation. The analysis includes heating effect, cavitation and effect of partial stemming. The excellent properties of ice and snow for attenuating blast waves are discussed. An experiment conducted in the Antarctic is cited, which illustrates the waste heat concept and has important implications on the seismic effects of nuclear underground detonations.

CHASZEYKA, M. A., and PORZEL, F. B., "Study of Blast Effects in Soil," Illinois Inst. of Technology, Chicago. Final Report of ARF Project No. D119 (1958).

The blast effects from prepositioned atomic and thermonuclear demolition munitions were investigated, with emphasis on the characteristics and magnitudes of cratering, ground shock, and associated air shock phenomena as a function of depth of burial, stemming, partial confinement, and air spaces surrounding the charge. The influence of soil type, moisture content, density, void ratio, and other soil characteristics on the propagation of the blast wave was studied. Basic theories of blast wave propagation are reviewed and applied to determinations of the characteristics of a blast wave in idealized mixtures of air and incompressible solid, various types of rhyolite tuff, soft and hard rocks, clay, sand, and ice.

CISTERNAS, A., "Crustal Structure of the Andes from Rayleigh Wave Dispersion," Calif. Inst. of Technology. CIT Report (1961).

Records from a Benioff Short Period Seismograph located at Huancayo (Peru) were digitized and then passed through a low pass filter to get the long period waves. In this way the dispersion curves of Rayleigh waves for paths along the Andes were computed from seismograms which otherwise would be unusable. Comparison with the empirical curve for "normal" continental crust and with specially computed theoretical models indicated a crustal thickness of the order of 50 km for periods between 20 and 25 seconds; the observed group velocity showed abnormally low values.

CLEWELL, D. H., and SIMON, R. F., "Seismic Wave Propagation," Geophys., V. 15, n. 1, pp. 50-60 (1950).

Seismic reflection energy is usually in the frequency range of 20 to 100 cps. The general absence of reflected energy below 20 cps is attributed to the fact that wave lengths in this range are large compared to thicknesses of reflecting bed and are transmitted efficiently, returning to the surface only by refraction. As the frequency increases, wave lengths become comparable to the discontinuities represented by stratification and more efficient reflection takes place. At still higher frequencies absorption and scattering by small irregularities form an effective cut-off. Improvements of the resolving power of the reflection seismograph will probably result from techniques which shorten and simplify the input signal rather than from efforts to widen the band of usable frequencies. Elimination of non-linear displacements in the vicinity of the shot point is an obvious approach.

CLOUD

CLOUD, W. K. See Carder, D. S., (3).

COAST AND GEODETIC SURVEY (Staff), "Ground Vibration Tests Near Valkaria, Florida," USCGS Report (1960).

Tests were conducted near Valkaria, Florida, to determine characteristics of the ground vibrations. Recordings of background and artificial disturbances were made with a Sprengnether Blast Meter and HTL 2-cycle geophones. By comparison to ground effects of general background and a distant train, nearby disturbances are shown to give the greatest displacements, velocities, and accelerations.

COKER, F. B., "Deep Well Seismic Program I and II," United Electrodynamics. Final Report of Project T/741 (1960).

The basic objective of this program was the measurement of seismic signal and noise conditions in a deep bore hole in the earth. Measurements were conducted in a 5000-foot deep bore hole in granite in western Wyoming with a set of deep well seismometers and a surface monitoring system.

The P-wave signal-to-noise ratio was found to be proportional to an exponential power of depth and to the logarithm of frequency. The amplitude of seismic ground noise decreased with depth in close agreement with Rayleigh wave theory. The attenuation with depth of seismic noise induced by surface winds suggests that shallow burial of instruments in windy area could effectively decrease the noise background.

Thus, deep-hole recording may be favored under very windy conditions or where insufficient surface area is available for a surface array.

COLE, R. H., Underwater Explosions. Princeton University Press, Princeton (1948).

COLE, R. H. See also Wilson, E. B., Jr.

COLES, H. W. See Loconti, J. D., et al.

COLLINS, F., and LEE, C. C., "Seismic Wave Attenuation Characteristics from Pulse Experiments," Geophys., V. 21, n. 1, pp. 16-40 (1958).

Laboratory data on the transmission of stress waves in rocks indicate that the attenuation exponent (db/ft) for steady state sine waves is roughly proportional to frequency in dry cores at atmospheric pressure. Measurements of the effects of pressure and water saturation, however, show that much more work is required before laboratory results can be extrapolated to conditions in the earth. Field experiments avoid these problems, but not, of course, without introducing others. The field tests and theoretical studies of Ricker indicate that the attenuation exponent is proportional to the square of the frequency at low frequencies; these results have not, however, been accepted unreservedly. We propose further experiments of the type conducted by Ricker, but with emphasis on recording the wave at several distances so that changes in shape can be observed as the wave travels through the medium.

To use such data to determine the attenuation exponent and the wave propagation equation, we propose that the pulses be converted to equiva-

lent steady state sine wave data by Fourier integral analysis. Geometric effects in the particular experiment can be eliminated by mathematical analysis and the attenuation exponent calculated from the steady state magnitudes and phases at different distances. The basis of the analysis method is the fact that the manner in which the attenuation exponent appears in the harmonic solution of the most general linear-wave equation is independent of the manner in which it varies with frequency. Hence at each frequency the attenuation exponent can be calculated from the steady state data for that frequency. The method is applied to data obtained in a quarry sandstone. Although the results are not consistent for different transmission distances, it is believed that data from additional experiments of this kind can be used to determine the attenuation exponent and the wave propagation equation.

In formulating the method, the Boltzmann superposition principle is used in which the general three-dimensional stress-strain relations for an isotropic material require two elastic constants and two memory functions. A preliminary study of the memory function for dilatational waves yields some interesting limitations on possible functions when we impose the restriction of elastic behavior with static stresses and strains. If the Laplace transform of this function is analytic at the origin, then the attenuation exponent increases with the square or some higher even power of the frequency at low frequencies. To obtain any other variation, the memory function transform must have a branch point at the origin (poles and essential singularities are ruled out). No memory function will yield an attenuation exponent precisely proportional to frequency over any frequency range, but a class of memory functions may exist yielding an attenuation exponent proportional to frequency raised to a power arbitrarily close to unity at low frequencies. This analysis is based on the assumption of linearity, which we do not wish to abandon until forced to by experimental data.

COLLINS, T. K., "Fundamental Investigations of High Explosives and Explosives Phenomena," Utah Univ., Salt Lake City, Inst. of Metals and Explosives Research. Final Report (1959).

A bibliography of 48 entries is presented. Information and data pertaining to an x-ray technique for measuring the density vs. distance relation in the detonation of explosives are presented.

COLORADO SCHOOL OF MINES, "Third Symposium on Rock Mechanics," Quart. Colo. School Mines (1959)

This quarterly contains papers from several leading figures in the fields of mining, seismology,and geology. A great deal of material concerned with underground explosions and nuclear blasts is included. The general areas of interest are:

1. Factors common to comminution, underground failures, and failures resulting from explosions.
2. Factors common to soil mechanics and rock failure.
3. Explosions and seismology.
4. Nuclear blasts in mining.

CONNOR

CONNOR, J. J., Jr., "Characteristics of Explosion-Generated Waves in Limestone at Small Distances," Master's thesis, St. Louis Univ., St. Louis, Mo. (1956).

The following conclusions can be made regarding the blast-produced seismic waves in the St. Louis limestone, as recorded at 15 and 25 meters. High frequency wave groups were generated; frequencies were from 40 to 75 cps. The entire train of waves is of short duration, motion is negligible after 0.1 second. Classical wave types P, SH, SV, and R were recognized and consistently occur at these short distances. The SV wave is related to the other early motion in such a manner that it is believed to be predominantly due to reflection of the P wave beneath the instrument. All the wave types present in the direct records are found to be reflected from the free vertical boundary, unaltered except in amplitude. The free boundary reflection results in a loss in amplitude of total motion as compared to total motion due to the direct waves alone. The loss in amplitude is most probably due to increased attenuation and scattering brought about by an increased distance of travel from the reflected waves. The shots that broke rock out of the vertical face show the same results as obtained by Thoenen and Windes (Trans. Am. Geophys. Union 19:109-115, 1938; U. S. Bureau of Mines, Report of Investigation no. 3353, 1937, and no. 3407, 1938, and Bulletin no. 442, 1942); decreased amplitudes, unchanged otherwise.

COOK, G. W., and KILEY, W. P., "Detection of Time of Arrival of First Earth Motion," David Taylor Model Basin, Carderock, Md. Report of Project 1.5b of Operation Jangle (1952).

Measurements were made on the arrival time of the first detectable earth motion at each of ten stations located between 100 and 600 feet from ground zero. The instrumentation consisted of seismic detectors which triggered electronic flash lamps; the time sequence of the lamp flashes was recorded photographically from a remote camera station. The data obtained shows the time of arrival at Station 1 (100 feet) to be 26.6 msec and to increase somewhat linearly to 134 msec at Station 10 (542 feet). The data are presented in both tabular and graphical form, and the instrumentation and methods developed to carry out the measurements are discussed.

COOK, K. L. See Berg, J. W., Jr.

COOK, M. A., The Science of High Explosives, Reinhold, New York (1958).

This book offers a rather complete treatment of the general subject of high explosives for the technically oriented person. It includes theory, practical applications, instrumentation systems, manufacture, storage, handling, etc.

COTELL, R. D. See Oliver, J., et al.

COULOMB, J. See Beaufils, Y., (2).

COX, E. F., "Microbarographic Waves at Great Distances from Explosions," Phys. Rev., V. 72, n. 2, pp. 180 (1947).

CRABTREE, R. W., "History of Explosives, Present Relation to Seismograph Work," Geophys., V. 12, n. 3, p. 493 (1947).

A brief introductory outline is given of the history of explosives, with particular reference to the difficulties involved in the development of a seismic explosive capable of meeting the varied requirements of reflection shooting. Attention is then given to deep shot-hole shooting, effects of pressure on general characteristics of seismic power, possible changes in rate of detonation and sensitivity, and uses of strong electric caps. The effects of changes in rates of detonation are studied both in relation to improved reflections in so-called dead areas and to the size of charges. Vibrations and their possible effects on water wells and oil wells are taken into consideration. The subject of directed energy is discussed briefly with reference to the shaped charge and its possible use in seismic exploration.

CRARY, A. P., "Seismic Studies on Fletcher's Ice Island. T-3," Trans. Am. Geophys. Union, V. 35, n. 2, pp. 293-360 (1959).

Seismic studies were made on Fletcher's Ice Island in the Arctic Ocean during June and July 1952, to determine the thickness and elastic characteristics of this ice body. Two types of seismic profiles were made, one using explosives detonated at or near the surface, and one using mechanical impacts. Compressional and torsional velocities were obtained, as well as good flexural waves at the longer distances. A single shot was fired at the surface at a distance of 5 1/2 miles for the generation of an air-ice coupled wave. In addition to these standard types, a constant frequency multi-reflected SV wave showed unusually large amplitudes at the long distances. The ice thickness was obtained independently by the seismic energy reflected from the ocean bottom. The arrival times through the island were compared with arrival times to the surrounding ice pack at sea level. The thicknesses obtained by these various types of measurement are quite consistent, giving from 160 to 170 feet, corresponding to an average density of about 0.91 gm/cm^3, as deduced from the elevations. This value of density was also obtained by direct measurements in the upper 50 feet of ice.

CRARY, A. P. See Oliver, J., et al.

CRAWFORD, J. M., DOTY, W. E. N., and LEE, M. R., "Continuous Signal Seismograph," Geophys., V. 25, n. 1, pp. 95-105 (1960).

This paper describes the "Vibroseis" seismic method, in which a continuous signal vibrator replaces dynamite as the source of energy. Cross correlation of the input and received signals provides time resolution and, in addition, enhances the signal-to-noise ratio at a rate proportional to the square root of the total vibration time. However, a rather formidable computing step is added to the conventional record-processing operation.

The theory of the method is discussed, and field operations with one type of equipment now being tested are described. The theoretical implications of some aspects of the method are attractive enough to warrant further development.

CYBULSKI

CYBULSKI, W. B., PAYMAN, W., and WOODHEAD, D. W., "Explosive Waves and Shock Waves. VII. The Velocity of Detonation in Cast TNT," Proc. Roy. Soc. Ser. A, V. 197, n. 1048, pp. 51-72 (1949).

DAUCHEV, P. S., "O zavisimosti nachal nogo davleniya vzryva ot koeffitsienta zaryaahaniya [On the Relation between the Initial Pressure of the Explosion and the Coefficient of Charging]," Trudy Inst. Geol., Akad. Nauk Kirgiz. S.S.R., V. 7, pp. 105-110 (1956).

Using the formulas of thermochemistry, the author derives the relation between the pressure on the walls of a hole and the value of the charging coefficient of an explosion. From this formula it can be seen that by proper selection of the value of the charging coefficient it is possible to obtain the greater seismic effect on the walls of the hole with smaller crushing effect.

DAVISON, C., "The Relative Seismicity of the Different Regions of the World," Geol. Mag., V. 71, n. 7, pp. 320-323 (1934).

DEFENSE ATOMIC SUPPORT AGENCY (Staff), "Electromagnetic Blackout Guide: Effects of High Altitude Nuclear Bursts on Electromagnetic Waves," DASA Rept. 3037 (1960).

This document describes the quantitative relationships between nuclear explosions at various altitudes, geographic locations and yields, and the absorbtive and refractive effects produced as a function of time, space, and frequency. Quantitative data are provided for war games and for evaluating communication systems and weapon systems. Many examples are described.

DEINEGA, S. A. See Melamud, A. Ya., et al.

DEN, N., "On Very Low Frequency Amplifiers to Observe the Explosion Seismic Waves and the Weak Seismic Waves" [Japanese with summary in English], Geophys. Notes, V. 7, n. 1 (1954). Reprinted from Zisin, J. Seism. Soc. Japan, Ser. 2, V. 6, n. 2, p. 101 (1953).

DENNISON, A. T. See Roberts, F. A.

DeNOYER, J., "Determination of the Energy in Body and Surface Waves (Part II)," Bull. Seism. Soc. Am., V. 49, n. 1, pp. 1-10 (1959).

Part II of this paper is concerned with the application of the methods for estimating the energy in seismic waves that were presented in Part I. Numerical results for the energy in the various phases of several earthquakes have been obtained.

der AGOBIAN, R., "A Method of Detection of Non-Ionizing Shock Waves and the Use of Radioelectric Waves for Their Study," Acad. Sci. Paris Compt. rend., n. 248, pp. 1308-11 (1959).

The detection of non-ionizing shock waves is made more sensitive by creating on their path an autonomous auxiliary plasma. The modifications produced in a thin cross section of the plasma by passage of the shock wave are studied by radioelectric exploration and optical observation.

DIBBLE, R. R., "Crustal Structure Project: The Seismic Energy and Magnitude of the Explosions," New Zealand Dept. of Sci. and Industry Research Geophys. Memorandum No. 5 (1957).

The seismic energy of the largest explosions for making a seismic refraction profile in Wellington Province was 1 x 10^{14} ergs, the thermal energy 5 x 10^{14} ergs, and the seismic efficiency, therefore, about 0.3%. The seismic energy can be calculated from the instrumental earthquake magnitude of 2.0 by using Gutenberg and Richter's 1954 formula $\log_{10} E = 11 + 1.6 M$.

DICKEY, D. D. See McKeown, F. A.

DIMENT, W. H., STEWART, S. W., and ROLLER, J. C., "Maximum Ground Accelerations Caused by Nuclear Explosions at Distances of 5 to 300 Kilometers," U.S. Geological Survey, Geological Survey Research 1960. Prof. Paper No. 400-B (1960).

Studies of maximum ground accelerations caused by underground explosions in bedded tuff yield the following empirical scaling relation: maximum acceleration (in units of gravity) is equal to approximately 0.6 times the 0.8 power of the yield (in kilotons) divided by the second power of the distance (in kilometers). Explosions in air at heights of 500 and 750 feet cause maximum accelerations roughly 0.1 as large as those in tuff.

DIMENT, W. H. See also Bunker, C. M., et al.; Stewart, S. W., et al.

DIX, C. H., "The Mechanism of Generation of Long Waves from Explosions, Geophys., V. 20, n. 1, pp. 87-103 (1955).

To explain the differentiation of the energy from an underground explosion into high-frequency pulses and low-frequency surface waves it is postulated that low-frequency waves are formed by energy returning to the vicinity of the shot after being reflected from a free surface or a similar reflecting horizon. In an attempt to justify this phenomenon mathematically, the vertical displacement due to a point source in a semi-infinite medium is calculated for points along a vertical line through the source. It is found that the reflected and direct traveling energies combine to produce a long-period displacement.

DOAK, J. B. See Tuve, M. A., et al.

DOBRIN, M. B., "Dispersion in Seismic Waves," Geophys., V. 16, n. 1, pp. 63-80 (1951).

Published theories and observations on dispersion in surface waves from earthquakes and in water-borne waves from shallow-water explosions are summarized nonmathematically. Dispersion similar to that in Rayleigh waves from distant earthquakes has been observed on ground roll from explosions in shot holes. This may be attributed to the low-speed weathered zone. In order of magnitude the ground roll data agree with theoretical curves of Sezawa and Jeffreys for solid layers, and of Press and Ewing for a liquid layer overlaying a solid, but there are certain quantitative differences because of the departure of the weathered layer from both simplifying assumptions.

DOBRIN

DOBRIN, M. B., "Submarine Geology of Bikini Lagoon as Indicated by Dispersion of Water-Borne Explosion Waves," Bull. Geol. Soc. Am., V. 61, n. 10, pp. 1091-1118 (1950).

The normal-mode theory of Pekeris has been applied to water-wave dispersion recorded from the seismic-refraction survey of Bikini Lagoon. Investigations of water waves of 50 cps and higher, in the lagoon within 1-2 miles of reefs, give results compatible with normal-mode predictions for a liquid bottom and with refraction indications. The data show a speed of 1.05 times that of water within 20 feet of the bottom, increasing to 1.3 at a depth of about 40 feet. Results of shots farther from the lagoon edge indicate speeds in the bottom much higher than shown by the refraction data. Dispersion patterns from shots in the central part of the lagoon show a discrepancy with the Pekeris theory that is attributed to a lateral variation in sedimentary composition between the edge and center of the lagoon. The Airy waves give information on the structure of the bottom to a depth of about 400 feet. Their group velocity and frequency are as predicted by the Pekeris theory for a bottom velocity of 6500 fps, which was found in the refraction studies. The fact that the Airy waves agree with the theory and the high-frequency waves do not, for data from shots near the lagoon center, suggests that the lateral change in type of sediment disappears within a depth of 100 feet.

DOBRIN, M. B., "Seismic Prospectings," Can. Oil Gas Indus., V. 12, n. 1, pp. 52-54 (1959).

This is a review of technological progress in seismic exploration for oil from 1949-1959. Dobrin discusses new methods developed to replace shorthole explosions as sources of seismic energy, such as the "thumper," a machine which drops a 3-ton weight on the earth several times a minute to produce signals for the geophone and the continuous mechanical oscillator (still in the experimental stage); the development of multiple channel magnetic tapes for seismic recording; the introduction of various types of record sections, that is, playback equipment with accessories for time correction, making possible presentation of seismic data in continuous cross sections many miles long; the development of the acoustic velocity logger; and the revival of refraction surveying as a result of improvement in recording equipment.

DOBRIN, M. B., et al., "Seismic-Refraction Survey of Bikini Atoll," Bull. Geol. Soc. Am., V. 57, n. 12, pt. 2, p. 1189 (1946).

In connection with the atomic bomb tests of 1946 the Bureau of Ordnance Instrumentation Section and the Oceanographic Section under Joint Task Force I conducted a reconnaissance seismic-refraction survey of Bikini Atoll to determine the subsurface structure. Depth charges were exploded on the bottom along four profiles across the lagoon. The resulting seismic waves were received by hydrophones on the bottom at the ends of the profiles. Distances from shot to hydrophone were determined from the travel time of the sound wave through water.

The time-distance plots indicate two sharp interfaces between three distinct zones having respective wave velocities of 7000, 11,000, and 17,000 fps. The first zone is approximately 2000 feet thick and most likely is composed of calcareous sediments similar to those being deposited at

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the earth phenomena results indicated an energy equivalence less than 1.0 kt of TNT. The earth phenomena were found to be a combination of air-induced and direct-earth effects. Some rough integrations of the horizontal earth accelerations, yielding particle velocities, are presented and discussed. A brief discussion of damage criteria in relation to surface structure is included in the report.

DOLL, E. B., and SALMON, V., "Scaled HE Tests," Stanford Research Inst., Menlo Park, Calif. Report of Project 1(9)-1 of Operation Jangle (1952).

Four high explosive (HE) tests were conducted at the Nevada Proving Ground in order to provide information for scaled predictions for shallow underground and surface nuclear tests. In general, the air blast scaled as predicted in both duration and amplitude. The sharp and highly damped oscillation acceleration due to air blast scaled as did air-blast pressure, but its period increased less rapidly than the scale factor. Particle velocity and permanent displacement did not scale well enough to permit predictions. Air-coupled phenomena were prominent due to the relatively shallow scaled charge depths and appeared to predominate in earth accelerations at large distances. A comparison with Dugway results (for dry clay) from similar tests indicates that the earth-acceleration amplitudes and durations were approximately inverse to each other for the two soils, with Dugway amplitudes considerably less than for the Jangle HE program.

DOMENICO, S. N., "Generation of Seismic Waves by Weight Drops," Geophys., V. 23, n. 4, pp. 665-683 (1958).

A series of experiments designed to evaluate the weight-drop technique was conducted in West Texas. These tests demonstrated the general nature of the seismic waves generated by a weight drop and the effectiveness of compositing drops in providing useful reflection information.

At the first of two test sites discrete waves from single drops consisted of a refracted wave, an air-earth coupled wave, reflected wave segments, and fragmentary waves which were likely dispersive surface waves. A 72-seismometer array provided appreciably more reflected wave segments on records from single drops and also on records from the composite of these drops than did a single seismometer. Additional testing revealed that records prepared from weight drops along three parallel lines 100 feet apart recorded at the same seismometer station are appreciably different. Compositing of the drop lines in general did not provide reflections superior to the best on individual lines.

At the second test site record quality appeared significantly superior to that at the first site. Discrete waves on records from single drops recorded by a 36-seismometer array were of the same types as those observed previously. However, the air-earth coupled wave, prominently developed at the first site, did not appear. Compositing of drops provided two prominent reflections which were correlatable over a 5-mile traverse.

DONN, W. L., EWING, M., PRESS, F., "Performance of Resonant Seismometers," Lamont Geological Laboratory, Tech. Rept. on Seismology No. 36 (1954).

A group of resonant vertical seismometers, each tuned to cover a part of the spectrum of microseism frequencies, was operated for about

one year. These instruments:

(a) Distinguish between simultaneous microseisms from two separate sources,
(b) Show an improved signal-to-noise ratio for microseisms from a single storm,
(c) Show the increase in period of frontal microseisms as cold fronts move seaward from the east coast of North America,
(d) Record only the envelope of the oscillations, which greatly facilitates measurement of intensity as a function of time.

Resonant seismometers appear to be useful tools in attempts at hurricane location by means of microseism amplitude studies.

DORMAN, J., and PRENTISS, D., "Particle Amplitude Profiles for Rayleigh Waves on a Heterogeneous Earth," J. Geophys. Research, V. 65, n. 11, pp. 3805-3816 (1960).

The relationship between vertical and horizontal particle amplitude and depth for Rayleigh waves was obtained for several models of a heterogeneous solid half-space using a new computing program for the IBM 650. The data show how the well-known characteristics of Rayleigh wave motion on a homogeneous half-space are modified in the common case in which a low-velocity region such as the mantle or asthenospheric low-velocity channel exists.

Theoretical particle amplitude profiles and dispersion curves, computed on the basis of bore-hole measurements of compressional and shear velocities made by Dobrin, Simon, and Lawrence, are compared with data on explosion-generated Rayleigh waves of 4 to 8 cps recorded by them in the bore hole. Observed particle trajectories and computed amplitude profiles are in good agreement except in the upper 10 feet, where the very large horizontal amplitudes predicted by theory, particularly for short periods, are not shown in the field observations.

Particle amplitude profiles, based on Gutenberg's model of the mantle, are given for a broad spectrum of mantle Rayleigh wave and long-period crustal Rayleigh wave frequencies. These data show that the heterogeneous character of the mantle cannot be neglected in the problem of crustal Rayleigh wave dispersion. They also show that no "captured waves" or "channeled waves" of unusual character exist in the Rayleigh mode. Instead, particle motion profiles for the heterogeneous earth differ only slightly from the profile for Rayleigh waves on a homogeneous half-space throughout the spectrum of this mode.

DOTY, W. E. N. See Crawford, J. M., et al.

DOWNHILL, B. See Wright, J. K., et al.

DOYLE, H. A., "Seismic Recordings of Atomic Explosions in Australia," Nature, V. 180, n. 4577, pp. 132-134 (1957).

Explosions of atomic weapons at Maralinga, South Australia, in October 1956 were recorded at roughly 2^{o} intervals to a distance of 10.7^{o}. Pn, Pl, Sn and Sl were identified; the velocities were 8.23, 6.12, 4.75, and 3.56 km/sec. Pn and Sn travel times were 6 and 14 seconds earlier than those given in the Jeffreys-Bullen tables for 10^{o}. The thickness of the crust was calculated as 35 km from P-wave data, 40 km from S-wave data.

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DOYLE, H. A., EVERINGHAM, I. B., and HOGAN, T. K., "Seismic Recordings of Large Explosions in Southeastern Australia," Australian J. Phys., V. 12, n. 3, pp. 222-230 (1959).

Three very large quarry explosions of 50-100 tons of high explosives in the Snowy Mountains area, New South Wales, were recorded at distances up to 375 km. The P- and S-wave velocities in the crust for this part of Australia were determined as 6.04 ±0.04, and 3.62 ±0.03 km/sec, respectively. The Pn velocity was found to be 8.03 km/sec (± 0.2 km/sec). Assuming the layer above the Mohorovicic discontinuity to be uniform, crustal thickness is calculated to be 37 km.

DOYLE, H. A. See also Bolt, B. A., et al.

DRAKE, C. L., "Dispersion of Explosive Sound on Georges Bank," Earthquake Notes, V. 26, n. 1, pp. 48-49 (1955).

DUCLAUX, F. See Beaufils, Y., et al.

DuSHANE, G., "Unidentified Seismic Events," Science, V. 129, n. 3344, p. 241 (1959).

An ordinary earthquake sends out compression waves in some directions and waves of rarefaction in others. An artificial earthquake sends out, as the first motion, only compression waves. It is this characteristic difference which permits the identification of an artificial shock. However, at more distant stations, it is possible that the first identifying compression wave will be so swamped by background tremors that seismic stations need to be more closely spaced and better instruments need to be developed in order to differentiate more accurately between natural and artificial shocks.

DUVALL, W. I., "Strain-Wave Shapes in Rock Near Explosions," Geophys., V. 18, n. 2, pp. 310-323 (1953).

The shapes of displacement, velocity, acceleration, and strain-wave pulses in solid elastic media near a spherical cavity in which the applied pressure pulse is of the form $\rho = \rho_0(e^{-\alpha t} - e^{-\beta t})$ have been calculated following the theoretical development by Joseph A. Sharpe. The strain waves were measured by strain gages mounted in solid rock surrounding the charge. The computed strain-wave pulse shapes at various distances from the cavity are compared with experimentally recorded strain-wave pulses. As a result of these comparisons it is concluded that: for short distances between the charge and gage, both theory and observation show the radial strain-wave pulse to be nonoscillatory; the shape of the strain-wave pulse is a function of the rock type, the applied pressure pulse and the distance from the cavity; for distances close to the charge the average theoretical decrease of peak strain with distance is $r^{-1.5}$. Experimentally, the observed decay of peak strain with distance is between $r^{-1.6}$ and $r^{-2.5}$ for different rock types and different explosives; since the shape of the dilatation pulse is independent of distance, that quantity should be measured when considering the absorption properties of the rock.

DUVALL, W. I. See also Blair, B. E.; Obert, L.

DVORAK, A., "The Measurement of Vibrations from Blasting Operations," [summary only, in English] Geofys. Sborn., n. 49, pp. 556-558 (1956).

DYK, K. See Byerly, P. E.

EDGERTON, GERMESHAUSEN AND GRIER, INC., (Staff), "Photographic Analysis of Earth Motion, Shot Rainier, Operation Plumbbob," Lawrence Radiation Laboratory Rept. No. WT-1532 (1958).

This report describes instrumentation and results of photographic coverage of the area in the neighborhood of Surface Zero on the underground shot, Rainier. Only one of the film records was suitable for earth motion analysis.

EHLERS, O. K., PIEPER, F. A., and TIEMANN, A. C., "Detonation of Operation Plumbbob," Report (1960).

Results are reported from a test to determine the percent of high explosive (HE) energy equivalence of the Rainier Shot of Operation Plumbbob. Determination was made by duplicating strong motion measurements of Rainier for a relatively small-scale HE detonation under carefully controlled conditions. The principal strong motion measurements made included acceleration, pressure, and strain. All measurements were made in the free field. In addition, pre- and post-shot, permanent-displacement-measurement surveys were made. A standardized method was developed using HE charges to determine effects to be expected from detonation of deep underground nuclear explosions in media other than that found in the Rainier test area.

ELSON, N., "Ground-Wave Propagation Across a Land/Sea Boundary — 300-m Waves," Nature, V. 163, n. 4159, pp. 114-116 (1949).

ENGLAND, J. L. See Tuve, M. A., et al.

EPINAT'EVA, A. M., "On Certain Types of Seismic Waves," Izvest. Akad. Nauk S.S.S.R. Ser. Geofiz, n. 1, pp. 23-36 (1956).

Theoretical and experimental data are given for the kinematic and dynamic characteristics of multiple reflected and reflecto-refracted waves. The first reflection occurs from the crevice boundary, located above the vibration excitation source. The experimental data agree with theory.

EPINAT'EVA, A. M. "Secondary Pressure-Bubble Pulses in Seismic Exploration [in Russian] ," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 4, pp. 43-60 (1951).

During seismic exploration over water-covered areas quite often an underwater explosion is followed by one or more secondary pulses which greatly complicate seismograms. These pulses occur because the gas bubble formed by the products of explosion expands until the pressure in the bubble drops below that of the surrounding water, and then contracts so that the pressure becomes very high, and a new sound wave is emitted on the subsequent expansion. Numerous experiments have been made to determine conditions necessary to avoid secondary pulses. Shots were produced with different kinds of explosives in amounts ranging from very small charges to more than 100 kg. Experiments were carried out in different reservoirs to test the influence of various boundary conditions. The depth of explosions ranged from 1 to 15 meters. Records of the explosion and secondary pulses were made by multichannel seismographs

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placed at different distances from the shot point. Experiments will be continued, but the following preliminary findings are presented: the ratio of the secondary amplitude, A_2, to that of the first, A_1, may be greater than one, for small charges of less than 300 grams, and may sometimes be as high as 3.3; with charges greater than 1 kg, A_2/A_1 is usually less than one, decreasing with every following pulse; secondary pulses are improbable when $Q=(h+30)/38 \times h^3$, Q being the amount of explosive in kilograms and h the depth of the shot.

EVERINGHAM, I. B. See Doyle, H. A., et al.

EWING, C. E., "Research and Development in the Field of Geodetic Science," Air Force Cambridge Research Laboratories Rept. No. TN-60-435, Air Force Surveys in Geophysics No. 124 (1960).

This report briefly surveys significant research and development activities in geodesy, namely, arc measurements, electronic surveying, eclipses and occultations, moon camera, satellites, and gravity measurements.

EWING, M., MUELLER, S., LANDISMAN, M., and SATO, Y., "Transient Analysis of Earthquake and Explosion Arrivals," Geofis. pura e appl., V. 44, pp. 83-118 (1959).

An electronic sound spectrograph has been used to analyze the transients in complicated earthquake and explosion signals. By this method, the group velocity at each of the spectral frequencies for each of the separate arrival branches can be obtained directly for any type of transient signal. In contrast to frequency analysis, it presents the fine spectral structure of the signal as it changes with time, not an average over a time that includes many parts of the signal.

Dispersion and body-wave spectrums of the P-wave have been observed by transient analysis, and possibly dispersion has been observed also in the S-wave and various multiple-reflected S-waves; the latter increase in period from one arrival to the next. The dispersed pattern of arrival of fundamental and higher mode surface waves has been observed for oceanic, continental, and mixed paths, and among these signals there is a clear indication of the second continental shear mode. The separation of surface waves for direct and complementary paths has also been achieved. Results compare well with those obtained by standard techniques.

The dispersion of the fundamental and higher mode signals from explosive sources in shallow water may easily be studied by means of sound spectrograms and amplitude sections. Bubble pulses and Airy phases are clearly defined on the spectrograms and sections of such shots.

EWING, M. See also Benioff, H., et al.; Donn, W. L., et al.; Oliver, J. (2); Press F. (3); Sato, Y., et al.

FINKELSTEIN, R., "The Normal Reflectance of a Shock Wave," U.S. Navy Dept., Bur. Ordnance, Explosives Research Rept. No. 6 (1944). (Library of Congress OTSPB Rept. 37077.)

The normal reflection of a shock wave from a rigid surface is studied in the light of the fact that when a structure is subjected to a shock the

resulting damage depends upon the duration of the blow and the initial pressure due to it. An analytical method is used to find pressure-time curves at a reflecting surface in air and in water. The pressure-time curves, obtained at a wall are described by their characteristics of peak pressure, curvature, and duration. It is found that in typical fluids the correct theoretical pressure-time curves for a wall are concave upward more strongly than their acoustic approximations. However, gases and water are found to behave differently. In gases the blow is prolonged, and the impulse delivered to a rigid wall exceeds the value predicted by acoustic theory. In water the blow is shorter, and the impulse is less than would be expected from acoustic approximation. The pressure-time curves obtained are given.

FINOS, S., and BARNES, D., "Blanca—a Study of the Maximum Vertical Earth Motion of the Mesa Slope," Technical Memorandum, Edgerton, Germeshausen and Grier, Inc., Las Vegas, Nev. (1960).

Blanca, a 23-kt device, was detonated October 30, 1958, in a tunnel in Area 12 of the Nevada Test Site. The point of detonation was a vertical depth of 988 feet; the nearest point to the surface of the mesa slope was 835 feet. First apparent earth motion appeared ~ 3.6 seconds after zero time; the maximum earth upheaval was reached ~ 5.5 seconds after zero. Approximately 15.9 seconds after zero, an earth rupture occurred on the mesa slope.

FISH, B. G., "Fundamental Considerations of Seismic Vibrations from Blasting," Mine & Quarry Eng., V. 17, n. 4, pp. 111-114 (1951).

This first article of a series reviews the generation and measurement of vibrations from blasting and practical problems arising therefrom in mining and quarrying operations. Morris's equation $A=k\sqrt{E}/d$ (where A is the maximum amplitude in inches, E the weight of explosive in pounds, d the distance in feet, and k a constant) has been found to give reasonably consistent results. Values of k vary from one site to another, but fall between 25 and 400, chiefly between 50 and 150.

FISH, B. G., "Fundamental Considerations of Seismic Vibrations from Blasting," Mine & Quarry Eng., V. 17, n. 4, pp. 111-114 (1951).

FISH, B. G., "Seismic Vibrations from Blasting. Reduction by Means of Short Delay Initiation," Mine & Quarry Eng., V. 17, n. 6, pp. 189-192 (1951).

Experiments have demonstrated the success of short-period-delay blasts, initiated by detonators and sequence switches, in reducing vibrations. By deriving an equivalent weight ratio (the ratio between the weight of charge fired instantaneously and the weight fired on each individual delay in a series producing the same maximum amplitude) an empirical rule was established that two-thirds of an instantaneous charge can be fired on each delay.

FISH, H. S. See Lambert, A. P. R., et al.

FITZPATRICK, R. C. See Willis, D. E., et al.

FLANDERS, P. L., and SAUER, F. M., "A Glossary of Geoplosics: The Systematic Study of Explosion Effects in the Earth," AD 247991, Stanford Research Institute, Report on Project No. 1080 (1960).

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This glossary contains terms reflecting all aspects of ground motion. It is meant to be of use to those involved in design of underground protective construction, in earth moving, and in the analysis of nuclear weapons phenomena.

FLANDERS, P. L. See also Adams, W. M., et al.

FLINN, E. A., "Local Earthquake Location with an Electronic Computer," Bull. Seism. Soc. Am., V. 50, n. 3, pp. 467-470 (1960).

A straightforward least-squares iterative procedure for locating local earthquakes now in use at the Australian National University is described. An IBM 650 electronic computer is used for all calculations, including estimates of the probability error of epicentral coordinates, depth of focus, and origin time.

Local earthquakes registered by the 9-station network of southeastern New South Wales which meet the following conditions can be treated by this procedure: (1) epicenters are close to at least 3 of the stations, to the degree that first arrivals in the P and S groups are the direct waves Pg and Sg; and (2) at least 6 first arrival times are observed.

FOOSE, R. M., and HOY, R. B., "Air and Ground Inspection Techniques for the Detection of Underground Explosive Tests," Stanford Research Institute, Menlo Park, Calif., and Office of Naval Research, Washington, D. C. Preliminary Rept. of Project 26.14 of Operation Hardtack II (1959).

Aerial-photographic, surface, and underground investigations were made before and after selected test shots during Operation Hardtack to assist in defining appropriate and effective procedures for the location of clandestine underground nuclear explosions. Results of six underground explosions are evaluated. Data and photographs are presented. Reconnaissance photography at a scale of 1:20,000 with 60% endlap and 40% endlap, proved highly satisfactory for regional information of gross patterns and accessibility. Detailed aerial photography proved invaluable as a basis for rapid mapping of detailed fracture patterns or other significant terrain features. Surface and underground inspection methods were less satisfactory.

FOOSE, R. M., et al., "Manual of On-Site Inspection of Unidentified Seismic Events," Stanford Research Inst., Menlo Park, Calif. Report on Contract No. AF 49(638)-954.

This report may be considered as an operational manual for implementing the techniques proposed in the syllabus for inspection and exploration of the site of an unidentified seismic event detected by a teleseismic network.

FOOSE, R. M., et al., "Syllabus of On-Site Inspection of Unidentified Seismic Events," Stanford Research Inst., Menlo Park, Calif. Report on Contract No. AF 49(638)-954.

This syllabus discusses and evaluates all observational and measurement techniques that may be applicable to the inspection of sites of unidentified seismic events. It also specifies promising lines of research that may improve or provide a better evaluation of the techniques.

FORTIN, J. P. See Rinehart, J. S.

FORTSCH, O., "Analyse der seismischen Registrierungen der Grossoprengung bei Haslach im Schwarzwald am 28 April 1948 [Analysis of the Seismograms of the Great Explosion at Haslach in the Black Forest on April 28, 1948]," Geol. Jahrb., Band 66, pp. 65-80 (1951).

Detailed study of the records has shown a great number of onsets of different waves. Among these are second onsets of longitudinal and transverse waves following first arrivals by a definite time interval. Four layers have been determined from the observations: granite, in which the velocities of longitudinal, transverse, and Rayleigh waves are 5.88, 3.39, and 3.09 km/sec; diorite, in which the velocities are 6.005, 3.47, and 3.20 km/sec; gabbro, in which the velocities are 6.55, 3.78, and 3.39 km/sec; and peridotite, in which the velocities are 8.34, 4.82, and 4.31 km/sec. A cross section of the earth's crust between Haslach and Fussen, based on seismic, gravimetric, and magnetic measurements, is included.

FORTSCH, O., "Beitrage, zur Ausbreitung elastischer Oberflachenwellen [Contribution to the Problem of the Propagation of Surface Waves]," Z. Geophys., Sonderband, pp. 59-67 (1953).

Experiments were made on the aviation field at Gottingen, Germany, with vibrations produced in the ground by a vibrating machine and by an explosion. Harmonic analysis of the seismograms indicates that the vibrations are identical. The observed waves were special Rayleigh waves confined to the upper layer. In a homogeneous medium the lower boundary of this layer remains perfectly rigid; in a stratified medium Rayleigh waves appear in pairs, the dispersion curve being also composed of two branches.

Observations of absorption and damping led to the conclusion that in the propagation of elastic waves the same proportional share of energy is absorbed per group wave length (group velocity/frequency). Also it can be readily seen that this loss of energy is caused by sliding friction.

FORTSCH, O. See also Reich, H.; Reich, H., et al.

FOWLER, C. M., GARN, W. B., and CAIRD, R. S., "Production of Very High Magnetic Fields by Implosion," J. Appl. Phys. V. 31, pp. 588-594 (1960).

Magnetic fields are produced in the 10 to 15 megagauss range by use of high explosives which compress the flux obtained from initial fields of approximately a hundred thousand gauss. The fields described here occupy a cylindrical volume and are essentially axial. A typical field might have these general characteristics: peak field, 14 megagauss; 2-μsec duration from 10 to 14 megagauss; field volume around peak, 6 mm diameter, 50 mm estimated length.

FRANK, W. J., ed., "Plowshare Series: Part I. Phenomenology of Underground Nuclear Explosions," Univ. of Calif., Livermore. UCRL Rept. No. 5675 (1959).

This report contains the proceedings of the Second Plowshare Symposium, May 13-15, 1959, San Francisco, California. The Plowshare

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Symposium discussed:
(1) Past underground explosions.
(2) Current theories on phenomena produced in underground explosions.
(3) The extrapolation of these facts and theories to excavation and power-recovery projects planned for the near future.
(4) Some thoughts on industrial and scientific applications envisioned somewhat farther in the future.

The first volume contains the complete text of the first day's talks, which were concerned with the underground nuclear explosions in Nevada in 1957 and 1958.

GAITHER, V., "Index of Wells Shot for Velocity [Eighth Supplement]," Geophys., V. 24, n. 5, pp. 944-955 (1959).

Information is tabulated on 516 well-velocity surveys not reported in previous indexes. Most of the wells listed were shot between September 1958 and September 1959. Corrections and/or additional information on 17 previously listed surveys are also given.

GAITHER, V., "Index of Wells Shot for Velocity (Ninth Supplement)," Geophys., V. 25, n. 6, pp. 1251-1259 (1960).

Information is tabulated on 340 well velocity surveys not reported in previous indexes. Corrections and/or additional information on 5 previously listed surveys are also given.

GALFI, J., GELLERT, F., and SEDY, L., "Development of Pressure Wave by Air Explosion," Geofiz. Kozl. V. 4, n. 2, pp. 41-44 (1955).

A method for the study of pressure ratios developed by freely-exploding explosives, using a photographic procedure adapted from seismic experiments, is described.

GALFI, J., and LIPTAY, I., "Pressure Gauge for Seismic Investigation Purposes" [in Hungarian with English Summary], Geofiz. Kozl. V. 3, pp. 143-156 (1954).

GAMBURTSEV, G. A., Osnovy seysmorazvedki [The Principles of Seismic Exploration], Gostoptekhizdat, Moscow (1959).

This is the second edition of Gamburtsev's "Seismic methods of exploration" which appeared in two volumes in 1937 and 1938. This noted book was written as a handbook for students of geophysics and practicing geophysicists. It contained 16 chapters covering the theory of seismographs of different types, and of amplifiers, transducers, filters, and recording apparatus; discussion on the basis of geometric optics of the propagation of various seismic waves when undergoing reflection or refraction on plane and curved boundaries; different questions of the interpretation of travel time curves of direct, reflected, and refracted waves; and other problems of seismic exploration. Characteristic of the book is the great number of pages devoted to the discussion of electromechanical analogs and of the application of this theory to the construction of seismographs and to the interpretation of seismograms.

In the present edition, the entire material of the first edition is preserved and the value of the book substantially increased by the inclusion of some 15 articles written in recent years by Gamburtsev, or by Gam-

burtsev in collaboration with his colleagues at the Institute of Earth Physics, on different questions of the theory of instruments used in seismic exploration and on some new methods of exploration such as deep seismic sounding, high frequency seismic exploration, and several other important additions.

GAMBURTSEV, G. A., "Glubinnoe seysmicheskoye zondironvaniye zemnoy kory [Deep Seismic Sounding of the Crust of the Earth]," Trudy Inst. Geofiz. Akad. Naut., S.S.S.R., V. 25, n. 152, pp. 123-133 (1954).

In seismological investigations using large explosions in 1949-50 in northern Tien Shan, in Central Asia, it was possible to determine the geologic structure to a depth of about 40 km by distributing geophones over a distance of about 300 km. Seismographs with lower frequency (about 10 cps), and higher amplification than usual were installed in groups to check extraneous noises. The best results were obtained by placing explosives on the bottom of the lake Issyk-Kul or Kara-Kul, at depths of about 25 meters. Two seismic waves were established, one with the velocity of the propagation of 8.0 km/sec, the other 6.5 km/sec.

GAMBURTSEV, G. A., "The Development of Experimental Seismology in the Soviet Union" [in Russian], Izvest. Akad. Nauk S.S.S.R., Ser. Geog. i Geofiz., V. 11, n. 5, pp. 409-414 (1947).

Experimental seismology is defined as that branch of seismology which operates with artifically created seismic waves. The most important phases of the evolution of experimental seismology in Soviet Russia during the last 30 years are outlined, with attention given both to studies of seismic waves and to development of seismic methods of exploration in geology and in prospecting for minerals. A detailed description of the use of reflected waves in seismic exploration is given. A recent improvement is the "correlation method of refracted waves" introduced by the Institute of Theoretical Geophysics of the Russian Academy of Sciences. This sensitive method makes possible the exploration of stratified or inhomogeneous media as well as the sounding of very deep ground.

Mention is made of improvements in the technique of measurements, introduction of multichannel registration of incoming waves, accurate filtering of troublesome phases, and precise time-interval measurements (up to 1/1,000 of a second) between individual events.

The author reports that geophysical exploration had not been stopped by the war but became more intensive in eastern regions of the Soviet Union.

GANE, P. G., "Seismic Results from the Explosion at Thabazimbi on the 27th August, 1949," Geophysical Research Institute, University of Witwatersrand, Johannesburg, mimeographed paper (1949).

GANNON, W. F., "Close-In Ground Measurements," Sandia Corp., Albuquerque, N. Mex. Report of Project 1.2b of Operation Jangle (1952).

The rate of progression of the underground wave, rate of expansion of the fireball, and the point of breakaway of the shock front from the fireball were determined for the Jangle Underground Burst. The two methods which were used were the normally closed thyratron switch and

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the normally open thyratron switch. The results of the close-in ground measurements showed that, for the first few feet, there was a very large expansion with a velocity of the order of 10^5 fps. From 25 to 100 feet, the velocity was 2700 fps. During the second hundred feet, the average velocity was reduced to 2500 fps. Beyond 200 feet, the velocity increased to more than 4000 fps. The tests have definitely proved that the velocity of a shock wave traveling through the earth can be measured by using a closed-diaphram switch in conjunction with a thyratron-pulsing circuit. The electronic chronograph which was used is subject to improvement.

GARLAND, G. D., ed., Canadian Geophysical Bulletin, Staff, Canadian Geophysical Bulletin, Vol. 12 (1959).

This volume contains reports of activities by Canadian scientists during 1959 and includes bibliographies for each of six major fields of geophysics; geodesy (including gravity), seismology and physics of the earth's interior, meteorology, hydrology, geomagnetism and aeronomy, and and oceanography and glaciology. The names of subcommittee chairmen who compiled most of the material in these fields are given at the beginning of each section.

GARN, W. B. See Fowler, C. M., et al.

GASKELL, T. E., "The Relation Between Size of Charge and Amplitude of Refracted Wave," Geophys. Prosp., V. 4, n. 2, pp. 185-193 (1956).

Experiments carried out using charges of up to 200 lb at a distance of about 20,000 feet from the geophones suggest that the amplitude of the refracted wave ground motion is roughly proportional to the weight of a charge. Simple energy considerations lead one to expect a relation of a form in which velocity amplitude is in proportion to W.

An explanation of the observed relation may be based on a theory according to which the efficiency of the explosion increases with the source size, that is the distance from the source at which the pressure wave of the explosion ceases to cause permanent deformation of the surrounding medium.

The above theory was further confirmed by measurements of the radius of the cavity produced by explosions of charges of different size in clay. Also, explosion of charges in artificial water-filled cavities were found to give seismic wave amplitudes three or four times greater than those produced by the same charge in a narrow hole. It is possible that these observations explain in part why the charges required in marine refraction experiments are very much smaller than those needed in refraction work on land, but additional reasons for this difference are also discussed.

GELLERT, F. See Galfi, J., et al.

GENESLAY, R., LABROUSTE, Y., and ROTHE, J.-P., "Reflexions a grande profondeur dans les grosses explosions (Champagne, octobre 1952) [Deep Reflections in Large Explosions (Champagne, October 1952)] ,' Bur. cen. seism. Intnat'l. Pubp., ser. A, Travaux sci., n. 19, pp. 331-334 (1956).

Records obtained by the Companie Générale de Géophysique from the Champagne, France, explosions in October 1952 have been interpreted,

with a particular view to verifying the existence of deep reflections. Three groups of reflected waves are recognized, one corresponding to reflections from boundaries within or at the base of the sediments, a second group representing multiple reflections in the sedimentary layers, and finally a group of deep reflections. For the first of the deep reflections, only the order of magnitude of velocity (4.5 km/sec) and depth (about 5000 meters) can be determined. For the next four reflections a depth of 8 to 11 km is estimated, assuming a velocity of 6.00 km/sec; this could be the top of the basalt layer. The principal train of reflections, at 10 seconds, probably corresponds to the Mohorovicic discontinuity; assuming a mean velocity of 7 km/sec for the lower part of the crust, its depth is about 30 km.

GENESLAY, R. See also Beaufils, Y., et al.

THE GEOPHYSICAL DIRECTORY, 15th ed., Houston, Texas (1960).

This directory, published annually, is intended to be a comprehensive, listing of all companies and individuals directly connected with, or engaged in, the geophysical exploration for petroleum. Information is included on the following: automotive equipment, boats, bulldozer service, core drilling contractors, core hole logging service, drilling bits, drilling rig builders (geophysical), electrical contractors, explosives, geophysical consultants, geophysical education, geophysical instruments, geophysical societies, geophysical supplies — miscellaneous field supplies, gravity meter contractors, helicopters, insurance, magnetometer contractors, marsh buggies, oil companies and individuals who have used geophysics during period 1942-1960 — domestic and foreign, personnel list, photographic supplies, radio and electrical supplies, radioactive surveys, reproduction service, seismograph contractors, shot hole casing, shot hole drilling contractors, soil analysis contractors, surveying crew contractors, torsion balance contractors and velocity data.

GEOTECHNICAL CORPORATION (Staff), "Wichita Mountains Seismological Observatory," Special Rept. of the Geotechnical Corporation (1960).

The Wichita Mountains Seismological Laboratory is equipped with the instrumentation recommended in 1958 by the Conference of Experts for detecting violations of a possible agreement on the suspension of nuclear tests. This report describes the observatory layout and equipment. The appendix lists recommended seismic apparatus for a control post.

GEOTECHNICAL CORPORATION (Staff), "Seismological Tests at Universities," The Geotechnical Corporation. Technical Rept. No. 60-10 (1960).

Seismic measurements were made at twelve universities to obtain data on which to base the selection of the period of the galvanometer for the short-period seismographs which are intended for use in seismological stations throughout the world. Instrumentation is described and extensive data logs are presented. On the basis of the tests, a galvanometer with a period of 0.75 second was recommended.

GEOTECHNICAL CORPORATION (Staff), "Wichita Mountains Seismological Observatory Report on Phase I," The Geotechnical Corporation. Special Rept. (1960).

This is a report issued on the results of the operation and maintenance of the Wichita Mountains Seismological Observatory operated by the Geo-

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technical Corporation of Garland, Texas, at Fort Sill, Oklahoma. This is the only station in the world whose instruments exhibit all of the characteristics recommended in 1958 by the Geneva Conference of Experts to study the methods of detecting violations of a possible agreement on the Suspension of Nuclear Tests. This report contains information on the location and layout of the observatory, and specification and performance characteristics of various instruments and instrument systems.

GEOTECHNICAL CORPORATION (Staff), "Wichita Mountains Seismological Observatory. Report on Phase II," The Geotechnical Corporation. Special Rept. (1960).

This report is an addition to the reports on Phase I, and contains evaluations of the various instruments and instrument systems in use at the observatory.

GERRARD, J., "Data-Processing Requirements," U.S. Dept. of State Rept. of Panel on Seismic Improvement, Appendix 16 (1959).

This report discusses anticipated problems, possible procedures, and areas in which study and development will be required in establishing an advanced data-processing system to accompany the suggested Geneva seismic network.

Speedy performance of calculations will require automatic data-processing equipment, and special-purpose machines optimized for this task should be designed. A technical program is suggested and a preliminary estimate of cost and personnel presented.

GERRARD, J., "Program to Establish a Complete Experimental Seismic Station for the Evaluation of Network Instruments and Methods," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 17 (1959).

A complete, experimental seismic station is suggested as a single major unit in the expanded Geneva network. The station would provide a facility for field evaluation of the instrumentation and methods suggested by the proposed research program. Some of the problems to be worked out at this experimental station are itemized, and phases for the establishment of the station are listed.

GERRARD, J., "Research Computing Facilities and a Digital Library of Seismograms," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 19 (1959).

The establishment of a computing center to assist in study and analysis of seismic records is proposed. Facilities which should be available at the center are listed and a preliminary budget is presented.

GERRARD, J., " 'Throw-Away' or Portable Seismic Probes for Operation on Land," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 14 (1959).

Simple "throw-away" or portable seismic units, which can be placed immediately and in quantity over a suspicious area, afford an effective means of supplying valuable information concerning aftershocks to the fixed seismic network. These units may furnish relatively detailed information on first-break patterns in any region where seismic activity is

high. Analog data transmission and visual monitoring of results will be adequate. These probes could be placed on the ground manually or dropped from the air and would be particularly useful in detecting the nature of a shock in regions where aftershock activity is high. The following factors which might affect the feasibility of obtaining useful data from the units are discussed: environmental factors affecting seismic unit performance at the site, optimum placement and monitoring of units, and data interpretation. The seismic equipment to be employed and the method of data processing within the unit are also discussed.

GERRARD, J., "Unattended Auxiliary Seismic Stations," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 3 (1959).

Simplified, unattended auxiliary seismic units within the network of manned stations specified at the Geneva Conference are recommended for use to insure a sufficient signal-to-noise ratio at the manned control posts and to obtain comprehensive information on first-motion patterns caused by an event. The seismic stations will be arrayed to receive the incoming wave train associated with the P-wave.

GERRARD, J., "Use of Multiple Arrays in Seismic Detection," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 15 (1959).

An increase in the effective signal-to-noise ratio can be realized by sampling the ground motion over a fixed area with an increased number of seismometers placed in suitable array pattern. Enhancement for a given increase in number of sampling sites for a given incoming wave will depend upon the selection of the site pattern, the manner in which data recombines, and the numerical operations performed on the raw and combined data. These factors will vary from shock to shock and from station to station. The selection of array patterns will be dependent upon the digital computer capabilities.

GERSHANIK, S., "Improvements on the Estimate of Seismic Charges," Ann. geofis., V. 8, n. 2, pp. 181-188 (1955).

GIBSON, F. C. See Zabetakis, M.

GILFILLAN, E. S. See Schorr, M. G.

GLASS, M. See Polatty, J. M., et al.

GOECKERMANN, R. H., "The Disposition of Radioactivity," U. of Calif., Livermore. Lawrence Radiation Laboratory Report.

Radiochemical analyses were made on samples obtained from underground explosions of 0.07- to 19-kt yield range in tuff at the NTS during 1957 to 1958. The sampling included rock cores and assorted samples of the vented material from totally- or partially-contained explosions. The radionuclides studied included tracer activities, fission products, and induced activities of observable half-life.

GOECKERMANN, R. H. See also Shelton, A. V., et al.

GOLENETSKIY, S. I., "Ob opredelenii nachalnoy ordinaty i sposobe pos troyeniya epitsentraeley pri leneynom godografe [On the Determination of the Initial Ordinate and the Method of Plotting Epicenters with a Linear Travel Time Curve]," Trudy Inst. Seys. Akad. Nauk Tadzhik, S.S.S.R., V. 71, n. 2, pp. 29-37 (1957).

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On the assumption of a linear travel time curve of diffracted waves, a method of determination of the initial ordinate is proposed that does not depend on the epicenter. A nomogram is described that is efficient for use in analyzing observations by the method of epicenters.

GOODE, T. B. See Polatty, J. M., et al.

GOODICKE, T. R., "Some Geological Results of Underwater Sound Measurements in the Bahamas," U. of Miami Marine Laboratory, Coral Gables, Fla. Report No. 60-3 on Contract Nonr-84001 (1960).

A series of underwater sound transmission experiments were carried out in the Tongue of the Ocean, Bahamas. A vertical hydrophone array extending from the surface to 600 feet was used to pick up direct sound waves and echoes from 4 1/2-pound TNT charges detonated at different depths. The sound impulses were recorded on magnetic tape, the impulses from the different hydrophones being recorded simultaneously on different tracks. The distance from the shot points to the hydrophone array varied from 520 to 840 yards. A total of 60 shots were recorded at depths varying from 50 to 4,000 feet. These shots were made at 6 stations, spaced at intervals of 5 naut. miles along 3 traverses across the Tongue of the Ocean. All of the records showed sub-bottom echoes. The deepest reflections observed showed arrival times of over 1 second from the time of the sea-floor echo. This indicates a sedimentary section to an approximate depth of 10 to 12,000 feet beneath the Tongue of the Ocean.

GOODIER, J. N., The Mathematical Theory of Elasticity in Elasticity and Plasticity, Wiley, New York (1958).

Goodier reviews the mathematical research on advanced problems in elasticity for the last 10 years; no elementary theory is discussed. Particular emphasis is given to the work of the Russian applied mathematicians; several books have been published by the Russians and a number of their problems are discussed. Selected aspects of the following advanced topics are reviewed: stress concentrations around holes of various shapes, stresses developed in punching, thermal stresses, and wave propagation and diffraction.

A comprehensive bibliography covers the literature of all countries.

GORANSON, R. W. See Tuve, M. A., et al. (2).

GREEN, J. B., "Proceedings of the Army-ORO Conference on Basic and Applied Research and Component Development, June 23-July 2, 1958, Volume III. Papers 17, 22, 28 and 29," Johns Hopkins University, Bethesda, Md. (1958).

Geophysics and the underground atomic tests, communications, and electronics are discussed in connection with a program to outline the long-range research programs of the U.S. Army.

GREIG, J. W. See Tuve, M. A., et al. (2).

GRIGGS, D. T., and PRESS, F., "The Use of Seismic Signals from Nuclear Explosions," U. of Calif., Los Angeles, and Calif. Inst. of Technology, Pasadena. Report.

The location and time of each shot in the Castle Series were determined in Australia by means of earthquake seismology. This series of shots added to knowledge of propagation of seismic waves through the earth and provided information indicating that the earth's inner core has a radius from the center of 1500 km, the outer core boundary is at 3500 km, and the surface is at 6500 km. Other significant seismic observations from nuclear detonations are discussed.

GRIGGS, D. T., and PRESS, F., "Probing the Earth with Nuclear Explosions," J. Geophys. Research, V. 66, n. 1, pp. 237-258 (1961).

Progress in seismology is reviewed with emphasis on the usefulness of past nuclear weapon tests in determining the internal structure of the earth. Shot times and locations are tabulated for 169 U.S. atomic explosions, with seismic data from Pasadena. The advantages of using large chemical explosions and future nuclear explosions detonated under the Plowshare program as controlled energy sources for carefully instrumented seismological experiments are discussed. Finally, an international program of explosions for seismological research is proposed, and specific suggestions are made for attacking several outstanding problems in seismology by means of chemical and clean nuclear explosions and the instrumentation network proposed at Geneva for nuclear test detection. Deep-oceanic seismometer lines are proposed as a means for making important improvements in seismic knowledge of the world and possible improvements in the detection of atomic explosions.

GRIGGS, D. T., and TELLER, E., "Deep Underground Test Shots," Report on Contract W-7405-eng-48 (1956).

This note considers the feasibility of conducting kt-weapons tests in underground holes of such depth that the explosion will be effectively contained. Such tests would allow greater freedom in a test program by freeing the detonation of the devices from weather constraints and permitting tests at any time at which a test object is ready without the problem of fitting the bomb into a test series. Costs, advantages, and disadvantages are compared with tower shots. A trial test shot, to be included in the next Nevada test series, is recommended.

GRIGGS, D. T. See also Press, F.

GROSSLING, B. F., "Seismic Waves from the Underground Atomic Explosion in Nevada," Bull. Seism. Soc. Am., V. 49, n. 1, pp. 11-32 (1959).

Seismic waves from the underground atomic explosion of Sept. 19, 1957, were recorded for 45 minutes on multichannel magnetic tape at a point 25 miles north of Holbrook, Ariz., about 370 miles from their source. Twelve vertical-component seismometers were laid out in the form of an L, 5280 feet by 1600 feet to permit determinations of apparent velocity and of direction of arrival. The frequency range recorded, about 6 to 40 cps, was higher than usual in earthquake seismology. During tape playback, supplementary filtering, gain adjustments, and changes in time scale served to improve the quality and legibility of the records.

The playback seismograms reveal strikingly well not only the Pn and P* waves transmitted and refracted by the crust, but also many

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others. Some of these, as clearly indicated by their directions of arrival, did not originate from the explosion. We have attempted only an elementary interpretation, our main purpose being to make the data available to anyone who might be interested in them. The relatively short wave lengths of the recorded events may make them of unusual significance. In addition to arrival times, we made a few measurements of absolute amplitude and of frequency spectra.

GUIDO, R. S., and WARNER, S. E., "Project Cowboy — Physical Properties of Salt Samples," U. of Calif., Livermore, Lawrence Radiation Laboratories. UCRL Rept. No. 6069 (1960).

Tests were performed to determine physical properties of the halite in which Project Cowboy (Winnfield, Louisiana) events were performed. The technique of collecting and preparing the samples is outlined. The following properties were determined:

Bulk density - 2.163 g/cm^3
Grain density - 2.191 g/cm^3
Porosity - 1.28%
Poisson's ratio - 0.36
Modulus of elasticity 1.36 x 10^6 psi

Dilatational velocity (Vp) - 10,300 to 13,900 fps, average ca. 12,500 fps.
Shear velocity (Vs) - 6710 to 7410 fps, average ca. 7140 fps.

Compressibility:	Jacketed	Unjacketed
0 psi	1.71 x 10^{-6}	1.39 x 10^{-6}
10^{-4} psi	constant: 0.22 x 10^{-6}	

Chemical analysis:
NaCl 94-96% by weight
$CaSo_4$ 4-5%

GUIDO, R. S., and WARNER, S. E., "Densities and Velocities Measured on Specimens from Instruments and Shot-Holes," U. of Calif., Livermore, Lawrence Radiation Laboratories. Report of Project Hobo on Contract W-7405-eng-48 (1960).

Results are given for bulk-density and pulse-velocity measurements performed on specimens of the Project Hobo medium. Test techniques, sample handling, and specimen preparation are described. Values are tabulated in terms of sample origin and geological identity.

GUTENBERG, B., "Interpretation of Records Obtained from the New Mexico Atomic Bomb Test, July 16, 1945," Bull. Seism. Soc. Am., V. 36, n. 4, pp. 327-330 (1946).

The ground and air waves produced by the New Mexico atomic bomb test were studied on the basis of records from 10 seismological stations situated at distances of 437 to 1136 kilometers from the explosion. The data obtained furnished information on the Pn, P, and S ground waves and on several distinct groups of sound waves; in the calculations, the time of explosion was known, with ±15 seconds. The results showed that the apparent velocity of Pn practically coincided with the value of 8.06 km/sec determined for southern California earthquakes; the origin time calculated from 2:05 to 5:11 min: sec, corresponding to those of SySy, Sy, or $\overline{S}$ in earthquakes. No unusual waves were apparent. Some results on sound waves also are given.

GUTENBERG, B., "Waves from Blasts Recorded in Southern California," Trans. Am. Geophys. Union, V. 33, n. 3, pp. 427-431 (1952).

GUTENBERG, B., "Bibliography on Microseisms," 1st edition, Calif. Inst. of Technology. CIT Technical Rept. No. 2 on AF 19(122)436 (1956).

This is a bibliography of information on microseisms of papers at the Pasadena Seismological Laboratory, and of references and abstracts contained in periodicals or bibliographical summaries. The author, title, source, originating agency, number of pages, and year of publication are given. In some instances an abstract of the article is included. Three-hundred-twenty-one articles are cited.

GUTENBERG, B., "Travel Times from Blasts in Southern California," Bull. Seism. Soc. Am., V. 41, n. 1, pp. 5-12 (1951).

Analysis of seismograms of a 70-ton blast at Corona recorded at the Pasadena group and the Lake Mead stations indicate a velocity of between 5.7 and 6.0 km/sec in the upper 6 km. At a depth of 10 km the velocity is about 6 1/2 km/sec, and below the Mohorovicic discontinuity at about 40 km, the velocity is 8.1 to 8.2 km/sec. S-wave amplitudes are much smaller than those in earthquakes with comparable P-waves. A velocity of about 3 3/4 km/sec is indicated for a depth of about 10 km.

GUTENBERG, B., and ANDREWS, F., "Bibliography on Microseisms," 2nd edition, Calif. Inst. of Technology. CIT Scientific Rept. No. 2 on AF 19 (122)436 (1956).

This is a revised and enlarged edition of the Bibliography on Microseisms. Over 600 articles on microseisms are cited.

GUTENBERG, B., and RICHTER, C. F., "Seismic Waves from Atomic Bomb Tests," Trans. Am. Geophys. Union, V. 27, n. 6, pp. 776 (1946).

The seismograms of the atomic bomb tests at Bikini on July 24, 1946, showed only longitudinal waves P. No transverse waves or surface waves were detected. The results for the eight stations employed are tabulated with brief remarks. Rough calculation of travel times confirms the previous results for the New Mexico test of 1945.

GUTENBERG, B., and RICHTER, C. F., Seismicity of the Earth and Associated Phenomena. Princeton Univ. Press, Princeton (1954).

A review by Fritz Gassman appears in Science, V. 121, n. 3146, p. 562 (1955).

HABBERJAM, G. M., and WHETTON, J. T., "On the Relationship Between Seismic Amplitude and Charge of Explosive Fired in Routine Blasting Operations," Geophys., V. 17, n. 1, pp. 116-128 (1952).

Experimental investigations of the relationship between seismic amplitude and size of charge were made in a quarry near Leeds. With the seismograph set in one position, a series of blasts at distances of 300 to 400 feet were recorded, and the variation of amplitude of an individual peak observed. A relationship between first peak amplitude and charge is given by $C = QA$ where Q varied between 1.26 and 3.16 and apparently depends on blasting conditions.

HAFE, J. E., and BRUNE, J. N., "Observations of Phase Velocity for Rayleigh Waves in the Period Range 100-400 Seconds," Bull. Seism. Soc. Am., V. 50, n. 3, pp. 427-439 (1960).

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Phase velocity as a function of period has been determined for Rayleigh waves in the period range 100 to 400 seconds. The results were derived from a study of seismograms from the southeastern Alaska earthquake of July 10, 1958, and from published data on the Assam earthquake of August 15, 1950. The method depends on measurement of the travel time of wave crests along an arc of known length, with proper correction for change of period with distance. For observations of a single Rayleigh wave train at a single pair of observing stations, crest identification is uncertain, and so too is the resulting curve of phase velocity versus period. A set of phase velocity curves may be computed, each one corresponding to a different choice of crest identification. Only one of these is consistent with the data from several earthquakes and several pairs of observing stations. In the present work, high precision in phase velocity measurement is achieved by using the observations of the Rayleigh waves R_3 and R_5 at Pasadena of the Assam earthquake. Data from the southeastern Alaska Earthquake are used to resolve the ambiguity resulting from uncertainty in crest identification. The final phase velocity curve is estimated to be accurate to better than 1% in the range of periods 100 to 400 seconds.

HAKE, L., "High Explosives, Arming, and Systematics, Project Cowboy," Sandia Corporation. Final Rept. No. SC-4823(RR) (1960).

Details for procuring and emplacing high explosives, arming and firing test vehicles, and furnishing time signals for Project Cowboy are given in this paper.

For coupled shots, charges of high explosives (Pelletol) were loaded in shafts below the mine floor. For decoupled shots, equal charges were mounted in the exact center of a spherical room. Both shots were fired within an hour of each other.

Data pertinent to 17 shots are presented in tables.

HALVERSON, R. R., "A Photographic Method of Measuring the Peak Pressure and Duration of the Shock Wave from an Underwater Explosion," Phys. Rev., V. 72, n. 2, p. 179 (1947).

HAMILTON, S. R., "Timing and Firing of High Explosives, Project Cowboy," Edgerton, Germeshausen, and Grier. Report No. B-2098 (1960).

The paper describes the timing and firing systems used in Project Cowboy (Winnfield, Louisiana). A record of actual firing time with respect to WWV of all shots is tabulated.

HAMILTON, W. A., et al., "Project Cowboy Permanent Deformations," U. of Calif., Livermore, Lawrence Radiation Laboratories. UCRL Rept. No. 6282 (1960).

Measurements of various shape and size test site cavities were made before and after coupled and decoupled Project Cowboy explosions in subsurface halite at Winnfield, Louisiana, in order to determine the permanent deformation of the halite resulting from the explosions.

Pre-shot measurements over several weeks determined creep-rates of deformation of the decoupled test chambers. Vertical creep ranged from .0003 to .0030 in./day, decreasing the dimensions of the chamber.

Creep rate decreased as the chamber aged. Maximum deformation/charge ratio was ca. .0003 in./lb Pelletol, with decreasing ratios for increasing chamber size. Volumes of cavities created by coupled explosions showed a constant volume/charge ratio of ca. .062 cubic feet/lb Pelletol.

HARMON, N. F., "Passive Instrumentation, DASA Projects 823 and 833.4. Volume IV," American Science and Engineering, Inc. (1960).

The design and operation of indent recorders (double pendulum and air gun systems) as impulse recording devices are treated. A series of high-explosive tests were conducted to determine the amount of energy that may safely be deposited in a confined volume and the amount of explosive that would not fail an indent recorder-casket geometry. The results are discussed.

HARRIS, C. M. See Kirvida, L.

HARVEY, R. B. See Lambert, A. P. R., et al.

HASKELL, N. A., "An Estimate of the Maximum Range of Detectability of Seismic Signals," Air Force Cambridge Research Center, Bedford, Mass. Report No. AFCRC TN-57-202; Air Force Surveys in Geophysics No. 87 (1957).

By using Lamb's expressions for the amplitude of seismic waves generated by a concentrated force applied at a point on the free surface of a solid body, together with available data on elastic wave attenuation in rocks and soil, and an estimate of the minimum seismic background noise level, the maximum theoretical ranges of detectability of seismic signals in typical Earth materials are calculated in terms of the peak force and total impulse exerted by the source. The calculated ranges are found to agree with seismological experience in general order of magnitude. Both theory and practice indicate that ranges of detectability of more than 1000 miles imply sources of earthquake or atomic bomb magnitude. Sources such as exceptionally large quarry blasts, major construction blasts demolitions, or explosive disasters, will in general be detectable at ranges between 100 and 1000 miles. Blasts on the more usual scale of routine engineering operations should be detectable at 10 to 100 miles, In the range from 1 to 10 miles, potentially detectable sources would range from ordinary sizes of shell and bomb bursts down to large rocket launchings, heavy gun recoil, and, occasionally, the operation of heavy machinery. Forces exertable by the muscular effort of a single man, the movement of individual vehicles, and the operation of light machinery will rarely be detectable at more than a mile, but often at more than 1000 feet.

HASKELL, N. A., "The Detection of Nuclear Explosions by Seismic Means," AD 248010 (1959).

This report is the publication of the 1959 Guenter Loeser Memorial Lecture, which was awarded to Dr. Norman A. Haskell. It is a general summary of the technical considerations of a detection network as revealed at the 1958 Geneva Conference.

The paper compares the various detection methods (e.g., air-acoustic, radioactive debris collection, electro-magnetic signal, and

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seismic), stating the equipment sensitivity available with each, the frequency or period range, extreme range of detection of explosions of 1 KT and above, location accuracy, and limitations. In addition to detection systems evaluation, the problems of on-site inspection of unidentified events are related, and a few political problems are lightly touched upon.

HASKELL, N. A., VANN, J. O., "The Measurement of Free Air Atomic Blast Pressures," Air Force Cambridge Research Center, Terrestrial Sciences Laboratory. Report on Project 1.3C of Operation Jangle (1952).

Free air peak pressure was measured as a function of time and space. Eight instrumented parachute-borne canisters were positioned from 2000 to 29,000 feet vertically above ground zero. Each canister contained an altimeter transducer, two differential pressure transducers, a radio telemetry transmitter, and a radio tracking beacon. The operation was a preliminary test of equipment and techniques. The positions actually attained by the canisters were inconsistent with the intended vertical array and did not provide an accurate test of the Fuchs altitude correction. There is justification for concluding that the data obtained supported the Fuchs theory within probable accuracy of the observations up to overpressures of 0.1 psi.

HAUBRICH, R. A., et al., "A Digital Seismograph System for Measuring Earth Noise," U. of Calif. Report on Contract No. AF 49(638)-905 (1961).

A digitally recording seismograph station, the first of an array of three, has been installed to record and study earth noise in the frequency range of .01 to 1.0 cps. The seismic system was calibrated to obtain the output voltage and phase relative to a given ground particle velocity over the mentioned frequency range and was capable of recording four channels of information (plus time) on paper tape at sample rates of up to three times per second with a dynamic range of 90 db. The analyses revealed a spectral peak between 0.1 and 0.2 cps with properties consistant with Rayleigh waves arriving from the southwest mixed with isotropic noise.

HAWK, H. L. See Thornbrough, A. D., et al.

HEAPS, S. N. See White, J. E., et al.

HEILAND, C. A., "Geophysics in War," Quart. Colo. School Mines, V. 37, n. 1 (1941).

HEINRICH, R. R. See Macelwane, J. B., et al.

HERBST, R. F., WERTH, G. C., and SPRINGER, D. L., "Use of Large Cavities to Reduce Seismic Waves from Underground Explosions," U. of Calif., Livermore, Lawrence Radiation Laboratories. Report (1961).

An analysis is given of an experiment designed to test the theory of seismic decoupling of underground explosions. The amplitude of the seismic signal from a 1.7-kt nuclear explosion in a hole in salt is calculated and compared with the measured value from the 1.7-kt Rainier shot in tuff at the same distance. A decoupling factor of about 300 results. The experiment, called Cowboy, is designed to test the decoupling principle by carrying out a series of eight high-explosive shots in two spheres made in a salt dome, and nine tamped shots for comparison. The seismic

data are obtained primarily at ranges of 14,000 and 22,000 feet and at frequencies of 10 to 30 cps. A salt-to-salt decoupling factor of 100 is obtained which is consistent with the predicted tuff-to-salt factor of 300. When the sphere is overdriven so that the walls do not move elastically (which violates a condition of the theory for full decoupling), decoupling factors of 10 and 30 are measured. The seismic data are interpreted to give the dependence of decoupling on the various parameters of the experiment. The decoupling deduced from measurements made 80 feet from the shot points is found to be consistent with that deduced from the measurements at 14,000 and 22,000 feet.

HERZBERG, G., and WALKER, G. R., "Initiation of High Explosives," Nature, V. 161, n. 4095, pp. 647-648 (1948).

HEWITT, C., "The Mechanism of Generation of Long Waves from Explosions," Geophys., V. 20, n. 1, pp. 87-103 (1955).

Cagniard's method is applied to the numerical calculation of the vertical displacement due to a point source in a semi-infinite elastic solid medium at three points on a vertical line through the source. The source is a step in the scaler displacement potential. From these calculated responses the response for any physically possible spherically symmetric source can be computed by application of the Duhamel integral.

Clear evidence of backward transmission of transverse wave energy is found along the vertical axis through the source. This, together with the energy of the longitudinal waves, also transmitted backwards, accounts for the mechanism by which energy is held near the source and near the free surface long enough to account for the generation of long period surface waves.

This mechanism of generation of long period surface waves is not restricted to the free surface case. Any good reflector, which also generates secondary transverse waves from longitudinal primary waves, will serve the purpose. It is suggested that this gives a clue to the mechanism of the formation of "ground roll" in many practical cases.

HIGGINS, G. H. See Johnson, G. W., et al; Kennedy, G. C.

HILL, M. N., and SWALLOW, J. C., "Seismic Experiments in the Atlantic," Nature, V. 165, n. 4188, pp. 193-194 (1950).

Experimental observations were made in August 1949 near 53°50' N. lat., 18°40' W. long., in water approximately 1300 fathoms deep. Depth charges set to fire at 900 feet were detected by quartz hydrophones suspended 150 feet below sono-radio buoys which transmitted information from the recording instrument to ship. Preliminary calculation of results indicates two interfaces, at depths of 7700 and 16,800 feet. Velocities of 6900, 6400, and 7300 fps in the uppermost layer, 16,300 and 17,300 fps in the intermediate layer, and 21,700 and 20,600 fps in the lowest medium were observed at different locations. The first layer is believed to be sediments which are not highly consolidated. The second may be granite or may also be early Paleozoic sediments, as the thickness is much less than the granitic layer of the continents.

HINZE, W. J. See Martin, D. L.

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HODGSON, J. H., "A Seismic Survey in the Canadian Shield, I: Refraction Studies Based on Rockbursts at Kirkland Lake, Ont.," Publ. Dom. Obs., V. 16, n. 5, pp. 113-163 (1953).

Rockbursts offer certain unique advantages as an energy source in seismological studies of the earth's crust because of the possibility of precise location and timing coupled with the same energy distribution as earthquakes. Immediately after World War II, steps were taken to set out a refraction profile for detailed studies of the crust. A seismograph was installed at Kirkland Lake to time the bursts at their source, and 14 stations were occupied at distances varying from 8 to 174 km. The stations were occupied one or two at a time, and the instruments were moved to new locations after bursts had been satisfactorily recorded. Stations were housed in portable prefabricated buildings. Several types of instruments were used during the project, those finally selected being of a type designed by Willmore.

In addition to the 14 field stations, records at 5 distant stations which recorded the earlier large bursts were used. First arrivals in the P and S groups suggest that the crust consists of a single layer, and the point at which Pn is first observed confirms this conclusion. Analysis of secondary arrivals suggests that the crust provides several alternate paths for each ray by lateral variations in rock types and by variable thickness, so that groups of phases are obtained rather than single distinct phases.

The records of the distant stations show a very large amplitude for about 20 seconds following the expected arrival time of the direct S waves. This group seems to be identical with that called L_0 by Ewing and Press.

Velocities of P and S in the crustal layer are 6.246 ± 0.015 and 3.544 ± 0.023 km/sec. The velocity of P below the Mohorovicic discontinuity is 7.913 ± 0.125 km/sec if near-station data are used, and 8.176 ± 0.012 km/sec if data of near and distant stations are combined. This suggests an increase of velocity with depth. Velocity of Sn based on the records of the distant stations only is 4.8 ± 0.10 km/sec. The mean thickness of the crust, based on the P waves is 35.4 ± 5 km/sec, the uncertainty being the result of the uncertainties in the velocities and not a true probable error. This uncertainty may correspond to the actual variation in crustal thickness.

HODGSON, J. H., "A Seismic Survey in the Canadian Shield, II: Refraction Studies Based on Timed Blasts," Publ. Dom. Obs., V. 16, n. 6, pp. 169-181 (1953).

During the rockburst studies, described in Part I of this series, blasts timed at their source were recorded at one or more of the stations of the profile.

One group of blasts at La Cave and at Rolphton, were timed automatically by the stations maintained at those points. These blasts frequently recorded at the other station of the pair, and sometimes at Ottawa. Timing and location were not as precise as in other sections of this work, but it was possible to determine mean velocities for P_1 and S_1 of 6.29 + 0.04 km/sec and 3.44 + 0.03 km/sec respectively. The uncertainties are Probable Errors of the means.

A second group of blasts, occurring at La Cave and at Temiskaming, were precisely located and were timed with the greatest possible accuracy. They were recorded at stations lying northwestward toward Kirkland Lake, and the series thus provided a reverse profile. The P_1 and S_1 velocities obtained, with probable errors, were 6.19 ± 0.07 km/sec and 3.54 ± 0.07 km/sec. A very strong phase in both the P and S groups, suggested the existance of a second layer, but this interpretation proved to be inconsistent with the evidence of other secondary arrivals.

The final group of blasts provided data on the variation of velocity with rock type. The source was near Sudbury and as the blasts were recorded at eight different stations of the rockburst profile a variation of 47^{o} of azimuth was obtained. This provided many different sections across the Huronian basin. Mean velocities and their Probable Errors, for P_1 and S_1 were 6.189 ± 0.023 and 3.551 ± 0.007 km/sec.

The mean for all determinations, including that made with the aid of rockbursts together with the Probable Error of the mean, proved to be: for P_1, 6.234 ± 0.012 km/sec; and for S_1, 3.544 ± 0.011 km/sec. Secondary arrivals, in general, satisfied the signle-layer travel-time curves developed for the rockburst profile, although in this case also there were variations from the curves such as might have been due to variations in rock type and variations in crustal thickness.

HOFMANN, R. B. See Stewart, S. W., et al.

HOGAN, T. K. See Doyle, H. A., et al.

HONDA, H., and NAKAMURA, K., "On the Reflection and Refraction of the Explosive Sounds at the Ocean Bottom," Sci. Repts. Tohoku Univ., 5th Ser., V. 4, n. 3, pp. 125-133 (1953).

Reflection and refraction at a solid sea bottom of explosive sounds originating in a point source in the water have been treated mathematically. When the velocities of the longitudinal and transverse waves of the floor are greater than the velocity of the sound waves in water, both kinds of waves are refracted back into the water from the bottom, after travelling some distance along the bottom surface at horizontal distances from the source larger than some definite critical values. Expressions of reflected and refracted waves are obtained for periodic as well as aperiodic cases. Some numerical examples are given.

HONDA, H., and NAKAMURA, K., "On the Reflection and Refraction of the Explosive Sounds at the Ocean Bottom, II," Sci. Repts. Tohoku Univ., 5th Ser., V. 6, n. 1, pp. 70-84 (1954).

The propagation of sound from a point source in an ocean of uniform depth overlying a semi-infinite elastic solid is investigated theoretically. The branchline integrals in the integral formulas are evaluated by various methods, and the expressions for waves reflected at the surface and bottom of the sea and the refracted waves propagating in the lower medium with the velocity of dilatational and distortional waves along the bottom surface are obtained. Paths of some waves and displacements in some pulses are shown as examples.

HOUSTON, B. J. See Polatty, J. M., et al.

HOUGSON

HOUGSON, E. A., An Engineer's Library of Seismology, Dominion Observatory, Ottawa.

HOWELL, B. F., Jr., "Ground Vibrations Near Explosions II," Earthquake Notes, V. 28, n. 4, pp. 21-28 (1957).

This paper is a continuation of previous work by Howell and others (see Geophys. Abs. 140-11822, 159-125, 160-89, 164-279). The objective of the program was to obtain an increased understanding of the generation of seismic pulses and of the manner of their transmission in the first few hundred feet from the source. Emphasis was on three phases of the problem: the variation of seismic pulse shape with distance from the explosion; the effect of depth of burial of the charge on the pulse generated; and division of seismic energy into separate pulses such as compressional, shear, Love, and Rayleigh waves. Explosions of dynamite were used to generate the waves, and all experiments were conducted in the field under natural conditions. Data derived from the experiments emphasize the important role played by the weathered layer both in generation and transmission of seismic waves; even a few tens of feet of transmission through the weathered layer can greatly alter the character of a seismic pulse.

HOWELL, B. F., Jr., "Energy Represented by Seismic Waves from Small Explosions," Bur. Cen. Seism. Intnat'l. Publ., Ser. A, Travaux Sci., n. 20, pp. 55-66 (1959).

The energy contained in seismic waves may divide unequally into kinetic and potential energy at any point, preventing dependable calculation of energy flux from a seismogram. The case of horizontally polarized shear waves reflected at the surface is developed as a simple example. The energy represented by a seismic pulse of a given amplitude depends also on transmission velocity and, in the case of surface waves, on wavelength, as well as on other less critical factors. Equations showing the penetration of Rayleigh waves are developed in some detail to illustrate this.

HOWELL, B. F., Jr., "Seismic Waves from Explosions," Earthquake Notes, V. 27, n. 3, p. 20 (1956).

HOWELL, B. F., Jr., and BUDENSTEIN, D., "Energy Distribution in Explosion-Generated Seismic Pulses," Geophys., V. 20, n. 1, pp. 33-52 (1955).

Three orthogonal components of ground velocity were recorded at distances ranging from 10 to 1172 feet from a small explosion. On the basis of transmission velocities and particle motion, the seismic waves were divided into three groups, corresponding to the direct arrival of body waves, an early-arriving surface wave believed to be the coupled wave, and Rayleigh surface waves. The relative energy content of each of these wave groups was determined graphically by squaring the amplitude of each of the pulses and taking the sum over the time interval during which a particular group arrived. At distances less than 400 feet from the shot, the direct arrivals had the most energy, but at greater distances the Rayleigh waves contained most of the energy. A rate of attenuation of 0.019 nepers per foot was determined for the direct wave, 0.011 nepers per foot for the second wave group, and 0.0053 nepers per foot for the third wave group.

HOWELL, B. F., Jr., and KAUKONEN, E. K., "Attenuation of Seismic Waves Near an Explosion," Bull. Seism. Soc. Am., V. 44, n. 3, pp. 481-491 (1954).

The energies of the first recorded pulses of seismic waves generated by a series of buried explosions are plotted as a function of distance from the shot point. At short distances the first pulse is a combination of the direct compressional wave, surface waves, and other pulses. Beyond 800 feet, it is a pulse refracted at the bottom of the weathered layer. Absorption, by whatever means it is accomplished, seems to be much greater for the first pulse near the shot than for the refracted pulse beyond 800 feet. The refracted pulse has about 1/600 the energy of the direct pulse. For both the direct wave along the surface and the wave refracted along the bottom of the weathered layer, the attenuation seems to be greater than would be required for a body wave spreading radially. The large difference in attenuation constants (for exponential attenuation) in the two cases suggests that the rock responds to the refracted pulse as though it were beyond the zone of plastic deformation, but that as far out as 375 feet the direct pulse is not beyond the zone.

HOWELL, B. F., Jr., and MATHUR, S. P., "Recognition of Seismic Pulses by Studies of their Frequency Spectra," Earthquake Notes, V. 27, n. 3, pp. 23-26 (1956).

HOWELL, L. G., and KEAN, C. H., "Note on Wave-Guide Propagation over a Shallow Salt Dome," Geophys., V. 18, n. 2, pp. 338-339 (1953).

Tests over the Hawkinsville salt dome show evidence of wave-guide propagation. The first-arriving wave train has a low frequency and a high group velocity. The large amplitude beginning of the high-frequency wave train exhibits a group velocity of sound in water, probably that of the shallow water table.

HOWELL, R. B., Jr., "Ground Vibrations Near Explosions," Bull. Seism. Soc. Am., V. 39, n. 4, pp. 285-310 (1949).

To increase knowledge of the basic seismic forms to be expected on the record of explosions, measurements were made at 14 locations along a line 97 to 3284 meters from a series of small blasts. Recording was by three electromagnetic induction seismometers (two horizontal and one vertical), three amplifiers, and a recording oscillograph. The following pulses were recognized on the records: P, the first to arrive; P_3, a compressional pulse arriving later than P; X_1 X_2 X_3, assumed to be body waves traveling along deeper paths than P and P_3; C, resembling Leet's "coupled" wave, but confined almost entirely to the longitudinal component; T, motion on the transverse component arriving nearly coincident with C; H, similar to Leet's hydrodynamic wave, with direct elliptical motion in a vertical plane; and R, a Rayleigh type motion. No satisfactory theory for C, H, and R is known.

HOWES, E. T., "Yearly Personnel Operating Estimated Costs for the Seismological Systems Laboratory," United Electrodynamics. Special Report for Project VT/070 (1961).

This report contains tabulated cost analyses, tables of organization etc., for the seismological systems laboratory. It estimates a grand total of $1,461,269 per annum, personnel cost.

HOY

HOY, R. B., and O'NEILL, B. J., Jr., "Investigation of On-Site Inspection Techniques for High-Explosive Tests in a Salt Mine," Stanford Research Inst., Menlo Park, Calif. Final Report of Project Cowboy, on SRI Project SU-2993 (1960).

AEC experiments for testing the effectiveness of decoupling provided a further opportunity to investigate techniques which an inspection team might use to locate a clandestine nuclear explosion. The investigation consisted of aerial-photographic interpretation, geologic mapping, and on-site examination, both surface and underground. The effects of a series of 11 shots were documented; characteristics of anomalous activity were determined, and evidence of human activity and other clues were tabulated. Results of the investigation indicate that detecting and locating a clandestine underground explosion in an environment similar to the Winnfield salt dome would be difficult. The detection problem was highlighted by experiments conducted by LRL which proved that the seismic signal from an underground detonation can be substantially reduced by decoupling methods. Thus it is conceivable that the seismic signal from a clandestine decoupled test might not be noted in an inspection control system, especially in an area where seismic signals from natural causes are common. However, if a seismic signal from any of the Cowboy test shots had been detected, locating the site of the event would have been possible; the chance of success would have decreased as the evidence of anomalous on-site human activity was eliminated. This research emphasized the necessity that an inspection team be cognizant of the geologic environment and seismic history of the area under its surveillance and that the team be extra-sensitive to any anomalous activity.

HOY, R. B. See also Foose, R. M.

HUDSON, D. E. See Caughey, T. K.

HUGHES AIRCRAFT COMPANY (Staff), "Project Vela, Telluric Communications," Hughes Aircraft Company. Final Report on Contract AF 33(600) 41789 (1960).

Based on a model concept which suggests a pattern of current flow in the upper crust of the earth that essentially duplicates the systematic flow of currents associated with the ionosphere, it has been hypothesized that the ability to observe changes of flow pattern in the normal telluric currents of the earth forms a basis for detecting underground explosions and earthquakes.

A test program has been prepared based upon this theory for purposes of gathering data from effects of Project Lollipop detonations. The instrumentation for land and ocean terminals is outlined and station site surveys are described.

HUGHES AIRCRAFT COMPANY (Staff), "Preliminary Report on Project Vela Telluric Communications," Hughes Aircraft Company. Preliminary Report on Contract AF 33(600)41789.

It has been postulated that underground explosions and earthquakes can be detected by observing changes in the normal flow pattern of telluric currents. This paper is the preliminary report of a test program for gathering data from effects of Project Lollipop detonations. The instrumentation and station site surveys are roughly outlined.

HUNT, A. G. See Wright, J. K., et al.

HUYAKUWA, M. See Nagumo, S., et al. (1).

IKEGAMI, R., "On Ground Vibrations Caused by Explosions," Bull. Earthquake Research Inst., Tokyo Univ., V. 29, n. 1, pp. 197-208 (1951).

IKEGAMI, R. See also Kishinouye, F., et al.

INTERNATIONAL GEOPHYSICAL YEAR BULLETIN NO. 11, "Seismic Studies in the Andes," Trans. Am. Geophys. Union, V. 39, n. 3, pp. 580-582 (1958).

Investigations were made by the Carnegie Andes Expedition for the International Geophysical Year during the summer of 1957 in the high regions of Peru, Bolivia, and northern Chile to test the idea that mountains may be held up by a network of relatively narrow roots or veins projecting into the earth's mantle layer to depths as great as 200 km. For this purpose seismic waves from explosions in the great open-pit copper mines of Peru and Chile (where single shots of 40 to 60 tons of dynamite are exploded almost daily) were measured. Recordings were made at more than 200 selected points deep in the mountains. Preliminary results indicate that the Andean structures are highly non-uniform. Reflections from the Mohorovicic discontinuity were obtained only in limited sectors along lines more or less parallel to the mountains. Reflections passing under the antiplane were extremely attenuated. The principal result of this seismic reconnaissance is the indication that there appear to be non-uniformities and regional differences in the mantle as in the crust. Under northern Chile the lighter crustal rocks project down to nearly 55 km, whereas in southern Peru the crust has the normal depth of 34 km and the Andes in that area are presumably held up by more diffuse roots projecting into the mantle.

ITO, I., "On the Relationship Between Seismic Ground Amplitude and the Quantity of Explosives in Blasting," Mem. Fac. Eng., Kyoto Univ., V. 15, n. 2, pp. 79-87 (1953).

ITO, I., TERADA, M., and SAKURAI, T., "Stress Waves in Rocks and their Effects on Rock Breakage," Mem. Fac. Eng., Kyoto Univ., V. 22, pt. 1, pp. 12-29 (1960).

Characteristics of stress waves produced in rocks by detonators or explosives are investigated experimentally. The dynamic characteristics of rocks under impulse loading produced by explosion of a detonator are discussed in the first part of the paper, and the following results were observed: Young's moduli for rocks are about two or three times greater than those obtained statically; dynamic strengths of rocks are greater than static ones; and various shock effects appear in accordance with the physical properties of rocks.

In the second part of the paper the changes in the propagation velocities of the induced stress waves near the point of an explosion are observed. Changes in the velocity of propagation of the stress waves with distance indicate the existence of a plastic wave of higher order in the region very near the point of explosion, and the appearance of this plastic wave seems to depend not only on the physical characteristics of the rocks but also on the shattering effect of the explosives. The compressibility of a rock under impulsive high pressure is peculiar to the physical prop-

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erties of the rock and has no relation to the nature of the explosive. The peak pressure of the wave front decreases very rapidly with distance and only within a few centimeters of the point of explosion do the explosives develop a different high pressure in proportion to their shattering effect.

JAKOSKY, J. J., and JAKOSKY, J. J., Jr., "Characteristics of Explosives for Marine Seismic Exploration," Geophys., V. 21, n. 4, pp. 969-991 (1956).

The history of offshore seismic shooting in California is reviewed with respect to charge type and damage to marine life. Several substitutes for the currently required black powder charges of low efficiency and high cost are examined. Experimental data in the form of pressure vs. time oscilloscope recordings are presented. Explosives were developed that can be employed more advantageously than black powder. These explosives will minimize damage to marine life, decrease present hazards of handling, and decrease the cost of explosives. "Multipulse" charges, composed of alternating layers of 40% gelatin and an inert substance enclosed in a tube, seemed to be the most satisfactory. Conventional seismic records obtained with black powder (90 lb) and multipulse charges (10 lb) are presented to demonstrate the superiority of the latter.

JAKOSKY, J. J., Jr. See Jakosky, J. J.

JEFFREYS, H., "On the Burton-on-Trent Explosion of 1944, November 27," Monthly Notices Roy. Astron. Soc. Geophys. Suppl., V. 5, n. 5, pp. 99-104 (1947).

Seismic waves from the Burton-on-Trent explosion of November 27, 1944, were recorded at four British and six continental stations. The five observations of Pn suggest that the times of Pn about distance 8^{o} for a surface focus are $3^{s} \times 9 \pm 1^{s} \times 3$ shorter than those given in the author's 1940 table. The anomaly cannot be explained by any permissible reduction of the thickness of the upper layers. It seems just possible that it might be explained by an increase of the velocity of Pn at shorter distances, but further investigation is needed before this explanation can be adopted. Sg was satisfactorily recorded, and it is likely that the low velocity of Sg found in the Oppau explosion was not due to misidentification but to ordinary errors of observation. The energy of the explosion and that of ground movement were in about the same ratio as in the Oppau explosion.

JOBERT, G. See Beaufils, Y., et al.

JOHNSON, G. W., "Some Basic Data on Underground Nuclear Explosions," U. of Calif., Livermore, Lawrence Radiation Laboratories Report.

A general description is given of an underground explosion. The containment and cratering data are given for nine underground nuclear explosions. The geological data for six explosions which were contained or nearly contained are reviewed.

JOHNSON, G. W., "Application of Nuclear Explosions as Seismic Sources," U. of Calif., Livermore, Lawrence Radiation Laboratories. UCRL Rept. No. 6030-T (1960).

The information of interest to earth science obtained from detonation of nuclear and large chemical explosions is briefly reviewed. The major

geophysical questions as suggested by Griggs and Press (see Geophys. Abst. 184-275) that might be resolved under a program of earth structure research involving both nuclear and chemical explosions are given.

Underground nuclear explosions in the United States and their interpretation, with a description of methods of stemming the explosion to assure containment of radioactivity, are summarized. An estimate of typical costs that might be incurred in the United States to provide seismic sources is presented. It is concluded that nuclear explosions can be economical and safe seismic sources; chemical explosives can be used for low energies, but at about a kiloton, nuclear explosions become comparable in cost, and at a few thousand tons they are much cheaper.

JOHNSON, G. W., "Mineral Resource Development by the Use of Nuclear Explosives," U. of Calif., Livermore, Lawrence Radiation Laboratories. UCRL Rept. No. 5458 (1959).

Characteristics of mechanical, thermal, and radioactive energy released from nuclear devices are examined for usefulness in mineral exploitation. Maximum rock excavation and fracturing with minimum air blast, uncontained radioactivity, and flash effects are desirable results. Event Rainier measurements in tuff at the Nevada Test Site show one kiloton can produce 400 tons melted rock, 300,000 tons crushed rock impermeable to water, 120,000 tons broken rock by caving. About 1/2 of the energy release appeared as heat. The depth of burial for complete containment of radioactivity = $450W^{1/3}$ (W = yield in kilotons).

Shattering of oil shale and low grade ores, fill and rip-rap production, harbor excavation, and artificial aquifer production are mentioned as possible uses of the mechanical energy. The thermal energy uses include power generation, process-heat generation, and release of oil from tar sands.

JOHNSON, G. W., and BROWN, H., "Non-Military Uses of Nuclear Explosives," Sci. Am., V. 199, n. 6 (1958).

Information is presented on an underground nuclear detonation (Rainier Burst) that was equivalent to 1,700 tons of TNT. The device was buried at a depth of 899 feet in a horizontal tunnel that was driven into the sloping side of a mesa in Nevada. Considerations are given to the use of underground nuclear explosions for power production and mining and the possibility of using surface explosions for excavating harbors.

JOHNSON, G. W., HIGGINS, G. H., and VIOLET, C. E., "Underground Nuclear Detonations," J. Geophys. Research, V. 64, n. 10, pp. 1457-1469 (1959).

Since 1952, eight nuclear explosions have been fired underground at the Atomic Energy Commissions's Nevada Test Site. The explosions varied in energy release from 55 tons to 19,000 tons of TNT equivalent. Depths of burial varied from shallow, to produce cratering, to deep, where no visible effects appeared on the surface. The major experimental data from these explosions, as well as the phenomenology of the deeper shots, are summarized here.

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JOHNSON, G. W., PELSOR, G. T., et al., "The Underground Nuclear Detonation of September 19, 1957—Rainier-Operation Plumbbob," U. of Calif., Livermore, Lawrence Radiation Laboratories. UCRL Rept. No. 5124 (1958).

Rainier, a nuclear device with an energy release of 1.7 kt, was fired in a tunnel under a mesa of volcanic tuff at the Nevada Test Site on September 19, 1957. The objectives of the test were (1) to verify containment predictions, (2) to measure the physical properties of the tuff before and after the event, (3) to obtain acceleration, displacement, and pressure measurements in the rock around the explosion, (4) to record and evaluate seismic effects at near and distant stations, and (5) to estimate yield from radiochemical and shock velocity measurements.

Practically all of the radioactivity as well as the heat (about 1/2 of the total energy release) was contained within a 60-foot radius of the shot point. Depth of burial for complete containment is estimated at $D = 450W^{1/3}$ (W = yield in kilotons). The physical properties of the tuff are tabulated. Peak particle acceleration ranged from 5.8 g on the surface over the shot point to .02 g, 2.5 miles from the shot point. Maximum range of permanent displacements is not indicated. Seismic signals recorded 350 miles distant correspond to an earthquake of magnitude 4.6 on the Gutenberg-Richter scale, but accelerations normally felt 60 miles from such a quake were confined to 3 miles around the nuclear shot point. The reasons for the discrepancy are not readily apparent. The small seismic effects indicated that yields greater than Rainier by two orders of magnitude could be safely fired at the Nevada Test Site. The explosion broke or crushed 700,000 tons of rock, but no radioactivity escaped to contaminate permeating ground water.

JOHNSON, G. W., and VIOLET, C. E., "Phenomenology of Contained Nuclear Explosions," U. of Calif., Livermore, Lawrence Radiation Laboratories Report (1958).

On September 19, 1957, the first completely contained nuclear explosion was fired at the Nevada Test Site. The explosion had an energy release equivalent to 1700 tons of high explosive, which was calculated as a total energy release of 1.7×10^{12} calories. The code name "Rainier" was assigned to this burst. From an analysis of cores obtained from drill holes into the Rainier zero site, as well as measurements made in these holes, it was concluded that the radioactivity, with negligible exceptions, was all trapped in the 700 tons of melted rock. When the cavity collapsed, this material fell to the bottom of the cavity. Experiments with this material have shown that it is in fine solution in the glass and is unavailable in amounts sufficient to cause ground water contamination. The region produced by the collapse of the cavity, comprising some 200,000 tons, is highly permeable to water and is not contaminated by radioactive debris. The crushed region produced by the shock is much less permeable. Gaseous radioactive fission products did not penetrate into this region during or after the explosion. More than one half the total energy release of the bomb was contained in rock initially at high temperature. Because of the presence of large quantities of water and the high permeability of the central region, the heat redistributed itself to the temperature of boiling water. The seismic ground shock was not felt beyond a distance of 2.5 miles. Electrical cabling and electronics recording systems

housed in a light metal-frame building at a distance of 2,000 feet from the center of detonation suffered no damage or visually observed effects of any sort. During the month of October, 1958, several additional underground shots were detonated at various scaled depths with energy releases from about 100 tons to more than 20 kt. Gross results from these explosions indicate that for explosions in the kiloton region and above, complete containment of all radioactive debris can be achieved.

JOHNSON, J. C. See Willis, D. E.; Wilson, J. T., et al.

JOHNSTON, T. F., and RAITT, R. W., "Transmission of Explosive Impulses in the Sea," Bull. Geol. Soc. Am., V. 58, n. 12, Pt. 2, p. 1269 (1947).

JOHNSTON, T. F. See also Raitt, R. W.

JOLLY, R. N., "Deep-Hole Geophone Study in Garvin County, Okla.," Geophys., V. 28, n. 3, pp. 662-670 (1953).

A deep-hole geophone study was made by The Carter Oil Co. in the Coleman Stephens No. 2 well in the Katie Pool of Garvin County, Okla. The deep-hole geophone was so constructed that it could be locked to the wall of the bore hole, thus permitting reduced charges, reduced noise, reliable amplitude measurements, and the recording of reflections at depth. A surface geophone spread was recorded for purposes of comparison.

It was found that the pulse amplitude decays in proportion to the negative 2.6 power of travel time, as anticipated from theory and previous experiments. Several reflections were recorded from the deep-hole geophones, and they correlated quite well with the surface reflection traces. The corresponding reflection coefficients were determined from the amplitude and travel-time data. The wave form of the pulse changed appreciably in the first 3000 feet of path of travel.

JONES, R. D., and SMITH, J. D., "High-Speed Auto-Data System for Blast Studies," Sandia Corp., Albuquerque, N. Mex. (1960).

A multichannel high-speed automated system for recording digitally the outputs of the analog transducers used in the study of blast effects from small HE charges is described. Test phenomena associated with these studies are recorded in 10 to 40 msec. Installation and operation of this data handling system are described.

JONES, W. M., "Note on Wood-Anderson Records of Mine Explosions at Wellington," Dominion Observatory. Dept. of Scientific and Industrial Research Bulletin, No. S-81 (1947).

JOOS, G., and TELTOW, J., "Propagation of Explosion Waves at the Surface of Separation of Two Media," Physik. Z., Band 40, pp. 289-293 (1939).

KARAPETYAN, B. K., "Rezul'taty seysmometrichesikikh nablyudeniy pri massovykh vzryvakh [Results of Seismometric Observations of Mass Explosions] ," Izvest. Akad. Nauk Armyan. S.S.R., V. 10, n. 3, pp. 21-33 (1957).

Seismometric measurements were made of many large quarry blasts in 1955-56 in different parts of the Armenian S.S.R. Thirteen seismometers were differently distributed around the shot points. The amount of explosives ranged from 1,700 to 26,800 kg; the depth of the bore pits in

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which the explosives were placed ranged from 3 to 9 meters, and the total number of pits from 6 to 40. The effect of the explosion is determined by the geologic conditions of the surrounding area, by the distance from the shot point, by the relative positions of the shot point and the point of the observation—no simple relation among all factors could be determined. Results are shown graphically and in tables of data characterizing the explosion as the seismic acceleration expressed in fractions of g.

KARNIK, V., "The Blast Near Eschenlohe, Bavaria, Recorded at Pruhonice," Stud. Geophys. Geod., Ceskoslov. Akad. Ved., V. 2, n. 4, pp. 400-401 (1958).

Two quarry blasts (of 6 and 12 tons of explosives, respectively) on February 15, 1958, near Eschenlohe, Bavaria, were recorded at Pruhonice, Czechoslovakia, about 360 km away. Onsets of Pn and Pg are clear and unambiguous. The Pn arrival is in good agreement with the travel time curves for central European near earthquakes, but the Pg arrival is early, showing a greater velocity (5.9 km/sec), as usually occurs in the case of explosions. The existence of two phases of Pg is confirmed (see also Geophys. Abs. 173-141).

Interpretation of transverse waves is more difficult because onsets are less clear. Sb and Sg, the latter with a velocity of 3.4 km/sec, were recognized.

KARNIK, V., and MAREK, V., "Travel Times from Quarry Blasts," Trav. Geophys., Nak. Ceskosk. Akad. Ved., n. 3, p. 57 (1954).

KARUS, Y. V., and PASECHNIK, I. P., "Izucheniye uprugikh i poglosh-chayusbchikh syoystv gornykh porod v ikh yestestvennom zaleganii metodami seysmoakustiki [The Investigation of Elastic and Absorbing Properties of Rocks in Place by Seismoacoustic Methods]," Izvest. Aka. Nauk. S.S.S.R., Ser. Geofiz., n. 6, pp. 514-526 (1954).

A method is described for measuring in place the elastic and absorptive properties of various rocks. Energy is introduced into the ground through electromagnetic or piezoelectric vibrators producing steady mechanical vibrations in the ground and detected by standard seismic equipment. The frequency of induced vibration ranges from 50 and 4,000 cps, and the energy consumption is only about 50 watts. By examining the seismic profiles it is possible to determine the phase velocities of the seismic waves as well as the coefficient of damping in different formations.

KASAHARA, K., "Wave Generation by Small Explosions, (1)" [In Japanese with English abstract], Busuri-Tanko, V. 12, n. 3, pp. 118-123 (1959).

A spectral analysis of P-waves recorded at underground stations 10-30 meters from the shot point is made. The fundamental characteristics of the waves may be explained by the theory of spherical origins provided that the apparent radius of the explosion origin is taken to be several times as large as that of the region subject to crushing. The effect might be attributed to the propagation of nonelastic stress waves outside the region of crushing.

The total amount of energy radiated as seismic waves from the explosion is also discussed.

KASAHARA, K., "Experimental Studies on the Mechanism of Generation of Elastic Waves IV," Bull. Earthquake Research Inst., Tokyo Univ., V. 32, 1, pp. 66-77 (1954).

KAUKONEN, E. K. See Howell B. F., Jr.

KEAN, C. H. See Howell, L. G.

KEESE, W. J., "America's Largest Controlled Blast: 440,966 lb of Dynamite in a Single Shot," Explosives Eng., V. 10, n. 5, pp. 147-150 (1932).

A brief description of the blasting details of the Manistique blast of March 16, 1932.

KEITI, A., and PRESS, F., "Upper Mantle Structure Under Oceans and Continents from Rayleigh Waves," Calif. Inst. of Technology. CIT contribution No. 1018 (1959).

Theoretical seismograms of Rayleigh waves based on several models of mantle structure are compared with actual records for various paths. It is found that the model 8099 of Dorman, Ewing, and Oliver explains seismograms for Pacific paths, but does not agree with records from Indian-Atlantic Ocean paths in the period range shorter than 100 seconds. The velocity of the Airy Phase corresponding to the group velocity maximum is about 0.10 km/sec lower for the Indian-Atlantic path than for the Pacific. This difference can be accounted for by reducing the shear velocity at the top of the mantle under the Indian and Atlantic Oceans by about 0.1 - 0.2 km/sec. The difference between the Pacific mantle and the Continental mantle can be explained by a reduction in shear velocity of the low velocity layer under the Pacific ocean, or by making the low velocity zone shallower.

KELLER, G. V., "Dispersion of Seismic Waves Near a Small Explosion," Trans. Am. Geophys. Union, V. 36, n. 6, pp. 1035-1043 (1955).

The characteristics of the ground vibrations caused by the detonation of small dynamite charges were studied at distances from 10 to 3070 feet from the point of detonation. The motion which was observed could be separated into several types on the basis of velocity and particle motion paths. The major part of the recorded motion following the arrival of body waves exhibited strong dispersion. A comparison of this dispersion with that theoretically predicted for Rayleigh waves by Love, Sezawa, and others, showed that these motions are probably Rayleigh waves of the first and second types. The complex particle motion orbits observed near the shot point are probably a result of the overlap of these two normal modes of surface wave propagation.

KENNEDY, G. C., "The Early Cavity History of Rainier and Comments on Energy Storage," U. of Calif., Los Angeles, Inst. of Geophysics. Report.

There are three major chemical environments in which underground shots can be made. The knowledge of explosions in these environments is important if they are to be used for the underground storage of heat. The behavior of these three systems, which are silicate (lava, granite, slate), limestone (Ca_2CO_3) and salt (NaCl), is grossly contrasting. The phenomenology of a shot in silicate is worked out in some detail while shots in salt and limestone are covered lightly.

KENNEDY

KENNEDY, G. C., and HIGGINS, G. H., "Temperatures and Pressures Associated with the Cavity Produced by the Rainier Event," U. of Calif., Livermore, Lawrence Radiation Laboratories. UCRL Rept. No. 5281 (1958).

Examination of core samples and radiochemical data from the Rainier shot indicates that, between 30 seconds and two minutes after the explosion, the cavity was filled with steam at 40 atmospheres and 1500°C. It had a lining of molten rhyolite, with very steep temperature gradients to the unfused tuff. The steam escaped at one or several fissures without carrying any radioactivity to the surface, and the reduction in pressure permitted the cavity to collapse.

KHUDZINSKY, L. L. See Melamod, A. Ya., et al.

KILEY, W. P. See Cook, G. W.

KIRILLOV, F. A., "The Seismic Effect of Explosion" [abstract in Russian], Izvest. Akad. Nauk S.S.S.R., Otdel. Fiz. -Mat., pp. 97-98 (1945).

Empirical relationships were formerly established between the intensity of the ground's oscillation and the distance to the explosion, weight of the explosive, and related factors (see Geophys. Abs. 120, no. 7835). The data then obtained are now expressed in a generalized formula for determining the displacement of a particle of the ground, or its velocity of oscillation. In the analysis, consideration is given to the dependence of the recorded oscillations of a horizon upon the location of the observation point, the depth of the explosive charge, the kind of explosive, and other factors. The period of the principal phase of oscillation is formulated as a function of distance. For practical application, estimates are offered of the amount of energy used by seismic waves in dry and humid ground, and the method of energy streams developed at the Seismological Institute is used to calculate the maximum depth of penetration of surface waves. Computation also is made of the coefficient of the damping of ground oscillations. The research was done at the Seismological Institute, Moscow.

KIRILLOVA, I. V., "O seysmicheskikn usloviyaky Zakavkaz'ya, Turisii i Irana [On the Seismic Conditions of Transcaucasia, Turkey and Iran]," Akad. Nauk S.S.S.R. Sovet po Seysmologii, Byull. no. 8 (1960).

A seismicity map has been compiled on the basis of published maps and data for the area south of the Black Sea, the Caucasus, and the Caspian Sea. Three zones are distinguished, characterized by high, intermediate, and unknown seismic activity, respectively. A sketch map shows the distribution of epicenters of earthquakes that occurred in the region between 1938 and 1953. The data bear out Kirillova's concept that fractures visible at the surface play a predominant role in determining the seismicity.

KIRILLOVA, I. V., and SORSKIY, A. A., "O metodike sostavleniya karty seysmicheskogo rayonirovaniya masshtaba 1:1,000,000 na primere Kavkaza [On Methods of Constructing a Map of Seismic Regionalization on a Scale of 1:1,000,000 Exemplified by the Caucasus]," Akad. Nauk S.S.S.R. Sovet po Seysmologii, Byull. No. 8 (1960).

The general seismicity map of the U.S.S.R. is on a scale of 1:5,000,000. In this paper, a seismicity map of the Caucasus on a scale of 1:1,000,000

is presented, which was constructed on somewhat different principles: analysis of seismostatistical data, analysis and inferences from geologic data, and inferences from data on the nature of the ground and topography. In addition to the seismicity map, a sketch map shows the location and density of epicenters and focal mechanism of Caucasus earthquakes, and another shows the distribution of deep structures and deep fractures in the region.

The seismicity map distinguishes zones of three degrees of seismicity. In the regions of high seismicity earthquakes of 8-point intensity have occured repeatedly and may occur in the future; in the zones of medium seismicity weak local earthquakes are frequent and stronger earthquakes are known; and in the zones of weak seismicity only weak local earthquakes (less than 7-point intensity) have occurred, and these rarely. In addition, the map shows the nature of the ground within each zone, classified from the engineering-geologic standpoint (according to the underlying rock type and topography) into seven categories of different degrees of resistance or susceptibility to earthquake damage.

KIRKWOOD, J. G., and BRINKLEY, S. R., Jr., "Theory of the Propagation of Shock Waves from Explosive Sources in the Air and Water, Progress Report," U.S. Office Sci. Res. and Devel. Rept. 4814, 39 pp., Washington, D.C., March 1945. (Library of Congress, OTS PB Rept., 32198.)

This report describes a new theory of propagation of shock waves from explosive sources. The partial differential equations of hydrodynamics and the Hugoniot relation between pressure and particle velocity are used to provide three relations between the four partial derivatives of pressure and particle velocity with respect to time and distance from the source at the shock front. An approximate fourth relation between the derivatives is set up by imposing a similarity restraint on the shape of the energy-time curve of the shock wave and by utilizing the second law of thermodynamics to determine, for an arbitrary distance, the distribution of the initial energy input from the source into dissipated energy residuals in the fluid already traversed by the shock wave and the available energy for futher propagation.

The theory may be used with equal facility for the determination of the pressure-time curves and peak pressure-distance curves from the theoretical initial conditions and for the extrapolation of experimental curves to smaller or large distances from the charge. Curve diagrams and tables illustrate the report.

KIRKWOOD, J. G., and SEEGER, R. J., "Surface Waves from an Underwater Explosion," J. Appl. Phys., V. 19, n. 4, pp. 346-360 (1948).

KIRKWOOD, J. G. See also Brinkley, S. R., Jr.

KIRVIDA, L., and HARRIS, C. M., "Some Experiments with a Phased-Array Seismic Detection System," AD 140785, Columbia University. Project Michigan Tech. Rept. TR-5.

This report concerns experiments which have been conducted to explore the possible usefulness of a phased-array detection system using geophones as sensing elements. An electrical system, using microphones instead of geophones, was developed for another purpose. Data are given showing the measured valves of the attenuation of vib-

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rating energy in the earth in the frequency range from 29 cps to 45 cps in two similar range locations. Data are also given showing total background noise observed. A beam pattern is shown for a ten-element linear array, obtained with measurements employing a 45 cps continuous tapping source. All of these data are preliminary tabulations. No conclusions are given.

KISHINOUYE, F., IKEGAMI, R., and YOSHIOKA, H., "An Apparatus for Examination of Seismograms, [Japanese with summary in English]," Zisin, J. Seism. Soc. Japan, Second Series, V. 4, n. 2, p. 31 (1951).

KISSLINGER, C., "Fourier Analysis of a Blast Record," Trans. Am. Geophys. Union, V. 29, n. 1, pp. 36-37 (1948).

This paper reports the Fourier analysis of a seismogram of a dynamite blast recorded by a Taylor-Macelwane seismograph. The first six harmonics were calculated for 26 sections of the record. The errors inherent in such an analysis are discussed.

KISSLINGER, C., "Observations of the Development of Rayleigh-Type Waves in the Vicinity of Small Explosions," J. Geophys. Research, V. 64, n. 4, pp. 429-436 (1959).

Study of the particle motion and dispersive properties of waves generated by small explosions has led to the identification of the fundamental M_1 mode and possibly a higher mode of this branch of the solution of the Rayleigh wave equation. In the particular field models, consisting of loams and clay over limestone, variations in near-surface conditions at the source have a greater effect on the recorded motion than do similar variations at the recording sites.

The features within the complex motion close to the source can be identified with specific wave types, which are well separated at the larger distances.

KISSLINGER, C., "Motion at an Explosive Source as Deduced from Surface Waves," Earthquake Notes, V. 31, n. 1-2, pp. 5-17 (1960).

The history of events occurring near the source following a small explosion has been deduced from the Rayleigh waves recorded at two distances. The Fourier analysis method developed by Sato, and Lamb's solution for the displacement on a half space, have been employed in two distinct approaches to this problem. The displacement history from the first approach shows an essentially rectilinear vibration of the earth particle following the initial compression. The second technique yields the vertical point force equivalent to the explosion. The vertical acceleration at the source from the first method agrees fairly well in general form with the force found in the second. Information about the phase velocities and the initial phases of the constituent frequency components is a valuable byproduct of the Fourier analysis technique.

KLIEFOTH, W., "Possibilities for the Utilization of Underground Nuclear Explosions for Scientific and Technological Purposes," Atomikeinenergie V. 5, pp. 384-6 (1960).

The latest American investigations on the utilization of underground nuclear explosions for scientific and technological purposes are reviewed. The Gnome project is described in some detail.

is presented, which was constructed on somewhat different principles: analysis of seismostatistical data, analysis and inferences from geologic data, and inferences from data on the nature of the ground and topography. In addition to the seismicity map, a sketch map shows the location and density of epicenters and focal mechanism of Caucasus earthquakes, and another shows the distribution of deep structures and deep fractures in the region.

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KIRKWOOD, J. G., and BRINKLEY, S. R., Jr., "Theory of the Propagation of Shock Waves from Explosive Sources in the Air and Water, Progress Report," U.S. Office Sci. Res. and Devel. Rept. 4814, 39 pp., Washington, D.C., March 1945. (Library of Congress, OTS PB Rept., 32198.)

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The theory may be used with equal facility for the determination of the pressure-time curves and peak pressure-distance curves from the theoretical initial conditions and for the extrapolation of experimental curves to smaller or large distances from the charge. Curve diagrams and tables illustrate the report.

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KIRKWOOD, J. G. See also Brinkley, S. R., Jr.

KIRVIDA, L., and HARRIS, C. M., "Some Experiments with a Phased-Array Seismic Detection System," AD 140785, Columbia University. Project Michigan Tech. Rept. TR-5.

This report concerns experiments which have been conducted to explore the possible usefulness of a phased-array detection system using geophones as sensing elements. An electrical system, using microphones instead of geophones, was developed for another purpose. Data are given showing the measured valves of the attenuation of vib-

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rating energy in the earth in the frequency range from 29 cps to 45 cps in two similar range locations. Data are also given showing total background noise observed. A beam pattern is shown for a ten-element linear array, obtained with measurements employing a 45 cps continuous tapping source. All of these data are preliminary tabulations. No conclusions are given.

KISHINOUYE, F., IKEGAMI, R., and YOSHIOKA, H., "An Apparatus for Examination of Seismograms, [Japanese with summary in English] ," Zisin, J. Seism. Soc. Japan, Second Series, V. 4, n. 2, p. 31 (1951).

KISSLINGER, C., "Fourier Analysis of a Blast Record," Trans. Am. Geophys. Union, V. 29, n. 1, pp. 36-37 (1948).

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KLIEFOTH, W., "Possibilities for the Utilization of Underground Nuclear Explosions for Scientific and Technological Purposes," Atomikeinenergie V. 5, pp. 384-6 (1960).

The latest American investigations on the utilization of underground nuclear explosions for scientific and technological purposes are reviewed. The Gnome project is described in some detail.

KLIMA, K. See Vanek, J.

KNOPOFF, L., "Deductive Seismology," U.S. Dept. of State, Rept. of Panel on Seismic Improvements, Appendix 6 (1959).

Observational seismology is concerned with the inductive problem and should be evaluated in terms of some probability or other weighting factor that describes the likelihood of the solution being correct. The deductive problem, on the other hand, is a problem in mathematical analysis and is exact. If the problem to be solved is appropriately described, then a specification of the nature of the structure, the source, and the receiver must be made. Problems to be solved are assumed to be problems in linear mechanics so that linear transform procedures are permissible. Problems of linear wave motions in solids to be considered are those of physical theory which determine the character of the wave motions following the arrivals. Methods are discussed for obtaining solutions for the elementary geometries such as half-spaces, layered media, wedges, half-plane diffraction problems, imbedded spheres, imbedded circular cylinders imbedded wedges, imbedded cylinders of irregular shape, the influence of irregularities in smooth simple surfaces, and others. Construction of a seismogram for more complex geometries is an exercise that may require extensive data processing and computational and data handling facilities of some size.

KNUDSEN, W. C., "Elimination of Secondary Pressure Pulses in Offshore Exploration (a Model Study)," Geophys., V. 23, n. 3, pp. 440-458 (1958).

The behavior of the gas bubble generated by explosive charges fired below the ocean's surface has been studied by means of a scale model. The motion of the bubble was recorded using a high-speed camera. A small pressure detector was used to record the pressure variation near the bubble. The behavior of the bubble generated by the equivalent of a 15-lb charge was studied, with the bubble subjected to the following boundary conditions: a single charge at various depths below the liquid surface; two charges on a vertical axis at various separations; a single charge at various separations below a solid plate; and a single charge at various separations to the side of the solid cylinder. Of these methods, the only one which appeared promising was the location of two charges on a vertical axis with both charges within 20 feet of the surface.

KOBAYASHI, N. See Omote, S., et al.

KOGAN, S. D., "Longitudinal and Transverse Wave Travel Times Calculated According to the Data on Nuclear Explosions in Marshall Islands," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 3, pp. 371-80 (1960).

The true wave travel times in the western region of the Pacific are 2 seconds less for P waves, 5 seconds less for P P waves, and 3 seconds less for PcP waves than those given by the Jeffreys-Bullen hodograph. The travel times of transverse waves are 4 to 5 seconds higher. The corrections for longitudinal waves are based on the absence of a granite layer in the Pacific Ocean, while for the transverse wave it must be related to the value of the travel rate of S waves in the upper layer.

KOGAN

KOGAN, S. D., PASECHNIK, I. P., and SULTANOV, D. D., "The Difference in the Periods of Seismic Waves Excited During Underground Explosions and Earthquakes [Razlichie v Periodakh Seismicheskikh Voln, Vozbuzhdaemykh pri Podzemnykh Vzryvakh i Zemletriaseniiakh] ," Doklady Akad. Nauk S.S.S.R., V. 139, n. 1283-6, 8p. (1959).

The difference in the periods of seismic waves excited during underground explosions and earthquakes was investigated. The period of the surface waves of an explosion at epicentral distances between 300 and 1100 km was found to be 2 ± 0.5 second. For this case, the period was practically independent of distance. At distances of 200 km, the period of the surface wave during explosions was found to be generally one-half the period of the surface waves during earthquakes; at distances of 1000 km, the period was only one-fourth; and at distances of 2000 km, the period was only one-fifth.

KOLSROD, E. R., "An Electrostatic Method for Controlling the Parameters of a Low Frequency Vibration Pickup," Navord Rept. No. 2202 (1951).

This report describes a theoretical and experimental investigation of certain features of a low frequency seismograph which was developed at the Naval Ordnance Laboratory under Task No. NOL-144.

KON'KOV, A. A. See Bune, V. I.

KONSTANTINOVA, A. G., "Dynamics of Instantaneous Coal and Gas Outbursts in Mines, Inferred from Seismo-Acoustical Observations," Izvest. Akad. Nauk. S.S.S.R., Ser. Geofiz., n. 2, pp. 150-158 (1959).

A study based mainly on material collected during Seismo-Acoustic observations during the rockburst of April 7, 1954, in the Yun Kom coal mine, central Donets Basin.

The material analysed included oscillograms, spectrograms, and phonograms recorded in the mine during the rockburst. The total duration of the rockburst was about 23 seconds. The oscillograms indicate that the rockburst can be divided into three cycles. Each cycle lasted about eight seconds and can be divided into two parts. The first part lasted about five seconds and is characterized by low frequency (largely 150-300 cps). The second part is characterized by higher frequencies and also a greater range of frequencies (600-1600 cps). The overlap of the low and high frequency intervals is only a few tenths of a second.

An analysis of the data makes it possible to establish certain characteristics of the rockburst process. The greatest destruction was produced by the splitting off of a mass of coal and of the walls of the mine gallery; these were pulverized. This splitting was caused by the press of the overburden to which the mine gallery is exposed from all sides except from the face of the workings. The press of the gas contained in the coal can be a contributing factor. The article reproduces many oscillograms, showing the process at different stages.

KORSCHUNOV, A., "On Surface Waves in Loose Materials of the Soil," Geophys. Prosp., V. 8, n. 4, pp. 359-379 (1955).

A method of observing the effects of hammering and of small blasts has been applied in a series of experiments on various soils, using a

three-component set of small mechanical leaf-spring seismographs. The seismograms were subjected to harmonic analysis. The experiments confirm the theoretical concept of Rayleigh waves generated in a layer overlying a semi-infinite medium. The dispersion curves resulting from different experiments correspond well with theoretical dispersion curves. A method of determining the absorption of surface waves is discussed.

It may be concluded that every seismic pulse generates a specific Rayleigh wave mechanism in loose layers and that most of the delivered energy is transformed into surface waves. The depth of penetration of the Rayleigh wave mechanism and its frequency spectrum depend upon the delivery of energy and upon the consistency of the particular soil.

Practical implications regarding refraction surveying are mentioned.

KOSMINSKAJA, I. P. See Weizman, P. S., et al.

KRAUSE, O. H. See Lindsay, W. F., et al.

KUBOTERA, A., "Stoneley Waves Generated by Explosions," J. Phys. Earth, V. 3, n. 1, pp. 23-30 (1955).

KUBOTERA, A., "Rayleigh and Sezawa Waves Generated by Explosions," J. Phys. Earth, V. 5, n. 1, pp. 33-41 (1957).

Ground motions generated by small dynamite charges have been studied, using seismometers set up at various depths in bore holes and varying the shot-hole depths. The surface waves observed can be considered to be Rayleigh and Sezawa waves. The Rayleigh wave has a velocity of 60 m/sec, — a period of 0.22 second, and its amplitude decreases exponentially with depth. The Sezawa wave has a velocity of 500 m/sec, a period of about 1.0-0.08 second, and its vibration mode has one node in the upper layer. These results are in good agreement with the theoretical behavior of Rayleigh and Sezawa waves.

KUPALOV-YAROPOLK, L. K., Vzryvnyye Raboty pri Seysmicheskoy Razvedke [Explosion Work in Seismic Exploration] , Moscow, Gostoptekhizdat (1958).

This book contains general information on geology, geophysical methods of exploration, and the use of explosives in seismic exploration. Explosives, their properties, and their application in seismic exploration are discussed, and regulations for their safekeeping, transportation, and deactivation are given.

LABROUSTE, Y., "Seismic Recordings of Nuclear Explosions [in French] ," Acad. Sci., Paris Compt. Rend., V. 247, n. 3, pp. 321-323 (1958).

The sites of four nuclear explosions at Bikini atoll calculated from seismic records are within 10 km of the exact locations recently published by the U. S. Atomic Energy Commission. The PP waves were particularly clear at Noumea, Parc-Saint-Maur, and Tamanrasset observatories; surface waves were absent at Noumea and Tamanrasset, but Rayleigh waves showing marked dispersion were recorded at Parc-Saint-Maur by the long-period vertical seismograph. The first arrival is interpreted as a compressional wave at four stations at very different azimuths (Riverview, Palisades, Bermuda, and Tamanrasset).

LABROUSTE

LABROUSTE, Y. See also Beaufils, Y., et al. (2); Geneslay, R., et al.

LABROUSTE, Y., and BEAUFILS, Y., "Refractions multiples dans les enregistrements seismographiques des explosions de Champagne, octobre 1952. [Multiple Refractions in the Seismographic Records of the Champagne Explosions, October 1952] ," Bur. Cen. Seism. Intnat'l. Publ., Ser. A, Travaux sci., n. 19, pp. 335-338 (1956).

Several noteworthy trains of refracted waves were recorded by the Companie Generale de Geophysique from the Champagne, France, explosions of October 1952. A P_1 phase travelled with a velocity of 1.80 km/sec along a surface layer about 60 meters thick. P_2 (v = 2.92), P_3 (v = 3.80), and P_4 (v = 4.50) correspond to boundaries at 369, 745, and 2435 meters in depth. A weak P_5 (v = 5.20) was the first arrival at distances between 5300 to 5550 meters corresponding to a boundary at 2897 meters, and P_6 (v = 6.00) appeared at distances between 13 and 40 km. Three series of multiple refractions, sometimes of large amplitude, complicated the seismograms.

LAMB, G. L., Jr., "Some Seismic Effects of Underground Explosions in Cavities," U. of Calif., Los Alamos Sci. Lab. Rept. No. La 2405 (1960).

A number of the effects created by a seismic explosion contained within an underground cavity of a size sufficient to ensure elastic behavior of the side walls are investigated theoretically. The Rayleigh waves generated by a source of compressional waves in a semi-infinite homogeneous elastic medium are calculated; the stress concentration around a spherical cavity in a homogeneous elastic medium acted on by an arbitrary body force is determined, and the results are specialized to the case of a uniform gravitational field with vanishing lateral displacement; the stress distribution around a prolate spheroidal cavity in a uniform gravitational field with vanishing lateral displacement is considered, and the plastic expansion of a spherical cavity in an infinite elastic medium is discussed. A final chapter discusses seismic waves generated by an air burst.

LAMBERT, A. P. R., FISH, H. S., and HARVEY, R. B., "Field Experiment No. 535: To Record the Effects Produced by the Detonation of a 40,000 Pound Hemisphere of TNT," AD 247012, Suffield Experimental Station Field Experiment No. 535.

This is a proposal for a cooperative trial between Canada, the U.S. and U.K. Its main objective is to collect data on the characteristics of ground motion and shock wave, check existing concepts of scaling laws applied to the effects of explosions on targets (aircraft sections, trenches, missile models, and vehicles) and compare the blast measurements obtained by Canadian, U.K., and U.S. instruments. Some exposures of dummies and animals are to be made.

The shot, 40,000 lb of TNT in 32.8-lb blocks, is to be fired at Watching Hill Range, Ralston, Alberta, after 1000 hours, 17 August 1960.

LAMPSON, C. W., "Effects of Underground Explosions, Final Report," U.S. Nat. Defense Research Committee Rept. No. A-479 (Library of Congress, OTS PB Rept. 50860) (1946).

Empirical formulas are given for the peak pressure, impulse, particle velocity, acceleration, and displacement of the medium as functions

of the distance, the size of charge, the depth of burial of charge and gauge, and the type of soil. These experimentally derived relationships are correlated with theoretical values obtained with the aid of a dynamic stress-strain curve for soil which is plotted in turn from experimental data. Evidence is presented to show that the shape of this curve is typical of a wide variety of soils.

The constants of the equations thus investigated are further correlated with the propagation velocities of seismic waves. The results allow a fairly good prediction of the magnitudes of the various seismic phenomena produced by shallow refraction shooting about a given area. Table, graphs, and sketches are included, and some of the problems are treated in detail in appendixes.

LANDAU, L., "On Shock Waves at Large Distances from the Place of Their Origin," Fiz. Zhur., V. 9, n. 6, pp. 496-500 (1945).

LANDISMAN, M. See Sato, Y., et al.

LATTER, A. L., "Concealment of Underground Explosions," RAND Corp., Santa Monica, Calif. Report (1960).

The Cowboy experiments on decoupling of underground nuclear explosions show that the principle of decoupling by means of a large hole is correct. The decoupling factor of 300, estimated in RAND Report R-348, is still the best estimate for a hole in salt relative to a tamped shot in Nevada tuff. It was found that decoupling is not an all-or-none effect and that, if the elastic limit of the medium is exceeded, the decoupling factor is reduced, but only gradually. As a result, it appears possible to explode a 20-kt device in a cavity no bigger than some which already exist, without producing a signal that could be detected by the Geneva system.

LATTER, A. L., LeLEVIER, R. E., MARTINELLI, E. A., and McMILLAN, W. G., "A Method of Concealing Underground Nuclear Explosions," J. Geophys. Research, V. 66, n. 3, pp. 943-946 (1961).

It is shown theoretically that the seismic signal from an underground nuclear explosion can be greatly reduced by carrying out the explosion in a large cavity. An estimate of the effectiveness of the method indicates that a yield of more than 300 kt (HE-equivalent) could be made to look seismically like a yield of 1 kt. Experiments with both chemical and nuclear explosions are needed to test the theory.

LATTER, A. L., MARTINELLI, E. A., MATHEWS, J., and McMILLAN, W. G., "The Effect of Plasticity on Decoupling of Underground Explosions," Report on Contract AT(11-1)-135 (1960).

The effect of plasticity, including work hardening, on decoupling underground explosions was studied both for cavities designed to give full decoupling according to the Geneva specification (70 m^3/ton of explosive energy) as well as small, overdriven cavities designed to give partial decoupling. An important result is that plasticity plays no role whatsoever for full-decoupling cavities, even those at great depth in which some plastic flow occurs during construction of the cavity. For overdriven cavities at great depth, plasticity affects the decoupling factor by an amount which depends upon the degree of overdriving and

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the depth as well as the detailed stress-strain curve of the medium. A further result of the study is that for cavities at a depth of about one km and in a medium like salt, which exhibits a reasonable amount of work hardening, the decoupling factor will be at least as great as that obtained in the overdriven Cowboy experiments and could be appreciably greater. To obtain more quantitative conclusions, better stress-strain data are needed for loading conditions appropriate to the decoupling problem. Plastic flow associated with pressure transients was ignored here, but should be examined.

LATTER, A. L., MARTINELLI, E. A., and TELLER, E., "Seismic Scaling Law for Underground Explosions," Phys. of Fluids, V. 2, n. 3, pp. 280-282 (1959).

Observations indicate that the amplitudes of distant seismic signals from underground nuclear explosions are approximately proportional to the total energy release. It is shown that these observations can be accounted for by a simple model which assumes that the nonlinear region close to the explosion is similar for all explosions and that the linear region transmits only low frequency waves.

LAUGHTON, A. S., "Laboratory Measurements of Seismic Velocities in Ocean Sediments," Proc. Roy. Soc. (London) Ser. A, V. 222, n. 1150, pp. 336-341 (1954).

Laboratory measurements were made of compressional wave velocities in samples of globigerina ooze and a grey claylike material collected in the north Atlantic in 1952. In uncompressed samples, the velocity in the ooze was 1.54 to 1.67 km/sec and the ocean density 1.58 g per cm^3: in the claylike material, which is less calcareous, velocity ranged from 1.47 to 1.52 km/sec and the mean density was 1.55 g per cm^3. The variation of velocity with compaction pressure was determined experimentally; the work indicates the existence of a gradient of velocity in the sediment which is of the same order of magnitude as that observed at sea.

LAWRENCE, P. L. See Dobrin, M. B., et al. (2); White, J. E., et al.

LAWRENCE, R. W., "Basic Research on Explosives," Explosives Eng., V. 20, n. 5, pp. 131-136 (1942).

The facilities, problems, and utility of basic research on explosives are examined, and the application of explosives in seismic prospecting is discussed.

LEE, C. C. See Collins, F.

LEE, M. R. See Crawford, J. M., et al.

LEET, L. D., "Earth Motion Due to Atomic Bomb," Science, n. 2671, p. 311 (1946).

LEET, L. D., "Earth Motion from the Atomic Bomb Test," Am. Scientist, V. 34, n. 2, pp. 198-211 (1946).

LEET, L. D., Earth Waves. Harvard University Press and Wiley, New York (1959).

Dr. Leet's latest book, second in a series of Harvard Monographs in Applied Science, deals entirely with the subject of seismology, both

theoretical and applied. After the mathematical theory of seismographs is developed, the instruments themselves are discussed in some detail. The new Leet seismometer is explained together with other station and prospecting instruments. From the seismographs used, the book proceeds to deal with the observed waves recorded. All the usual waves, P, S, and surface, are mentioned, and an introduction is made to two newly observed waves. The mathematical theory in this section is stated in its final form. Illustrations and examples are used here and throughout the book to make the text very clear. An interesting section is included on the appearance of seismograms of earthquakes from various epicentral distances. The subject of microseisms is discussed in the final chapter.

Dr. Leet's book is a basic reference for seismologists who have had a general mathematical background and who wish to acquaint themselves with some more recent advances in the subject.

LEET, L. D., "Blasting Vibrations' Effects, Pt. 1," Explosives Eng., V. 28, n. 6, pp. 176-178 and 190 (1950).

This is a review of the main types of elastic waves and the principles of seismographic recording.

LEET, L. D., "Vibrations from Delay Blasting," Bull. Seism. Soc. Am., V. 39, n. 1, pp. 9-20 (1949).

Systems of delay blasting are discussed with reference to their effectiveness in reducing vibrations. Standard-delay (long-delay) blasting by caps detonating at intervals of 1 to 6 seconds effects no fundamental reduction of vibration because the vibration pattern from each set of explosives is completed before the next begins. The method devised by the U.S. Bureau of Mines of simultaneously detonating charges spaced about half a wave length apart achieved cancellation of one peak but did not reduce the maximum amplitude. Results of experiments with short delays were so erratic that Bureau of Mines investigators concluded such shooting was not practical. Renewed attempts since 1945 to reduce vibration by short-delay firing, using either caps or a switch applying current to standard caps at predetermined delay intervals, have been more successful, although the mechanism by which the reduction was achieved was not well enough understood to permit application with equal success under a variety of conditions. The character of vibration records in controlled comparison tests indicates that reduction of vibration occurs at the source. The author suggests two factors which may produce the observed effects by reducing the amount of vibration in the solid face: a decoupling coefficient based on the fact that gasses from delay holes move through rock already partially shattered and decoupled from the solid face by the instantaneous shot, and an interference coefficient, or interference and cancellation of waves in the zone of shattering.

LEHMANN, I., "On Two Explosions in Danish Waters in the Autumn of 1946," Geofis. pura e appl., V. 12, pp. 145-161 (1948).

Explosions in ammunition sunk into the sea off the Danish coast were at the Kobenhavn, Lund, and Gottingen observatories. Records of two such explosions are described in detail and compared with that of an earthquake.

LeLEVIER, R. E. See Latter, A. L., et al.

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LIFSON, H. See Pekeris, C. L., et al

LINDSAY, W. F., HEUSINKVELD, M., VILLAIRE, A. E., and KRAUSE, O. H., "Close-In Pressure Measurements with Tourmaline Crystals on Tamped Detonations, Project Cowboy," U. of Calif., Livermore, Lawrence Radiation Laboratories. UCRL Rept. No. 6184 (1960).

Experiments were designed to measure dynamic stress conditions resulting from explosions in earth media and to provide data for comparative calculations on seismic disturbances from tamped and decoupled explosions.

Tourmaline crystal transducers placed close (3 to 50 feet) to tamped high explosive detonations detected dynamic elasto-plastic stress waves generated in salt. Detonations occurred at 110 feet below the 800-foot working level of the Carey Salt Mine near Winnfield, Louisiana.

Elastic stress waves of one kilobar magnitude and with velocities of about 15,000 fps were observed. Inelastic stress waves up to six kilobars in magnitude were measured. Their velocities ranged between 9000 to 12,000 fps. Approximate peak pressures, pressure arrival times, and pulse durations were calculated.

Data obtained from large-scale detonations gave approximate correlation with theory. However, ambiguous results also were observed and have not been explained.

LIPTAY, I. See Galfi, J.

LOCONTI, J. D., COLES, H. W., and THRON, C. D., "Ground Zero Locators," AD 129238, Quartermaster Research and Development Command, High Polymer Series, Rept. No. 7.

This report outlines the general requirements for ground zero locators and discusses the factors influencing sensitivity, the fabrication, coating, testing, final assembly, and placement of locators.

A foamed polystyrene sphere supporting three coatings meets the requirements and provides an inexpensive, sturdy device for the intended purpose.

LONGMAN, I. M. See Pekeris, C. L.; Pekeris, C. L., et al.

LORRAIN, P. H. See Andrews, T. J., et al.

LYAKHOV, G. M., "Reflection and Refraction of Shock Waves in Multicomponent Media in Water," Izvest. Akad. Nauk S.S.S.R., n. 5, pp. 58-63 (1959).

An analysis is made of shock wave motion in several media and of reflection and refraction at the boundary of two media and at a stationary barrier.

MA, E., "Issledovaniye gruppovyk vzryvov v seysmorazvedke metodom otrazhennykh voin [Investigation of Group Shots in Seismic Exploration by the Method of Reflected Waves] ," Prikladniya Geofiz., n. 26, pp. 14-29 (1960).

The arrangement of charges in pattern shooting used for seismic exploration is analyzed; linear, rectangular, and circular distributions,

and their directional characteristics are considered. Surface grouping of unequal charges is shown to produce the needed directional characteristic. A method using a three-dimensional distribution of pattern charges is proposed.

MA, E., "Primenenii kurgovogo gruppirovaniya zaryadov pri seysmorazveke po metodu otrazheniy [Application of Circular Grouping of Charges in Seismic Exploration by the Reflection Method] ," Prikladniya Geofiz., n. 26, pp. 3-13 (1960).

The method of circular grouping of charges is discussed. As used in the Chinese People's Republic in 1954 and 1955, equal charges are placed on the surface at the center of a circle and at six equidistant points along the circumference. The weight of individual charges ranges from 0.2 to 5 kg, and the radius of the circle from 5 to 25 meters. A mathematical treatment is given for the seismic waves reflected from a plane discontinuity at depth. The method proposed increases the percentage of the effective energy of the explosion and permits checking by repeated seismic sounding at the same point.

MacCARTHY, G. R., "An Annotated List of North Carolina Earthquakes," J. Elisha Mitchell Sci. Soc., V. 73, n. 1 (1957).

This paper is an attempt to list all earthquakes which have their origin or have been felt within North Carolina.

MacCARTHY, G. R., "A Note on the Virginia Earthquake of 1833," Bull. Seism. Soc. Am., V. 48, pp. 177-180 (1958).

An earthquake of about 6 intensity occurred in eastern Virginia, August 27, 1833. This shock is described in terms of contemporary accounts.

MacCARTHY, G. R., "The Formation of Joints as a Possible Cause of Certain Seismic Phenomena," Southeastern Geology, V. 1, n. 4 (1960).

Rough computations indicate that rock jointing may liberate sufficient energy to produce small seismic effects.

MacCARTHY, G. R., and SINNA, E. Z., "North Carolina Earthquakes: 1957," J. Elisha Mitchell Sci. Soc., V. 74, n. 2 (1958).

Some details of three small earthquakes which occurred in western North Carolina in 1957 are given. All were of magnitude 5-5 1/2 on the Modified Mercalli Intensity Scale.

MACELWANE, J. B., ROBERTSON, F., HEINRICH, R. R., and BLUM, V. J., "The Variability of Vibrations from Quarry Blasts," St. Louis Univ. Inst. of Technology (1948).

During the years 1938-48, the authors studied vibrations in the ground generated by blasts in the Fort Bellefontaine and Prospect Hill quarries, St. Louis, Missouri. The vertical component of ground motion was observed, using a Taylor-Macelwane mechanical seismograph with natural frequency of three cps, near-critical damping, and adjustable magnification. Records were made, at different distances from the quarries, of blasts ranging in size from 200 to 1300 lb. Records of similar blasts were sometimes alike, but more often different. A detailed

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study of this variability, using displacement and deduced acceleration as criteria, shows a wide scatter of data. The report includes several seismograms and numerous graphs of displacements and accelerations plotted against the amount of explosives and distances.

MADDOCK, I., "Seismic Detection Programme, Operation Macseagull Plan," United Kingdom Atomic Energy Authority. Report on Plan UDP 3 (1961).

This paper describes the elements of planning preceding Operation Macseagull, a program for studying the results of underwater detonations at Loch Striven.

MANOHAR, M. D. See Banerji, S. K.

MARC SHIOWITZ and ASSOCIATES (Staff), "Preliminary Study of the Data Processing Subsystem Requirements for the Seismological Systems Laboratory," Marc Shiowitz and Associates. Final Rept. (1961).

This report is a study to determine the data processing requirements, both equipment and cost, for the seismological systems laboratory. Total costs for personnel and equipment are estimated at $1,138,480 per annum.

MAREK, V. See Karnik, V.

MARK, J. C., "The Detection of Nuclear Explosions," Los Alamos Scientific Lab., N. Mex. Report (1959).

Various environments in which an explosion might be staged, signals that might be propagated, instrumentation that might be effective in recording these signals, and the problem of sorting out signals of nuclear events from natural or man-made non-nuclear events are fully considered.

MARK, J. C., "The Detection of Nuclear Explosions," Nucleonics, n. 8, pp. 64-73 (1959).

Nuclear explosions may be detected by several methods. Contained underground explosions may best be monitored by a seismograph. Such exposions however, must be distinguished from earthquakes. An earthquake sends out rarefaction as well as compression waves, both of which transmit as longitudinal waves. The rarefaction waves are almost always transmitted in two roughly opposite quadrants. Explosions, on the other hand, would be expected to transmit compressions in all directions. Thus the direction of the first motion observed in various directions from the epicenter should distinguish between nuclear explosions and earthquakes.

MARTIN, D. L., and HINZE, W. J., "Energy Partition of Underground Explosions," Army Engineer Research and Development Laboratories, Ft. Belvoir, Va. Technical Rept. No. 1513-TR on AFSWP-789 (1958).

This study presents the analyses of data obtained from explosions with nine charge conditions. The shots were fired at the Waterways Experiment Station (WES), Vicksburg, Mississippi. The investigation was designed to yield information concerning the partitioning of energy from high explosives of the same total energy release but of different energy densities. The explosive charges, 27 lb of Composition C^{-4} and 54 lb of ammonia dynamite (AD), were detonated underground. It is concluded that: the explosive of higher density, when freely vented,

tends to expend a greater amount of energy to the air and, as a result of stemming of the charge holes, partitions a greater proportional amount of energy into the ground than does the explosive of lower energy density when charges of equivalent total energy release are detonated under identical conditions.

MARTIN, H., "Theory of the Recording of an Impulse by an Electrodynamic Vibrometer," Gerlands Beitr. Geophys., Band 63, Heft 3, pp. 209-233 (1953).

MARTINELLI, E. A. See Latter, A. L., et al. (3).

MASICH, N. M. See Andrews, T. J., et al.

MASON, R. G., "A Small-Scale Field Investigation of Motion Near the Source," Geophys. Prosp, V. 5, n. 2, pp. 121-134 (1957).

In the experiments described, a falling weight was used as the source of energy with a recording system that permitted quantitative measurement and the display of two-dimensional pictures of ground displacement on a cathode ray oscillograph. The first wave at points within 100 feet of the source had the characteristics of the P wave and a velocity of 2170 fps; beyond 100 feet the amplitude became so small that the wave could no longer be identified with certainty. The next arrivals were predominantly vertical motion and were identified as S waves. Beyond 140 feet, the first arrival was a refracted wave traveling in the lower medium and identified as an S wave. The refracting interface was at about the expected depth of the water table. At 40 feet from the source and beyond, the largest amplitudes were associated with motion having the characteristics of Rayleigh waves.

MATHEWS, E. A. See Latter, A. L., et al.

MATHUR, S. P. See Howell, B. F.

MATUMOTO, T. See Matuzawa, T., et al.

MATUZAWA, T., MATUMOTO, T., and ASANO, S., "The Crustal Structure as Derived from Observations of the Second Hokoda Explosion"[in Japanese with English abstract], Zisin, J. Seism. Soc. Japan, Ser. 2, V. 13, n. 2, pp. 78-89 (1960).

The crustal structure of the Kwanto area and of northeast Japan as derived from observations of the second Hokoda explosion are discussed. In the Kwanto area three layers were observed above the M-discontinuity: the first layer (velocity 1.74 km/sec, thickness 0.92 km) does not exist north of Hitati; the second layer (velocity 5.5 km/sec, thickness 4.3 km) thins northward at a distance of 40 km from Hokoda, and near Tamura; the third layer (velocity 6.2 km/sec) approaches the surface. The near-surface presence of the 6.2 km/sec layer is also supported by surface geology and gravity data. In northeast Japan, except in the areas of Siroiwa and Kaneyama, a thin surface layer is underlaid by a 5.8 km/sec second layer with a thickness of 4-8 km; it corresponds to the 5.5 km/sec layers of the Kwanto area. Under Hokoda the velocity of the Pn waves is 7.7 km/sec and the depth to the M-discontinuity is 27.5 km; the discontinuity rises northward at an angle of about 2^{o}.

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McKAY, A. E., "Review of Pattern Shooting," Geophys., V. 19, n. 3, pp. 421-437 (1954).

Patterns of shot holes and patterns of seismometers are now standard technique in many areas currently being surveyed by the seismograph. This paper reviews some of these pattern arrangements and shows comparison records in a number of areas such as New Mexico, west Texas, western Oklahoma, Mississippi, and Florida. Although pattern shooting is definitely proved as a useful technique, it is not to be construed as a cure-all for difficult shooting areas.

McKEOWN, F. A., and DICKEY, D. D., "Some Relations Between Geology and Effects of Underground Nuclear Explosions at Nevada Test Site, Nye County, Nevada," U.S. Geological Survey, Geological Survey Research. USGS Prof. Paper No. 400-B (1960).

The effects of stress waves produced by the Logan and Blanca explosions on rock exposed in tunnels appear to be controlled by (1) the direction of propagation of the waves through rocks of different composition and physical properties, and (2) the angles of intersection between the direction of propagation and fractures in the rocks.

McMILLAN, W. G. See Latter, A. L., et al. (2).

MEDVEDEV, S. V., "Seysmometr diya opredeleniya ball'nosti zemletryaseniy [Seismometer for Determining the Intensity of Earthquakes]," Trudy Inst. Geofiz. Akad. Nauk S.S.S.R., n. 36(163), pp. 127-133 (1956).

A seismometer, designed for determination of the class of an earthquake according to the scale of intensities, suggested by Medvedev and recently adopted in part by Russian seismological observatories, consists of a spherical pendulum suspended in a tripod and having a natural period of vibration of 0.25 second and a damping ratio of 0.50. The damping ratio is adjustable over wide limits by an electromagnetic arrangement. The pendulum mass is formed as a spherical cap carrying a stylus in its middle that traces the deflection of the pendulum on the record beneath.

A sample record is included. The seismic impulse was produced artificially by an explosion of 1800 tons of TNT at a distance of 600 meters. The polar diagram of the deflections shows that the greatest amplitudes were observed not in the plane directed from the point of observation to the shot point, but at an angle of about 45°.

MEDVEDEV, S. V., "Voprosy seysmicheskogo rayonirovaniya [Problems of Seismic Regionalization]," Akad. Nauk S.S.S.R. Soviet po Seysmologii Byull., n. 8, pp. 5-27 (1960).

The seismicity map of the U.S.S.R., published in 1957 on a scale of 1:5,000,000, is reproduced and discussed from the point of view of earthquake distribution and sources of data. Maps from other countries—Western United States, Japan, Germany, Rumania, India, Hungary, Turkey, and China—are also described briefly and reproduced.

Inadequacies in the present methods of seismic regionalization are pointed out. The time factor is neglected, and no estimate is given of the probability of earthquakes of a given intensity for each point. Zones are not differentiated according to the spectral composition of surface

wave oscillations, nor according to focal depth or focal mechanism of the earthquakes. Movements of the foundations of constructions in the different zones are not completely characterized quantitatively. The differential effect of ground conditions on the intensity of oscillations is not taken into account. Finally, the boundaries of the different seismic zones are not drawn with sufficient accuracy.

It is proposed that seismic regionalization be established on a "two-stage" principle. The first stage would be compilation of a map of "prediction of seismicity," showing zones where earthquakes of a given magnitude energy at the focus originate, and indicating focal depth and the probability of such earthquakes. The second stage would be compilation of a map of "prediction of seismic effects." This map would give the magnitude, spectral composition, ground oscillations at the earth's surface, and probability of earthquakes. The former would be based on seismic data; the latter would also take into account the geologic conditions. Possible lines of investigation to be pursued toward these ends in the next few years are outlined.

MELAMUD, A. Y., KHUDZINSKY, L. L., and DEINEGA, S. A., "A Station for Intermediate Magnetic Recording of Seismic Waves," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 2, pp. 128-137 (1960).

A description of Russian apparatus designed for intermediate recording of seismic vibrations, using the method of frequency modulation. The instruments are designed for frequencies ranging from 20 to 500 cps and can be combined with equipment designed for low, middle, and high frequencies. The range of the useful frequency can be increased by a simple modification of the preamplifier wiring. Thus, the frequency spectrum of the station could be adapted for use as an intermediate recording station in deep seismic exploration. A great advantage of the station described is the precise reproduction of the records for detailed analysis in the laboratory. The installation does not produce any additional distortion of recorded vibrations and thus can be used in studies of the dynamic characteristics of seismic waves. The apparatus can easily be built as a portable station.

MENZEL, H., "On the Spectrum of Seismic Waves Produced by Explosions" [in Italian], Ann. geofis. (Rome), V. 4, n. 3, pp. 301-321 (1951).

In an attempt to explain changes in the spectrum of waves propagating through the upper layers of the crust, two physical phenomena are analyzed; the interference of the direct wave reflected at the free surface of the earth; and the dissipation of energy by reflection, refraction, and diffraction within the upper layer.

In the mathematical analysis of these two phenomena, the ground is assumed to be a perfectly elastic medium. The effect of the explosion on the surrounding medium is assumed to follow three phases, as suggested by Morris (see Geophys. Abstract 12026). During the first phase the chemical reaction is accomplished without mechanical effects. This is followed by a second phase, the spreading of disintegration of the ground up to the radius where the deformation becomes elastic, beyond which an elastic spherical wave motion is produced. The waves propagating from the point of explosion are assumed to be spherical longitudinal waves. The displacement of a point along the ray is given by the grad-

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ient of the stress with respect to the radius vector, with the center of the coordinates placed in that point. The differential equation of wave motion has the shape $p\frac{\partial^2 F}{\partial t^2} = (\gamma + 2\mu)\,\Delta F$ where p is the density of the ground, and μ and γ are the Lamb constants. By introducing a complex variable, the solution of this equation can be obtained, but numerical evaluation of the results, even under simplifying assumptions, is difficult. It can be concluded, however, that the greatest effect on the incoming seismic wave is produced by the detrital layer, which strongly influences the frequencies of the direct and reflected waves.

MERRILL, R. H., "Static Stress Determinations in Salt, Project Cowboy," Applied Physics Research Laboratory. APRL Rept. on Memo of Understanding, AEC No. AT (29-2)-914 (1960).

Tests were made to determine the stress field in a salt dome and the stress concentrations on the surface of a 12-foot diameter salt sphere in the Carey Salt Mine near Winnfield, Louisiana.

Stress in the salt near and far from the surface of underground openings was determined by (1) measuring the change in the deformation of bore hole before and after stress relieving the hole by overdrilling, and (2) calculating the stress from the relationship between measured bore-hole deformation and the applied stress.

Instrumentation consisted of a bore-hole gage, a straingage indicator, and a diamond drill. Gage sensitivity was about 30 micro-inches. The modulus of elasticity was computed from stress-strain and stress-deformation measurements.

It was determined that the salt at site Cowboy was plastic, not elastic, and inferred that the degree of plasticity of salt is dependent upon the age of the opening.

A detailed description of the apparatus and procedure plus graphic presentations of accumulated data and test results are contained in the report.

MERRILL, R. H., "Static Stress Determinations: Hockley Salt Mine," Applied Physics Laboratory. APRL Rept. on Memo of Understanding, AEC No. AT (29-2)-919 (1960).

Measurements were made to determine the static stress field in the halite of the Hockley Salt Mine, Houston, Texas.

The static stress in the salt was determined by measurements of the variation in diameter of eight bore holes before and after stress relieving. Three observations suggest plastic flow in the salt: (1) The measured stresses appear to be independent of the position in the bore hole, while theory (assuming medium perfectly elastic, homogeneous, isotropic) predicts a concentration of stress near the bore-hole collar; (2) The magnitudes of the principal stresses are nearly equal, suggesting a plastic material with Poisson's ratio of 0.5 in a unidirectional stress field; (3) The average of the principal stress is about .70 of the computed theoretical stresses due to the overburden; the lower value can be attributed to a reduction of stresses due to plastic flow.

MERRILL, R. H., HOOKER, V. E., "Static Stress Determinations and Crushed Zone Measurements: Site Hobo," Applied Physics Research Laboratory. APRL Rept. No. E38-7.1 (1960).

Post-detonation measurements were made to determine the static stress field in the volcanic tuff, and volume and shape of the crushed rock zone surrounding the underground explosions fired during Project Hobo (Nevada Test Site, Mercury, Nevada).

The modulus of elasticity (E) of the tuff was determined in the laboratory ($.16 \leq E \leq .56 \times 10^6$ psi). The stress in the tuff at positions along a horizontal tunnel was determined by post-shot measurements of the variation in diameter of bore holes before and after stress relieving.

The measured principal stresses of only two bore holes agree reasonably well with computed theoretical stresses (assuming medium perfectly elastic, homogeneous, isotropic) due solely to the overburden.

MICKEY, W. V., "Seismic Background Observations and Measurements at U.S. Naval Air Station, Norfolk, Virginia," U.S. Coast and Geodetic Survey. USCGS Rept. on Order No. 188/4859/60 (1960).

Seismic studies were carried out at the Naval Air Station, Norfolk, Virginia, to determine the general noise level of the area and its characteristics. Measurements were made, both inside and outside a building, with a variety of seismometers. Earth particle displacements were found to vary over the range .05 to 4.1 μ. Based on simple harmonic motion, calculated earth-particle accelerations varied from about 10^{-2} to 10^{-4} g.

MICKEY, W. V. See also Carder, D. S.

MILNE, A. R., "Comparison of Spectra of an Earthquake T-Phase with Similar Signals from Nuclear Explosions," Bull. Seism. Soc. Am., V. 49, n. 4, pp. 317-329 (1959).

Hydrophones from a surface vessel in 1300 fathoms of water off Juan de Fuca Strait detected, in the course of the "Hardtack" series of tests in the Marshall Islands, 3 acoustic signals which had peaks in their energy spectra at frequencies less than 20 cps. Two of these appear to have originated from nuclear explosions; the third, though having a similar energy spectrum, was apparently a T-phase from an earthquake near Cape Mendocino with its epicenter at 40°16'N., 124°12'W., and an original time of 23:04:46, on May 24, 1958.

Travel-time measurements and signal spectra indicate that the nuclear explosions originated within Eniwetok Atoll. The coupling of their signals to the water path apparently was similar in nature to that of the earthquake T-phase, but the duration of the signals from the nuclear explosions was considerably less.

MINTROP, L., "On the Stratification of the Earth's Crust According to Seismic Studies of a Large Explosion and of Earthquakes," Geophys., V. 14, n. 3, pp. 321-336 (1949).

Analysis of the records of the Helgoland explosion of April 18, 1947, at 19 stations gave the following longitudinal velocities: 3.5 (sedimentary), 5.2 (granite), 6.5 (basalt), 8.1 (peridotite), and 9.2 km/sec (perhaps pyroxenite). A depth of 57 km for this last interface was determined from

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time-distance curves of both reflected and refracted waves. Other reflections indicate a disturbed zone between 110 and 118 km, and interfaces at 170 and 183 km. Time-distance curves from the Helgoland blast and the 1908 Messina earthquake show eight interfaces at depths of 4, 13, 28, 57, 110, 118, 170, and 183 km, the longitudinal velocities being 3.5, 5.2, 6.5, 8.1, 9.2, about 7, 11.0, and 16.3 km/sec respectively. The 7 km/sec velocity is estimated on the assumption that the 110-118 km zone is a plastic layer. A number of reflections occur beneath the 16.3 km/sec layer and the velocity may be about 9 km/sec, in close agreement with results obtained by other investigators, assuming velocity increases gradually with depth from the base of the crust. Transverse wave velocities were 2 (sedimentary), 2.9 (granite), 3.6 (basalt), 4.5 (peridotite), 5.0, 6.2, and 8.8 km/sec, the velocity within the disturbed zone being unknown. The author concludes that the plastic layer between 110 and 118 km represents a globe-girdling belt, the depth corresponding to the depth of the isostatic surface calculated by Hayford and Helmert.

MITCHELL, D., and PATERSON, S., "Spread of Detonation in High Explosives," Nature, V. 160, n. 4065, pp. 438-439 (1947).

MONAKHOV, F. I., PASECHNIK, I. P., and SHEBALIN, N. V., "Seismic and Microseismic Observations at the Soviet Stations During the International Geophysical Year," American Meteorological Society, (Trans. No. T-R-258 of Izdatel'stvo Akademii Nauk S.S.S.R.) Rept. on Contract AF 19(604) 6113 (1959).

The basic scientific results are presented of microseismic studies obtained from an analysis of microseismic data. During the IGY the Soviet Union set up 5 Arctic and 2 Antarctic seismic stations for the study of those almost unknown (seismically) regions, and 6 tripartite microseismic stations used to determine directions to the source of microseisms. In addition, 19 seismic stations are conducting regular observations of amplitudes and periods of microseismic oscillations. All the stations are equipped with Soviet instruments. The magnification of earthquake-recording instruments varies from 600 to 40,000. The equipment at the stations has a magnification of about 7000 with periods of 4-5 seconds.

MORELLI, C., "Studio di alcune esplosioni subacquel nel Golfo di Trieste [Study of Submarine Explosions in the Gulf of Trieste]," Ann. Geofis. (Rome), V. 2, n. 1, pp. 113-136 (1949).

Explosives detonated on the sea bottom at distances of 3-10 km and in a marble quarry 16 km from the Trieste seismograph station were recorded by the Wiechert and Alfani instruments as well as the Geiger accelerometer. The velocities of P and S waves were determined as 2680 and 1720 m/sec respectively. Strong amplitudes of the direct longitudinal waves were observed in the water at short distances from the shot points. Rayleigh-type surface waves were found at the boundary of the water-ground system as predicted by the theory of Press and Ewing.

MORI, K. See Nagumo, S., et al.

MORRIS, G., "Some Considerations of the Mechanism of the Generation of Seismic Waves by Explosives," Geophys., V. 15, n. 1, pp. 61-69 (1950).

When an explosive is detonated, the walls of the shot hole are subjected instantaneously to pressures of several hundred t/in^2. This sudden impact

on the walls causes a shock wave which spreads out spherically. The initial stresses greatly exceed the strength of the medium and cause fracturing of the ground, but as the pulse moves outward, the stresses decrease and at the critical radius where the stresses just equal the elastic limit, the pulse becomes an elastic pulse. It is then transmitted essentially unchanged through the ground.

MORRIS, W. E., "Blast and Shock Measurements. III. Transient Ground Displacement Measurement," Naval Ordnance Lab., White Oak, Md. Report (1952).

An attempt was made to measure the transient ground displacement for the surface and underground shots of Operation Jangle. The method of high speed photography of the ground motion is described. Negative results were obtained for both the surface and underground shots. This method does not appear promising for any future nuclear surface tests. With good photography, this method has considerable promise for underground nuclear explosions and is recommended for future tests.

MORRIS, W. E., "Ground Acceleration Measurements," Naval Ordnance Lab., White Oak, Md. Report on Project 1.1 of Operation Jangle (1952).

Ground acceleration from nuclear detonations on the surface and underground were measured in the vertical, radial, and transverse directions at various distances. The propagation, effect of depth, frequency characteristics, and attenuation of the ground acceleration are discussed. It was found that when the high frequency transient air blast acceleration is considered, the surface shot is more effective in producing maximum acceleration; when the air blast effect is excluded and only the fundamental type acceleration is considered, the underground shot is more effective. These results scaled reasonably well with the 40,000-lb TNT charge detonated at the site. A new inductance-type accelerometer and recording system are described.

MOUNCE, W. D. See Rust, W. M., Jr.

MURAUCHI, S. See Omote, S., et al.

MURPHEY, B. F., "Particle Motions Near Explosions in Halite," J. Geophys. Research, V. 66, n. 3, pp. 947-958 (1961).

Peak particle velocities and displacements were measured for tamped (coupled) and cavity (decoupled) explosions in halite. Recordings are illustrated of particle velocity versus time in the salt medium and of pressure versus time on the cavity wall. Peak particle velocities from tamped shots decrease as $d^{-1.65}$ over distances equivalent to 40 to 800 feet for 1000 lb of high explosive. Decoupling factors that were directly observed apply only to close-in stations. One method of extrapolating close-in data yields distant decoupling factors ranging from 40 to 100 for these particular experiments. Actual measurements (verbal communication from Herbst, 1960) of distant decoupling factors give larger numbers by a factor of 2. Extrapolation to nuclear explosions is not attempted here.

MURPHY, B. F., and AMES, E. S., "Air Pressure Versus Depth of Burst," Report (1959).

MURPHEY

Air-blast pressure measurements for scaled depths of burst from 1λ to 3λ are presented to extend information available for use in some Plowshare projects.

MURPHEY, B. F., and VORTMAN, L. J., "Cratering with Chemical Explosives," Sandia Corp., Albuquerque, N. Mex. Report.

The field of cratering with chemical explosives is reviewed. Implications on cratering with nuclear explosives are discussed briefly.

MURPHEY, L. M. See Carder, S. D., et al. (2).

NAGUMO, S., MORI, K., and KAYAKAWA, M., "Experimental Studies on Seismic Disturbances and Reflection Waves" [in Japanese with English summary], Geol. Survey Japan Rept. No. 164 (1955).

Owing to the complex geologic structure, the major problem of reflection seismology in Japan is distinguishing reflected waves on the seimograms. After preliminary tests on the effect of topography, experiments were made, involving three shot holes averaging 20 meters deep, 800 meters apart, with geophones at 80 inch intervals and charges of 1.125 kg, to test the effect of distance and time on amplitudes. The distance at which maximum signal-to-noise ratio occurred was found to differ for each shot point. It is concluded that for best results most suitable shot-detector distances should be checked before setting each speed.

NAKAMURA, K. See Honda, H. (2).

NANNEY, C. A., "Evidence for Correlations Between Microseisms and Earthquakes," Naval Research Laboratory. NRL Rept. No. 5237 (1959).

This is a detailed, interim report of observations of correlations between microseisms and earthquakes. Correlations were found between:

(a) Microseism frequency and the occurence of large earthquakes;
(b) Microseism amplitudes and the occurrence of large and deep earthquakes;
(c) Smaller shocks and a local increase of microseism amplitudes;
(d) Long-period microseisms and the occurrence of deep earthquakes;
(e) Microseism propagation directions and the great circle path to the location of significant earthquakes.

The correlations were found to test significantly at a 0.01 statistical significance level or greater.

NATURE, "Ground Vibrations Near Dynamite Blasts," Nature, V. 144, n. 3653, p. 791 (1939).

NATURE, "Recordings at Kew of the Brest Explosion," Nature, V. 160, n. 4058, p. 184 (1947).

NATURE, "Seismological Observations of the Helgoland Explosion of April 18, 1947," Nature, n. 4215, p. 256.

NATURE, "Earth Movement Resulting from an Atomic Bomb Explosion," Nature, V. 159, n. 4029, pp. 85-86 (1947).

NATURE, "Pressure Waves from Explosions," Nature, V. 134, pp. 976-977.

NAVAL ORDNANCE LABORATORY (Staff), "Naval Ordnance Laboratory Low-Frequency Seismograph," AD 77612, NOL Memo No. 10226 (1949).

This memorandum describes the NOL Low-Frequency Seismograph, Type I.A, outlines the theory of its operation, and gives instructions for its installation, operation, and maintenance.

NEITZEL, E. B., "Seismic Reflection Records Obtained by Dropping a Weight," Geophys., V. 23, n. 1, pp. 58-80 (1958).

Measurements of the wave-shape of the seismic transient generated by dropping a weight indicate that the weight drop has a much higher efficiency than shooting dynamite. The surface wave which is generated by the weight drop is very large, but it is minimized by the use of large seismometer groups, many drops per trace, and large offset distances. For experimental studies, a special recording instrument adaptable for either shooting or weight dropping is used. The weight truck is hydraulically operated. Weight-dropping versus shooting studies indicate that the quality of weight drop records is limited by the large surface wave generated by the weight impact on the ground.

NEUMANN, F., Earthquake Intensity and Related Ground Motion, U. of Washington Press (1954).

NEWTON, R. G., "A Progressing Wave Approach to the Theory of Blast Shock," J. Appl. Mechanics, V. 19, pp. 257-262 (1952).

NIELSEN, D. E. See Olsen, J. L., et al.

NORDYKE, M. D., "Nuclear and Chemical Explosive Cratering Experiment Applicable to Plowshare," U. of Calif., Livermore, Lawrence Radiation Laboratory. UCRL Rept. (1961).

A brief review of nuclear cratering experiences and an outline of recent chemical cratering used to confirm theories are presented. To correlate the results, dimensional analysis indicated that a basic scaling law of $W^{1/3}$ is correct, where W is the weight of the explosive. Chemical cratering explosions and the Stagecoach program defined completely the depths-of-burst curves for desert alluvium from surface to containment depths. Preliminary results from the Scooter explosion indicated that $W^{1/3.4}$ scaling is adequate to predict crater dimensions. Data from the Buckboard program showed that it is unsatisfactory to use 1000-lb charges or smaller for cratering programs in hard-rock media.

NORDYKE, M. D. See also Shelton, A. V., et al.

NORTHWESTERN UNIVERSITY GAS DYNAMICS LABORATORY (Staff), "The Kinetics of Gases," Northwestern University Gas Dynamics Lab. GDL Rept. on AEDC-TN-60-130 (1960).

The fundamental features of real gas effects are reviewed with emphasis on high temperature effects. Topics considered include the thermal and caloric equations of state, basic effects in flow processes, and the speed of sound in reacting gases. The kinetics of the processes of dissociation and recombination and ionization and charge neutralization are discussed along with some applications. Analyses are presented describing chemical non-equilibrium effects in some flow situations, among them inviscid flow after sudden changes in fluid properties and the mixing of parallel streams.

NUCKOLLS

NUCKOLLS, J. H., "A Computer Calculation of Rainier (The First 100 Milliseconds)," U. of Calif., Livermore, Lawrence Radiation Laboratory, UCRL Report.

The purpose of these calculations is to test and develop a capability for predicting the phenomena of underground nuclear explosions from the laws of physics and the properties of materials. A special code, UNEC (Underground Nuclear Explosions Code), was developed for the IBM-709 computer to make these calculations. They extend in time from a few microseconds to ~ 100 msec after the Rainier explosion, and in space to a radius of several hundred feet from the site of detonation. Results are generally in good agreement with experiment.

OBERT, L., and DUVALL, W. I., "A Gage and Recording Equipment for Measuring Dynamic Strain in Rock," U.S. Bureau of Mines, Reports of Investigations, No. 4581 (1950).

OBERT, L., and DUVALL, W. I., "Generation and Propagation of Strain Waves in Rock," U.S. Bureau of Mines, Reports of Investigations, No. 4683 (1950).

In an investigation of the generation and propagation of strain waves produced in rock by the detonation of high-velocity explosives, 51 shots ranging in size from 1 to 64 sticks were fired and recorded at distances of 2 to 54 feet. The principal rock in the area was greenstone with stringers of epidote. Data on size of charge, distance, maximum compressive strain, maximum tensile strain, rise time (time required for wave to reach first compression peak), half period, major frequency, maximum rate of strain, and velocity of propagation are tabulated and certain relations are shown graphically. The maximum compressive strain, E, is given by the relation $E = K(\sqrt[3]{W/D})^n$ where K and n are constants, W the charge size in sticks, and D the travel distance in feet. The duration of the compressive half of the pulse increases with increasing size and distance, indicating that the absorption of high-frequency components is greater than that of low-frequency components.

O'BRIEN, P. N. S., "The Relationship Between Seismic Amplitude and Weight of Charge," Geophys. Prosp., V. 5, n. 3, pp. 349-352 (1957).

OBSERVATORY, The, "The Burton-on-Trent Explosion," The Observatory, V. 67, n. 837, pp. 54-56 (1947).

OFFICE OF NAVAL RESEARCH (Staff), "Symposium on Microseisms," AD 29338, National Academy of Science, Special Rept. (1953).

This publication, edited by J. T. Wilson and Frank Press, includes the presented papers, formal discussions, and floor comments of participants in the symposium held in Harriman, N. Y., in September, 1952. A short history of microseismology is presented and various observations and theories are discussed.

OLIVER, J., "The Phase Compensation Method of Equalization," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 9a (1959).

A method of equalization based upon well-understood properties of the earth rather than upon the empirical behavior of waves from another earthquake is presented. Once phase velocities have been determined over an entire continent or over the world, phase compensation can be

based upon known properties. The method of determining phase velocities and a simplified method of seismogram-analysis which permits the effects of these mechanisms to be subtracted from the recorded seismic wave train and thus determination of the nature of the sense of seismic pulse near the source are described. The method requires a network of stations so that individual phases of the seismic wave train may be traced across a given interval. Results of preliminary measurements in the United States demonstrate that such a study is feasible with a network of stations such as that proposed by the Geneva Conference.

OLIVER, J., "Seismic Waves in the Intermediate Period Range," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 8 (1959).

Body waves, surface waves, and microseisms in the intermediate period range from 1 to 20 or more seconds but generally in the 4- to 12-second range are discussed as important areas for emphasis in a research program. Good instrumentation is needed for these studies and in the case of body waves a large network of uniform instrumentation is important.

OLIVER, J., "On the Long-Period Character of Shear Waves," Bull. Seism. Soc. Am., V. 51, n. 1, pp. 1-12 (1961).

S and multiple S phases at moderate to large epicentral distances are frequently followed by normally-dispersed, long-period wave trains for which surface particle motion is elliptical and progressive and in the plane of propagation of the SV wave. The character of such phases can be explained as the result of coupling between the incident shear waves and dispersive PL waves in the near-surface wave guide. A detailed study of shocks in Mexico and in Montana recorded at Resolute, and less detailed studies of other data support this hypothesis.

OLIVER, J., CRARY, A. P., and COTELL, R., "Elastic Waves in Arctic Pack Ice," Trans. Am. Geophys. Union, V. 35, n. 2, pp. 382-392 (1954).

Experimental studies of the propagation of elastic waves in Arctic ice were made on the Beaufort Sea near Barter Island, Alaska, and on the Arctic Ocean near T-3, the ice island floating near the North Pole. Velocities of observed longitudinal waves ranged from 2400 to 2910 m/sec, with one exception. Shear-wave velocities were determined at three places, and for these three, elastic constants were calculated using 0.9 g/cm^3 as the density. Air-coupled waves were prominent where shots were fired at or near the ice surface at distances more than 200 times the ice thickness. Ice thicknesses determined from the air-coupled waves were less than measured thicknesses. Flexural waves were also observed. A high-frequency wave with velocity of about 1700 m/sec was detected, most prominently when the shot was on the surface of the ice or in a dry hole. The method of propagation is not understood.

OLIVER, J., and EWING, M., "Seismic Surface Waves at Palisades from Explosions in Nevada and the Marshall Islands," Proc. Nat. Acad. Sci. U. S., V. 44, pp. 780-785 (1958).

Surface waves from large nuclear explosions in the Marshall Islands were detected at Palisades, New York, at a distance of about 105°, and presumably may be detected by long-period seismographs throughout the world. Surface waves from nuclear explosions in Nevada were detected

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at Palisades at a distance of about 33° and presumably could be detected throughout most of North America. No information is available on these waves for oceanic paths. Signals from both sites consist entirely of dispersed Rayleigh wave trains. The dispersive pattern may be explained by using dispersion curves developed in studies of earthquake-generated surface waves. No Love or body waves were detected at Palisades. All the foregoing data are for sources on or above the earth's surface. Rainier, the small underground nuclear explosion, was not detected at Palisades.

OLIVER, J., and MAJOR, M., "Leaking Modes and the PL Phase," Bull. Seism. Soc. Am., V. 50, n. 2, pp. 165-180 (1960).

The PL phase is a normally dispersed train of waves of periods greater than about 10 seconds beginning at or near the time of the initial P wave and sometimes continuing at least to the time of the beginning of the Rayleigh-wave train. With adequate instrumentation the PL phase is commonly observed at distances less than about 25° from shallow shocks. In general, surface particle motion is elliptical and progressive, and amplitudes are not greater than about one-quarter those of Rayleigh waves of the same period. Comparison of PL- and Rayleigh-wave dispersion shows that both waves propagate in roughly the same near-surface wave guide. Whereas Rayleigh waves correspond to normal-(nonleaking) mode propagation, PL waves appear to correspond to leaking-mode propagation within this wave guide.

OLIVER, J., POMEROY, P., and EWING, M., "Long-Period Seismic Waves from Nuclear Explosions in Various Environments," Science, V. 131, n. 3416, pp. 1804-1805 (1960).

Large nuclear explosions in the solid earth, the hydrosphere, and the lower and upper atmosphere have generated seismic waves of periods greater than 5 seconds, which have been detected at great distances from the source. This report is a summary of the principal evidence now available on the subject.

Although there is great contrast between the explosive sources discussed and natural earthquakes, and although several unexpected waves were generated by nuclear explosions, virtually all the waves so generated can be identified and explained in terms of knowledge of seismic-wave propagation based on earthquake data.

OLIVER, J. See also Brune, J. N.; Carder, D. S. and Mickey, W. V.; Pomeroy, P.

OLSEN, J. L., BENNETT, W. P., and NIELSEN, D. E., "Temperature and Radiation Distributions in the Rainier Shot Zone," U. of Calif., Livermore, Lawrence Radiation Laboratory. UCRL Report.

In an attempt to understand the phenomenology of underground nuclear explosives and their applications to the Plowshare Program, extensive radiation and temperature measurements were made in the Rainier shot zone. In order to make the measurements, it was necessary to drill holes through the zone-of-effect, using standard underground drilling techniques with modifications for remote operations and radiation control. The cores taken from these holes were used for radiochemical analyses and physical

properties studies. The radiation distribution in the shot zones was determined by logging the drill holes for γ radiation using a standard Jordon RAMS unit having a range of 1 mr/hr to 1000 r/hr. Temperature distributions were measured using platinum resistance thermometers and thermistors.

OLSON, R. W., "The Technical-Economic Aspects of Automatic Data Reduction," Geophys. Prosp., V. 4, n. 4, pp. 335-347 (1956).

OMOTE, S., YAMAZAKI, Y., KOBAYASHI, N., and MURAUCHI, S., "Ice Tremors Generated in the Floating Lake Ice (Part 1)," Bull. Earthquake Research Inst., Tokyo Univ., V. 33, pt. 4, pp. 668-679 (1955).

Vibrations set up by the formation of cracks in floating sheets of ice on Lake Suwa, Japan, closely resemble those of natural earthquakes in many respects. P-wave velocities within the ice, measured by means of small explosions, ranged between 2900 m/sec in the daytime (temperature 5°C, ice soft) and 3230 m/sec at night (temperature -10°C). A second phase with a velocity of 1820 m/sec (measured when V1 = 8200 m/sec) cannot be S, as V_1V_2 is only 1.78; a third phase (1460 m/sec) is apparently due to waves passing through the water beneath the ice; and a fourth (330 m/sec) is considered to be due to flexural waves of the ice sheet. Epicenters were located from P-wave arrivals at 12 precisely located detectors; as a check, the origin points of several known explosions were calculated in the same manner and found to be in good agreement with the true origin. A few foci were determined from the commencement time of the flexural waves, which, although not as distinct as the P-wave arrivals, were nevertheless clearer than those of surface waves in natural earthquakes. The two sets of foci so nearly coincide that it is reasonable to assume that the compressional and flexural waves started from the same point simultaneously.

O'NEILL, B. J., Jr. See Hoy, R. B.

PASECHNIK, I. P. See Karus, Y. V.; Kogan, S. D., et al.; Monakhov, F. I., et al.

PATERSON, N. R., "Seismic Wave Propagation in Porous Granular Media," Geophys., V. 21, n. 3, pp. 691-714 (1956).

PATERSON, S. See Mitchell, D.

PAYMAN, W., WOODHEAD, D. W., and TITMAN, H., "Explosion Waves and Shock Waves. Part II: The Shock Wave and Explosion Products Sent Out by Blasting Detonators," Proc. Roy. Soc., Ser. A, V. 148, n. 865, pp. 604-622 (1935).

PAYMAN, W. See also Cybulski, W. B., et al.

PEARCE, T. H. See Carder, D. S., et al. (2).

PEET, W. E., "A Shock Wave Theory for the Generation of the Seismic Signal Around a Spherical Shot Hole," Geophys. Prosp., V. 8, n. 4, pp. 509-533 (1960).

The shape of the seismic signal generated by an explosive charge is assumed to be governed by shock-wave phenomena in a nonlinear region around the shot hole. The dimensions of this shock-wave region are shown to depend on the weight of the charge and the properties of the medium in which the shot is fired. For an ideally elastic medium the

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amplitude of the pulse outside the non-linear zone is found to vary as the 1/3 power of the charge weight. If the medium and (or) seismic instrument attenuate the high frequencies more than the low, a power law of the type $A = cQ^n$ (where A = amplitude, Q = charge weight, c = a constant) can be expected in which n = 1/3. The exponent n is a function of charge weight and theoretically can reach a maximum value of 4/3 for very small charges; for large charges, however, values near to 1/3 are to be expected.

PEKERIS, C. L., "New Methods for Interpretation of Seismic Records from Underwater Explosions," Oil Gas J., V. 45, n. 47, p. 126 (1947).

A study of the wave theory of propagation of sound produced by explosion in shallow water revealed that, in addition to the arrival times of the various refracted waves used in the seismic exploration of the ocean bottoms by the standard refraction method, the pressure wave received at large ranges from the source should exhibit certain features, which are also characteristic of the depth of water and the structure of the bottom.

All of the theoretically predicted new features have been discovered and measured in a study of more than 120 records obtained by M. Ewing and L. Worzel at five stations on the eastern continental margin. The deductions about the structure of the bottom made from the various features, including the standard refraction data, are consistent.

PEKERIS, C. L., "Theory of Propagation of Explosive Sound in Shallow Water," Columbia Univ., Div. War Research Repts., New York. (Library of Congress, OTS PB Rept. 28993).

This report presents a theoretical interpretation of pressure waves generated in shallow water by explosions of charges of TNT ranging from 0.5 to 300 lb. The normal-mode theory of propagation of sound in layered media, developed by the writer in 1941, was extended to cover the case of explosive sound, and the predictions of the theory about the shape and variation of amplitude in the received pressure pulse were investigated in detail. It was found that the theory predicted the existence of a series of readily identifiable new features in the pressure wave, each of which is characteristic of the depth of water and the structure of the bottom. The deductions about the distribution of sound velocity in the bottoms, based on an analysis of the various features of the pressure waves, are given in tabular form, and it can be seen that they agree among themselves. Tables and graphs are included.

PEKERIS, C. L., "Theory of Propagation of Explosive Sound in Shallow Water," Geol. Soc. Amer. Mem., n. 27 (1948).

PEKERIS, C. L., and LONGMAN, I. M., "The Motion of the Surface of a Uniform Elastic Half-Space Produced by a BuriedTorque-Pulse," J. Roy. Astron. Soc., V. 1, n. 2, pp. 146-153 (1958).

In this investigation we determine the motion of the surface of a uniform elastic half-space produced by the application of a torque-pulse at a point below the surface. The axis of the torque is taken to be parallel to the surface and its time variation is assumed to be represented by the Heaviside unit function H(t). Our results are compared with those

of Pinney (1954, see Geophys. Abstract 160-172), who treated the same problem by a different method. The principal feature of physical interest found is that, for ranges where the direct S wave is preceded by a diffracted SP wave, the displacement at the surface starts with an infinite amplitude at the time of arrival of the SP wave, and that this is followed by an even stronger infinity at the time of arrival of the S wave. Also, for small ranges, for which there is no SP wave, the displacement starts with a sharp pulse in the form of a Dirac delta function. None of these features was brought out by Pinney's curves. The results are shown in graphs.

PEKERIS, C. L., LONGMAN, I. M., and LIFSON, H., "Application of Ray Theory to the Problem of Long-Range Propagation of Explosive Sound in a Layered Liquid," Bull. Seism. Soc. Am., V. 49, n. 3, pp. 247-250 (1959).

In order to test the applicability of ray theory even to extremely large ranges, we have applied it to the problem of determining the exact shape of the pressure pulse received at a range r equal to 460 times the depth of the layer H, in the case of an explosion in a layered liquid. The time variation of the pressure at the source was assumed to be given by a Heaviside unit function. Comparison is made with a previous solution of this problem which was obtained, for the identical conditions, by the use of the normal mode theory. The exact ray-theory solution exhibits the well-known characteristic features of a ground wave followed by a dispersive water wave, but the pattern of the received pressure pulse is more ruffled than in the normal mode solution, in which the higher modes, as well as branchline integrals, were neglected. The applicability of ray theory to long-range propagation is made feasible by virtue of the mutual cancellation at long ranges of all but a group of the last-arriving rays.

PELSOR, G. T., "Cavity Formation," U. of Calif., Livermore, Lawrence Radiation Laboratory. UCRL Report.

The process of cavity formation in an underground explosion is traced with a one-dimensional hydrodynamic calculation.

PELSOR, G. T. See also Johnson, G. W.

PENNSYLVANIA STATE UNIVERSITY, MINERAL INDUSTRIES EXPERIMENT STATION (Staff), "Model Studies of Seismic Energy Distribution Around Different Types of Source," Penn. State University, Mineral Ind. Exp. Sta., University Park. Quarterly Rept. No. 1 on Contract AF 19(604)7383 (1960).

Through the use of models, the seismic pulses to be expected around different types of energy sources such as a fault displacement or an explosion are compared. R is intended not only to observe the differences in the pulses generated at the source but also the effects of structure in the regions surrounding the source. In this way it is hoped that a better insight will be obtained into the difference which may be expected between seismic waves recorded from natural and artificial sources. All experiments are two-dimensional in character, structures being simulated by variations in the thickness of composition of the model. Actual source conditions for earthquakes are duplicated as accurately as possible in order to check whether assumed theoretical conditions for which mathematical theory was developed are confirmed.

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PENNSYLVANIA STATE UNIVERSITY, MINERAL INDUSTRIES EXPERIMENT STATION (Staff), "Model Studies of Seismic Energy Distribution Around Different Types of Source," Penn. State University, Mineral Ind. Exp. Sta., University Park. Quarterly Rept. No. 2 on Contract AF 19(604)7383 (1961).

Data are sought through model studies on how the characters of seismic pulses vary with azimuth for different types of source and for different simulated geologic environments in the vicinity of the source. The techniques for rapid and systematic recording of comparable data were refined, and a library of pulse patterns, made under simple conditions, was accumulated.

PERKINS, B., Jr., "Subsurface Structure of Snake River Valley, Idaho, from Seismograph Records of Ammunition Explosions," Geophys., V. 12, n. 3, p. 496 (1947).

In August and October 1945 and October 1946 a series of explosions of unserviceable ammunition was made by the United States Army-Navy Explosives Safety Board. The charges ranged from 38,000 lb of TNT to 500,000 lb and were observed at distances ranging from 600 feet to 51,000 feet. The subsurface to a depth of 700 feet is shown by logs of two water wells.

Three distinct velocity zones are indicated. The first zone, composed of thick beds of lava separated by thin layers of clay, sand, and gravel, has a sound velocity of 6600 fps and is approximately 500 feet thick. The second zone is similar to the first to a depth of 700 feet except for the presence of water. The sound velocity in this bed is 9900 fps; apparently the bed starts at the water table and extends to a depth of 4500 feet. The third zone transmits the sound wave at 19,800 fps and may consist of tightly folded sediments or igneous rock. Absorption coefficients for the third zone are calculated. They are 0.14 per km for the P wave, having a period of 0.2 second, and 0.09 per km for the S wave, whose period is 0.5 second.

PERKINS, B., Jr., and THOMPSON, A. A., "Preliminary Report on Medium Studies. Operation Hardtack, Phase II," Report on Operation Hardtack (1958).

On Operation Hardtack, thirty instruments were installed for the Tamalpais Shot to measure the ground shock parameters of the seismic wave resulting from a contained nuclear explosion in tuff material of a weapon having a total energy yield equivalent to 0.057 kt of TNT. About half the records were lost due to an oscillator power supply failure, caused by the malfunctioning of the battery charger following the final dry run. The following measurements were recorded at Tamalpais and are reproduced: five stress time histories were measured from 100 to 410 feet from the explosion. Two displacement time histories were recorded at 300 feet from the detonation. Four displacement time histories were recorded at distances greater than 10,000 feet from the explosion. On the Evans Shot, ten instruments were installed to measure the (free field) ground shock parameters of the seismic wave resulting from a contained nuclear explosion in tuff material with a predicted yield equivalent to 8 kt of TNT. The energy yield resulting in the Evans Shot was so much less than the expected yield that the amplitudes of all records were too small to be of value.

PERRET, W. R., "Preliminary Report on Measurement of Soil Stresses Caused by an Underground Explosion," Sandia Corp., Albuquerque, N. Mex. Report (1952).

The procedures followed in placing gages and data analysis for test HE-3 underground explosion are discussed. The type and reliability of best results are indicated. It is concluded that principal stresses caused by such explosions may be derived from these data.

PERRET, W. R., "Subsurface Motion from a Confined Underground Detonation. Part I," Interim Rept. No. ITR-1529 on Project 26.4b of Operation Plumbbob (1957).

Strong motion observations within the mesa adjacent to Rainier shot of Operation Plumbbob (1.7 kt) were made on a horizontal radius (along the access tunnel) and a vertical radius by Sandia Corporation under Project 26.4b. Principal data were derived from radial component acceleration measurements. Long-base strain gages provided some secondary data. Horizontal radius data were derived from gages at distances ranging from 100 to 1355 feet from the burst point. Vertical radius data were obtained over distances ranging from 366 to 896 feet at the mesa top surface. Many of the accelerometers used in Project 26.4b were given set ranges so far below actual peak accelerations that recorder system overloading caused saturation and serious loss of precision in record peak amplitudes. All arrival time data are good but amplitude data are questionable in many cases. Accelerometers at closer stations on both radii were not seriously overranged and data from them are reliable. Corrections based on a few records from Project 26.4a gages of a vertical radius installation were made for the overranged Project 26.4b gages of the vertical radius. Corrected and uncorrected acceleration-time data for the vertical radius gages were converted to particle velocity and displacement information by integration. Horizontal radius data show peak accelerations decreasing approximately as the inverse square of range. Peak accelerations from the vertical radius decrease with range up to the vicinity of transition from weak bedded tuff to the welded tuff (rhyolite) cap rock. From this region upward toward the surface record, character changes radically. A sharp upward acceleration pulse is followed by a relatively long period of free fall at about -1 g (true zero g for the accelerometer biased to +1 g in calibration). A sharp upward rebound pulse and a decaying oscillatory train complete the motion. Free fall originates at all gages nearly simultaneously but ends at progressively later times upward. Rebound initiation sequence suggests that horizontal parting or spalling occurred at three levels from beneath the cap rock upward to the surface. Initial peak accelerations through the cap rock region increase with increasing radial range. This cannot be attributed to surface reflection except at the surface gage. The anomalous increase in amplitude may be caused by continuously decreasing seismic impedance (pc) upward through the cap rock, with consequent continuous reflection of the compression wave with enhanced peaks.

Horizontal strain gages on the tunnel walls survived for periods too short to observe significant motion. Strain gages on the vertical radius showed significant, but small, compressive strains; however, they may have been constrained from free tensile motions by mounting cables.

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PERRET, W. R., "Surface and Subsurface Strong Motion Measurements. Operation Hardtack," Report (1959).

Strong motion measurements were made within rock on a vertical radius directly above Evans shot at ranges from 235 feet to the surface at 850 feet and on the mesa surface at ranges out to 12,000 feet from the surface zeros of Tamalpais, Evans, and Blanca shots of Operation Hardtack, Phase II. The complementary surface motion project observed motion of an array of targets in the vicinity of Evans and Blanca surface zeros by means of calibrated motion photography. Vertical radius instrumentation was primarily accelerometers, but stress, strain, and temperature gages were included. Surface motion measurements comprised only vertical and horizontal radial accelerations. Signals from all gages of the vertical array were very weak, and precision suffered accordingly because Evans yielded only about 1 % of anticipated energy. Acceleration data from the vertical array follow the trends of variation with radial range similar to those indicated by Rainier data: peak accelerations vary inversely with fourth power of range up to the base of the caprock, where the trend inverts and peaks increase toward the surface. Stress, strain, and temperature gages yielded no relevant information. Surface accelerations include a few data which represent signals of only a few percent of gage range and are consequently of low precision. Peak accelerations decrease with increased range, but scatter does not permit a clear distinction between suggested R and R variation. Photography showed that the ground surface above Evans did not move more than 2 inches, the limit of resolution of the camera system. Movement of targets near Blanca surface zero was defined for a period of greater than 8 seconds after detonation.

PERRET, W. R., "Subsurface Earth Motion," Sandia Corp., Albuquerque, N. Mex. Report.

Subsurface earth motion is the time history of transient mechanical effects produced by large contained explosions and observed within the containing medium in the region extending from just outside the explosion cavity to an adjacent free surface or to the region of essentially pure elastic reaction. The studies performed in this region provide direct knowledge of reaction of the medium to explosive energy. The instruments for observing such transient effects consist primarily of accelerometers, supplemented by several specially developed velocity gages and stress or strain gages. Programs designed to explore motion in the rock surrounding the Rainier, Tamalpais, and Evans shots are discussed.

PERRET, W. R., "Preliminary Summary Report of Strong-Motion Measurements from a Confined Underground Nuclear Detonation," Rept. No. ITR-1499 (1958).

This report presents a summary of the background, techniques employed, and results of the strong motion measurements of Shot Rainier, the first confined underground nuclear detonation by the United States. The report is compiled from preliminary reports of the individual projects by the five participating agencies. Stanford Research Institute measured close-in ground motion on the mesa top and slope (see ITR-1528). The U. S. Coast and Geodetic Survey measured more remote surface motion (see WT-1530). Sandia Corporation and the U. S. Army Engineer Research

and Development Laboratories measured subsurface ground motion from near the shot point to the mesa top (see ITR-1529, ITR-1531). Edgerton, Germeshausen, and Grier, Inc. photographed the surface motion of the mesa (see WT-1532). All measurements from all projects are tabulated and briefly discussed.

PERRET, W. R., and PRESTON, R. G., "Preliminary Summary Report of Strong-Motion Measurements from a Confined Underground Nuclear Detonation. Operation Plumbbob," Report (1958).

The background, techniques employed, and results of the strong-motion measurements from the first test by the United States of a confined, underground, nuclear detonation are summarized.

PERRET, W. R. See also Adams, W. M., et al.; Wistor, J. W.

PERRI, E., "Sopra un'onda lenta superficiale provocata da esplosione vicina: I [On a Slow Surface-Wave Produced by Nearby Explosions: I]," Geofis. pura e appl., V. 27, pp. 7-29 (1954).

Records of experimental explosions at Fegino (Genoa) show a surface wave having higher velocity than that of Rayleigh waves but appreciably less than that of shear waves, and anomalous dispersion. Analyzed mathematically, this wave is found to be a compound wave formed by superposition of a condensational and a distortional wave, both damped, having the same frequency and same initial phase. Absorption of energy in the x and z directions is considered. It is assumed that the wave is propagated along the x axis, with the distortional wave having a lower absorption coefficient in the x and z directions.

Equations are derived for the phase velocity $V*$ as functions of the respective specific velocities of the two component waves, $v_1 = (V_*/\Omega_1)$; $v_2 = (V_*/\Omega_2)$ where Ω_1 and Ω_2 are respectively the velocities of undamped longitudinal and transverse waves in the same medium. The formulas are valid for any homogeneous isotropic medium.

The phase velocity calculated according to Perri's formulas, 788 m/sec, is in good agreement with the experimental results.

PERRI, E., "Sopra un'onda lenta superficiale provocata da esplosione vicina: II [On a Slow Surface-Wave Produced by a Nearby Explosion: II]," Geofis. pura e appl., V. 29, pp. 84-105 (1954).

The author completes his investigation of the surface wave (e) already discussed in Part I [see preceding entry]. The following subjects are treated: the spatial distribution of the displacement vector and correlative "locus" (ideal stationary trajectory) of a point displaced by periodic strain of the wave; the ratio between the maximal components of the e-wave motion, as well as the corresponding group velocity; an estimate of λ and μ of surface rocks, through the dynamic method given by the author based on the recording of any pulses (e) spread by an explosion (Genoa-Fegino experiments, 1939); and an analytical demonstration of the geometric divergence between (rectilinear) seismic rays relative to a theoretical plane wave and the (curvilinear) rays along which flows the energy of the wave motion examined.

PETERSCHMITT, E. See Beaufils, Y., et al. (2); Rothe, J. -P., Rothe, J. -P., et al.

PHINNEY

PHINNEY, R. A., "Leaking Modes in the Crustal Waveguide Part I: The Oceanic PL Wave," Calif. Inst. of Technology. CIT Contribution No. 1013 (1959).

In this report the problem of the seismic signal associated with the earliest P wave is treated from the modal point of view, where the signal is regarded as a quasi-surface wave, coupled both to the motion of the earth's layered surface and to body waves propagating in the underlying media. Predictions made are relevant to both explosion and earthquake sources. The analog between PL waves and normal modes in the case treated by Pekeris is exploited and it is also believed that PL waves are related to an attenuated pseudo-surface wave of a free solid halfspace. Late arriving quasi-standing waves are treated briefly and their relevance to certain seismic phenomena is mentioned.

PICKETT, G. R., "Seismic Wave Propagation and Pressure Measurements Near Explosions," Quart. Colo. School Mines, V. 50, n. 4, pp. 1-77 (1955).

PIEPER, F. A., et al., "Subsurface Accelerations and Strains from an Underground Detonation - Part II," Sandia Corp., Albuquerque, N. Mex. Report No. WT-1531 (1958).

Attempts by the U. S. Army Engineer Research and Development Laboratory to measure subsurface acceleration, pressure, stress, and strain during event Rainier were largely unsuccessful due to recorder failures. Permanent displacement measurements were obtained and found to be most strongly influenced by the free surface of the mesa and the dip and strike of the bedding.

PIEPER, F. A., TIEMANN, A. C., and SIEVERS, R. H., Jr., "Subsurface Accelerations and Strains from an Underground Detonation. Part II. Operation Plumbbob," Report (1958).

The objectives of this project were to measure transient and residual ground motion from Shot Rainier, Operation Plumbbob. The measurements consisted of acceleration, pressure, stress, strain, and permanent displacement in the free field below the floor of the main entrance tunnel. Most records were lost because of the zero-time surge in the power supply of the recording instruments.

PIEPER, F. A. See also Ehlers, O. K., et al.

PLEUCHOT, M. See Richard, H.

POLATTY, J. M., GOODE, T. B., BENDINELLI, R. A., HOUSTON, B. J., "Drilling and Grouting Support, Project Cowboy," Army Engineers Waterways Experiment Station. Final Rept. on Project Cowboy (1961).

Laboratory studies, field drilling, and field grouting phases of Project Cowboy are described in this report. Operations included design of:

(a) Saltgrouts for grouting instrument and for stemming HE shot holes drilled in halite;
(b) Saltcrete for filling steel plugs used to seal the cavities;
(c) Saltgrout for grouting in place steel liners and walkways in access tunnels to the cavities;
(d) Grouts for correcting for lost circulation of drilling mud.

POLDERVAART, A., "Crust of the Earth, a Symposium," Geological Society of America (1955).

POMEROY, P., and OLIVER, J., "Seismic Waves from High-Altitude Nuclear Explosions," J. Geophys. Research, V. 65, n. 10, pp. 3445-3457 (1960).

Seismic waves of long period were well recorded at epicentral distances as great as 9300 km from two high-altitude nuclear explosions, Teak and Orange, which were fired in the Johnston Island area on August 1 and 12, 1958, respectively. Seismic waves recorded at Honolulu, at a distance of approximately 1300 km, may be divided into three types: (1) a normally dispersed, oceanic Rayleigh wave train in which the wave periods decrease from about 4.1 to 1.6 km/sec; (2) an inversely dispersed, oceanic Rayleigh wave train in which the wave periods increase from about 6 to 10 seconds as the corresponding velocities decrease from about 1.3 to 1.0 km/sec; (3) a T-phase consisting of waves with periods less than about 0.5 second and corresponding to a velocity of 1.47 km/sec.

From the normally dispersed train, group velocities of waves in the 35- to 14-sec period range were computed for the two paths, both of which traverse primarily a typical deep oceanic basin. These group-velocity data plus possible corresponding phase-velocity data are compared with theoretical values for oceanic structures. The inversely dispersed train, although predicted by classical theory, has not been observed in siesmograms from natural earthquakes.

Surface waves of long period were recorded at Palisades, New York, from both of the high-altitude nuclear explosions, and these waves have amplitudes comparable to those generated by the larger of the near-surface explosions in the Marshall Islands. Special instruments at Palisades, not operated for Teak, indicate that amplitudes for the long-period body waves from Orange are comparable to those from the Marshall Islands shots. In contrast, seismic body waves of short period are apparently generated much more efficiently by near-surface explosions than by high-altitude explosions.

POMEROY, P. W. See also Carder, D. S., and Mickey, W. V.; Oliver, J. E., et al.

PORZEL, F. B., "Close-In Shock Time-of-Arrival Measurements and Hydrodynamic Yield," Illinois Inst. of Technology, Chicago. Armour Research Foundation. Report.

This paper is in two parts. Part A is primarily concerned with close-in shock time-of-arrival measurements for the determination of hydrodynamic yield, on operations Rainier and Hardtack II. Part B is primarily concerned with the theoretical concepts used in Part A, and in particular, discusses some implications of the theory for these measurements which apply to control and use of explosions, aside from the specific test operations described in Part A.

PORZEL, F. B. See also Anderson, D. C.; Chaszeyka, M. A. (2).

PRESS

PRESS, F., "Seysmicheskoye issledovaniye zemnoy kory [Seismic Exploration of the Earth's Crust]," Priroda, n. 8, pp. 33-37 (1958).

The paper describes the explosion-seismic method of exploration of the earth's crust and gives some of the results to date. The lesser depth of the Mohorovicic discontinuity under the ocean and the change in gravity along a line from continent to ocean are considered as evidence of isostatic compensation in the earth's crust. P-wave velocities between 8.0 and 8.2 km/sec have been found in the mantle under both continents and oceans, 6.0 to 7.0 km/sec in the basic rock under the ocean floor. Velocities of S waves in the mantle under the continents are found to be 4.6 to 4.8 km/sec (no data are yet available for transverse waves in the mantle under the ocean) and 3.5 to 3.6 km/sec in the crust under the continents. The refraction-correlation method, phase-velocity method, and Lg-wave method are described briefly. The mean thickness of the continental crust has been determined from the curves of the phase velocities of Rayleigh waves as 47 km under the Sierra Nevada block and 30 km under San Francisco Bay. Lg waves are instrumental in determining the outline of the continents, as the Lg-wave guide disappears at the continental shelf.

PRESS, F., "Aftershocks as a Means of Identification of Earthquakes," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 4 (1959).

A statistical study, limited to earthquakes of magnitude 4-5 and aftershocks that occurred within one week after the initial tremor, was made of aftershocks with a view toward using their presence or absence as a means of identifying earthquakes. It was concluded that aftershocks could be of some use. The capability of the method depends upon how quickly temporary stations can be installed near the epicenter of a suspicious event; for southern California the capability is 50%.

PRESS, F., "Long Period Surface and Body Waves," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 5 (1959).

It is believed that earthquakes are more efficient in the generation of lower frequency body waves and surface waves than are explosions of equivalent magnitude. Preliminary studies reveal differences in spectra of body waves and surface waves; therefore, these differences are a possible method of distinguishing explosions from earthquakes. An extensive research program is recommended that would emphasize statistical studies of spectra, Love/Rayleigh energy distribution, and SV/SH ratios of earthquakes, quarry blasts, and underground nuclear explosions. Also phase and group velocities of surface waves and their variations across continents would be studied with special tri-partite arrays of long-period seismographs.

PRESS, F., "Seismic Wave Propagation," Trans. Am. Geophys. Union, V. 41, n. 2, pp. 150-151 (1960).

In the United States in 1957-60 the major emphasis in research on seismic wave propagation has been on theoretical studies of fundamental aspects of wave propagation and combined theoretical and experimental studies pointed at unraveling the complicated nature of seismograms to glean more information about the propagation medium and the source. New developments are reviewed briefly, and a bibliography representative of recent progress is given.

PRESS, F., "A Fast, Convenient Program for Computation of Surface-Wave Dispersion Curves in Multilayered Media," Calif. Inst. of Technology. Report for Contracts AF-49(638)910, NAS W-81, and NAS W-6.

A digital computer program for computing theoretical dispersion curves and displacements for Rayleigh and Love Waves is presented, and described for the IBM 7090 computer.

The Thompson-Haskell matrix formulation for layered elastic media is employed in an iterative process. This method enables specification of modes, automatic layer reduction, determination of displacement at depth, insertion of earth curvature correction, root prediction, group velocity determination, and computations for laminated plates and combinations of liquid and solid layers.

This process allows rapid calculation of dispersion curves for realistic models, replacing tedious hand calculations for oversimplified models.

PRESS, F., BEN-MENAHEM, A., and TOKSOZ, M. N., "Experimental Determination of Earthquake Fault Length and Rupture Velocity," Calif. Inst. of Technology. CIT Contribution No. 1040.

Three methods for determining the fault parameters of length and rupture velocity are examined with ultrasonic models. The theory behind the methods is shown to have a valid though approximate basis. Oversimplified assumptions and imperfect experimental data restrict initial results to only rough indications of fault parameters. When applied to the great Chilean earthquake of May, 1960, a fault length of the order of 1000 km and a rupture velocity near the speed of shear waves in crustal rock is found.

PRESS, F., and EWING, M., "Propagation of Explosive Sound in a Liquid Layer Overlying a Semi-Infinite Elastic Solid," Geophys., V. 15, n. 3, pp. 426-445 (1950).

The Pekeris theory of normal-mode sound propagation from an impulsive point source located in the first of two liquid layers is extended to include the case of a liquid layer overlying a semi-infinite elastic solid. The mathematical theory is developed for both a harmonically varying point source and an arbitrary initial time-varying disturbance at the source. Phase and group velocity curves, as well as dispersion curves in the first and second normal modes, are presented for conditions approximating basaltic, granitic, and sedimentary bottoms.

It is found that for solid bottoms, large amplitude waves appear only after the arrival of the first shear waves; and that there is an arrival of a train of very low frequency waves travelling with the speed of Rayleigh waves in the bottom, the waves increasing in frequency and amplitude with increasing time. For both liquid- and solid-bottom theory, a high-frequency wave travelling with the speed of sound in water arrives riding on a low-frequency rider wave; the water waves and the rider waves merge to form a train of waves of large amplitude that is known as the Airy phase. The frequency of the latter is determined by the depth of water and the elastic structure of the bottom. The ideal location of geophones and hydrophones is discussed in the light of the theory.

PRESS

PRESS, F., and EWING, M., "Ground Roll Coupling to Atmospheric Compressional Waves," Geophys., V. 16, n. 3, pp. 416-430 (1951).

A theoretical treatment of ground roll in a layered medium shows that effective coupling exists for surface waves whose phase velocity equals the speed of sound in air. In hole shots a geophone records ground roll as an orderly sequence of dispersive Rayleigh waves, but an air microphone records a constant frequency train following the abrupt arrival transmitted with the speed of sound in air.

In air shots, however, the ground roll recorded by a geophone predominates after the arrival of the direct air wave and then only as a train having a constant frequency and phase velocity. The character of the record is independent of the height of charge above the ground surface. If the Rayleigh wave velocity exceeds the speed of sound in air, coupling cannot exist, and the ground roll is essentially the same for both air and hole shots. The paper includes samples of records obtained in field tests that corroborated these results.

PRESS, F., and EWING, M., "Waves with Pn and Sn Velocity at Great Distances," Proc. Nat. Acad. Sci. U.S., V. 41, n. 1, pp. 24-26 (1955).

PRESS, F., and GRIGGS, D. T., "Geophysical Investigation of Continental Crustal Structure," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 10 (1959).

A program is proposed for the investigation of crustal structure along several profiles, each 400 km long starting in the vicinity of the Sierra Nevada, the Great Basin, and the Rocky Mountains. Twelve-channel oscillographic and magnetic tape recording apparatus with groups of 4 seismometers per channel with each group spaced at intervals of 1000 feet will be used. Overall channel response will extend down to 2 cps with variable high and low frequency cutoff. Explosions will be loaded and detonated by the contractor and continuous radio contact will be maintained between shot point and recording position. It is also proposed to establish a network of long period seismograph stations to analyze the data for phase and group velocity of surface waves and to use Fourier transform methods to recover the shape of the initial impulse. Explosive and earthquake sources will be used and modern computing machine methods of data reduction and analysis will be exploited. This work will be performed jointly with the explosion studies. Explosion methods reveal fine details of crustal structure variation, whereas the surface wave method reveals the regional picture.

PRESS, F. See also Benioff, H., et al.; Donn, W. L., et al.; Griggs, D. (2); Keiti, A.

PRESTON, R. G., and ADAMS, W. M., "Predicted Phenomenology and Effects of Project Dribble Experimental Explosions," U. of Calif., Livermore, Lawrence Radiation Laboratory. UCRL-LRL-UOPAC 61-134. Progress Rept. No. 2 (1961).

The paper presents predictions about the particle motion resulting from detonations in salt (Project Dribble, Tatum Salt Dome, Purvis, Mississippi). Included are predictions of structural effects of the detonations on the cavity, and predictions about the thermal behavior of the

cavity at detonation and during cooling. The particle motion predictions are summarized in graphical plots of pressure, velocity, and displacement vs. radial range from the detonation site, and in plots of the time variation of pressure and particle velocity at specified radial ranges.

PRESTON, R. G. See also Adams, W. M., et al.; Perret, W. R.

PUBLICATIONS OF THE DOMINION OBSERVATORY (Staff), Ottawa, Bibliography of Seismology.

This bibliography has been published quarterly or bi-annually since 1929. It contains an author-title listing of journal articles, books, and reports concerned with the general field of seismology. An extensive search has been conducted in both foreign and domestic literature. Abstracts are not included.

RAITT, R. W., "Studies of Ocean-Bottom Structure Off Southern California with Explosive Waves," Bull. Geol. Soc. Am., V. 60, n. 12, pt. 2, p. 1915 (1949).

Sediment thickness and basement velocity in the Pacific Ocean area between Point Eugenia and Santa Cruz Island and extending 800 nautical miles west of San Diego have been studied by reflection and refraction methods. TNT bombs were used as sound sources, and recording was by pressure-actuated crystal hydrophones.

Beyond the continental slope, in water about 2000 fathoms deep, the sediment thickness was a few hundred meters, and the basement velocity approximately 6.5 km/sec. One 60 km reversed profile indicated that the velocity increases to 8 km/sec at a depth of about 5 km beneath the basement surface. A strong second arrival with a velocity of 3.6 km/sec may be a basement shear wave.

Inside the continental slope the greatest sediment thickness observed was about 3 km in Santa Cruz basin, where water depth is 1050 fathoms. Basement velocities range from 4.5 km/sec near land, where metamorphic rocks outcrop, to 6.3 km/sec beneath Santa Cruz basin.

RAITT, R. W., "Seismic Refraction Studies of Eniwetok Atoll," U.S. Geol. Survey, Prof. Paper No. 260-S (1957).

Observed seismic velocities at Eniwetok Atoll indicate the presence of 6 layers of rock, in which the average velocities are 2.44, 3.06, 4.15, 5.59, 6.90, and 8.09 km/sec respectively. Previous drilling permits the identification of the first 2 layers as calcareous deposits and the third layer (4.15 km/sec) as volcanic. The calculated depth of the third layer beneath the drilling sites was about 0.3 km greater than the depths at which volcanic rock was penetrated by the drill. This may be due to the fact that, in calculations, the vertical seismic velocities in the first two layers were assumed to be equal to the horizontal velocities measured in those layers, whereas the vertical velocities are probably less because of the presence of unconsolidated material between the cemented layers in the first 2 zones.

The fourth layer (5.59 km/sec) is thought to be a hard crystalline rock, probably basalt. The fifth layer (6.90 km/sec), identified with the crustal layer extensively present in the Pacific Ocean basin is found at

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a depth of 9-10 km, and the sixth layer (8.09 km/sec), characteristic of the layer just below the Mohorovicic discontinuity, is reached at a depth of 16-17 km.

RAITT, R. W., and JOHNSTON, T. F., "Transmission of Explosive Impulses in the Sea," Bull. Geol. Soc. Am., V. 58, n. 12, pt. 2, p. 1269 (1947).

Underwater explosions produce short, intense, steep-fronted pressure pulses that have proved useful in the study of underwater transmission. Observations made at sea near San Diego by using electric blasting caps as sound sources demonstrate a number of significant features of sound transmission in the sea. During the measurements, the sea temperature near the surface generally decreased with depth, causing downward refraction of the sound rays. A theoretical "shadow zone" is cast by the sea's surface under these conditions. Oscillograms of the received pulses fall into three general classes, which are described.

RAITT, R. W. See also Johnston, T. F.

REED, R. P., and TAYLOR, W. E., "Pressure Observations in the Crater Vicinity During the Explosion of Small Charges in Dry Sand," Sandia Corp., Albuquerque, N. Mex. Report (1960).

Characteristics of the pressure pulse from the explosion of $\frac{1}{2}$-oz RDX spheres buried in dry sand were measured at scaled distances from 0.26 to 5.16 ft/lb$^{1/3}$. Variables were depth of charge burial, distance from the charge center, and relative size of sand particles in which the explosion was performed. Measurements of the pressure pulse were made from recordings of the pressure-induced strain wave propagated in strain-gage instrumented metal rods which extended into the crater zone.

REICH, H., "Geologische Ergebnisse der seismischen Beobachtungen der Sprengung auf Helgoland [Geological Results of the Seismic Observations of the Helgoland Explosion]," Geol. Jahrb. Band 64, pp. 243-266 (1950).

Seismic observations of the Helgoland explosion of April 18, 1947, provided important evidence on the structure of the continental shield. This was found to consist of three separate layers. The uppermost is a layer of granite, the seat of the most important thermal anomalies caused by radioactivity and physico-chemical processes, about 10 km thick or less. The next layer is gabbro, characterized by greater mechanical strength and by less marked faulting. This layer is the source of eruptive products brought to the surface by volcanic activity. It overlies the third, peridotite, layer.

The discontinuous character of the stratification of the crust of the earth was shown by the form of the travel-time curve which is not a curved line, but a combination of straight segments. The velocities of seismic waves determined by these observations were 5400 m/sec in the upper layer, 6400 m/sec in the middle layer, and 8200 m/sec in the lowest one. The depth of the granite layer is about 10 km, that of the gabbro about 30 km and that of the peridotite undetermined.

REICH, H., "Die geologischen Ergebnisse seismischen Registrierungen grosser Sprengungen in Deutschland [The Geologic Results of Seismic Registration of Large Explosions in Germany]," Geofis. pura e appl., V. 40, pp. 41-48 (1958).

A review of the results of seismic records of large explosions in Germany south of Hamburg, west of Wurzburg, Main, west of Regensburg and Ulm in the Danube district, and in the foreland of the Bavarian Alps. Travel times for distances of 15 to 30 km, basement velocities, intercept times, and approximate depths of the basement are given. In the Alps foreland and northwestern Germany travel times were more than 7 seconds for 30 km and basement depths more than 5 km; in the Main and Danube areas travel times for 30 km were 5.5 seconds, basement depths less than 1 km. Velocities of more than 6.4 km/sec were noted near Ingolstadt (in the Danube area) at 600 meters depth, southwest of Wurzburg at 2400 meters, and southwest of Hamburg at 7000 meters. These are gabbroic rocks; all three cases correspond to positive magnetic and gravity anomalies.

REICH, H., FORTSCH, O., and SCHULZE, G. A., "Results of Seismic Observations in Germany on the Helgoland Explosion of April 18, 1947," J. Geophys. Research, V. 56, N. 2, pp. 147-156 (1951).

Depths to and velocities in crustal layers as determined from records of the Helgoland explosion by Schulze and Fortsch, Willmore, and Mintrop are discussed and compared. Velocities inferred from the summarized observations are 5.4 km/sec in the upper (granitic) layer, 6.18 and 6.6 km/sec in the middle (gabbroic) layer, and 8.32 and 8.19 km/sec in the lower (peridotitic layer). Observational data indicate the granitic and gabbroic layers are not horizontal. If the nonuniform elastic properties of the sedimentary layer and inclination along profiles are considered, a more uniform depth for crystalline rocks is found.

REICH, H., SCHULZE, G. A., and FORTSCH, O., "Das geophysikalisches Ergebniss der Sprengung von Haslach in sudlichen Schwarzwald [Geophysical Findings Resulting from the Haslach Explosion in the Southern Black Forest]," Geol. Rundschau, V. 36, pp. 85-96 (1948).

Analysis of the seismograms of explosions of 73 and 11 tons of explosives in Haslach on April 28 and 29, 1948, registered at numerous stations along the profile from Haslach to the outskirts of the Alps and at several points of the Rhine Valley, showed three layers of the crust: the upper, a granite layer in which the velocity of longitudinal waves is 5.9-6.0 km/sec; the second, a gabbro layer in which the velocity is 6.55 km/sec; and the third, a peridotite layer, with 8.2 km/sec. The average thickness of the upper layer is about 21 km, the depth to the second discontinuity is 31 km. From comparison of these results with geological and gravitational data, it is concluded that the gabbro and peridotite layers are rising near Mannheim-on-the-Rhine, that the peridotite is sinking in the upper Danube region, and that the gabbro layer is rising in the Alpine foreland.

REINHARDT, H. G., "Steinbruchsprengungen zur Enforschung des tieferen Untergrundes [Quarry Explosions in the Investigation of Deeper Crustal Structure]," Geol. Jahrb., Band 4, Heft 3, pp. 349-350 (1955).

Quarry explosions and other large industrial blasts yield valuable seismic data on crustal structure because the time and focus are accurately known. Data from such explosions have been compiled in recent years years in East Germany in the hope that they will lead to better understanding of the structure of the deeper parts of the crust in that country. Information on the relationship of the Paleozoic to the crystalline sub-

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basement under the North German basin would have economic as well as scientific value. For this purpose, profiles about 50 km long would suffice. It is proposed that large explosions be set off in deep bore holes; the main technical problem would be that of finding explosives and fuses which would be reliable under relatively great hydrostatic pressure (see also Geophys Abs. 162-147).

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "Explosion-Seismic Observations in Northeastern Japan," Bull. Earthquake Research Inst., Tokyo Univ., V. 29, pt. 1, pp. 97-105 (1951).

Eight stations approximately 20 km apart were set up along the Tokoku railway to observe an explosion of 57 tons of dynamite at Isibuti. Two phases with velocities of 5.26 and 6.13 km/sec were observed. The thickness of the upper layer is 1.3 km. A phase with velocity of 3.37 km/sec which was observed at three stations may be the S wave.

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "The Second Explosion Seismic Observations in Northeastern Japan," Bull. Earthquake Research Inst., Tokyo Univ., V. 30, pt. 3, pp. 274-291 (1952).

Eighteen stations were set up in two profiles east and south from an explosion of 7.8 tons of dynamite at Isibuti. In the eastern profile, three layers were recognized in which the velocities are 2.56, 4.67, and 6.08 km/sec. The upper layers are 0.75 and 1.59 km thick. In the southern profile, no second layer was observed, and the velocity in the lower layer was 5.91 km/sec. A phase with velocity of 3.37 km/sec was observed in both profiles.

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "The Third Explosion Seismic Observations in Northeastern Japan," Bull. Earthquake Research Inst., Tokyo Univ., V. 31, pt. 4, pp. 281-288 (1953).

Nineteen stations were set up along two profiles, one south along the arc of the island for 300 km and the other west from the shot point transverse to the island. Velocities of 5.91, 7.17, and 3.58 km/sec were observed on the southern profile and of 5.81 and 3.5 km/sec on the western profile. If a sloping interface between the surface and the granitic layer is assumed for the western profile, then the velocity is 5.94 km/sec, and the granitic layer would come to the surface about 70 km east of Isibuti.

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "The Fourth Explosion Seismic Observations in Northeastern Japan," Bull. Earthquake Research Inst., Tokyo Univ., V. 32, pt. 1, pp. 79-86 (1954).

To study the seismic waves from an explosion of 29.7 tons of dynamite in the Kamaisi mine about 18 km west of the city of Kamaisi, 19 temporary observation points were set up in 2 profiles, three velocities were identified: 6.19, 7.37, and 8.20 km/sec. Thicknesses of the layers were computed as 27.2±3.0 km, 5.1±3.3 km, and 32.3±1.3 km. In the western profile, an apparent P-wave velocity of 5.76 km/sec was observed.

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "Observation of Seismic Waves from the First Great Explosion at Kamaisi Mine," (Japanese with summary in English), Zisin, J. Seism. Soc. Japan, Second Series, V. 6, n. 3, pp. 6-13 (1953).

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "Observations of Seismic Waves from the Second Kamaisi Explosion [in Japanese with English summary], Zisin, J. Seism, Soc. Japan, V. 7, n. 4, pp. 209-215 (1955).

An explosion of nearly 42 tons of explosives at the Kamaisi mine, Iwate-ken, on September 13, 1953, was observed at 15 temporary stations set up on a north-south line. The P-wave velocity in the uppermost layer in this area is 6.05 km/sec; in the underlying layer, 7.27 or 7.55 km/sec. Corresponding S-wave velocities are 3.46 km/sec and 4.57 or 4.75 km/sec. The thickness of the upper layer is 22.2 or 25.6 km from P-wave curves, 32.4 or 35.8 km from S-wave data, and 22.13 km from data on reflected waves.

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "Observations of Seismic Waves from Four Explosions Near Kamaisi Mine [in Japanese with English abstract]," Zisin, J. Seism, Soc. Japan, ser. 2, V. 10, n. 2, pp. 89-96 (1957).

Seismic observations were made of the waves generated by four explosions near the Kamaisi Mine in May 1954 to check conclusions drawn from the results of five earlier explosions concerning the crustal structure of northeastern Honshu, Japan. Results from both sets of explosions indicate an anticline with axis trending north-south and a well-defined boundary between the Paleozoic rocks and underlying granites.

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "Observations of Seismic Waves from Four Explosions Near the Kamaisi Mine," Bull. Earthquake Research Inst., Tokyo Univ., V. 37, pt. 1, pp. 89-91 (1959).

In order to determine more precisely the position and form of the dipping boundary between the layers having P-wave velocities of 5.75-5.85 and 6.10-6.20 km/sec, respectively (see Geophys Abs. 173-256, 174-240), four explosions were set off in the vicinity of the Kamaisi mine in Japan. Complete data are tabulated and numerous seismograms are reproduced. The earlier assumption that this P_2-P_3 boundary rises eastward and almost reaches the surface near the Kamaisi mine is confirmed.

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "Crustal Structure in Northern Kwanto District by Explosion Seismic Observations [in Japanese with English summary]," Zisin, J. Seism, Soc. Japan, ser. 2, V. 11, n. 2, pp. 102-113 (1958).

Seismic observations were made in Japan, from temporary observation stations between Lake Nozori in Gumma Prefecture and Hokota in Ibaraki Prefecture, of tremors generated by a series of explosions set off at Nozori and Hokota for the purpose of determining crustal structure in the northern Kwanto district. The Mohorovicic discontinuity was found to be at a depth of 25 to 30 km; since the depth of earthquake foci near Mount Tukuba in Ibaraki Prefecture is generally greater than 30 km, earthquakes near Tukuba evidently occur in the upper part of the mantle.

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "Crustal Structure in Northern Kwanto District by Explosion—Seismic Observations. Part 1: Description of Explosions and Observations," Bull. Earthquake Research Inst., Tokyo Univ., V. 36, pt. 3, pp. 329-348 (1958).

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Two explosions of 3.70 and 1.55 tons of dynamite made in connection with construction of a dam near Lake Nazori in Gumma Prefecture, Japan, and one planned for purposes of crustal study at Hokota, were observed at a total of 33 stations more or less on a line between the two shot points. The exact location of each station, altitude, azimuth, distance from shot point, type of electromagnetic seismometer, observers, and arrival times of P-waves at each station are tabulated and 31 seismograms are reproduced.

P-wave velocity in the surface layer was found to be 2.7 km/sec near Nozori and 1.79 km/sec near Hokota: deeper layers showed P velocities of 5.5 km/sec and 7.7 km/sec.

RESEARCH GROUP FOR EXPLOSION SEISMOLOGY (Japan), "Observations of Seismic Waves from the Second Hokota Explosion [in Japanese with English abstract]," Zisin, J. Seism, Soc. Japan, ser. 2, V. 13, n. 2, pp. 90-96 (1960).

Seismic waves from the detonation of about 1 ton of explosives near Hokoda, Ibaragi Prefecture, Japan, on August 16, 1957, were observed at 18 temporary stations in Japan. The purpose of the study was to determine the crustal structure of the northern Kwanto district and of northeast Japan; moreover, the profile obtained is in reverse to that from the earlier Kamaisi explosions and can be used to verify the structure for northeast Japan derived from the earlier profile. Travel-time tables and diagrams are included.

RICE, M. H. See Walsh, J. M.

RICHARD, H., and PLEUCHOT, M., "Seismic Efficiency of Explosives," Geophys. Prosp., V. 4, n. 2, pp. 167-184 (1956).

Parameters commonly used to characterize explosives are derived from laboratory tests and are not directly applicable to seismic purposes. A coefficient of seismic efficiency based on galvanometer deflections is presented. It allows the comparison of different explosives under field conditions. The efficiencies of several types of explosives were determined from both buried and surface charges. Precautions concerning experimental design and analysis are discussed. Preliminary results indicate that the coefficient of seismic efficiency depends on the type of explosive only and not on the size of the charge or experimental conditions. Economic aspects are stressed, and data are presented on the cost of various explosives required to attain the same seismic efficiency.

RICHARD, H. See Beaufils, Y. et al.

RICHARD, T. C., and WALKER, D. J., "Measurement of the Thickness of the Earth's Crust in the Albertan Plains of Western Canada, Geophys., V. 24, n. 2, pp. 262-284 (1939).

Following seismic observations in the Albertan plains from the Ripple Rock explosion, a refraction line some 81 miles long and parallel to the frontal thrust of the Rocky Mountains and about 60 miles to the east thereof was observed by 2-way shooting.

Fifteen seismic parties, spaced at roughly uniform intervals along the line and using the method of close geophone correlation, were employed, the object being to map as many refractors or reflectors as pos-

sible as far as the Mohorovicic discontinuity. The results indicate that this discontinuity occurs at a minimum depth of 43 km where the velocity is about 8.2 km/sec, while an intermediate layer with a minimum depth of 29 km and velocity 7.2 km/sec has been registered.

Other intermediate refractors were observed. These results are compared with those obtained in other parts of the American continent and elsewhere.

The operational, instrumental, and theoretical aspects of the work are discussed.

RICHTER, C. F. See Gutenberg, B. (2); Wood, H. O. (2).

RICKER, N. H. "The Form and Laws of Propagation of Seismic Wavelets," World Petroleum Con., 3rd session, Proc., sect. 1, pp. 514-536 (1951).

The wavelet theory of seismogram structure was developed about twelve years ago from mathematical investigations of the form of a seismic disturbance resulting from the explosion of a charge of dynamite and of the laws of propagation of the disturbance.

From the theory the following important laws have been deduced: The center of the wavelet travels with a velocity given by the square root of elasticity divided by the density; the breadth of the wavelet is proportional to the square root of the propagation time of its center; the amplitude of the displacement function is proportional to the -4/2 power of the travel time of its center; the amplitude of the velocity function is proportional to the -5/2 power of the travel time of its center; the amplitude of the acceleration function is proportional to the 6/2 power of the travel time of its center; the amplitudes of the displacement, earth particle velocity and acceleration are proportional to the 5/6 power of the mass of the charge, the charges being spherical, and the explosion pressure being independent of the size of the charge.

An extensive series of experimental studies were carried out over a comparatively simple, homogeneous and isotropic earth. Two areas were chosen, one 3 miles north of Limon, Colorado, the other 37 miles north of Limon at the crossroads village of Last Chance. Both are located in the thick section of Pierre shale in the Denver basin in the eastern part of Colorado. Numerous graphs are presented of the data incicating that in the shale there is good agreement between experiment and wavelet theory.

RICKER, N. H., and SORGE, W. A., "The Primary Seismic Disturbance in Shale," Bull. Seism. Soc. Am., V. 41, n. 3, pp. 191-204 (1951).

Studies for the purpose of determining the form and laws of propagation of the primary seismic disturbance were made in the Pierre shale of eastern Colorado where the shale is 4000 or 5000 feet thick. Three vertical-component geophones were placed in a drill hole at depths of 822, 622, and 422 feet and a horizontal component at 522 feet. Charges were fired at depths varying in steps of 25 feet, throughout the length of 310-foot holes drilled at distances of 50 to 1600 feet from the instrument hole. Results show that the disturbance broadens as the square root of the travel time, and the law of decay of amplitude of earth-particle velocity is reasonably close to the -5/2 power of the travel time. The "seis-

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mic punch", which is the earth-particle velocity for a travel time of 1000 msec, is very low for shallow shots, and increases as the shot is placed deeper, reaching a maximum for shot depths of about 100 feet. For the mathematical theory of the propagation of these distrubances, see Geophys. Abstract 7297.

RIGGS, E. D., "Seismic Wave Types in a Borehole," Geophys., V. 20, n. 1, pp. 53-67 (1955).

Experiments with multiple seismometer arrays within a bore hole revealed a well-developed secondary wave following the compressional wave. The wave was generated under controlled conditions and was identified as a tube wave traveling through the fluid column. The measured tube-wave velocity agrees closely with the velocity calculated from Lamb's formula for a thick-walled tube. Although the amplitude of the tube wave is higher than that of the formation compressional wave, the accuracy of formation-velcoity data can be assured by using proper techniques of measurement.

RINEHART, J. S., and FORTIN, J. P., "Wave Propagation in Rocks," Colorado School of Mines Research Foundation, Inc., Golden, Colo. Paper presented at Geological Society of America Meeting (1960).

The compressive stress pulse generated in rock surrounding an explosion was investigated. The parameters of the transient disturbance are propagation velocity, particle velocity, particle displacement, and stress. The transmission and reflection of a stress wave at an interface was studied. The mechanism of spalling, including generation of multiple spalls, is discussed. The partition of stress at boundaries between dissimilar rocks is shown. Critical spalling velocities were computed for several different types of rocks.

RINEHART, J. S. See also Auberger, M.

RISNICHENKO, J. V. See Weizman, P. S., et al.

RITSEMA, A. R., "On the Seismic Records of Nuclear Test Explosions, Indonesia Medjalah Ilmu Alam," V. 113, pp. 123-127 (1957); reprinted as Indonesia Univ. Dept. Geology Contr. No. 30.

Origin times of the nuclear test series carried out by the United States in the Pacific in 1956 have been calculated by the Geophysical Institute at Djakarta, Indonesia, using data compiled in the international seismological bulletins published at Strasbourg. The times thus calculated are identical with those derived by Burke-Gaffney and others for the same series.

During the 1954 and 1956 test series, the Z-component seismograph at Lembang was the only instrument in Indonesia at which waves generated by these explosions could be expected. The first Bikini test was not recorded; records of the other Bikini tests are clear except for number 7 (June 25, 1956), but neither of the Eniwetok tests showed any trace. In keeping with the explosion character of the initial disturbance, all direct waves recorded at Lembang started with a compression, and the dilatational motion following the first compression had the largest amplitude. No S-waves, surface waves, or channel waves were observed. The total ab-

sence of any reflected P-waves, such as PP or PcP, is remarkable. It is suggested that local crustal structure at the point of reflection for PP may cause interference phenomena that reduce PP wave energy to zero. Similarly, irregularities of the core boundary may cause extinction of PcP.

ROBERTS, F. A., and DENNISON, A. T., "A Device for Overcoming the Effects of Static on Seismic Shot Signals," Geophys. Prosp., V. 1, n. 3, pp. 192-196 (1953).

ROBERTSON, F. See Macelwane, J. B., et al.

ROBIN, G. de Q., "Seismic Shooting and Related Investigations: Glaciology III, Norwegian-British-Swedish Antarctic Expedition, 1940-52," Sci. Results, V. 5, pt. 3 (1958).

A seismic profile about 425 miles long was made from the coast to the plateau in Queen Maud Land, Antarctica, in order to determine the thickness of ice. Some 950 shots were fired at 178 stations with partial or complete success at 134 points. Portable equipment with six recording channels adapted for operation at low temperature was used. Both refraction and reflection techniques were employed.

Travel times, surface heights of seismic stations, and ice thickness are shown in tables. Contours of the surface, location of mountain areas in which bedrock rises above sea level, and the route of the profile are shown on a map.

ROCARD, Y. "The Short-Period Seismic Signals Obtained During the Reggane Nuclear Test, February 13, 1960," Acad. Sci., Paris. Compt. rend., V. 250, pp. 2041-2 (1960).

During the nuclear explosion of February 13, 1960, near Reggane, the short-period seismic signals appear definitely weaker at a distance of 2350 km than one would have thought from the American results obtained during the Nevada tests. The signals appear very strong at 686 km.

ROCARD, Y. "The Seismic Signals with Long Period Obtained During the Reggane Nuclear Test on February 13, 1960," Acad. Sci., Paris. Compt. rend. V. 250, pp. 2244-6 (1960).

The nuclear explosion of February 13, 1960, near Reggane has furnished at El Golea a seismic wave of the Rayleigh surface-type, shaped according to the theoretical predictions for a pulse excitation. At Tamanrasset, on granite terrain, only a vertical component was observed.

ROETHLISBERGER, H., "Seismic Survey, 1957, Thule Area, Greenland," Technical Rept. No. 64 (1959).

Seismic reflection soundings were carried out in the vicinity of Camp Tuto, Thule, Greenland, on the edge of the ice cap. Ice thicknesses ranging from 200 to 800 feet were determined. With a short shot point to geophone distance only sporadic results could be obtained, while with a long distance, up to 3.5 times the ice thickness, very strong reflection signals were recorded. Evidence was found that some of the reflections did not occur at a single clear interface, indicating the presence of alternate layers of moraine and ice at the bottom of the ice cap. At one location, where the result of the seismic sounding could be compared with drilling results, the error was found to be less than 10 feet, the depth at the place

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being about 200 feet. Later reflection signals on the seismic records are analyzed by means of a master chart. The usefulness of the refraction method was established along the ice tunnel.

ROLLER, J. C. See Byerly, P. E., et al.; Diment, W. H., et al.

ROMNEY, C., "Seismic Measurements," Air Force, Washington, D. C.

Preliminary technical conclusions are presented based on the analysis of seismograms recorded at more than 40 stations at the time of the Rainier explosion and seismograms recorded at more than 90 stations at the time of the Hardtack underground nuclear explosions.

ROMNEY, C., "Amplitudes of Seismic Body Waves from Underground Nuclear Explosions," J. Geophys. Research, V. 64, n. 10, pp. 1489-1498 (1959).

Seismic waves from underground nuclear explosions in Nevada were observed at a number of temporary stations along a line extending eastward to Maine. A study of the seismograms from these stations and from a large number of permanent stations has shown that the amplitude of Pn varies inversely as the cube of the distance between 200 and 1100 km. Pn then disappears and a late-arriving higher velocity wave appears with relatively large amplitude. This later P wave has a slight amplitude maximum at about 2000 km, after which it decreases irregularly with distance.

Between 200 and 2000 km the amplitude of S (or Lg) varies inversely as the cube of the distance. The vertical, radial, and transverse components are of approximately equal size, and are about 3 times the amplitude of Pn between 200 and 1000 km.

At distances of 100 km or more, the amplitudes of the body waves are proportional to the first power of the explosive yield. The explosions produced seismic waves equivalent in size to those from natural earthquakes of magnitude: $M = 3.65 + \log Y$, where Y is the energy of the explosion expressed in kilotons of TNT equivalent.

ROMNEY, C., "Deep-Hole Detection Techniques," U. S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 18 (1959).

Theoretical reasoning and some experimental work suggest that seismographs installed and operated at depths of several thousand feet below the surface may detect smaller P-wave signals than those at the surface. This is suggested by the belief that surface noises die off rapidly with depth. A long-term research program now in progress and problems for future study are discussed.

ROMNEY, C., "Short Period Shear Waves and Their Application to Discriminating Between Earthquakes and Explosions," U. S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 2 (1959).

Four approaches are presented for developing suitable criteria for using the shear waves to discriminate between earthquakes and explosions: existence of SH, azimuthal variations of SH/SV ratio, absence of SN in some nuclear explosions, and the ratio of S/P. Six type questions are presented to be answered by a possible experimental program, and recommendations are made for the conduct of the program with an estimate of costs and time schedules.

ROONEY, W. J. See Tuve, M. A., et al. (2).

ROSENFELD, A. H., "Detection of Bomb Tests," in Fallout, a Study of Superbombs, Strontium 90 and Survival, John M. Fowler ed., Basic Books, N. Y. (1960).

Before agreement can be reached on cessation of nuclear tests, a practical system must be devised for detecting and identifying nuclear explosions; this was the conclusion reached at the Geneva Conference of Experts in 1958. The size of nuclear explosions to date has ranged from somewhat less than a kiloton to over 2 megaton equivalents of TNT. They may be exploded on the surface, underground, or in outer space. Surface testing is easily detected and the problem of detecting explosions in outer space is not an immediate problem, the feasibility of such tests being several years away. The first U. S. underground test was the 1.7-kt "Rainier" explosion held 900 feet below a mesa surface in the Nevada Proving Grounds, Sept. 1957. This and subsequent underground explosions indicate that they are relatively easy to mask but that the most promising means of detection lies in seismic detection methods. The key to distinguishing earthquake shocks from nuclear explosions lies in the fact that earthquakes result from slow shearing of rock whereas nuclear shocks are sudden, compressional, and radiate shock waves nearly equally in all directions. Seismic stations set up to detect for nuclear explosions would have to be spaced carefully to ensure against using natural earthquakes to hide deliberate testing.

ROTHE, J.-P., "L'enregistrement dans les stations francaises des ondes seismiques de l'explosion de Helgoland [Seismic Wave Recordings by French Stations from the Helgoland Explosion]," Acad. Sci., Paris, Compt. rend., V. 224, pp. 1572-1574 (1947).

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The velocity of the P1 waves (5.5) is the normal velocity of waves through the granitic layer. The velocity of the Pn waves is abnormally high. The surface of the Mohorovicic discontinuity is less steep under northern Europe than under the Alps.

ROTHE, J.-P. See also Beaufils, Y. et al. (2); Geneslay, R., et al.

ROTHE, J.-P., PETERSCHMITT, E., and STAHL, P., "Les ondes seismiques des explosions d'Haslach (Foret Noir). [Seismic waves from the explosion at Haslach in the Black Forest]," Acad. Sci., Paris. Compt. rend., V. 227, n. 5, pp. 354-356 (1948).

The seismic effect of the explosions of April 28 and 29, 1948, destroying the Haslach subterranean installations (48° 16'N, 8° 07'E), was recorded by portable seismographs along the Strasbourg-Kempten profile and by the Strasbourg, Messtetten (Messtettin), Stuttgart, Basel, Zurich, Neuchatel, and Chur observatories. The velocity of longitudinal waves in the vicinity of Haslach was 5630 m/sec; at stations more than 80 kilometers from Haslach, 6410 m/sec; and at distances of 140-190 kilometers, 8130 m/sec. Transverse waves were not clearly recorded only the S_1 wave with velocity of 3300 m/sec was observed. The depth of discontinuity between the granite and basaltic layers was found to be 16±0.5 km and the depth of the Mohorovicic discontinuity in southern Germany, 30-32 km.

ROTHE, J.-P., and PETERSCHMITT, E., "Etude seismique des explosions d'Haslach. [Seismic Study of the Haslach Explosions], Physique du Globe, tome 5, pt. 3, pp. 13-38 (1950).

Analysis of the seismographic records of the Haslach explosions indicates the existence of the following four layers in southern Germany: granite gneiss — 2.4 km thick with velocity of 5.63 km/sec; deep granite-17.7 km thick with velocity of 5.97 km/sec; gabbrobasalt — 10.1 km thick with velocity of 6.54 km/sec; and peridotite with velocity of 8.15 km/sec. The basaltic layer is very well defined, the P impulses and the reflections from the upper surface of the intermediate layer being very clearly shown on the seismograms.

An extensive bibliography is included.

ROTHLISBERGER, H., "Messung der Geschwindigkeit elasticher Wellen in Sandstein [Measurement of the Velocity of Elastic Waves in Sandstone], Schweiz. Na. Gesell, Verh., 129 Vershammlung, pp. 107-109 (1949).

The velocity of propagation of seismic waves in different rocks of the Swiss Alps was measured using the accelerometer designed by the Institut fur Geophysik. (See Geophys. Abstract 12375.) At the same time, elastic properties and densities were measured in a laboratory.

In the field, explosions of about 40 kg gum dynamite were electrically produced and recorded. The time of arrival of the first wave was determined at distances greater than 5 meters from the shot point. The accuracy of time recording was about 0.1 msec. Determinations of the velocity were made in sandstones that varied slightly in water content, color and other properties. Velocities in general ranged from 2.0 to 2.5 km/sec with a velocity of 3.075 km/sec in one place. Where it was possible to determine the time of arrival of the transverse wave, Poisson's ratio was found to be 0.258±0.005.

In the laboratory, the measurements were made on sandstone samples of 4 x 4 x 80 cm, which were excited to vibrations after they had been clamped in a vise at one end. The computed values of the velocity were always lower than those found in the field even though corrections for three dimensional stress conditions were taken into account. The causes of these discrepancies are not clear.

RUFF, A. W., "Seismic-Wave Measurements in Underground Blasting," Mines Mag., V. 48, n. 12, pp. 8-15 (1958).

Reflected-wave theory applied to blasting has shown that the reflected tension wave from an exploded charge produces rock failure. Therefore, the character of the seismic wave at the point of failure and the rock strength should determine the type of primary fracturing, and measurement of the character of the wave from an exploded charge should indicate the relative efficiency of the wave source and the transmitting medium. Shielding and bonding of strain gages, the strain-gage circuit, cap-firing circuit, and powder comparisons in testing are briefly described. The principle of superposition of seismic waves and the effect of stemming on seismic waves are discussed. Results are analyzed.

RUMYANTSEV, B. N., "Concerning Waves Created on the Surface of an Incompressible Liquid by a Shock Wave," Priklad. Mat. i Mekhan. V. 24, pp. 240-8 (1960).

Planar and three-dimensional problems associated with the motion of an incompressible liquid as pressure is applied to its surface are examined. The influence of gravity is disregarded. The problem is visualized as follows. An explosion occurs above the liquid's surface and after a time the shock wave reaches the liquid and interacts with it. To determine the movements of the liquid and gas, the problem has to be solved jointly in both phases. However, to a first approximation, it is assumed that the motion of the liquid does not influence that of the gas. The motion of the gas is taken to be known. The planar problem is solved for three instances: (1) the shock wave pressure is constant, (2) the pressure is an arbitrary function of x/t (where "x" is the abscissa and "t" the time), and (3) the explosion over the liquid has cylindrical symmetry. The three-dimensional problem is solved for two particular cases: (1) where a circular zone of constant pressure expands in all directions at a constant velocity and (2) where half of the explosion energy is absorbed into the gaseous phase.

RUSSELL, M., "More Seismic Research Asked to Improve Atomic Test Detection," Science, V. 130, n. 3366, pp. 26-28 (1959).

New data obtained from the underground tests in Hardtack II showed that the capability of the Geneva System to detect and identify underground events was considerably less than had been originally estimated by the Geneva Conference of Experts. A panel on seismic improvement concludes that a vigorous research program in seismology would improve the ability to detect and identify earthquakes of small magnitude. The Geneva System could be improved upon by (1) increasing the array of seismometers in the arrays at each station and (2) by incorporation of criteria for detection based on the fact that the peak frequency of long waves in underground explosions is twice that for earthquakes. An auxiliary network of unmanned seismic stations may be needed. An experimental testing program of many high-explosive and some nuclear shots

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is needed. Techniques which prevent transfer to the surrounding earth of some of the energy of underground nuclear shots, called decoupling, can reduce the seismic signal by a factor of 10 or more.

RUST, W. M., Jr., and MOUNCE, W. D., "Measurement of Earth Pressures and Movements under Detonation," National Research Council Report No. 19 (1942).

RYALL, A. S., and BLACKFORD, M. E., "Bibliography of Small Earthquakes, and Local Earthquakes," U. of Calif. Special Rept. (1961).

Articles on earthquakes and shocks are cited. Abstracts are included for approximately 80% of the references.

SACHS, D. C., and SWIFT, L. M., "Underground Explosion Effects: Operation Teapot." Report on Operation Teapot (1959).

Measurements were made of surface and subsurface effects of an underground explosion of a 1.2-kt nuclear burst. The measurements included free-field earth and air-blast effects, as well as loading on underground structural devices. From the 76 channels installed on Teapot Shot 7, 75 usable records were obtained. The free-field quantities measured include air-blast pressure, earth acceleration, earth stress and strain, and permanent earth displacement. The results are discussed by phenomenon and, in each case, the Teapot data are compared with pretest predictions. Also, where data are available, comparisons are made with previous underground nuclear test results. Some aspects of seismology and soil mechanics as applied to underground explosion phenomena are presented. The most pertinent high explosives results from subsequent tests conducted at the Teapot location are summarized.

SACHS, D. C. See also Adams, W. M., et al.; Swift, L. M., et al. (2).

SADOVSKII, M. A., "Experimental Investigations of the Mechanical Effect of an Impact Wave from Explosion" [in Russian], Trudy Inst. Seys., n. 116 (1945).

The mechanical effect of an impact wave caused by explosion was investigated by a determination of the resulting pressure. A piezoelectrical manometer, equipped with a device for registration, served for measuring the maximum pressure and impulse against obstacles as functions of the distance from the explosion and of the weight of the explosive. In an accessory study preliminary observations were made of the time during which the wave preserves its impact force and of the velocity with which it propagates. The apparatus and procedures of the investigation are described, and the results are given.

SAGOMONYAN, A. Ya., "Propagation of a Plane Shock Wave in Ground," Izvest. Akad. Nauk S.S.S.R., n. 5, pp. 64-71 (1959).

A mathematical analysis is made of plane shock wave propagation in plastic media. The selected media reflect the properties of sand and argillaceous soil while offering a more efficient solution for problems arising in shock wave propagation in light soils.

SAKURAI, T., "On the Propagation and Structure of the Blast Wave," J. Phys. Soc. Japan, V. 8, n. 5, pp. 662-669 (1953).

SAKURAI, T. See also Ito, I., et al.

SALMON, V. See Doll, E. B. (2).

SALVADORI, M. G. See Skalak, Richard, et al.

SATO, Y., "Synthesis of Dispersed Surface Waves by Means of Fourier Transform," Bull. Seism. Soc. Am., V. 50, n. 3, pp. 417-426 (1960).

Flexural disturbances propagated upon a thin aluminum plate were studied experimentally. The thickness of the plate is 1.0 mm, and the distances between the source and the observation points are r = 0, 3.0, 5.0, 7.0, 15.0 and 20.0 cm.

Using the method of Fourier Transform, the dispersion curve was obtained. It agrees well with the theory, and the thickness of the plate was estimated with good accuracy (0.981 mm).

Disturbances at the distances 7.0, 3.0, and 0 cm were numerically reproduced by means of Fourier synthesis from the data obtained at r = 15 cm and 20 cm, and were compared with the observed disturbances. The agreement of the two kinds of curves is fairly good, with a little larger discrepancy for the case r = 0 than for the others.

SATO, Y., "Definition, Classification and Representation of Surface Waves" [Japanese with summary in English], Zisin, J. Seism. Soc. Japan, Second Series, V. 9, n. 1, pp. 16-20 (1956).

SATO, Y., LANDISMAN, M. and EWING, M., "Love Waves in a Heterogeneous Earth. Part 2: Theoretical Phase and Group Velocities," J. Geophys. Research, V. 65, n. 8, pp. 2399-2404 (1960).

Love wave phase and group velocities have been calculated for the first 14 radial modes for the Jeffreys-Bullen and Lehmann I models. Sphericity, an arbitrary number of discontinuities, gradients within each shell, and a liquid core have been taken into account. A new result is the prediction of maximum values of group velocity of about 7.5 km/sec for all the higher modes and the relation of these maxima and the period cut-offs to travel-time results.

SAUER, F. M. See Flanders, P. L.

SAVARENSKY, E. F., "Seismology in the Chinese People's Republic," [in translation] Bulletin of Akad. Nauk. S.S.S.R., Geophys. Series, n. 6 (1958).

This is a brief report on the trip made by Savarensky, as chairman of the council on seismology of the Russian Academy of Sciences, to China in 1957-1958. From a map given it can be seen that over half the territory of China is seismically active. The central and western portions of China are subject to violent earthquakes, for example, the earthquake of Hansu on Dec. 16, 1920, one of the most violent earthquakes of the entire globe. China is only a little less dangerous seismically than Japan, the most dangerous region being in eastern Tibet. Here near the boundary between India and China an earthquake of magnitude 8.6 occurred on Aug. 15, 1950.

The foci of most of the earthquakes are located within the earth's crust. At present China has 25 seismic stations. All the equipment of

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these stations is built in China, although most of the instruments are of foreign design. Two tripartite seismic stations, one in Shanghai, another in Canton, are built for the study of microseisms.

Along with the industrial development of the country, much attention is being given to engineering seismology and to the development of earthquake-resistant industrial construction. The article ends with the description of several seismic stations in different parts of China.

SCHORR, M. G., and GILFILLAN, E. S., "Predicted Scaling of Radiological Effects," Technical Operations, Inc., Arlington, Mass. Report on Project 2.0 of Operation Jangle (1952).

The radiological contamination which may result from fission bombs detonated near the surface of the earth and underground is predicted. The radiation received is primarily a result of the initial radiation from the early fission products and fallout of radioactive material from the high cloud. The distribution of the fallout is determined by constructing a mathematical model and adjusting the parameters of the model to fit actual Jangle data. The model is then scaled up to larger weapons by scaling these parameters in conformity with existing formulations of explosion cloud dynamics. The initial radiation is calculated in a straightforward manner. The resulting dose and dose-rate contours are given, as are the areas enclosed by given contours. It is concluded that the base surge at the Jangle underground explosion did not contain an appreciable amount of radioactive material. The cratering action of explosives is discussed, and it is found that atomic bombs exploded near the earth surface should give crater radii which scale as the one-sixth power of the energy release rather than the one-third power scaling applicable to high explosives.

SCHULZE, G. A., "Seismische Ergebnisse der Helgoland-Sprengung" ["Seismological Findings from the Helgoland Explosion], Die Naturwissenschaften," V. 34, n. 9, p. 288 (1947).

A special meeting of the Royal Society was devoted to reports by the representatives of Denmark, Netherlands, Belgium, France and Germany on seismological observations made in different countries during the Helgoland explosion on April 18, 1948. Seismic waves were observed up to 1000 kilometers distance. The Pn phase previously observed only during natural earthquakes has been positively identified for the first time. Its velocity was 8.1 km/sec. In northwestern Germany the depth of the Pn layer was 27 km ± 3 km. Another discontinuity was found at a depth of 11 kilometers, below which the longitudinal velocity was 6.4 km/sec.

SCHULZE, G. A., and FORTSCH, O., "Die seismischen Beobachtungen bei der sprengung auf Helgoland am 18 April 1947 zur Erforschung des tieferen Untergrundes [Seismic Observations During the Explosion on Helgoland on April 18, 1947 for the Exploration of the Crust]," Geol. Jahrb., Band 64, pp. 205-242 (1950).

Seismic observations of the Helgoland explosion were made at the Leipzig, Jena, and Stuttgart observatories, and at 24 seismic stations, along three profiles south, south-east, and north-east from the source.

The velocities of P and S were 5.40 km/sec and 2.94 km/sec indicating a Poisson's ratio of 0.288. The thickness of this layer is 6.0 ± 1.0 km. The travel-time curves of P and S are straight lines.

The P* wave appears on seismograms of stations at distances greater than 107 km. The velocity for the first 200 km is 6.18 km/sec, and then suddenly increases to 6.6 km/sec. The depth of the P* layer is 9.3 ± 1.5 km. The velocities of S* are 3.67 km/sec and 3.87 km/sec, and Poisson's ratios are 0.228 and 0.238.

At all stations in northwestern Germany, the Pn velocity was 9.32 km/sec but beyond this region the velocity was 8.14 km/sec. This decrease may be the effect of an inclined boundary surface of the peridotite layer, but gravity measurements contradict this assumption. The Sn velocity is 4.38 km/sec, and Poisson's ratio is 0.283.

SCHULZE, G. A. See also Reich, H. et al. (2).

Science Council of Japan, "Seismology and Physics of the Interior of the Earth," National Report on Japan, 1954-1956. Sci. Council Japan, Natl. Comm. Geodesy, Geophysics Sec., Seismology Rept. (1957).

A summary of seismological observations and studies in Japan during 1954 through 1956 presented to the 11th General Assembly of the International Association of Seismology and Physics of the Earth's Interior in Toronto, Canada, in September 1957. It includes lists of seismological stations and major earthquakes and a bibliography of seismological papers published in Japanese periodicals from 1954-1956.

SCIENCE NEWS LETTER, "Find New Earthquake Wave may Aid Detection of Enemy," Sci. News Letter, V. 36, n. 17, p. 266 (1939).

SCIENCE NEWS LETTER, "Navy Builds Seismographs to Record Man-Made Blasts," Sci. News Letter, V. 52, n. 1, p. 7 (1947).

SCIENCE NEWS LETTER, "Man-Made Quake Waves Studied After Explosions," Sci. News Letter, V. 53, n. 18, p. 281 (1948).

SCIENCE NEWS LETTER, "Man-Made Shock Waves Measured by New Device," Sci. News Letter, n. 17, p. 263.

SCIENCE NEWS LETTER, "Hope to Detect Bomb Test," Sci. News Letter, V. 52, n. 17, p. 261 (1947).

SCIENCE NEWS LETTER, "Seismographs Cannot Detect Secret Atom Bomb Tests," Sci. News Letter, p. 118 (1947).

SCIENCE NEWS LETTER, "H-Bomb Tests Help Seismologists," Sci. News Letter, V. 72 (1957).

Scripps Institute of Oceanography (Staff), "Marine Physical Laboratory Bibliography," AD 240420, Marine Physical Laboratory Special Report.

This bibliography lists material by title and classification, author and contract number, and date and publication in the following subject areas; acoustics, signal processing, marine geophysics, physics, and miscellaneous.

SECTION, L. G., "Instrument Chart and Engineering Information, Project Cowboy," UCID-4214 (1960).

SEDY

This report is a consolidated description of participants, programs, structures, and instrumentation pertaining to Project Cowboy. It includes names of participating agencies, program descriptions and responsibilities, structure locations, dimensions, and instrument locations and function.

SEDY, L. See Galfi, J., et al.

SEEGER, R. J. See Kirkwood, J. G.

SENGBUSH, R. L. See Dobrin, M. B., et al.

SHAN'GIN, N. V. K., "voprosu o zatukhanii seymicheskikh voln [On the Damping of Seismic Waves]," Uchenyye Zapiski, Leningrad Univ. n. 210, pp. 168-190 (1956).

Elastic vibrations in the ground are produced by using a drop hammer composed of a tripod, a cast iron spherical ram weighing about 50 kg and a simple hoist; the ram is raised to a height of 3 meters and let fall on a short post buried in the ground. Waves measurable at a distance of 150-200 meters were produced in this manner to investigate the upper layers of the ground to a depth of about 25 meters. The propagation of seismic waves, first through homogeneous ground and later through stratified ground composed of two or three strata was investigated. The variation of the amplitude A of the wave was assumed to vary according to the relation $A = (c/r)e^{-Kr/2}$, where c is the constant characterizing the decrease of the amplitude due to geometric dissipation of the wave front. K is the constant of damping related to the imperfect elasticity of the ground, and r is distance from the "shot point".

If the actual thickness of the second layer is less than a certain critical thickness the wave will not be among the first arrivals. This fact is to be taken into account in interpreting the results of seismic surveys.

SHARPE, J. A., "The Production of Elastic Waves by Explosion Pressures. Part I: Theory and Empirical Field Observations," Geophys., V. 7, n. 2, pp. 144-154; "Part II: Results of Observations Near an Exploding Charge," Geophys., V. 7, n. 3, pp. 311-321 (1942).

A solution for the problem of the wave motion produced when a pressure of arbitrary form is applied to the interior surface of a spherical cavity in an ideally elastic medium is derived. This solution is shown to be in qualitative agreement with a number of field observations of the effect of shot-point conditions on the characteristics of reflection-seismograph records. (Abstract of Part I.)

A high-fidelity recording system has been used to observe the elastic-wave motion at vertical separations from an exploding charge ranging from 15 to 300 feet. The motion near the charge has a predominant frequency of about 1000 cps for rigid material and a duration of a few milliseconds. The motion becomes increasingly complex, and low-frequency components become dominant as the point of observation recedes from the source. A secondary wave which may be a bound wave associated with the fluid in the drill hole was observed. (Abstract of Part II.)

SHARPE, J. A., "The Effect of Charge Size on Reflection Records," Geophys. V. 7, n. 3, p. 336 (1942).

The writer has collected a large number of recordings, made under carefully controlled conditions, in which the size of charge has been changed by a factor of 5:1 or 10:1. Sample recordings illustrate the effect of charge size on the ratio of reflected energy to ground roll and other nonreflection interference, and the effect of charge size on the frequency content of reflected motion.

SHEBALIN, N. V. See Monakhov, F. I., et al.

SHELTON, A. V., NORDYKE, M. D., and GOECKERMANN, R. H., "The Neptune Event—a Nuclear Explosive Cratering Experiment," U. of Calif., Livermore, Lawrence Radiation Laboratory, UCRL Report (1960).

The Neptune device was detonated underground in a room approximately 12 x 17 x 10 feet, at the end of a hooked drift. The yield was 115 ± 15 tons. The shot and its effects are described and the major contributions of the data to the theory and prediction of cratering phenomenology are indicated.

SHEPHERD, W. C. F., "Speed Around the Initiating Point of the Detonation Wave in High Explosives," Nature, V. 160, n. 4055, p. 92 (1947).

SHOCK, L., "The Progressive Detonation of Multiple Charges in a Single Seismic Shot," Geophy., V. 15, n. 2, pp. 208-218 (1950).

The relative efficiencies of various sizes of explosive charges for the generation of seismic energy were investigated and a procedure devised whereby a number of charges of the most efficient size would be detonated progressively in such a manner that the energy from all the individual charges would arrive simultaneously at the recording position. The results of investigations of this system of progressive detonations, using both horizontal and vertical spacings of the individual charges, are presented, and its possible application in reflection and refraction seismic surveys is discussed.

SHOPLAND, R. C., "Report on the Registration of Earthquakes for January, 1961," Geotechnical Corp. Report on Registration of Earthquakes, Vol. 1, No. 2 (1961).

This report presents tables of data on earthquakes registered at the Wichita Mountain Seismological Observatory, Fort Sill, Oklahoma, during January, 1961.

SHOPLAND, R. C., "Report on the Registration of Earthquakes for February, 1961," Geotechnical Corp. Report on Registration of Earthquakes, Vol. 1, No. 2 (1961).

This report presents tables of data on earthquakes registered at the Wichita Mountains Seismological Observatory, Fort Sill, Oklahoma, during February, 1961.

SHOR, G. G., Jr., "Deep Reflections From Southern California Blasts," Trans. Am. Geophys. Union, V. 36, n. 1, pp. 122-138 (1955).

Two records showing reflections from the Mohorovicic discontinuity at normal incidence have been obtained from large quarry blasts in southern California. Each record shows a strong reflection with corrected

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travel time near 10.6 seconds. An earlier reflection appears near 9.0 seconds. Strong reflections were also obtained at distances slightly beyond critical. Computations of the thickness of the crust near the quarries have been made using velocity data obtained from blast and earthquake refraction studies. The results using any crustal model that fits the refraction data or by assuming a single-layer crust agree closely. In this area the Mohorovicic discontinuity is 32 km below sea level, and the mean velocity in the crust is 6.2 km/sec. The data give additional evidence for the existence of a zone in which velocity decreases with depth.

SHORT, N. M., "Excavation of Contained TNT Explosions in Tuff," U. of Calif., Livermore, Lawrence Radiation Laboratory. UCRL Rept. No. 6445 (1961).

The effects of two contained HE explosions in volcanic tuff were examined by mining directly into the explosion sites. The features characteristic of these two explosions are compared to an earlier 1000-lb explosion in salt. For explosions in tuff it is concluded that:

(1) Joints exercised a primary role in locating the surfaces of fracture failure,

(2) Early venting inhibits development of carbon-marked fractures,

(3) The medium undergoes greater expansion and more readily collapses after the shot than does salt.

SHORT, N. M., "Fracturing of Rock Salt by a Contained High Explosive," U. of Calif., Livermore, Lawrence Radiation Laboratory. UCRL Rept. No. 6054 (1961).

A study of fractures induced in halite by high explosives was conducted as part of Project Cowboy, Winnfield, La.

Additional cleavage sets intersecting the primary cleavage, warped cleavage surfaces, and absence of crushing, granulation, or fusion within three feet of the shot suggests plastic deformation within that zone. At points beyond this zone, failure was by nearly vertical tensile fracture radial about the shot point. The cylindrical shape of the shot chamber apparently affected the type and distribution of the fractures.

Predictions of failure under dynamic shock stress, based on a theoretical model, were verified only in a general way. Limited simple scaling of the effects of this high explosive detonation to nuclear dimensions can be done, but most effects should probably be modified.

SIEVERS, R. H., Jr. See Pieper, F. A., et at.

SIMA, H. See Suzuki, Z. (2).

SIMON, R. F. See Clewell, D. H., Dobrin, M. B., et al.

SKALAK, R., SALVADORI, M. G., and WEIDLINGER, P., "On the Application of the Theory of Locking Media to Ground Shock Phenomena, I; II: Wave Propagation in a Plastic-Elastic Medium; III: Spherical Waves in an Ideal Locking Medium," MITRE Corp., New York (1960).

Recent investigations on ground-shock phenomena indicate that the dynamic response of certain nonlinear (locking) media may approximate the behavior of cohesive granular soils and porous rock under high pressures. There is a considerable body of fairly recent American and U.S.S.R.

scientific literature on this topic. It appears that the Russian investigation parallels our efforts in this field. The theory of wave propagation in such materials should have application to the design of underground shelters at very high pressure levels and may give some additional information on problems associated with phenomena near ground zero in case of surface bursts or underground explosions. In Sections II and III, results of current investigations are presented.

SLICHTER, L. B., "Seismic Studies of Crustal Structure in New England by Means of Quarry Blasts," Bull. Geol. Soc. Am., V. 50, n. 12, pt. 2, p. 1934 (1939).

During the past year observations of five large quarry blasts have been made at about 30 different locations in New England by means of a group of 12 three-component portable seismographs. Instruments were spaced at suitably chosen intervals at distances between 1500 feet and 350 km from the blasts. The orientation of the instruments was also adjusted to the direction of the source. To insure a precise time-scale radio, second signals were simultaneously recorded on all records. The records may be read to a precision of 0.05 second or less, if desired, which renders the identification of phases unusually certain. In the Connecticut Valley, after a superficial layer of low-velocity sediments was penetrated (near Meriden a local thickness of about 2 km and a velocity of the compressional wave of 4.33 km/sec is indicated), a layer of uniform wave velocity 6.32 km/sec persists until a depth of 23.5 km, when the velocity increases to 7.82 km/sec. Comparisons between results obtained at different localities will be shown. The work is being continued, and most recent data will be presented.

SLUTSKOVSKIY, A. I. "Po povodu stat'l A. M. Yepinat'yevoy 'Povtoruyye udaru pri seysmicheskikh nablyudeniyakh' [On A. M. Yepinat'yeva's paper 'Secondary Pressure-Bubble Pulses in Seismic Exploration']," Prikladnaya geofiz., V. 10, pp. 109-113 (1953).

The theoretical analysis of secondary pressure-bubble pulses by Yepinat'yeva (see Geophys. Abs. 147-13222) was based on the assumption that the duration of the first explosion is always shorter than that of the secondary pulses and that the pressure produced by this explosion grows exponentially. These assumptions were based on experiments in reservoirs of relatively limited dimensions. However, Slutskovskiy during 1950 participated in a long series of experiments on the frequency spectrum of the first explosion and the following "seismic reverberation" in the conditions of the open sea.

SMITH, B. L. See Bennett, W. P., et al.

SMITH, J. D. See Jones, R. D.

SORGE, W. A. See Ricker, N. H.

SORSKIY, A. A. See Kirillova, I. V.

SPIEKER, L. J., "Seismometer Array and Data Processing System," Final Report on Phase I of Contract AF 33(600)-41840.

This report describes in detail the study of the optimum utilization of arrays with up to 100 seismic detectors. The result of the study shows that signal-to-noise ratio improvements greater than the generally ac-

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cepted maximum of the square root of the number of seismometers are possible. Optimum signal processing and data display system were investigated for this case. Following separate analysis of each segment of this problem, a program for computer simulation of the entire theory was established. This simulation included seismometer outputs containing both signal and noise from a large array feeding into signal processing programs.

SPRINGER, D. L. See Herbst, R. F., et al.

STAHL, P. See ROTHE, J.-P., et al.

STENGLE, E., "Effect of Shot Depth on the Generation of Seismic Energy," Pennsylvania State University, Col. of Min. Ind., University Park, Technical Rept. No. 2 on Contract No. 54-75 (1955).

STEWART, S. W., HOFMANN, R. B., and DIMENT, W. H., "Some Aftershocks of the Hebgen Lake, Montana, Earthquake of August 1959," Geological Survey Research 1960. U. S. Geological Survey, Prof. Paper 400-B (1960).

Two portable seismographs were operated intermittently at three stations from August 21 to August 24, 1959, to record aftershocks of the Hebgen Lake, Mont., earthquake of August 18, 1959, for the purpose of determining possible differences between ground motion caused by earthquakes and that caused by underground nuclear explosions and those of earthquakes.

At the Keg Spring station, 604 aftershocks were recorded with sufficient amplitude to permit calculation of approximate magnitudes. The weighted values of the numbers of shocks indicate increasing numbers of aftershocks for decreasing magnitudes from 3.7 to 1.2. Thirty aftershocks were sufficiently well-recorded at two stations to determine the approximate locations of their epicenters. A group of epicenters in the eastern part suggests a zone of activity trending slightly east of north. This alignment does not correlate with any known surface effects of the earthquake or with any known geologic trends. The area is underlain by Cenozoic volcanic rocks and alluvium. Most of the remaining epicenters were in the area where the surface was deformed by the earthquake.

STEWART, S. W. See also Byerly, P., et al., Diment, W. H., et al.

ST. JOHN, J. W., "Construction of a Non-Linear System for a Seismograph Utilizing the Hall Effect," AD 246471. Master's Thesis, Air University (1960).

A non-linear detection system for a seismograph is explained in this report. The design utilizes Hall generators and shaped magnetic pole pieces. The system can detect movements of one ten-thousandth of an inch and can transmit data to a recorder in such a manner that the data can be interpreted directly by an operator.

STREET, K., "Need for High Explosive and Nuclear Tests for Research Program," U. S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 7 (1959).

To date no exclusive phenomena have been found that are characteristic only of the seismic phenomena produced by a nuclear explosion. It is imperative that the parameters that can conceivably affect to a signif-

icant extent the magnitude and type of seismic effects produced by a nuclear explosion, be explored in a thorough manner so that these effects can be compared with those produced by natural earthquakes. It is necessary to investigate either theoretically or experimentally the effect of the following parameters on the body and surface waves proposed for use in discrimination: dependence of the waves on yield of the explosion, effect of the medium in which shot is fired, depth of burial, local environment, and large-scale geologic environment. As experimental programs for use of nuclear and HE explosions to explore, a number of parameters is outlined.

STUDER, M. V. See Birkenhauer, H. F., (S. J.).

SULTANOV, D. D. See Kogan, S. D., et al.

SUTTON, D. J. See Bolt, B. A., et al.

SUZUKI, Z., and SIMA, H., "On Forms of Seismic Waves Generated by Explosion, I," Tohoku Univ. Science Repts., Ser. 5, V. 6, n. 1, pp. 85-94 (1954).

Seismographic observations were made on the grounds of the Geological Survey of Japan at Kawasaki at intervals of 25 cm from 11.25 to 25.25 meters. The source was a detonating cap fired at a depth of 74 cm. The ground motion generated consisted of some simple and regular wave groups and an irregular motion that is the apparent result of the superposition of wave groups. The period of the waves was constant within the range of observation. The amplitude ratio to the standard amplitude in a wave group varies linearly with distance. The "growing rate" of waves varies regularly in the order of their appearance in the group, the head of the group decaying with distance while the tail increases. Thus, the initial motion of later phases is sometimes misread.

SUZUKI, Z., and SIMA, H., "On Forms of Seismic Waves Generated by Explosion, II," Tohoku Univ. Science Repts., Ser. 5, V. 6, n. 3, pp. 162-170 (1955).

Wave motion from the detonation of a cap consists of several regular wave groups, which are governed by a simple law of propagation and an irregular part that is apparently the result of the superposition of regular waves. Waveform varies widely even within the distance range of one or two wavelengths, which is not in agreement with mathematical studies on elastic or viscoelastic waves unless an unreasonable large viscosity is assumed.

SWALLOW, J. C. See Hill, M. N.

SWIFT, L. M., "Close-In Earth Motions, Project Hobo," U. of Calif., Livermore, Lawrence Radiation Laboratory, UCRL Rept. No. 6397 (1961).

This report contains close-in earth motion data from Project Hobo (four underground HE shots in tuff at NTS of 100-lb, 200-lb, and two 1000-lb charges). The results of data analyses show that:

(1) Peak particle velocities in tuff were essentially identical to similar shots in salt.

(2) Reduction of overburden stress without change of medium produces a marked reduction of peak particle velocity and an in-

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crease of pulse duration, with a less marked decrease of peak displacement. The data of quasi-permanent displacements were not considered reliable enough to permit conclusions as concerning their variations.

SWIFT, L. M., "Surface Effects," Stanford Research Inst., Menlo Park, Calif. Report.

The close-in surface effects of a deep underground explosion are described. The first arrival is a relatively sharp pulse of upward acceleration which imparts an upward velocity to the surface formations. Under the influence of this velocity, the surface continues upward, being decelerated only by the force of gravity or a little more, so that there is an appearance of a slow upward "heave." During this upward movement, cracks tend to form in the surface, but there is little tendency toward lateral or vertical displacements across the cracks, unless a major discontinuity of the formation intersects the surface. After reaching its peak, the "hump" falls back to its original position and lands with a second shock. If venting occurs it is usually in the late stages unless the burial is classed as shallow. The final positions of points on the surface near ground zero were found lower than their original position.

SWIFT, L. M., et al., "Surface Motion from an Underground Detonation, Operation Plumbbob," Report No. ITR-1528 (SRI) (1957).

A preliminary analysis of data concerning on-surface and near-surface earth motions produced by Shot Rainier (1.7 kt charge detonated approximately 900 feet below ground surface) at the Nevada Test Site is presented here.

The instrumentation is described and the measurements of acceleration, strain, velocity, and displacement are summarized in tables and graphs.

SWIFT, L. M., SACHS, D. C., BRENNER, J. L., and WELLS, W. M., "Surface Motion from an Underground Detonation," Preliminary Report (1958).

Surface and near-surface acceleration and strain were measured on a deep underground nuclear burst (Rainier shot: 900 ft; 1.7 kt) to permit extrapolation of results to nuclear detonations of other yields under different test or employment conditions. Results indicate that a large earth cap, beginning approximately 180 feet below the mesa surface, separated from the mesa over the charge and subsequently fell back into place. The only significant vertical displacement occurred at or near ground zero and reached a maximum of 1 foot. Both acceleration and horizontal strain measurements suggest that the principal disturbance on the mesa surface was confined to a small region around ground zero. From preshot seismic survey data and Rainier gage arrival times and average vertical strains it is concluded that the medium was many-layered with seismic velocities which were widely different in the various layers. These conclusions resulted from a preliminary analysis of the data.

SWIFT, L. M., SACHS, D. C., and WELLS, W. M., "Earth Motion Measurements. Part I; Seismic Studies and Cavity Studies," Preliminary Report and Operation Hardtack II (1959).

Several parameters were measured of ground motion caused by two deep underground nuclear detonations (Evans and Blanca). Primary measurements included vertical acceleration and velocity in a deep hole over Evans zero, horizontal and vertical acceleration on the mesa surface, and horizontal surface strain. On Evans, only one half of the electronic gage records were useful, and no cork-wire or reed-gage data were obtained due to the low yield. Vertical acceleration in the Evans deep hole was one-tenth or less than that predicted. Peak horizontal components of surface acceleration exceeded the vertical, suggesting that much of the blast energy in earth was channeled into rock layers near the surface. Geophone arrival times gave average velocities of 6000 to 7200 fps, consistent with those expected for tuff. On Blanca, limited data were obtained from vertical accelerometers reactivated in the Evans deep hole. Accelerations measured on the mesa surface on Blanca showed vertical maxima consistently larger than the horizontal. Surface strain data indicated that much of the blast energy was refracted or reflected from subsurface layers. Reed gage data indicated that the vertical response spectrum shifts to low frequencies with increasing distance from the burst.

SYLVANIA ELECTRONICS SYSTEMS (Staff), "Communications Study for Project VELA UNIFORM," Sylvania Electronics Systems Rept. on Contract No. AF 33(600)-42159.

This is a detailed, comprehensive report presenting findings and recommendations pertinent to the design of a communications system for proposed world-wide data collection stations which would receive seismic information and transmit the information to a central evaluation agency. The study consists of two phases:

(1) Preliminary design of a global communications network for VELA UNIFORM,

(2) Supporting communications design studies for an experimental program. Complete results of each study finding are presented.

Information on system requirements, system analysis, equipment and cost breakdowns, and other pertinent material is included.

TATEL, H. E., et al., "Studies of the Earth's Crust Using Waves from Explosions," Proc. Am. Phil. Soc., V. 97.

TATEL, H. E. See also Tuve, M. A. (5).

TAYLOR, G., "The Formation of a Blast Wave by a Very Intense Explosion, I. Theoretical Discussion," Proc. Roy. Soc. (London), V. 201, Ser. A, pp. 159-174 (1950).

On the assumption that a finite amount of energy is suddenly released in an infinitely concentrated form, the motion and pressure of the surrounding air are calculated. It is found that a spherical shock wave is propagated outward whose radius R is related to the time (t) since the explosion started by the equation $R = S(\gamma)t^{2/5}E^{1/5}p_0^{-1/5}$, where p_0 is the atmospheric density, E is the energy released and $S(\gamma)$ a calculated function of γ, the ratio of the specific heats of air. The effect of the explosion

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is to force most of the air within the shock front into a thin shell just inside that front. As the front expands, the maximum pressure decreases till, at about 10 atm., the analysis ceases to be accurate. At 20 atm., 45% of the energy has been degraded into heat which is not available for doing work and is used up on expanding against atmospheric pressure. This leads to the prediction that an atomic bomb would be only half so efficient, as a blast-producer, as a high explosive releasing the same amount of energy. In the ideal problem the maximum pressure is proportional to R^{-3}, and comparison with the measured pressures near high explosives, in the range of radii where the two might be expected to be comparable, shows that these conclusions are born out by experiment.

TAYLOR, G., "The Formation of a Blast Wave by a Very Intense Explosion II. The Atomic Explosion of 1945," Proc. Roy. Soc. (London), V. 201, Ser. A., pp. 175-186 (1950).

Photographs by J. E. Mack (MDDC-221) of the first atomic explosion in New Mexico were measured, and the radius, R, of the luminous globe or "ball of fire" which spread out from the center was determined for a large range of values of t, the time measured from the start of the explosion. The relationship predicted in Part I, namely that $R^{5/2}$ would be proportional to t, is surprisingly accurately verified over a range from R = 20 to 185 meters. The value of $R^{5/2}t^{-1}$ so found was used in conjunction with the formulae of Part I to estimate the energy E which was generated in the explosion. The amount of this estimate depends on what value is assumed for γ, the ratio of the specific heats of air. Two estimates are given in terms of the number of tons of the chemical explosive TNT which would release the same energy. The first is probably the more accurate and is 16,800 tons. The second, which is 23,700 tons, probably overestimates the energy, but is included to show the amount of error which might be expected if the effect of radiation were neglected and that of high temperature on the specific heat of air were taken into account. Reasons are given for believing that these two effects neutralize one another. After the explosion a hemispherical volume of very hot gas is left behind and Mack's (ibid) photographs were used to measure the velocity of rise of the glowing center of the heated volume. This velocity was found to be 35 m/sec. Until the hot air suffers turbulent mixing with the surrounding cold air it may be expected to rise like a large bubble in water. The radius of the "equivalent bubble" is calculated and found to be 293 meters. The vertical velocity of a bubble of this radius is 35.7 m/sec. The agreement with the measured value, 35 m/sec, is better than the nature of the measurements permits one to expect.

TAYLOR, W. E. See Reed, R. P.

TAZIME, K., "Dispersion by a Small Explosion," Nuturi-Tanko, V. 8, n. 3, pp. 127-132 (1955).

Records were made of the waves from the explosion of a cap at a depth of 0.75 meters, at geophones set every 0.25 meters on a straight line from 0.25 to 11.30 meters. The dispersion observed was qualitatively the same as that observed on large-scale exploration.

TAZIME, K., "Wave Groups Generated by a Very Small Explosion," J. Phys. Earth, V. 4, n. 3, pp. 113-126 (1956).

TAZIME, K., "Relations Between Charge Amounts and Periods in Resulting Seismic Wave Groups," J. Phys. Earth, V. 5, n. 1, pp. 51-59 (1957).

Variation of periods in surface waves were observed with various charges ranging from a cap to about 0.2 kg and buried at depths of one and two meters. The waves observed were considered to be the zero and first order of Rayleigh and Sezawa waves respectively, due to a surface layer 19 meters thick. As the charge size was increased, the periods of the wave groups were found to increase toward asymptotic values satisfying quarter wavelength laws. If H is the thickness of the surface layer, and V_{p1} the P velocity in this layer, the quarter wavelength laws for the Rayleigh and Sezawa waves observed are $4 = T, V_{p1}/H$ and $4 = 3T, V_{p1}/H$, respectively. The asymoptotic periods correspond to the Airy phases, and hence it is concluded that the stationary phases of wave groups will be observed as a result of a large explosion.

TELLER, E. See Griggs, D.

TELLER, E. See Griggs, D.; Latter, A. L., et al.

TELTOW, J. See Joos, G.

TERADA, M. See Ito, I., et al.

THIRLAWAY, H. I. S., "Depth of Focus Discrimination Within the Crust at First Zone Distances," Special Report. United Kingdom Atomic Weapons Establishment, Aldermoston, England. OFFICIAL USE ONLY

THOENEN, J. R., "Earth Vibrations from Quarry Blasts," Crushed Stone J., V. 13, n. 2 (1938).

THOENEN, J. R., and WINDES, S. L., "Seismic Effect on Quarry Blasting," U. S. Bureau of Mines, Bulletin No. 442 (1942).

This study is based upon data collected from records of several hundred tests conducted at 28 stone quarries situated in 11 Southern and Eastern States, in a limestone mine, and in 20 residential structures of various types. The tests covered the detonation of explosive charges in regular quarry practice ranging in weight from 1.5 to 42,000 lb. Distances between shot points and seismometer stations ranged from 100 feet to 2 miles. Transmitting mediums through which the seismic waves were propagated ranged from granites through limestones, shales, and clays to unconsolidated sand and gravel beds. Amplitudes of ground displacement as recorded ranged from 0.0001 to 0.06 inch and similar movements in structures from 0.0001 to 0.01 inch for quarry blasts and up to 0.3± inch for mechanical vibrations. Frequencies of the seismic waves ranged from 3 to 80 cps and the duration of individual vibrations from 0.1 to 8 seconds.

THOENEN, J. R., and WINDES, S. L., "Seismic Phenomena as Revealed by Quarry Blasting," Trans. Am. Geophys. Union, pp. 109-115.

THOMPSON

THOMPSON, A. A., "The Relation of Seismic Energy Attenuation to the Area Under the Stress-Strain Curve," Ballistic Research Labs., Aberdeen Proving Ground, Md. BRL Memorandum Rept. No. 1261 on DA Project 5B03-04-002 and ORD Project TB3-0112 (1960).

Seismic energy attenuation in a sand medium was determined by measuring the total energy at various distances from an explosive source and also by measuring the area between the loading and unloading parts of the stress-strain curve. Theory and experiment show that the value of attenuation determined from the stress-strain curve may be less than the true value when the attenuation is very large.

THOMPSON, A. A., "The Comparison of Strain and Kinetic Energy in a Plastic Wave Moving Through Sand," Ballistic Research Labs., Aberdeen Proving Ground, Md. BRL Memorandum Rept. No. 1263 (1960).

The time-histories of strain and kinetic energy for a unit volume of material have been measured in sand plastically deformed when traversed by a stress wave. Most of the total energy in the medium was strain-energy, practically all of which was lost in the medium during propagation. Considerably less than 50% of the total energy appeared as kinetic energy. The dynamic stress-strain curve used for these strain-energy determinations showed that in the very plastic region most of the strain energy was applied to the medium after the time of peak stress. The above facts are quite different from phenomena encountered in elastic or viscoelastic propagation.

THOMPSON, A. A.,"The Generation and Propagation of Seismic Energy from a Buried Explosive Source," Ballistic Research Labs., Aberdeen Proving Ground, Md. BRL Memorandum Rept. No. 1267 on ORD Project TB3-0112 (1960).

When energy was measured near a deeply buried explosive source in sand, the seismic generation process proved to be of much longer duration than was expected from consideration of the rate at which the medium was loaded by a detonation. Since a large portion of the energy is applied to the medium while its particles are decelerating, the resistive forces of the strained medium are dominant during a good part of the time in which energy is transferred from the exploding source to the soil. Furthermore, the characteristics of the medium are more important in determining the frequency of oscillatory motion at a distance from the buried explosive source, than the loading rate as related to the detonation rate of the explosive. The detonation rate also had relatively little effect on the attenuation of seismic energy that was generated and propagated in the medium. Some conclusions are suggested concerning the use of seismic energy measurements, for determining mechanical energy input, and for prediction of damage to buried structures.

THONE, F., "Quakes Betray Big Guns: Scientific Tool for Study of Earthquakes Adapted for Tracing Origin of Earth-Shaking Explosions," Sci. News Letter, V. 37, n. 14, pp. 218-219 (1940).

THORNBROUGH, A. D., AMES, E. S., and HAWK, H. L., "Instrumentation Systems, Project Cowboy," Sandia Corp., Albuquerque, N. Mexico. Report No. SC 4470(RR) (1960).

Project Cowboy was carried out to investigate minimizing of seismic waves from underground explosions by decoupling. Comparisons were made between tamped (coupled) and decoupled explosions in a salt mine near Winnfield, La. This report contains detailed information, written and graphic, on Project Cowboy's instrumentation system and results.

Percentages of instrumentation results that were good are: velocity, 96; acceleration, 96; pressure, 77; strain, 67; displacement, 100; temperature, 88; earth pressure, 83. Good results totaled 92%.

THRALLS, H. M., "Topography and its Apparent Effect on Average Velocity," Proc. Tulsa Geophys. Soc., V. 5, pp. 31-42 (1957-58).

The effect of changes in topographic overburden on velocity, one of the most commonly ignored factors in seismic interpretation, is discussed. The geophysical prospect discussed as an illustration is an area of low structural relief in Oklahoma. In this case records were time corrected to a "base-of-shot" datum, and a conversion velocity for each shotpoint was determined by an increment of increase or decrease in velocity of 1.0 fps per foot of overburden as the surface elevation increased or decreased from that at the base point. It is concluded that topographic changes cannot be safely ignored if the magnitude of elevation change is equal to or greater than the order of magnitude of subsurface structural relief sought. The time increment factors associated with topographic changes are additive in the majority of instances resulting in an apparent topographic overburden effect that is greater than measured observations.

THRON, C. D. See Loconti, J. P., et al.

TIEMANN, A. C. See Ehlers, O. K., et al.; Pieper, F. A., et al.

TILLOTSON, E., "Seismology in Britain," Nature, V. 163, n. 4143, pp. 500-501 (1949).

A brief account is given of seismological activities during the past decade or so in Britain. Among these are E. R. Lapwood's investigation of the diffraction effects at the surface of a semi-infinite homogeneous elastic medium from a pulse emitted by a buried line source, G. E. R. Deacon's observations of microseisms, P. L. Willmore's moving-coil seismograph with nearly constant response to ground velocities of frequency 2-25 cps and maximum sensitivity of 5000 cm/cm/sec, and M. N. Hill's long-period inductance-bridge seismograph. Studies of the records of the Helgoland explosion in 1947 and the Soltau explosion of 1946 are also reported.

TITMAN, H. See Payman, W., et al.

TOKSOZ, M. N. See Press, F., et al.

TRYGGVASON, E., "Crustal Thickness in Fennoscandia from Phase Velocities of Rayleigh Waves," Special Rept. No. 2 on Contract DA-91-591-EUC-1637 (1961).

This paper reports on the Press-Ewing method of Rayleigh wave phase velocity amplification. This method is used to determine crustal thicknesses in Fennoscandia. Records from earthquakes in Mexico and the Kurile Islands are used. Crustal thickness in Fennoscandia was found to be nearly constant (about 35 km) within the area studied.

TRYGGVASON

TRYGGVASON, E. and BATH, M., "Upper Crustal Structure of Iceland," J. Geophys. Res., V. 66, n. 6, (1961).

This report contains the results of the seismic measurements made by a Swedish-Icelandic expedition in Iceland during the months of August and September, 1960. This is a continuation of work started a year earlier and is the first detailed investigation of the deeper structure of the lava beds on Iceland. Measurements were made at eight locations, each with a refraction profile from 20 to 41 km long, in order to obtain values on thickness and structure of the lava layer which covers the whole island. The profiles were laid near a line in a southwest-northeast direction across central Iceland. The lava layer was found to consist of three sections with longitudinal wave velocities of 3.7 ± 0.3, 4.95 ± 0.2, and 5.55 ± 0.05 km/sec. The 3.7-km/sec section was found mainly in southwest Iceland, where the other two sections were not found. In north Iceland the 4.95-km/sec section was found near the surface and the 5.55-km/sec section at a depth of about 2 km. The total lava thickness ranges from 1.73 to 4.81 km: it is thin in the southwest and thick in the northern part of Iceland. Below the lava layers, the longitudinal wave velocity is about 6.2 km/sec, increasing to 6.7 km/sec at a depth of about 5 km. Shear waves were clearly recorded on three profiles in north Iceland, but were recorded not at all or only faintly on other profiles.

TSVETAEV, A. A., "Testing the Application of Air Explosions in Seismic Reflection Exploration in Russian," Prikladniya Geofiz., n. 1, pp. 82-87 (1945).

To obviate the drilling shot holes in seismic exploration, an investigation was made in several localities of the U.S.S.R. in 1942-43 to test the use of explosions set off in air. The procedure employed in the Emba region, Kazakh S.S.R., in connection with salt-dome exploration, consisted in laying out spreads equal in length to the minimum shooting distance and firing shots from both directions along the line of the section. As the anticipated depths to the reflecting horizons ranged from 3000 to 4000 feet and the average velocity of propagation thereto is about 8000 fps, expectations of arrival times not greater than 1 sec lead to the choice of a minimum shooting distance of 1150 feet. Explosions were fired over rocky soil, grassy fields, sand, and clay saturated with salt water.

It was found that seismograms obtained from air shots do not differ materially from those recorded from buried charges in the same locality, except that all arrival times for air shots are about 0.03-0.04 seconds longer than for buried charges. Since this difference does not complicate interpretation, it appears that air shots reduce the cost of operations without impairing the efficacy of seismic exploration. Optimal results were obtained with the charge suspended at a height of 5-7 feet above the ground. Other findings are given.

TUKEY, J. W., "Equalization and Pulse-Shaping Techniques Applied to the Determination of Initial Sense of Rayleigh Waves," U.S. Dept. of State, Rept. of Panel on Seismic Improvement, Appendix 9 (1959).

An empirical method or so-called "black-box" method is described that determines the effect of the propagating medium and the seismograph

on the recorded wave train, and then applies this effect inversely to similar trains in order to infer the sense of the pulse, that is, the nature of the disturbance near the source. The method is best applied to long-period surface waves. Some details of the method and its implementation are discussed in Annexes A through E as follows: phase compensation, numerical techniques, synthesis of digital phase compensators, details of analysis, and possibilities of implementation in practice.

TUVE, M. A., "The Earth's Crust," in Carnegie Inst. of Washington YEAR BOOK, Nos. 46-58 (1948-1959).

TUVE, M. A., GORANSON, R. W., GREIG, J. W., and ROONEY, W. J., "Progress Report on Studies of Deep Crustal Layers by Explosive Shots," Union Geod. geophys. internat., Sec. Seismologie, Travaux sci., Ser. A, fasc. 17, pp. 5-6 (1950).

A preliminary report on the program of the Carnegie Institution of Washington (See also Geophys. Abstract 11098.)

TUVE, M. A., GORANSON, R. W., GREIG, J. W., ROONEY, W. J., DOAK, J. B., and ENGLAND, J. L., "Studies of Deep Crustal Layers by Explosive Shots," Trans. Am. Geophys. Union, V. 29, n. 6, p. 772 (1948).

As part of a study of the nature of the earth's crust, undertaken as a cooperative venture between the Department of Terrestrial Magnetism and the Geophysical Laboratory of the Carnegie Institution of Washington, an attempt has been made to determine the layering of the crust underlying the region around Washington, D. C., and the Appalachian highlands, using the best combination of refraction, and vertical- and critical-angle reflection of seismic waves resulting from controlled detonations of high explosives. From time-distance curves of refraction observations made to distances of 350 km from exploding charges of 600 to 4000 lb, the following layering and compressional wave velocities have been found in the vicinity of Washington: 0-10 km, 6.0-6.17 km/sec; 10-24 km, 7.05 km/sec; 42-? km, 8.15 km/sec.

TUVE, M. A., and TATEL, H. E., "Seismic Observations Corona (Calif.) Blast," Trans. Am. Geophys. Union, V. 31, p. 324 (1950).

TUVE, M. A., and TATEL, H. E., "Coherent Seismic Wave Patterns," Science, V. 112, pp. 452-453 (1950).

TUVE, M. A., and TATEL, H. E., "Seismic Crustal Exploration, Colorado Plateau and Wasatch-Uinta Mountains," Trans. Am. Geophys. Union, V. 36, P. 532 (1955).

TUVE, M. A., TATEL, H. E., and ADAMS, L., "Coherent Explosion Wave Patterns at 100 Kilometers," Trans. Am. Geophys. Union, V. 32, p. 316.

TUVE, M. A., TATEL, H. E., and HART, P., "Crustal Structure from Seismic Explosions," J. Geophys. Res., V. 59, pp. 415-422 (1954).

TUVE, M. A. TATEL, H. E., and NANDA, J., "Prolonged Seismic Wave Reception: Interpretation as Scattered Waves," Trans. Am. Geophys. Union, V. 31, p. 324 (1950).

TUVE, M. A. See also Tatel, H. E.

ULOMOV ULOMOV, V. I., "Nekotoryye osobennosti stroyeniya zemnoy kory Sredney Azii po zapisyam moshchnogo vzryva [Some Features of the Structure of the Earth's Crust in Central Asia According to the Recording of a Powerful Explosion]," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 1, pp. 131-134 (1960).

Analysis of seismograms of 29 seismic stations in central Asia obtained from a powerful explosion 100 km from Tashkent on December 19, 1957, made it possible to construct a 1000-km profile of the crust. The profile was constructed according to the transverse travel-time curves of P* and P head waves related respectively to the basalt and Mohorovicic discontinuities for a distance of more than 300 km. The high sensitivity of the seismographs VEGIK, SGK, and SVK, the high speed of the recording tape (120-240 mm/min) and the radio signal of the moment of the explosion made it possible to determine the depth of the discontinuities with an accuracy of ±5 km. A gravity-geological map covering an area of about 1000 km by 200 km was compiled.

UNITED ELECTRODYNAMICS (Staff), "International Control System Cost Volume III," United Electrodynamics Rept. on VT/055 (ARPA).

This atlas supports Volumes I and II of an estimate of the costs of installing and operating 170 proposed International Control System networks for the purpose of detecting and identifying clandestine nuclear explosions. Illustrative material accompanied by brief descriptions of the contents is organized as follows: network configuration, communication routing, network seismic coverage, phase I sites, cost category sites, and trial U.S.A. sites. The basis for cost estimating is explained and illustrated.

UNITED ELECTRODYNAMICS (Staff), "Investigation of Proposed Use of Large Seismometer Arrays in the U.S.S.R. for the Detection of Underground Nuclear Explosions, Volume III," United Electrodynamics Rept. on VT/055 (ARPA).

This atlas provides coincident reference material supporting the preceeding Volumes I and II. Maps and accompanying data relative to the proposed establishment of 22 seismic stations in the U.S.S.R. are organized within the following categories: general information, seismicity, network coverage, locations, trial U.S.A. locations, and U.S.S.R. reference material. The location maps include data on preferred areas, weather, classification, and geology.

U. S. DEPARTMENT OF STATE, "The Need for Fundamental Research in Seismology." Report of the Panel on Seismic Improvement, U. S. Dept. of State, Washington, D. C. (1959).

The Panel of Seismic Improvement was appointed by the Special Assistant to the President to review the feasibility of improving the Geneva Control System to detect and identify underground events.

The strategic requirements of detection and the need to maintain position in the field of seismology make necessary greatly increased support for research. The various phases requiring special priority fall into the following broad fields: conditions at the source, effects of transmission through the earth, instrumentation for recording seismic signals, and improvement of data processing.

The summary report is based on the following separate reports which are included as appendixes:

Press, F. and Griggs, D. T., "Improved Equipment for Existing Seismic Stations," pp. 17-18.

Romney, C. F., "Short Period Shear Waves and Their Application to Discriminating Between Earthquakes and Explosions," pp. 19-21.

Gerrard, J., "Unattended Auxiliary Seismic Stations," pp. 22-41.

Press, F., "Aftershocks as Means of Identification of Earthquakes," p. 42.

Press, F., "Long-Period Surface and Body Waves," pp. 43-45.

Knopoff, L., "Deductive Seismology," pp. 46-51.

Street, K., Jr., "Need for High Explosive and Nuclear Tests for Research Program," pp. 52-57.

Oliver, J. E., "Seismic Waves in the Intermediate Period Range," pp. 58-59.

Tukey, J. W., "Equalization and Pulse Shaping Techniques Applied to the Determination of Initial Sense of Rayleigh Waves," pp. 60-129.

Oliver, J. E., "The Phase Compensation Method of Equalization," pp. 130-131.

Press, F. and Griggs, D. T., "Geophysical Investigation of Continental Crustal Structure," pp. 132-133.

Oliver, J. E., "Ocean Bottom Seismographs," pp. 134-136.

Benioff, H., "Suggestions for Standards of Noise Amplitude, and Spectrum," pp. 137-138.

Benioff, H., "Improved Seismographs," pp. 139-144.

Gerrard, J., "Throw-Away or Portable Seismic Probes for Operation on Land," pp. 145-152.

Gerrard, J., "Use of Multiple Arrays in Seismic Detection," pp. 152-163.

Gerrard, J., "Data-Processing Requirements," pp. 164-183.

Gerrard, J., "Program to Establish a Complete Experimental Seismic Station for the Evaluation of Network Instruments and Methods," pp. 184-185.

Romney, C. F., "Deep-Hole Detection Techniques," pp. 186-192.

Gerrard, J., "Research Computing Facilities and a Digital Library of Seismograms," pp. 193-194.

Gerrard, J., "Considerations on the Standardization of Seismometers to be Used in the Geneva Network," pp. 195-214.

U.S. NATIONAL BUREAU OF STANDARDS, "Geomagnetic Effects of Nuclear Explosions," Tech. News Bull., V. 43, n. 7, pp. 121-122 (1959).

In August 1958 the United States fired 2 nuclear bombs at high altitudes from Johnston Island in the Pacific. Analysis of changes in the earth's magnetic field indicate that "these night-time explosions ionized the upper atmosphere at a distance of 2000 km to nearly daytime intensity, resulting in electric current flows that temporarily altered the geomagnetic field."

UTZMANN, R. See Beaufils, Y., et al.

VANEK, J., and KLIMA, K., "Untersuchung des seismischen Effekts bei Sprengungen mit Millisekundenzundung in Gruben [Investigation of the Seismic Effect in Blasts with Millisecond Firing in Mines]," Freiberger Forschungsh., Geophysik, pp. 68-75 (1959).

VAN MELLE

The results of measurements of the seismic effect in mine blasts with millisecond firing, together with macroscopic estimation of the effect of the blasts, show that the mechanism of such explosions in mines is very probably different from that in quarries. The increase of demolition energy (E_Z) in the case of mines is accomplished at the expense of displacement energy (E_A), whereas in quarries the increase in E_Z is at the expense of seismic energy (E_S). A series of controlled experiments in mines and quarries would be necessary to support this opi nion.

VAN MELLE, F. A., "Note on 'The Primary Seismic Di sturbance in Shale' by N. Ricker and W. A. Sorge," Bull. Seism. Soc. Am., V. 44, n. 2A, pp. 123-125 (1954).

Ricker and Sorge (Geophys. Abs. 13223) described experiments which seem to be in agreement with a law of decay of amplitude of the earth-particle velocity from small explosions with the -5/2 power of the travel time. Computations of the energy in the compressional wave from a 1-lb shot of 60% dynamite at a distance of 722 feet (distance between shot and geophone in a hole in Pierre shale at Limon, Colo., listed by Ricker and Sorge) indicate that this energy is of the order of 0.05 percent of the chemical energy available. This agrees with experimental work done by a crew of Shell Development Co., although the Shell values of the same order were found over a greater range than is compatible with a -5/2 power decrease of the velocity amplitude.

Reflections have been observed with travel times of 7 to 8 seconds (Geophys. Abs. 12946). Extension of the -5/2 power law to such travel times indicates that the velocity amplitude of the reflection, where speed contrasts are as high as 2:1, will be so low that it falls below the particle velocity of the wind disturbance. If a higher output of energy per pound of explosive is assumed for the locality of Junger's experiments than for Pierre shale, then the difficulties for short travel times become serious. The indications are that the -5/2 power law has a rather narrow range of validity.

VANN, J. O. See Haskell, N. A.

VILLAIRE, A. E. See Lindsay, W. F., et al.

VIOLET, C. E. See Johnson, G. W., et al.; Warner, S. E.

VON SCHMIDT, O., "Propagation of Waves Due to Explosion in Liquids and Solids," Z. tech. Physik, Band 19, Heft 12, pp. 554-560 (1938).

VORTMAN, L. J., "Relative Cratering Efficiency of Nuclear Explosives," Report (1959).

Results of nuclear and high-explosive cratering charges fired in Nevada Test Site desert alluvium are used to determine the cratering efficiency of nuclear explosive relating to TNT.

VORTMAN, L. J. See also Murphy, B. F.

WALKER, D. J. See Richard, T. C.

WALKER, G. R. See Herzberg, G.

WALSH, H. R. J., "An Experiment on Soils Loaded Dynamically by a Shock Tube," Air Force Special Weapons Center, Kirtland A.F. Base, New Mexico. Report No. AFSWC TN 60-39 on Project 1080 (1960).

The Air Force 6-foot shock tube was used to pass air shocks across the upper surface of different soils samples of controlled properties. Gages of certain available types were buried within the samples or mounted upon the supports of the sample container. The tests were intended eventually to develop into an experimental study of energy transmission in soils of all types, first by investigation of the experimental difficulties apparently common to any such tests. The apparatus and procedures are described, and data from a few tests are presented. The compaction observed in the samples is described, and certain preliminary results are qualitatively discussed, including shock transmission in the sample pores, the velocities and attenuation of transmitted waves, and the extent to which differences in sample properties were reflected in the various measurements.

WALSH, J. M., and RICE, M. H., "Dynamic Compression of Liquids from Measurements on Strong Shock Waves," J. Chem. Phys., V. 26, pp. 815-823 (1957).

High explosives were used to drive strong shock waves into various liquids, and a moving-image camera was employed to determine velocities associated with the shock waves. The measured velocities are transformed to pressure-compression points by applying the conservation relations. The pressures attained vary among the 15 liquids studied but are typically in the range 50 kilobars to 150 kilobars. For water, more extensive experimentation suffices to determine the Hugoniot curve from 30 kilobars to 450 kilobars. The highest pressure for each of the liquids extends the available data range from static experimentation several-fold. A shock-wave-reflection experimental method is described, the purpose of which is to measure the useful thermodynamic variable $(\Delta H/\Delta V)_p$ at high pressures. Results are given for water. Qualitative experiments to study the transparency of shocked water, carbon tetrachloride, ethyl alcohol, and benzene are reported.

WARNER, S. E., "Report on Surface Acceleration Measurements, USGS Tunnel, Room B, Nevada Test Site, April 5, 1957," Report on Contract W-7405-eng-48 (1957).

Detonation of an underground charge in a tunnel was instrumented for recording accelerations at several points on the surface over the shot point. From the resulting records, it was desired to obtain the amplitude and frequency of acceleration resulting from the blast and peculiar to the configuration and material involved. Eight Statham bonded strain-gage accelerometers were arrayed within a circle of radius 150 feet from a point vertically over the shot point, 165 feet underground. Recording utilized a Heiland Model 708C oscillograph located at a vantage point approximately 2000 feet distant and connected to the transducers by multiconductor cable. The recorder was started a few seconds before shot-time and ran approximately 15 seconds after the blast. The explosion was essentially contained although several large fissures were permanently opened inside the 150-foot radius. Results are summarized.

WARNER

WARNER, S. E., and VIOLET, C. E., "Properties of the Environment of Underground Nuclear Detonations at the Nevada Test Site, Rainier Event."

Results of past studies of the environment of the Rainier event (Nevada Test Site) are presented in this paper. In situ measurements and measurements on removed samples are described in text and summarized in tables and charts. These include static and dynamic measurements.

WARNER, S. E. See also Guido, R. S.

WATERWAYS EXPERIMENT STATION (Staff), "Cratering from High Explosive Charges — Compendium of Crater Data," Waterways Experiment Station, Vicksburg, Miss. Report No. 1 of Technical Report No. 2-547 (1960).

All available high-explosive cratering data from test series in various media are compiled in narrative and tabular form. The data are grouped according to data obtained from cratering in soils, frozen ground, rock, ice, and snow.

WATERWAYS EXPERIMENT STATION (Staff), "Grouting Support, Project Hobo," U.S. Army Engineer Waterways Experiment Station, Miscellaneous Paper No. 6-409 (1960).

This paper describes materials, equipment, and procedures used in the design and pumping of:

(1) Grout mixtures to match the in-situ densities and sonic velocities of the surrounding medium;
(2) Quick-setting grout mixtures to contain the detonation of the HE Pelletol;
(3) Special mixtures to provide a dry hole for the Pelletol detonation.

Field-cast grout specimens were tested in the laboratory. The field grouting was considered successful. Laboratory test results of the field-cast specimens checked with the results of density tests made in the field.

WEATHERBY, B. B., "Effects of Subsurface Detonations in Earth, Part 2," U.S. Office of Sci. Res. and Devel., Rept. No. 3036 (1943). (Library of Congress, OTS PB Rept. 50855.)

A description is given of the new SG-3 detectors of a moving-coil type which were developed for measuring horizontal and vertical components of particle velocities in earth waves. They are suitable for the waves generated by subsurface detonations causing large displacements and high accelerations. Some 60 shots ranging in charge from 2.5 lb to 515 lb of dynamite were recorded for tests, and a study was made of wave characteristics. Graphs and formulas show the first maximum of the velocity, the acceleration, and displacement occurring with an increase in the weight and the distance of the charge.

The findings indicate that accelerations and frequencies were much higher in the limestone than in loam. When vertical detectors were buried at different depths, no significant variations in the wave form were observed. Moreover, when the depths of the shots were increased, the measured velocity and associated acceleration and displacement at the surface remained virtually constant. As no decrease in these values

occurred in spite of an appreciable increase in path length, it follows that within the range of 24 feet of depth for the 40-lb charges used, the deeper shots were more effective wave generators than the shallower shots. Tables, schematic drawings, graphs, and photographs of records are given with the discussion.

WEIDLINGER, P., "On the Application of the Theory of Locking Media to Ground Shock Phenomena," MITRE Corp., Rept. SR-18 (1960).

Recent and current investigations on ground shock phenomena are reviewed. Separate material concerned with wave propagation in a plastic-elastic medium and spherical waves in an ideal locking medium is presented in text and graphs.

WEIDLINGER, P., "A Study on the Effect of a Progressing Surface Pressure on a Viscoelastic Half-Space," MITRE Corp., Rept. SR-22.

Free-field effects due to progressing pressure loadings on the surface of a semi-infinite linearly viscoelastic (standard solid) half-space are described. Numerical results are presented for a hypothetical viscoelastic material and the free field stresses are evaluated. They are compared with the corresponding stresses in the material in its relaxed and unrelaxed elastic state.

WEIDLINGER, P. See also Baron, M. L., et al.; Skalak, R., et al.

WEIZMAN, P. S., KOSMINSKAJA, I. P., and RISNICHENKO, J. V., "New Deep Seismic Sounding Data on the Structure of the Earth's Crust and on Mountain Roots," Bur. Cen. Seism. Intnatl. Publ., Ser. A, Travaux Sci., n. 20, pp. 97-112 (1959).

In its present form the method of deep seismic sounding is similar to the correlation refraction method; however, it investigates greater depths, using shot-point distances up to 300 km or more and charges of the order of 50-300 kg (in water) or up to 800 kg (in shot-hole groups). Recording is done by special portable low-frequency (5-15 cps) multichannel stations. Sensitivity is enhanced not only by the use of low frequencies but by suitable grouping of shot points and receivers and choice of a quiet time and place for observations.

Results of investigations in different parts of central Asia and other parts of the U.S.S.R. show that this method has a higher resolving power than other methods of investigating crustal structure; it permits detailed study of mountain, foothill, and platform regions. In all areas investigated the boundaries of the granitic, basaltic, and subcrustal layers could be distinguished. The observed wave groups are complex, indicating that the transitions between layers are complex.

Crustal thickness was found to be greater under the mountainous areas of central Asia than under platforms and plains, showing that the mountains have roots. The roots of the folded systems of the Tien Shan, Pamir, and Turkmen S.S.R. appear to be a general downbuckling of the M-discontinuity. This boundary and the top of the basaltic layer show local elevations and depressions that do not conform to the present surface relief. The roots of Hercynian structures appear to consist of a thickening of the basaltic layer, those of Alpine structures of the granitic.

WELLS

Comparison of deep seismic sounding data with gravity data shows that the negative gravity anomalies of the mountains reflect mainly the depth and shape of the M-discontinuity.

WELLS, W. M. See Swift, L. M., et al. (2).

WENSRICH, C. J., "Explosives—A Bibliography," U. of Calif., Livermore. Lawrence Radiation Laboratory, UCRL Report (1960).

The information presented in this bibliography was taken from books, published literature, and reports, and covers the period 1950 to April 1960.

WERTH, G. C. See Herbst, R. F., et al.

WESTON, D. E., "The Low-Frequency Scaling Laws and Source Levels for Underground Explosions and Other Disturbances," J. Roy. Astron. Soc. Geophys., V. 3, n. 2, pp. 191-202 (1960).

A general approach is used to show that the source spectrum level for the energy radiated from a disturbance is usually proportional to frequency^2 at low frequencies, and also that this low-frequency energy is proportional to total energy^2 for body waves. There are differences for one- and two-dimensional propagation, and also for interface waves. Applied to underground explosions, the theory provides the best explanation of the empirical law that seismic amplitude is proportional to charge weight. The reason why underwater explosions have much more low-frequency energy than those underground (10% efficiency compared to 0.05%), making underwater explosions more suitable as sources for seismic investigations, is discussed.

The general method is applicable to a wide range of other mechanical disturbances and also to electromagnetic pulses.

WESTON, D. E., "Underwater Explosions as Acoustic Sources," Proc. Phys. Soc. (London), V. 76, pt. 2, pp. 233-299 (1960).

WHETTON, J. T. See Habberjam, G. M.

WHITE, J. E., HEAPS, S. N., and LAWRENCE, P. L., "Seismic Waves from a Horizontal Force," Geophys., V. 21, n. 3, pp. 715-723 (1956).

As part of a program of fundamental research on seismic waves, a generator was built for applying a transient horizontal force at the surface of the ground and the resulting seismic waves were observed in some detail. The force is applied when a mass swinging through an arc strikes a target anchored to the earth. Surface geophones along a line in the direction of the force register vertically polarized shear waves refracted back up to the surface, whereas geophones on a line perpendicular to the force register horizontally polarized shear waves are often different, indicating anisotropy. Geophones buried below the target show a down-going shear wave. Variation of amplitude with angle, and other features, are in qualitative agreement with the results given by Rayleigh and others for the waves due to a force at a point in an infinite solid. Love waves and other surface waves were observed, which of course would not be expected from an interior force.

WHITESIDE, T., "UK Measurements, Part I: Operational Report and Statement of Results, Operation Cowboy," AWRE Rept. No. T16/60 (1960).

This paper reviews the UK participation in Project Cowboy (a project to determine the extent to which underground explosions can be concealed from detection by use of decoupling techniques). Instrumentation is described and the results are graphically summarized.

WHITMAN, G. B., "The Propagation of Spherical Blasts," Proc. Roy. Soc. (London), Ser. A, V. 203, pp. 571-581 (1950).

WHITMAN, R. V., "Soil Mechanics Considerations Pertinent to Predicting the Immediate and Eventual Size of Explosion Craters," Sandia Corp., Albuquerque, N. Mex. (1959).

In some soils and rock formations of interest, deviation from cube-root scaling are to be expected where nuclear explosives are used to form craters. This is significantly true in the case of soft clays and with stronger clays and saturated sands. Inasmuch as underground nuclear explosions to date have been limited to one type of soil, this paper applies some of the ideas of soil mechanics to guide extrapolations to other media.

WILLIG, F. J., "Applications of High Explosives and High Speed Photography to Physical Research Experiments," Los Alamos Scientific Lab. Report (1954).

The types of experiments conducted in connection with fundamental research programs in the fields associated with the behavior of materials subjected to high-explosive shock are reported. The description of the photographic equipment involving the use of two types of camera is limited to those used in the experiments. The types of explosives used were a mixture of TNT and RDX, employed as a prime mover, PETN used primarily in the form of primacord and a mixture of TNT and inert salts, used as a prime mover in place of the TNT-RDX mixture when a lower detonation velocity or lower shock pressure is desired.

WILLIS, D. E., "A Study of Seismic-Wave Propagation and Detection," U. of Mich., Inst. of Science and Technology. IST Rept. No. 2945-19-F (1960).

An investigation of the seismic waves generated by high-explosive detonations disclosed that ratios of maximum vertical ground displacements were approximately equal to the ratios of the respective charge sizes. With use of this relationship several high-explosive and nuclear explosions were scaled to a 1.7 kt nuclear shot (event Rainier). Empirical equations were developed which describe the decrease in the maximum vertical component of ground motion between 1 and 1000 km. Empirical equations which allow the decrease in vertical ground particle velocity to be computed as a function of distance and frequency were also determined for compressional waves. The method of firing, depth of charge, and rock type were found to affect the spectra of seismic waves generated by explosions.

WILLIS, D. E., "Some Observations on the Attenuation of Seismic Waves," Earthquake Notes, V. 31, n. 4 (1960).

WILLIS

A number of quarry blasts were recorded on magnetic tape using low frequency seismometers. Spectral analyses were performed on these recordings using variable passband filters. Empirical equations involving geometrical spreading plus an appropriate absorption factor were found to fit observed attenuation. Examples are presented showing the effect of various parameters on the spectra of seismic waves generated by these blasts.

WILLIS, D. E., FITZPATRICK, R. D., and WILSON, J. T., "Observations of High-Frequency Seismic Energy," AD 210597, U. of Mich., Inst. of Science and Technology. IST Rept. No. 2144-305-T.

Observations of seismic waves generated by nuclear and high-explosive blasts and earthquakes were made with standard refraction-type geophones. The output of the geophones was recorded on magnetic tape and seismic level recorders. A comparison and analysis of seismic data from various sources is shown. High-frequency seismic waves appear to have been transmitted over large distances from the three types of sources.

WILLIS, D. E., and JOHNSON, J. C., "Some Seismic Results Using Magnetic Tape Recording," Earthquake Notes, V. 30, n. 3, pp. 21-25 (1959).

The techniques of using and analyzing magnetic-tape recordings of seismic disturbances are illustrated by a discussion of recordings made of seismic waves from the detonation of a 30-ton charge of dynamite in the St. Lawrence Seaway channel near Cornwall, Ontario, in July 1958. The use of magnetic-tape recordings by seismologists has been limited as a prospecting tool due to the limited recording time and the relatively high initial cost and maintenance of the equipment. The major advantage of such signal storage, however, is that the original event can be recreated at any future time, and thus lends itself to reduction of the data in many different ways. The more useful treatments include frequency analyses, autocorrelation, or crosscorrelation processes and direct comparison or summation of signals received by separate detectors. The greatest use of magnetic-tape recordings has been in detailed frequency analyses; it is believed that these frequency-analyses techniques have achieved more accurate results than could have been achieved by conventional and available computer techniques.

WILLIS, D. E., and WILSON, J. T., "Maximum Vertical Ground Displacement of Seismic Waves Generated by Explosive Basts," Bull. Seism. Soc. Am., V. 50, n. 3, pp. 455-460 (1960).

An investigation of the seismic waves generated by several high explosive detonations disclosed that ratios of maximum vertical ground displacements were approximately equal to the ratios of the respective charge sizes. By use of this relationship, several high explosive and nuclear explosions were normalized to a 1.7 kiloton underground nuclear shot (Rainier). The following empirical equations were found to fit the observed data:

$$A = \frac{0.65 \pm 0.15}{R^{3/2}}$$

from 1 to 100 km and

$$A = \frac{(0.013 \pm 0.003)\, e^{-(0.0072 \pm 0.0003)R}}{R^{1/2}}$$

from 100 to 1000 km where A is the maximum vertical ground displacement in cm, and R is the distance in km.

WILLMORE, P. L., "Seismic Aspects of the Helgoland Explosion," Nature, V. 160, n. 4063, pp. 350-351 (1947).

On April 18, 1947, the British Royal Navy carried out the demolition of German fortifications on the Island of Helgoland by the simultaneous detonation of 3997 tons of explosives. Extensive arrangements were made in advance by geophysical institutions in various countries for simultaneous seismic observations on a continental scale. Permanent seismological observatories within 1000 km stood alerted; the stations at Copenhagen, De Bilt, and Prague organized field parties; 23 stations were operated by the Gottingen Geophysical Institute and other German organizations; the German Admiralty sent ships with hydrophones to the North Sea; and the U.S. Navy supplied 10 two-component horizontal seismographs, distributed along a line from Bremerhaven to northern Italy.

As a result, readable seismograms were obtained from most field stations as far as Trieste and from permanent observatories as far as Puy de Dome, 998 km away. The times for the first arrivals indicate a slightly higher velocity than that given by the Burton-on-Trent explosion, possibly because of the thick alluvial and glacial deposits underlying the near stations.

WILLMORE, P. L., "Seismic Experiments on the North German Explosions, 1946 to 1947," Phil. Trans. Roy. Soc. London, Ser. A, V. 242, n. 843, pp. 123-151 (1949).

Observations of seismic waves at distances up to 50 km from the Soltau explosion, and between 50 to 1000 km from the Helgoland explosion indicate an average velocity for the first arrivals of 4.4 km/sec between 4 and 24 km from the shot point; 5.95 km/sec between 24 and 120 km; and 8.18 km/sec beyond 120 km. Significant local variations were found at the shorter distances. Alternative hypotheses of the distribution of velocity in the upper layers gave estimates of 27.4 and 29.6 km for the depth of the ultrabasic layer. P* was not significantly recorded, but several onsets 7 or 8 seconds after Pn may have represented a wave traveling for most of its path in the ultrabasic layer and reflected at the critical angle between that layer and the surface. It was not clear whether the onsets close to the expected time of Pg should be treated as one or more phases. Confused motion persisted during the period when transverse waves were expected, but, with the possible exception of Sn, there was no significant concentration of observations about lines representing recognized phases.

The thermal energy of the Helgoland explosion was 1.3×10^{20} ergs, and the energy in the seismic waves was of the order of 10^{17} ergs.

WILMARTH

WILMARTH, V. R., "Some Effects of Underground Nuclear Explosions on Tuff," Geological Survey, Washington, D. C. (1959).

The effects of the Rainier (1.7 kt at a scaled depth of 690 feet), Logan (5 at 482), and Blanca (19 at 319) explosions on tuff were determined from observations and measurements on the surface and in drill holes and tunnels. Rock slides above the explosion points were the most obvious surface effects. Movement took place mainly along preexplosion fractures. Displacements were observed at distances up to 3000 feet on the surface and up to 2500 feet in tunnels. Below the Rainier chamber a hemispherical breccia zone about 75 feet in radius was found. The breccia contains angular blocks of tuff in a pulverized matrix which contains droplets and fragments of radioactive glass. The glass contains the bulk of the fission products and seems to be restricted to the breccia zone. Beyond the breccia for a radial distance of at least 110 feet from the chamber, the tuff is minutely fractured and is characterized by low compressive strength, low velocity, and high permeability. One year after the explosion, temperatures greater than 2°C above normal extended 120 feet horizontally and 80 feet vertically from the chamber. Integration of anomalous temperature data indicates that over half the energy in the explosion was in the form of heat. The temperatures probably dropped below the boiling point of water a few hours or days after the explosion because of the rapid transfer of heat by steam through explosion-produced and natural fractures.

WILMARTH, V. R. See also Bunker, C. M., et al.

WILSON, E. B., Jr., and COLE, R. H., "Measurement of Underwater Explosion Pressures, Progress Report," U.S. Office of Sci. Res. and Devel., Rept. No. 523 (1942). (Library of Congress, OTC PB Rept. 32190.)

This report from the Carnegie Institute of Technology discusses a number of problems related to the measurement of pressures of underwater shock waves. It describes small, exceedingly simple tourmaline gages which, together with auxiliary cathode-ray equipment, give very promising results on the pressure-time curves for underwater explosions. These gages consist of a thin crystal slice less than 20 x 52 mm, with two electrically-conducting faces, fastened to a shielded cable and coated with a thin insulating layer. Details and diagrams of the equipment appear in the appendix.

WILSON, J. T., "Geophysical Institutes of the U.S.S.R. and of the People's Republic of China," Trans. Am. Geophys. Union, V. 40, n. 1, pp. 3-24 (1959).

Part 1, U.S.S.R., lists the institutes and other bodies dealing with geophysics and related subjects under the direction of the Academy of Sciences, U.S.S.R., and the Dept. of Science of the Ministry of Geology. Also noted are the Arctic Institute, Leningrad; the Dept. of Geophysics, University of Moscow; Institute of Geophysics Academy of Sciences of Georgia. Those visited are described in some detail. Their organization, history, personnel, accounts of some past and present activities, purpose and proposed investigations are outlined. Observations on laboratories, training, libraries, and museums are noted.

Part 2, China, lists and describes the institutes of the Academia Sinica and the universities of the People's Republic of China; also the Institute of Geological Prospecting under the Ministry of Geology.

WILSON, J. T., CHAPELLE, W., and JOHNSON, J. C., "Observations of Higher-Mode Rayleigh Waves," U. of Mich., Inst. of Science and Technology (Willow Run Labs). IST Memorandum Rept. No. 2144-409-R on Project MICHIGAN, Contract DA 36-039-sc-52654 (1959).

Observations of Rayleigh waves were made using explosives and large falling weights as sources. Low-frequency vertical and horizontal geophones were used out to a range of 1900 feet. The velocities and frequencies of the various observed seismic waves are discussed, and surface-wave dispersion curves compiled. Weight drops were found to generate higher frequencies than explosive charges. Second-mode Rayleigh waves were observed.

WILSON, J. T. See also Byerly, P. E.; Willis, D. E., et al.

WINDES, S. L. See Thoenen, J. R. (2).

WISTOR, J. W. and PERRET, W. R., "Ground Motion Studies at High Incident Over-Pressure," Sandia Corp., Albuquerque, N. Mex. Report on Project 1.5 of Operation Plumbbob (1957).

Measurements were made of vertical and radial accelerations and displacements produced in the ground by air-shock following a 39 kt nuclear explosion at a burst-height of approximately 700 feet. Instruments used in the study are described. Applications of the data in the design of protective shelters are discussed briefly.

WOLF, A., "The Limiting Sensitivity of Seismic Detectors," Geophys., V. 7, n. 2, pp. 115-122 (1942).

WOOD, H. O., and RICHTER, C. F., "A Study of Blasting Recorded in Southern California," Bull. Seism. Soc. Am., V. 21, pp. 21-46 (1931).

(1) For surface paths, or paths of slight depth in the upper ("granitic" —Jeffreys) layer in this region the velocities of the longitudinal and transverse waves are, respectively, about 5.5 km/sec and 3.21 km/sec. (With natural shocks, originating below the surface, slightly higher values probably may be expected);

(2) A thickness of the upper layer of about 15 km, or of about 25 km, is indicated;

(3) No waves have been identified as Pn or Sn with any definiteness;

(4) Waves identified as P* and S* appear to be registered in some longitudinal waves in the second layer;

(5) In several cases readings of apparent phase-intervals suggest the existence of a longitudinal wave reflected as a transverse wave at a depth of about 15 km.

(6) In one or two cases readings of apparent phase-intervals suggest the possibility of a longitudinal wave reflected as such at a depth of 25 km;

(7) At the smaller distances there is some indication of a wave traveling with a velocity of 2.6 km/sec.

WOOD, H. O., and RICHTER, C. F., "A Second Study of Blasting Recorded in Southern California," Bull. Seism. Soc. Am., V. 23, n. 3, pp. 95-110 (1933).

WOODHEAD

The paper discusses the travel-time curves recorded for a blast of 800 lb of 20% dynamite in weathered rock at a depth of about 16 feet; and for a blast of 20 tons of high explosive set in crystalline limestone. The first was usefully recorded at distances between 12.5 and 13.5 km; the second at distances ranging from 8.5 to 290 km. A significant paragraph in the summary states: "In the present study no positive evidence has been found to indicate reflected waves, or waves refracted along deeper layers. Phases considered in previous study to indicate such waves are now found to be susceptible of alternative explanations."

A note by Hugo Benioff is included, in which he describes a convenient method for timing blasts. This method was used for the above study.

WOODHEAD, D. W. See Cybulski, W. B., et al.; Payman, W., et al.

WOODS HOLE OCEANOGRAPHIC INSTITUTE (Staff), "Oceanographic and Underwater Acoustics Research Conducted During the Period 1 November 1959 - 30 April 1960," Woods Hole Oceanographic Inst., Woods Hole, Mass. Report on Contracts NOnr-136700 and NOnr-212900 (1960).

Contents:

Active detection
- Explosive echo ranging
- Directional explosive echo ranging

Oceanography
- Thermistor chain and contouring temperature recorder
- Sound velocity measurements
- Current measurements in the Tongue of the Ocean

Submarine geology and geophysics
- Seismic refraction studies in the Western Mediterranean
- Seismic reflection studies
- Bottom reflection and reverberation studies

Acoustic instrumentation
- Thermistor chain hydrophone
- Upside-down echo sounder
- Deep telemetering hydrophone
- A new spectrum analyzer
- Oceanographic computer
- Precision graphic recorder instrumentation

WRIGHT, J. K., CARPENTER, E. W., HUNT, A. G., and DOWNHILL, B., "Observations of the Explosion at Ripple Rock," Nature, V. 182, n. 649, pp. 1597-1598 (1958).

The explosion at Ripple Rock in Seymour Narrows on the west coast of Canada on April 5, 1958 was one of the world's largest man-made non-nuclear explosions, in which 1400 tons of explosive were detonated in a series of tunnels honeycombing the rock. Among the teams observing the blast was one from the Atomic Weapons Research Establishment of Foulness, England, which made the close-in and air blast measurements reported here. Three types of seismic instruments were used, a ground velocity meter and Cambridge accelerometers at the surface, and variable-inductance accelerometers underground in shaft and tunnel. Air blast measurements were made with mechanical gages.

Peak accelerations in or out and up or down were fitted to an expression $A=3r^{-2.75}\times 10^{8}$g's (r is in feet), and agreed well with Lampson's estimates. Peak velocities were fitted to an expression $V=2r^{-1.2}\times 10^{8}$ fps and agreed well with unpublished estimates of the Atomic Weapons Research Establishment. The seismic velocity obtained for the local basalt was 15,000 fps. Seismic energy was estimated as 7.10^{16} ergs, or about 2×10^{-3} of the available energy calculated on the basis of 4×10^{16} ergs per ton.

Air blast records clearly showed the effects of the 50 feet of rock and water covering the explosive in reducing the peak pressure. Origin time was estimated as 9:31:02.05 ± 0.02 sec (PST).

WYLIE, R. W., "Analysis and Reduction of Data Recorded under Project Cowboy," A.F. Cambridge Research Laboratories. Report No. AFCRL-802, Final Report (1961).

This report contains analyses of eight 200-, 500-, and 1000-lb chemical detonations fired in salt at Winnfield, Louisiana. The analyses revealed the following:

(1) The predominant energy of the decoupled signals is concentrated in the first few arrivals whereas the tamped signals are characterized by many arrivals of rather constant amplitude.
(2) The 500- and 1000-lb tamped and decoupled shots revealed that the tamped shots transmitted a greater quantity of low frequency energy than the decoupled shots.
(3) The total seismic energy is partitioned differently between the various modes of propagation for tamped and decoupled shots and is a function of the size of the explosive and cavity.
(4) The effect of decoupling can be thought of as a linear filtering of the tamped signal response.
(5) Amplitude density ratios computed from spectral response characteristics indicated that the decoupling is a function of frequency, shot size, and distance from the source.

YAMAZAKI, V. See Omote, S., et al.

YENNIE, D. R. See Arons, A. B.

YOSHIKAWA, S., "Mechanism of Fracture of Rock by Explosion (II)" [in Japanese with English summary], Zisin, J. Seism. Soc. Japan, V. 8, n. 2, pp. 108-113 (1955).

The strain rate of rock near an explosion is measured by an instrument newly devised for the purpose. The strain waves are calculated from the records. A shear wave produced at the free surface as a reflection of a compressional wave caused by the explosion is very remarkable near the surface, the fracturing of rock being attributed chiefly to this wave. The relationship between stress and strain must be in the plastic region for this case.

YOSHIKAWA, S., "The Propagation of Waves Near Explosion and Fracture of Rock (I)," Kyoto University, Kyoto, Japan. Disaster Prevention Research Inst., Bulletin No. 21 (1958).

YOSHIOKA

The processes of fracture and plastic deformation occurring in rocks under the high but transitory pressure of an explosion were studied experimentally at the Ikuno, Kamioka, and Kishu mines in Japan, using a seismometric pickup and strain gage designed to measure the mode of propagation of the waves within the fracture and plastic zones formed by the explosion.

Strain wave shapes were found to be influenced by pressure, distance from shot point, and the free surface; the pulses were found to consist of component waves having different velocities. Two kinds of waves were detected near the shot point, an elastic wave of relatively high frequency and a plastic wave of lower frequency. An increase in the amount of explosive caused a decrease in velocity of the plastic wave. In general, most rock fractures produced by explosion pressures result from tensional strain reflected from the free surface, while at the same time compressional strain is within the elastic limit of the rock. Rock in intimate contact with the explosion is fractured by direct pressure, but the amount thus fractured is small in comparison with the total rock fractured.

YOSHIOKA, H. See Kishimouye F., et al.

ZABETAKIS, M. G., and GIBSON, F. C., "Investigations Relating to Gas Phase Detonations, Project Cowboy," U. S. Bureau of Mines, Final Rept. on Project Cowboy (1960).

This paper reports the results of experiments undertaken to determine the feasibility of using a hydrogen-oxygen mixture for spherical detonations at atmospheric and reduced pressures. Gas handling systems, initiating systems, and detonation studies are considered in detail and detonation velocity measurements are summarized in tables.

Curtailment of the program precluded any gas-detonation tests at the Winnfield (Project Cowboy) site.

ZVEREV, S. M., "Opyt seysmorazvedochnykh nablyudeniy na rekakh Zapadnoy Sibiri [Experience of Seismic Survey Observations on Rivers of Western Siberia]," Razved. Prom. Geofiz. n. 21, pp. 16-23 (1958).

Tests were made during the years 1949-1955 on rivers of Western Siberia to evaluate the use of river beds as profiles for seismic exploration. Seismic receivers were fixed to floating wooden beams tied together into a long line. Strings of piezoreceivers were placed on the bottom of the river. The best conditions for the transfer of energy to the ground are created when the explosive is suspended near the water surface over deep parts of the river. This method of seismic surveying is less expensive than ordinary operations on land.

ZVOLINSKII, N. V., "Concerning the Emission of an Elastic Wave from a Spherical Underground Explosion," Prikladniya Matemat. Mekhan., V. 24, pp. 126-133 (1960).

The flow of a plastic medium into an incompressible state under the influence of an explosion is investigated. The propagation of the detonating wave and the release of the elastic wave are examined. Spherical symmetry is assumed while the work involved in the transformation of the plastic state into an incompressible condition is taken to be proportional to the change in the maximum displacement. The detonating wave

ZVOLINSKII

propagation is pictured as occurring in four stages. First, the shock wave propagates itself through the undisturbed medium. Next, the elastic wave is propagated through the undisturbed medium; followed by a zone of packing. Third, plastic flow continues but the packing of the medium stops. Finally, as the zone of packing is stopped, the rear of the elastic wave is severed from it and the elastic wave goes off to infinity. Each of the stages is discussed, but numerical calculations are not presented. The kinematic propagation is illustrated qualitatively by a diagram.

Appendix A
REPORTS and ARTICLES SPONSORED by VELA UNIFORM

A.1. REPORTS

AIR FORCE TECHNICAL APPLICATIONS CENTER (Staff): "Relative Seismicity of the U.S.S.R., U.S.A., and U.K." (Special Report for ARPA).

AKI, K., and PRESS, F.: "Upper Mantle Structure Under Oceans and Continents from Rayleigh Waves," CIT Contribution No. 84.

ANDERSON, D. L.: "Elastic Wave Propagation in Layered Anisotropic Media," CIT Contribution No. 1036.

BEN-MENAHEM, A.: "Radiation of Seismic Surface-Waves from Simple Models of Fault Planes, Part I: Rayleigh Waves (83); Part II: Sh Waves (82)," CIT Contribution No. 995.

CALESS, T. W.: "Compendium of Contract Information in the VELA UNIFORM Program," Univ. of Mich. Report on Contract No. SD-78 (1961).

CISTERNAS, A.: "Crustal Structure of the Andes from Rayleigh Wave Dispersion," CIT Report (1961).

FOOSE, R. M., et al.: "Manual of On-Site Inspection," Report on SRI Project SU-3420 (1961).

FOOSE, R. M., et al.: "Syllabus of On-Site Inspection," Report on SRI Project SU-3420 (1961).

GEOTECHNICAL CORPORATION (Staff): "Wichita Mountains Seismological Observatory — Report on Phase I," Geotech. Tech. Rept. 61-1.

GEOTECHNICAL CORPORATION (Staff): "Wichita Mountains Seismological Observatory — Report on Phase II," Geotech. Tech. Rept. 61-2.

HAUBRICH, R. A., et al.: "A Digital Seismograph System for Measuring Earth Noise," Univ. of Calif. Report (1961).

MARC SHIOWITZ & ASSOCIATES: "Preliminary Study of the Data Processing Subsystem Requirements for the Seismological Systems Laboratory — Final Report" (1961).

PHINNEY, R. A.: "Leaking Modes in the Crustal Waveguide, Part I: The Oceanic PL Wave," CIT Contribution No. 1013.

PRESS, F., et al.: "A Fast, Convenient Program for Computation of Surface Wave Dispersion Curves in Multilayered Media," CIT Contribution No. 1040.

PRESS, F., BEN-MENAHEM, A., and TOKSOZ, M. N.: "Experimental Determination of Earthquake Fault Length and Rupture Velocity," CIT Contribution No. 1040.

PRESTON, R. G., and ADAMS, W. M.: "Predicted Phenomenology and Effects for Project DRIBBLE Test Detonations — VELA UNIFORM Explosion Series," UCRL-LRL-UOPAC 61134, Progress Report No. 2 (1961).

SPIEKER, L. J.: "Seismometer Array and Data Processing System — Final Report," TI Report on Phase I on Contract No. AF 33(600)-41840.

SYLVANIA ELECTRONIC SYSTEMS (Staff): "Communications Study for Project VELA UNIFORM," Report on Contract No. AF 33(600)-42159.

TRYGGVASON, E.: "Crustal Thickness in Fennoscandia from Phase Velocities of Rayleigh Waves," Special Report No. 2 on Contract No. DA-91-591-EUC-1637.

A.2. JOURNAL ARTICLES

AKI, K.: "Further Studies of the Mechanism of Circum-Pacific Earthquakes from Rayleigh Waves," J. Geophys. Research, V. 65, n. 12 (1960).

ALSOP, L. L., SUTTON, G. H., and EWING, M.: "Free Oscillations of the Earth Observed on Strain and Pendulum Seismometers," J. Geophys. Research, V. 66, pp. 631-641 (1961).

BRUNE, J., BENIOFF, H., and EWING, M.: "Group and Phase Velocities for Rayleigh Waves of Period Greater than 380 Seconds," Science, V. 133, p. 757 (1961).

GODZIN, M. G., and HAMILTON, J. H.: "Wichita Mountains Seismological Observatory," (see Abstract listed under Geophysical Corporation) Geophysics, V. 26, n.3 (1961).

PHINNEY, R. A.: "Leaking Modes in the Crustal Waveguide, Part I: The Oceanic PL Wave," J. Geophys. Research, V. 66, n. 5 (1961).

TRYGGVASON, E., and BATH, M.: "Upper Crustal Structure of Iceland," J. Geophys. Research, V. 66, n. 6 (1961).

Appendix B
LIST of JOURNALS and STANDARD ABBREVIATIONS

Acad. Sci., Paris Compt. rend.
Academie des sciences, Paris, Comptes rendus

Am. Scientist
American Scientist

Ann. geofis. (Rome)
Annali di geofisica (Roma)

Appl. Mechanics Rev.
Applied Mechanics Review

Atomic Energy (U.S.S.R.)
Atomikeinenergie

Australian J. Phys.
Australian Journal of Physics

Bull. Earthquake Research Inst., Tokyo Univ.
Bulletin of the Earthquake Research Institute of Tokyo University

Bull. Geol. Soc. Am.
Bulletin of the Geological Society of America

Bull. Seism. Soc. Am.
Bulletin of the Seismological Society of America

Bur. Cen. Seism. Intnat'l. Publ.
Bureau Central Seismological International Publications

Busuri - Tanko
Busuri - Tanko

Can. Geophys. Bull.
Canadian Geophysical Bulletin

Can. Oil. Gas Indus.
Canadian Oil and Gas Industries

Centro Brasil. Pesquisas Fisicas
Centro Brasileiro de Pesquisas Fisicas

Crushed Stone J.
Crushed Stone Journal

Dis. Prevent., Kyoto Univ.
Disaster Prevention, Kyoto University

Doklady Akad. Nauk S.S.S.R.
Doklady Akademii Nauk S.S.S.R.

Earthquake Notes
Earthquake Notes

Explosives Eng.
Explosives Engineer

Fiz. Zhur.
Fizicheskii Zhurnal

Freiberger Forschungsh.
Freiberger Forschungshefte

Geofis. pura e appl.
Geofisica pura e applicata

Geofiz. Kozl.
Geofizikai Kozlemenyek

Geofys. Sborn.
Geophysikalni Sbornik

Geol. Foren. i Stockholm Forh.
Geologiska Foreningens i Stockholm Forhandlingar

Geol. Jahrb.
Geologisches Jahrbuch

Geol. Mag.
Geological Magazine

Geol. Rundschau
Geologische Rundschau

Geol. Soc. Am. Mem.
Geological Society of America Memoir

Geophys.
Geophysics

Geophys. J. Roy. Astron. Soc.
Geophysical Journal of the Royal Astronomical Society

Geophys. Notes
Geophysical Notes

Geophys. Prosp.
Geophysical Prospecting

Geophysik
Geophysik

Gerlands Beitr. Geophys.
Gerlands Beitroge Geophysik

Indian J. Phys.
Indian Journal of Physics

Izvest. Akad. Nauk Armyan. S.S.R.
Izvestiya Akademii Nauk Armyanskoi S.S.R.

Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz.
Izvestiya Akademii Nauk S.S.S.R., Seriya Geofizicheskaya

Izvest. Akad. Nauk S.S.S.R., Ser. Geog. i Geofiz.
Izvestiya Akademii Nauk S.S.S.R., Seriya Geografich eskaya i Geofizich eskaya

J. Acous. Soc. Am.
Journal of the Acoustical Society of America

J. Appl. Mechanics
Journal of Applied Mechanics

J. Appl. Phys.
Journal of Applied Physics

J. CGS
Journal of the Coast and Geodetic Survey

J. Chem. Phys.
Journal of Chemistry and Physics

J. Elisha Mitchell Sci. Soc.
Journal of the Elisha Mitchell Scientific Society

J. Geophys. Research
Journal of Geophysical Research

J. Phys. Earth
Journal of Physics of the Earth

J. Phys. Soc. Japan
Journal of the Physical Society of Japan

J. Roy. Astron. Soc. (Can.)
Journal of the Royal Astronomical Society of Canada

J. Roy. Astron. Soc. Geophys.
Journal of the Royal Astronomical Society of Geophysics

Mem. Fac. Eng., Kyoto Univ.
Memoirs of the Faculty of Engineering, Kyoto University

Mine & Quarry Eng.
Mine and Quarry Engineer

Mines Mag.
Mines Magazine

Monthly Notices, Roy. Astron. Soc.
Monthly Notices of the Royal Astronomical Society

Nature
Nature

Die Naturwissenschaften
Die Naturwissenschaften

Nucleonics
Nucleonics

Nuturi - Tanko
Nuturi - Tanko

The Observatory
The Observatory

Oil Gas. J.
Oil and Gas Journal

Phil. Trans. Roy. Soc. London
Philosophical Transactions of the Royal Society of London

Phys. Globe
Annales de l'institute de physique du Globe de l'Universite de Paris et du bureau central de magnetisme terrestre

Phys. of Fluids
Physics of Fluids

Phys. Rev.
Physical Review

Physik. Z.
Physikalische Zeitschrift

Prikladniya geofiz.
Prikladniya geofizik

Prikladniya Matemat. Mekhan.
Prikladniya Matemat. Mekhan.

Priroda
Priroda

Proc. Am. Phil. Soc.
Proceedings of the American Philosophical Society

Proc. Nat. Acad. Sci. U. S.
Proceedings of the National Academy of Sciences of the U. S.

Proc. Phys. Soc. (London)
Proceedings of the Physical Society of London

Proc. Roy. Soc. (London)
Proceedings of the Royal Society of London

Proc. Tulsa Geophys. Soc.
Proceedings of the Tulsa Geophysical Society

Publ. Dom. Obs.
Publications of the Dominion Observatory

Quart. Colo. School Mines.
Quarterly, Colorado School of Mines

Razved. Prom. Geofiz.
Razvedochansyai Promyslovaye Geofizikee

Rev. Modern Phys.
Review of Modern Physics

Riv. geofis. appl.
Rivista di geofisica applicata

Schweiz. Na. Gesel.
Schweizer Naturf. Gesell, Verh.

Sci.
Science

Sci. Am.
Scientific American

Sci. News Letter
Science News Letter

Sci. Prog.
Science Progress

Sci. Repts. Tohoku Univ.
Science Reports of the Tohoko University

Sci. Results
Science Results

Stud. Geophys. Geod., Ceskoslov. Akad. Ved
Studia Geophysica et Geodaetica Ceskoslovenska Akademie Ved

Tech. News. Bull.
Technical News Bulletin

Trans. Am. Geophys. Union
Transactions of the American Geophysical Union

Trav. Geophys., Nak. Ceskosk. Akad. Ved
Travaux Geophsiques 1953, Nakladatelstui Ceskoslovenska Akademie Ved

Trudy Inst. Geol., Akad. Nauk Kirgiz S.S.R.
Trudy Instituta Geologii, Akademiya Nauk Kirgiz S.S.R.

Trudy Inst. Seys. Akad. Nauk Tadzhik S.S.R.
Trudy Instituta Seysmologii, Akademiya Nauk Tadzhik, S.S.R.

Trudy Inst. Geofiz. Akad. Nauk, S.S.S.R.
Trudy Instituta Geofizicheskaya Akadamiya Nauk, S.S.S.R.

Uchenye Zapiski Leningrad Univ.
Uchenye Zapiski, Leningrad University

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(Rept. no. 4410-10-B)
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Nearly 600 publications on seismology and underground explosion detection are cited in this bibliography. A listing of authors and titles is arranged by subjects. The subject headings used represent the main study of interest to the VELA UNIFORM Program of the Advanced

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Addendum No. 1

NOTE TO USERS

In November 1961, VESIAC published A Bibliography of Seismology for the VELA UNIFORM Program, Report No. 4410-10-B. This first addendum to the Bibliography contains abstracts for approximately 150 additional publications on seismology and the detection of underground explosions. In view of plans to publish quarterly addenda to the Bibliography, we have placed the first addendum in a loose-leaf notebook and will print subsequent addenda on punched paper for insertion in the notebook. The original Bibliography can be punched and inserted in the notebook also.

The addendum, like the Bibliography, has two main parts: author-title listing by subject, and abstracts of publications cited; both listings are arranged alphabetically by authors. Each author of a publication with multiple authors is listed separately, but the complete reference and abstract are given only under the first-named author. Publications with no author credit are listed under the names of their corporate authors.

Additions or corrections to the addendum or to the original Bibliography will be appreciated. Please write:

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Ann Arbor, Michigan

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The bibliography will be most effective if users follow these directions:

1. To select areas of interest, consult the Subject Outline, Section 1.
2. Next, refer to Section 2, where the Subject Outline is repeated, with the author and title of each abstracted article, book, or report listed under the appropriate subject heading.
3. Turn to Section 3, where the abstracts are arranged alphabetically by author.
4. Refer to Appendix A for a list of reports and articles sponsored by the VELA UNIFORM Program.

1

SUBJECT OUTLINE — VELA UNIFORM PROGRAM

I. Research in Seismology

1. Seismic Source Mechanisms
   a. Earthquakes
   b. Explosions[1]
   c. Seismic Noise
   d. Other Artificial Devices (Oscillators, Weight Drops, Etc.)
2. Seismic Wave Propagation
   a. Theoretical
   b. Observational
   c. Models
3. Seismic Propagation Paths
   a. U. S. Crustal Structure
   b. Foreign Crustal Structure
   c. Mantle and Core
   d. Geophysical Constants (Seismic Velocity, Rock Density, Etc.)
4. Seismic Signal Detection
   a. Surface
   b. Array
   c. Deep Well
   d. Underwater
   e. Special Purpose
5. Seismic Data
   a. Processing
   b. Analysis
6. General Studies

II. Research in Electromagnetic Signals from Underground Disturbances

1. Source Mechanisms
2. Model Studies

[1]A great number of entries in this bibliography report on seismic phenomena resulting from an explosion. However, to list the reports of every study which uses an explosion energy source under Section I.1.b, "Explosions," would prove unwieldy and less informative than the more discriminative listing chosen. In this grouping, only those articles which are specifically source studies, e.g., energy transfer (coupling and decoupling), cavity formation, plastic zone studies, explosion thermodynamics, etc., are listed under I.1.b.

2

AUTHOR-TITLE LISTING BY SUBJECTS

I. Research in Seismology

1. Seismic Source Mechanisms

a. Earthquakes

AKI, K., "Interpretation of Source Functions of Circum-Pacific Earthquakes Obtained from Long-Period Rayleigh Waves"

AKI, K., "The Use of Love Waves for the Study of Earthquake Mechanism"

AKI, K., and NORDQUIST, J. M., "Automatic Computation of Impulse Response Seismograms of Rayleigh Waves for Mixed Paths"

BANERJEE, K. N., "Response Characteristics of Electromagnetic Seismographs"

BENIOFF, H., et al., "Excitation of the Free Oscillations of the Earth by Earthquakes"

BESSONOVA, E. N., et al., Investigation of the Mechanism of Earthquakes

BOGERT, B. P., "Hand Digitized Seismic Data"

BOGERT, B. P., "An Observation of Free Oscillations in the Earth"

BOLT, B. A., "Revision of Earthquake Epicenters and Seismic Traveltime Curves Using the IBM 704 Computer"

CHAO, T. C., "Meterologiya i seysmologiya v kitaye" ("Meteorology and Seismology in China")

CLOUD, W. K., and HUDSON, D. E., "A Simplified Instrument for Recording Strong Motion Earthquakes"

HOUSNER, G. W., "The Earthquake Ground Shock Problem and Its Relation to the Explosive-Generated Ground Shock Problem"

NESS, N. F., et al., "Observations of the Free Oscillations of the Earth"

SATO, Y., et al., "Love Waves in a Heterogeneous, Spherical Earth, Part 1: Theoretical Periods for the Fundamental and Higher Torsional Modes"

SAVARENSKY, E. F., et al., "On the Determination of the Energy of Elastic Waves Generated by Earthquakes"

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STAUDER, W., "Three Kamchatka Earthquakes"

STAUDER, W., and ADAMS, W. M., "A Comparison of Some S Wave Studies of Earthquake Mechanisms"

VESIAC (Staff), "A Consideration of H. I. S. Thirlaway's 'Depth of Focus Discrimination within the Crust at First-Zone Distances' "

1. Seismic Source Mechanisms (cont.)

b. Explosions

AHO, A. E., "Graphical Statistical Analysis of Fracture Patterns in Rock Encountered in Engineering Projects"

AKI, K., and NORDQUIST, J. M., "Automatic Computation of Impulse Response Seismograms of Rayleigh Waves for Mixed Paths"

BANERJEE, K. N., "Response Characteristics of Electromagnetic Seismographs"

BOGERT, B. P., "Hand Digitized Seismic Data"

CARDER, D. S., MURPHY, L. M., PEARCE, T. H., and MICKEY, W. V., "Surface Motions from Underground Explosions"

CARLSON, R. H., Nuclear Explosives and Landslide Dams

CHAO, T. C., "Meterologiya i seysmologiya v kitaye" ("Meteorology and Seismology in China")

CHASZEYKA, M. A., "Studies of Surface and Underground Nuclear Explosions"

COX, E. F., "Microbarometric Pressures from Large High Explosive Blasts"

FLANAGAS, W. G., and SHAFFER, L. E., "An Application of Nuclear Explosives to Block Caving Mining"

FREILING, E. C., "Fractionation I: High-Yield Surface Burst Correlation"

HASKELL, N. A., "A Static Theory of the Seismic Coupling of a Contained Underground Explosion"

HASSMAN, M., and COHEN, E., "Review of Blast Closure Systems"

HESS, W. N., and NORDYKE, M. D., "Throwout Calculations for Explosion Craters"

HILL, G., "Still-Warm Cavern Yields Secrets of '57 Atom Blast"

HUDSON, D. E., et al., "Ground Accelerations Caused by Large Quarry Blasts"

LAING, E. B., and COHEN, E., "Design Below Ground Arch and Dome Type Structures Exposed to Nuclear Blast"

LEET, L. D., Vibrations from Blasting Rock

LEET, L. D., "Vibrations from Construction Blasting"

MICKEY, W. V., "Operation Plowshare, Project Scooter, Surface Motion from a Cratering Shot in Desert Alluvium"

MURPHEY, B. F., "High Explosive Crater Studies: Desert Alluvium"

NORDYKE, M. D., "Nuclear Craters and Preliminary Theory of the Mechanics of Explosive Crater Formation"

NUCKOLLS, J., "Theory of Underground Explosions"

RINEHART, J. S., "On Fractures Caused by Explosions and Impacts"

SATO, Y., et al., "Love Waves in a Heterogeneous, Spherical Earth, Part 1: Theoretical Periods for the Fundamental and Higher Torsional Modes"

SCHWIND, J. J., et al., "PS Converted Waves from Large Explosions"

1. Seismic Source Mechanisms (cont.)

   b. Explosions (cont.)

      SERBIN, H., "The Intense Stress Field Produced in the Elastic Earth by a Bomb Blast at the Surface"

      SMITH, F. L., and YOUNG, T. R., "Nuclear Explosives and Mining Costs"

      SNAY, H. G., and MATTHIAS, R. H., "A Theory of the Propagation of Shockwaves and Their Formation by Explosions"

      SWIFT, L. M., and WELLS, W. M., "Postshot Disturbances and Surface Motions—Operation Hardtack II"

      VESIAC (Staff), "A Consideration of H. I. S. Thirlaway's 'Depth of Focus Discrimination within the Crust at First-Zone Distances'"

   c. Seismic Noise

      BANERJEE, K. N., "Response Characteristics of Electromagnetic Seismographs"

      DARBYSHIRE, J., and HINDE, B. J., "Microseisms"

      GUTENBERG, B., "Microseisms"

      SATO, Y., et al., "Love Waves in a Heterogeneous, Spherical Earth, Part 1: Theoretical Periods for the Fundamental and Higher Torsional Modes"

   d. Other Artificial Devices (Oscillators, Weight Drops, Etc.)

      RYKUNOV, L. N., and FEOFILAKTOV, V. D., "A Piezoelectric Emitter of Single-Stroke Ultrasonic Pulses for Modeling Seismic Waves"

2. Seismic Wave Propagation

   a. Theoretical

      AKI, K., and NORDQUIST, J. M., "Automatic Computation of Impulse Response Seismograms of Rayleigh Waves for Mixed Paths"

      BOLT, B. A., "Revision of Earthquake Epicenters and Seismic Traveltime Curves Using the IBM 704 Computer"

      BOLT, B. A., and BUTCHER, J. C., "Rayleigh Wave Dispersion for a Single Layer on an Elastic Half Space"

      BREKHOVSKIKH, L. M., Waves in Layered Media

      BULLEN, K. E., "Seismic Ray Theory"

      CALOI, P., "Seismic Waves from the Outer and Inner Core"

      CHASZEYKA, M. A., "Studies of Surface and Underground Nuclear Explosions"

      DERESIEWICZ, H., "The Effect of Boundaries on Wave Propagation in a Liquid-Filled Porous Solid, I: Reflection of Plane Waves at a Free Plane Boundary (Non-Dissipative Case)"

      DIX, C. H., "Elastic Pulse Reflection—Evaluation of Some Determinants"

      DIX, C. H., "The Seismic Head Pulse, Reflection and Pseudo-Reflection Pulses"

      DUCLAUX, F., Seismometrie Théoretique (Theoretical Seismometry)

      HARKRIDER, D. G., and ANDERSON, D. L., "Computation of Surface Wave Dispersion for Multilayered Anisotropic Media"

2. Seismic Wave Propagation (cont.)

a. Theoretical (cont.)

HEALY, J. H., and PRESS, F., "Two Dimensional Seismic Models with Continuously Variable Velocity Depth and Density Functions"

HOCHSTRASSER, U., and STONELEY, R., "The Transmission of Rayleigh Waves across an Ocean Floor with Two Surface Layers, Part II: Numerical"

HOOK, J. F., "Seismic Wave Propagation in Inhomogeneous, Isotropic Media— Outline of Method of Analysis"

KOGAN, S. Ya., "On the Determination of the Energy of Seismic Waves of Arbitrary Form"

NUTTLI, O. W., "The Effect of the Earth's Surface on the S Wave Particle Motion"

OGURTSOV, K. I., "The Improvement of Accuracy in Asymptotic Approximations for the Intensity of Waves Propagated in a Laminated Elastic Medium"

PODYAPOLSKI, G. S., and VASSILEV, Yu. I., "A Rayleigh-Type Wave at a Non-Free Surface"

VOLAROVICH, M. P., et al., "Investigation of the Attenuation of Elastic Waves in Rock Specimens"

b. Observational

ARKHANGELSKAYA, V. M., "Dispersion of Surface Waves and Crustal Structure"

BOLT, B. A., "Machine Processing of Seismic Travel-Time Data"

BOLT, B. A., "Revision of Earthquake Epicenters and Seismic Traveltime Curves Using the IBM 704 Computer"

CALOI, P., "Seismic Waves from the Outer and Inner Core"

CHASZEYKA, M. A., "Studies of Surface and Underground Nuclear Explosions"

DIMENT, W. H., et al., "Crustal Structure from the Nevada Test Site to Kingman, Arizona, from Seismic and Gravity Observations"

FORBES, C. B., and HEALD, C. L., "Refraction Seismic Survey — Porpoise Area"

HUNKINS, K. L., "Seismic Studies of Sea Ice"

KISSLINGER, C., MATEKER, E. J., Jr., and McEVILLY, T. V., "SH Motion from Explosions in Soil"

KOGAN, S. D., "Travel Times of Longitudinal and Transverse Waves, Calculated from Data on Nuclear Explosions Made in the Region of the Marshall Islands"

KOVACH, R. L., and PRESS, F., "Rayleigh Wave Dispersion and Crustal Structure in the Eastern Pacific and Indian Oceans"

McDONAL, F. J., ANGONA, F. A., MILLS, R. L., SENGBUSH, R. L., VAN NOSTRAND, R. G., and WHITE, J. E., "Attenuation of Shear and Compressional Waves in Pierre Shale"

NAFE, J. E., and BRUNE, J. N., "Observations of Phase Velocity for Rayleigh Waves in the Period Range 100 to 400 Seconds"

NUTTLI, O. W., and WHITMORE, J. D., "An Observational Determination of the Variation of the Angle of Incidence of P Waves with Epicentral Distance"

POPOV, I. I., "Dispersion of Long-Period Love Waves in the Continental and Oceanic Crust along the Path Indonesia-Crimea"

2. Seismic Wave Propagation (cont.)

c. Models

BOLT, B. A., and DORMAN, J., "Phase and Group Velocities of Rayleigh Waves in a Spherical, Gravitating Earth"

BREKHOVSKIKH, L. M., Waves in Layered Media

DENOYER, J. M., "The Effect of Variations in Layer Thickness on Love Waves"

HEALY, J. H., and PRESS, F., "Two Dimensional Seismic Models with Continuously Variable Velocity Depth and Density Functions"

HOCHSTRASSER, U., and STONELEY, R., "The Transmission of Rayleigh Waves across an Ocean Floor with Two Surface Layers, Part II: Numerical"

KUHN, V. V., "The Peculiarities of Seismic Waves in Media with Vertical Interfaces"

NAGUMO, S., KAWASHIMA, T., and HONSHO, S., "Model Experiment on Rayleigh Wave"

RINEHART, J. S., "Model Experiments Pertaining to the Design of Underground Openings Subjected to Intense Ground Shocks"

RYKUNOV, L. N., and FEOFILAKTOV, V. D., "A Piezoelectric Emitter of Single-Stroke Ultrasonic Pulses for Modeling Seismic Waves"

3. Seismic Propagation Paths

a. U. S. Crustal Structure

AKI, K., "Interpretation of Source Functions of Circum-Pacific Earthquakes Obtained from Long-Period Rayleigh Waves"

AKI, K., "The Use of Love Waves for the Study of Earthquake Mechanism"

AKI, K., and NORDQUIST, J. M., "Automatic Computation of Impulse Response Seismograms of Rayleigh Waves for Mixed Paths"

ARKHANGELSKAYA, V. M., "Dispersion of Surface Waves and Crustal Structure"

DIMENT, W. H., et al., "Crustal Structure from the Nevada Test Site to Kingman, Arizona, from Seismic and Gravity Observations"

FORBES, C. B., and HEALD, C. L., "Refraction Seismic Survey — Porpoise Area"

HARKRIDER, D. G., and ANDERSON, D. L., "Computation of Surface Wave Dispersion for Multilayered Anisotropic Media"

NAFE, J. E., and BRUNE, J. N., "Observations of Phase Velocity for Rayleigh Waves in the Period Range 100 to 400 Seconds"

NUTTLI, O. W., "The Effect of the Earth's Surface on the S Wave Particle Motion"

OLIVER, J. E., et al., "Crustal Structure of the New York-Pennsylvania Area"

VESIAC (Staff), "A Consideration of H. I. S. Thirlaway's 'Depth of Focus Discrimination within the Crust at First-Zone Distances'"

WOTTLIN, W. O., SERIFF, A. J., and BROMAN, W. H., "Seismic Observations by Shell Development Company of the Pre-Gnome Explosions — Data"

3. Seismic Propagation Paths (cont.)

b. Foreign Crustal Structure

AKI, K., "Interpretation of Source Functions of Circum-Pacific Earthquakes Obtained from Long-Period Rayleigh Waves"

AKI, K., "The Use of Love Waves for the Study of Earthquake Mechanism"

AKI, K., and NORDQUIST, J. M., "Automatic Computation of Impulse Response Seismograms of Rayleigh Waves for Mixed Paths"

ARKHANGELSKAYA, V. M., "Dispersion of Surface Waves and Crustal Structure"

BÅTH, M., "Polarization of Transverse Seismic Waves"

BÅTH, M., and TRYGGVASON, E., "Deep Seismic Reflection Experiments at Kiruna"

BOLT, B. A., and BUTCHER, J. C., "Rayleigh Wave Dispersion for a Single Layer on an Elastic Half Space"

HARKRIDER, D. G., and ANDERSON, D. L., "Computation of Surface Wave Dispersion for Multilayered Anisotropic Media"

HOCHSTRASSER, U., and STONELEY, R., "The Transmission of Rayleigh Waves across an Ocean Floor with Two Surface Layers, Part II: Numerical"

KOGAN, S. D., "Travel Times of Longitudinal and Transverse Waves, Calculated from Data on Nuclear Explosions Made in the Region of the Marshall Islands"

KOGAN, S. Ya., "On the Determination of the Energy of Seismic Waves of Arbitrary Form"

KOVACH, R. L., and PRESS, F., "Rayleigh Wave Dispersion and Crustal Structure in the Eastern Pacific and Indian Oceans"

NUTTLI, O. W., "The Effect of the Earth's Surface on the S Wave Particle Motion"

POPOV, I. I., "Dispersion of Long-Period Love Waves in the Continental and Oceanic Crust along the Path Indonesia-Crimea"

SHURBET, D. H., "Determination of Sedimentary Thickness in the Mexican Geosyncline by Rayleigh Wave Dispersion"

TRYGGVASON, E., "Crustal Structure of the Iceland Region from Dispersion of Surface Waves"

VESIAC (Staff), "A Consideration of H. I. S. Thirlaway's 'Depth of Focus Discrimination within the Crust at First-Zone Distances'"

c. Mantle and Core

BÅTH, M., "Polarization of Transverse Seismic Waves"

BÅTH, M., "Deep Seismic Reflection Experiments at Kiruna"

CALOI, P., "Seismic Waves from the Outer and Inner Core"

HOOK, J. F., "Seismic Wave Propagation in Inhomogeneous, Isotropic Media—Outline of Method of Analysis"

KOGAN, S. D., "Travel Times of Longitudinal and Transverse Waves, Calculated from Data on Nuclear Explosions Made in the Region of the Marshall Islands"

3. Seismic Propagation Paths (cont.)

c. Mantle and Core (cont.)

NUTTLI, O. W., "The Effect of the Earth's Surface on the S Wave Particle Motion"

NUTTLI, O. W., and WHITMORE, J. D., "An Observational Determination of the Variation of the Angle of Incidence of P Waves with Epicentral Distance"

PRESS, F., "The Earth's Crust and Upper Mantle"

RICHARDS, T. C., "Motion of the Ground on Arrival of Reflected Longitudinal and Transverse Waves at Wide-Angle Reflection Distances"

SCHWIND, J. J., et al., "PS Converted Waves from Large Explosions"

STAUDER, W., "S Waves and Focal Mechanisms: The State of the Question"

STAUDER, W., and ADAMS, W. M., "A Comparison of Some S Wave Studies of Earthquake Mechanisms"

VOSKRESENSKY, Y. N., "Some Types of Diffracted Waves Detected by the Adjustable Directional Receiver Method"

d. Geophysical Constants (Seismic Velocity, Rock Density, Etc.)

BÅTH, M., and TRYGGVASON, E., "Deep Seismic Reflection Experiments at Kiruna"

BAYUK, E. I., "The Investigation of the Elastic Properties of Rock Samples Taken from a Deep Borehole at High Pressures"

BOLT, B. A., and DORMAN, J., "Phase and Group Velocities of Rayleigh Waves in a Spherical, Gravitating Earth"

BULLEN, K. E., "Seismic Ray Theory"

GRINE, D. R., "VELA UNIFORM—Dynamic Properties of Rocks"

LOMBARD, D. B., "The Hugoniot Equation of State of Rocks"

MATHEWS, J., "Static Deformation of a Plastic Medium"

McDONAL, F. J., ANGONA, F. A., MILLS, R. L., SENGBUSH, R. L., VAN NOSTRAND, R. G., and WHITE, J. E., "Attenuation of Shear and Compressional Waves in Pierre Shale"

RINEHART, J. S., "On Fractures Caused by Explosions and Impacts"

SERATA, S., and GLOYNA, E. F., "Principles of Structural Stability of Underground Salt Cavities"

SERBIN, H., "The Intense Stress Field Produced in the Elastic Earth by a Bomb Blast at the Surface"

SHURBET, D. H., "Determination of Sedimentary Thickness in the Mexican Geosyncline by Rayleigh Wave Dispersion"

SWAIN, R. J., HEALD, C. L., and SNODGRASS, D. T., "Shear and Compressional Velocity Measurements, Project Hobo"

VOLAROVICH, M. P., et al., "Investigation of the Attenuation of Elastic Waves in Rock Specimens"

4. Seismic Signal Detection

a. Surface

ANDERSON, J. A., and WOOD, H. O., "Description and Theory of the Torsion Seismometer"

ARCHANGELSKY, V. T., "Questions Concerning the Theory of the Long-Period Vertical Seismometer"

BANERJEE, K. N., "Response Characteristics of Electromagnetic Seismographs"

BERCKHEMER, H., and HILLER, W., "Kurzperiodische Stations-seismographen mit Tragerfrequenzverstarker und mechanischer Registrierung" ("Short-Period Station Seismographs with Carrier-Frequency Amplifier and Mechanical Recording")

BOGERT, B. P., "Hand Digitized Seismic Data"

LINKOV, E. M., and TRIPOLNIKOV, V. P., "A Magnetoelectronic Seismograph"

PANASSENKO, G. D., "On Determining the Elements of a Seismic Ray from the Data of a Single Station"

PASECHNIK, I. P., "Seismic Method of Detecting and Identifying Nuclear Explosions"

WATT, P. A., "The Application of a D-C Amplifier to Seismic Recording"

b. Array

CLOUD, W. K., and HUDSON, D. E., "A Simplified Instrument for Recording Strong Motion Earthquakes"

PANASSENKO, G. D., "On Determining the Elements of a Seismic Ray from the Data of a Single Station"

PASECHNIK, I. P., "Seismic Method of Detecting and Identifying Nuclear Explosions"

c. Deep Well

PASECHNIK, I. P., "Seismic Method of Detecting and Identifying Nuclear Explosions"

d. Underwater

DAVIS, P. D., Jr., "Automatic Marine Seismic Monitoring and Recording Device"

DOW, W., "A Telemetering Hydrophone"

EWING, J., and EWING, M., "A Telemetering Ocean-Bottom Seismograph"

PASECHNIK, I. P., "Seismic Method of Detecting and Identifying Nuclear Explosions"

e. Special Purpose

ANDERSON, J. A., and WOOD, H. O., "Description and Theory of the Torsion Seismometer"

ARCHANGELSKY, V. T., "Questions Concerning the Theory of the Long-Period Vertical Seismometer"

4. Seismic Signal Detection (cont.)

e. Special Purpose (cont.)

COX, E. F., "Microbarometric Pressures from Large High Explosive Blasts"

GILMAN, R., "Report on Some Experimental Long-Period Seismographs"

MORRIS, R. H., and SCHNEIDERHAN, R. C., "Operation Hardtack, Phase II, Earth Motion Studies, Project 26.5 (UCRL)"

PASECHNIK, I. P., "Seismic Method of Detecting and Identifying Nuclear Explosions"

5. Seismic Data

a. Processing

AKI, K., and NORDQUIST, J. M., "Automatic Computation of Impulse Response Seismograms of Rayleigh Waves for Mixed Paths"

BOGERT, B. P., "Hand Digitized Seismic Data"

BOLT, B. A., "Machine Processing of Seismic Travel-Time Data"

BOLT, B. A., "Revision of Earthquake Epicenters and Seismic Traveltime Curves Using the IBM 704 Computer"

MEIDAV, T., "Nomograms to Speed up Seismic Refraction Computations"

SIMPSON, S. M., Jr., "Initial Studies on Underground Nuclear Detection with Seismic Data Prepared by a Novel Digitization System"

TARKHOV, A. G., and SIDOROV, A. A., "The Mathematical Processing of Geophysical Data"

WOOD, C. A., "Plot Seismic Data with Electronic Computers"

b. Analysis

AKI, K., and NORDQUIST, J. M., "Automatic Computation of Impulse Response Seismograms of Rayleigh Waves for Mixed Paths"

BOGERT, B. P., "Hand Digitized Seismic Data"

BOGERT, B. P., "An Observation of Free Oscillations of the Earth"

BOLT, B. A., "Revision of Earthquake Epicenters and Seismic Traveltime Curves Using the IBM 704 Computer"

CLOUD, W. K., and HUDSON, D. E., "A Simplified Instrument for Recording Strong Motion Earthquakes"

LEET, L. D., "Ground Vibrations from Trinity Tests"

LEET, L. D., Vibrations from Blasting Rock

SIMPSON, S. M., Jr., "Initial Studies on Underground Nuclear Detection with Seismic Data Prepared by a Novel Digitization System"

WOOD, C. A., "Plot Seismic Data with Electronic Computers"

6. General Studies

AHO, A. E., "Graphical Statistical Analysis of Fracture Patterns in Rock Encountered in Engineering Projects"

AUGER, P., "Current Trends in Scientific Research"

6. General Studies (cont.)

BATZEL, R. E., "Radioactivity Associated with Underground Nuclear Explosions"

BENIOFF, H., et al., "Excitation of the Free Oscillations of the Earth by Earthquakes"

BERCKHEMER, H., and HILLER, W., "Kurzperiodische Stations-seismographen mit Tragerfrequenzverstarker und mechanischer Registrierung" ("Short-Period Station Seismographs with Carrier-Frequency Amplifier and Mechanical Recording")

BOGERT, B. P., "An Observation of Free Oscillations of the Earth"

BREKHOVSKIKH, L. M., Waves in Layered Media

BURGUNKER, M. E., Russian-English Dictionary of Earth Sciences

BYRNE, C. J., "Instrument Noise in Seismometers"

CARLSON, R. H., Nuclear Explosives and Landslide Dams

CHAO, T. C., "Meteorologiya i seysmologiya v kitaye" ("Meteorology and Seismology in China")

COX, E. F., PLAGGE, H. J., and REED, J. W., "Meteorology Directs Where Blast Will Strike"

DEHLINGER, P., "Seismology in the U. S. S. R."

DWORNIK, S. E., and ORR, D. G., "Reflectance Studies of Vegetation Damage"

FOOSE, R. M., and HOY, R. B., "Identification of Possible Underground Nuclear Explosions by On-Site Inspection"

GILMAN, R., "Report on Some Experimental Long-Period Seismographs"

HAGIWARA, T., HIRONO, T., HISANDA, T., KAWASUMI, H., et al., "East Asian Area Seismology and Earthquake Engineering Seminar Monograph Japan"

HENRIE, T. A., RENNER, R. A., OLSON, R. L., LEONE, O. Q., and BAKER, D. H., Jr., "Problems in Recovering Thermal Energy from Molten Salts"

HOFFMAN, G. A., "Thermoelectric Powerplants Utilizing Contained Nuclear Explosions"

JACOBS, J. M., SMELCER, N. K., and VORESS, H. E., "Bibliographies of Interest to the Atomic Energy Program"

KOOPMANS, L. H., "An Evaluation of a Signal-Summing Technique for Improving the Signal-to-Noise Ratios for Seismic Events"

LAVER, F. J. M., Waves

LINKOV, E. M., and TRIPOLNIKOV, V. P., "A Magnetoelectronic Seismograph"

LONG, R. P., "Evaluation of Methods of Installation of the Wiancko-Carlson Earth Pressure Gage"

MELTON, B. S., "Useful Concepts for the Engineering Design of Seismographs"

NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL, "A Report to the Public on the Biological Effects of Atomic Radiation"

NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL, "The Biological Effects of Atomic Radiation"

6. General Studies (cont.)

NESS, N. F., et al., "Observations of the Free Oscillations of the Earth"

PETERSON, P., "Checking the Performance of Electrodynamic Seismometers"

ROSENBAUM, J. H., "Shockwave Propagation in Shallow Water, I"

RYKUNOV, L. N., and FEOFILAKTOV, V. D., "A Piezoelectric Emitter of Single-Stroke Ultrasonic Pulses for Modeling Seismic Waves"

SEVIN, E., SHENKMAN, S., and WELCH, E., "Ground Shock Isolation of Buried Structures"

SMITH, F. L., and YOUNG, T. R., "Nuclear Explosives and Mining Costs"

VAN DORN, W. G., "Some Characteristics of Surface Gravity Waves in the Sea Produced by Nuclear Explosions"

II. Research in Electromagnetic Signals from Underground Disturbances

1. Source Mechanisms

SULLIVAN, W., "Scientists Told of A-Test Clues"

TROITSKAYA, V. A., "Effects in Earth Currents Caused by High-Altitude Atomic Explosions"

2. Model Studies

BREAKOVSKIKH, L. M., Waves in Layered Media

3

ABSTRACTS

ADAMS, W. M. See Stauder, W. V.

AHO, A. E., "Graphical Statistical Analysis of Fracture Patterns in Rock Encountered in Engineering Projects," Bull. Geol. Soc. Am., V. 71, n. 11, pp. 1719-1720 (1960).

The directional competence of badly fractured rock in engineering foundations can be analyzed by plotting the various types of fractures on a Schmidt equal-area projection and combining the data suitably. Improved understanding of fracture conditions may enhance grouting efficiency and permit safer structural design and tunneling procedures.

AKI, K., "Interpretation of Source Functions of Circum-Pacific Earthquakes Obtained from Long-Period Rayleigh Waves," J. Geophys. Research, V. 65, n. 8, pp. 2405-2417 (1960).

The source functions of 53 shocks of the circum-Pacific belt were obtained by a method of equalization applied to Rayleigh waves in the period range of 35 seconds to 150 seconds recorded at the Seismological Laboratory, Pasadena. The source function was interpreted in terms of the direction of forces at the source. The interpretation was checked by additional information concerning the earthquake as well as by an error analysis. The horizontal forces deduced from the source function showed a systematic geographic distribution, which favors Benioff's hypothesis on the circum-Pacific tectonics. The vertical forces are found to be mostly directed upward on the oceanic side.

AKI, K., "The Use of Love Waves for the Study of Earthquake Mechanism," J. Geophys. Research, V. 65, n. 1, pp. 323-331 (1960).

Long-period Love waves of continental path were successfully used for the study of the mechanism of earthquakes. Wave forms were compared for earthquakes of similar size which occurred within a limited area and were recorded by the same instrument at a given station. The aftershocks of the Kern County earthquake of 1952 and the series of Nevada shocks during 1954 were studied, and the direction of lateral fault motion derived from Love waves was found to agree perfectly with that derived from the data on body waves. In matching wave crests, we observed a time difference which cannot be explained by postulating a single couple for an earthquake source; this observation strongly supports Honda's hypothesis that the seismic waves are generated by a pair of couples. This additional information from the Love wave data confirmed the belief that the fault-plane solutions have great geotectonic significance, at least for the area studied.

AKI, K., and NORDQUIST, J. M., "Automatic Computation of Impulse Response Seismograms of Rayleigh Waves for Mixed Paths," Bull. Seism. Soc. Am., V. 51, n. 1, pp. 29-34 (1961).

A program has been devised to compute theoretical seismograms of Rayleigh waves for a given epicenter and a given station entirely automatically on an electronic computer.

The earth's surface is divided into three regions; continents, Pacific Ocean, and oceans other than the Pacific. Allowance can be made for differences in structure in these regions. This simple division seems satisfactory at present for Rayleigh waves of periods longer than 35 seconds.

ANDERSON, D. L. See Harkrider, D. G.

ANDERSON, J. A., and WOOD, H. O., "Description and Theory of the Torsion Seismometer," Bull. Seism. Soc. Am., V. 15, n. 1 (1925).

The torsion seismograph is considered comprehensively. Reference is made to the research program under which it was developed and to several cognate undertakings. The advantages of photographic registration, and of small instrumental dimensions, are pointed out. The principle of the torsion suspension and its properties are discussed. The construction of the instrument and its adjustments are described. An abridged theory of the seismometer is given, especially for the case of critical damping. Its action as an accelerometer is emphasized. The terms "efficiency," "magnification," and "efficiency with respect to velocity of vibration," and also "sensitiveness" are formulated and defined. Methods for determining the constants are given. Auxiliary apparatus and methods are described.

In the appendix, the theory of the seismometer is treated more fully and more generally. Special cases are discussed. "Sensitiveness" is discussed in its relation to "efficiency" and "magnification," and also to damping. The decay of proper motion is considered, and the best value of damping is approximated. The case of an "impulse" is defined and considered; also the case of a number of successive "impulses," is defined. The case of a constant angular acceleration is discussed. Finally, sample seismographic records are shown and described.

ANGONA, F. A. See McDonal, F. J.

ARKHANGELSKAYA, V. M., "Dispersion of Surface Waves and Crustal Structure," Izvest. Akad. Nauk S. S. S. R., Ser. Geofiz., n. 9, pp. 904-927 (1960).

A synopsis is presented of foreign publications which appeared during the last decade and which reflect the present status of crustal-structure studies based on surface-wave observations.

Determinations are given of the oceanic crustal structure in the basins of the Pacific, Atlantic, Indian, and Arctic Oceans, and the Arctic basin of the North Atlantic; also of the continental crust of Africa, North America, Europe, the Antarctic, Asia, and Eurasia. These determinations lead to conclusions as to the relative uniformity of the crustal structure both on the continents and in the oceanic basins.

ARCHANGELSKY, V. T., "Questions Concerning the Theory of the Long-Period Vertical Seismometer," Izvest. Akad. Nauk S. S. S. R., Ser. Geofiz., n. 10, pp. 955-960 (1961).

The theory of suspension of the pendulum for a vertical seismometer is considered, and basic terms in the equation of motion of the pendulum are shown.

AUGER, P., "Current Trends in Scientific Research," UNESCO Publications Center, New York (1961).

The main trends and recommendations concerning scientific research, the dissemination of scientific knowledge for peaceful ends, and the applications of scientific research are surveyed. The trends apply to nearly all phases of science: fundamental sciences, earth and space, medicine, food and agriculture, fuel and power research, and industrial research.

BAKER, D. H., Jr. See Henrie, T. A.

BANERJEE, K. N., "Response Characteristics of Electromagnetic Seismographs," Proc. Natl. Inst. Sci. India, V. 26, pt. A, n. 4, pp. 348-354 (1960).

A mathematical analysis is presented for the response characteristics of an electromagnetic seismograph associated with a combination of damped and sustained harmonic displacement of the ground. The seismometer and galvanometer have been assumed to have initial motions. Numerical results show clearly that the magnitude as well as the direction of the initial motions of the seismometer and galvanometer play an important part in the nature of records obtained in seismograms; in many cases the recorded trace may be quite different from the ground motion. If the contributions of the initial motions of the seismometer and galvanometer and of the transient part of the response are taken into consideration in the interpretation of seismograms, the relationship between the amplitude in the seismogram and the extent of energy released at the hypocenter will be better understood.

BÅTH, M., "Polarization of Transverse Seismic Waves," in A. H. Cook and T. F. Gaskell (eds.), The Earth Today, Interscience Publishers, New York, pp. 106-123 (1961).

A theoretical investigation is made of the changes of the polarization of transverse seismic waves during their propagation through the earth. The polarizations have been computed theoretically and numerically for reflection at the core boundary and at the earth's surface, for refraction and reflection at the base of the crust, and for passages through continuously varying media. It is demonstrated that great changes of the vibration properties (vibration angle and particle orbit) may occur everywhere except in continuously varying media, through which transverse waves propagate with practically unchanged vibration properties. The consequences of these results for earthquake mechanism studies, based on transverse waves, are discussed.

BÅTH, M., and TRYGGVASON, E., "Deep Seismic Reflection Experiments at Kiruna," Seism. Inst., Univ., Uppsala, Sweden, Contractor's Scientific Report No. 4 on Contract No. DA-91-591-EUC-1637 (1961).

In August 1955, a series of specially arranged quarry blasts in the Kiruna iron ore mines was recorded with a refraction apparatus approximately 10 km away. The experiments were the first seismic investigations of the deeper crustal structure in Fennoscandia and were mainly undertaken in order to study near-vertical reflections from crustal discontinuities. The records show clear, direct P waves with sharp onsets and a velocity of 5.65 ± 0.13 km/sec (in porphyry). P waves reflected

from crustal discontinuities are weak and erratic, in agreement with theoretical expectation for near-vertical reflections. Approximate depths to the Conrad and the Mohorovicic discontinuities are calculated as 19 km and 33-34 km. There is general agreement with the explosion records written by the Grenet seismograph at Kiruna. The differences which exist can be explained by the different frequency response of the two instruments.

BATZEL, R. E., "Radioactivity Associated with Underground Nuclear Explosions," J. Geophys. Research, V. 65, n. 9, pp. 2897-2902 (1960).

The detonation of a contained or partially contained nuclear explosion is accompanied by the deposition of a large fraction of the energy in the form of high-temperature, high-pressure regions. The nature of the surrounding medium, the time-temperature history, and the time of cavity collapse or venting determine the extent to which undesirable nuclides such as Sr^{90} and Cs^{137} will appear outside a fused, relatively insoluble matrix and be available to ground water or to the atmosphere. The movement of these undesirable radioactive nuclides relative to the groundwater movement can be predicted on the basis of measured K_D's (distribution coefficients) for the radioactivities in the medium.

The induced radioactivities are a 20% to 25% contribution to the fission product radioactivity for times of about one day, and a 1% contribution for times equal to about one week. The contribution decreases to 0.1% after about 45 days, but later, because of the Co^{60} present, it increases to about 2% for a period of 3 to 15 years.

BAYUK, E. I., "The Investigation of the Elastic Properties of Rock Samples Taken from a Deep Borehole at High Pressures," Izvest. Akad. Nauk S. S. S. R., Ser. Geofiz., n. 12, pp. 1173-1177 (1961).

The elastic parameters were determined for rock samples from the Novo-Alekseevskaya deep borehole at high all-around pressures with the application of methods whereby the velocities v_{P_M} and $v_{P_{rod}}$ of the longitudinal waves are measured on a single sample.

The experiments demonstrated that the elastic parameters of rocks increase with an increase in pressure especially intensively up to 1000 kg/cm^2, and that they also depend on the depth from which the samples were taken, as well as on the mineralogical composition of the rock.

A comparison was carried out of the laboratory values of the velocities of longitudinal waves measured with the pressure taken into consideration, to the data of the seismic logging of the Novo-Alekseevskaya borehole. The author concludes that a good agreement was obtained between the v_{P_M} velocities and the layer velocities.

BENIOFF, H., et al., "Excitation of the Free Oscillations of the Earth by Earthquakes," J. Geophys. Research, V. 66, n. 2, pp. 605-619 (1961).

The free oscillations of the earth have been experimentally verified from an analysis of strain-seismograph and pendulum-seismograph recordings made in California and Peru from the great Chilean earthquake of May 1960. Both spheroidal and torsional oscillations were revealed

by a power spectral analysis of the seismograms. The gravest spheroidal mode shows a split spectral peak with periods of 54.7 and 53.1 minutes. The theoretical prediction for the Bullen B model according to Alterman, Perkeris, and Jarosch is 53.7 minutes. The oscillations were observed for all modes up to 38 with corresponding periods as short as 3.7 minutes. For the higher modes, agreement in the observed period is found between the Chilean earthquake and the Kamchatka earthquake of 1952. In almost all cases agreement between experimental and theoretical predictions is close. Differences which occur should make it possible to discriminate between the several earth models which have been proposed.

From the width of the spectral peak, values of the dissipation function Q^{-1} for the earth could be determined with an accuracy greater than was previously possible. For the spheroidal mode S_3 (T = 35.5 minutes), Q = 380, and for the mode S_{18} (T = 6.2 minutes), Q = 170. On the assumption that Q is independent of frequency, this implies a higher Q in the core than in the mantle.

A method is described for deducing the fault length and rupture velocity from analysis of phase difference between components of ground motion. Preliminary results indicate a fault length for the Chilean earthquake of about 1000 km and rupture velocities in the range 3 to 4 km/sec.

BERCKHEMER, H., and HILLER, W., "Kurzperiodische Stations-seismographen mit Tragerfrequenzverstarker und mechanischer Registrierung" ("Short-Period Station Seismographs with Carrier-Frequency Amplifier and Mechanical Recording"), Z. Geophys., V. 26, n. 1, pp. 1-8 (1960).

A new short-period seismograph system developed at Stuttgart, Germany, is described. The pendulum has a mass of 1 kg and a natural period of 1-1.5 seconds. The mechanical displacement is converted into electric signals by means of variable inductances which form the branches of an a-c current bridge. This bridge is fed by a current of 50 cps taken from a power line or from a transistor oscillator. An amplifier with three transistor stages and phase discriminator drives a pen motor of the differential moving-coil type, recording on smoked paper. All three components are tuned naturally. Maximum magnification is adjustable between 3000 and 40,000. The seismograph operates mainly as a displacement meter. The exact solution and an approximation of the dynamic magnification function are given. A schematic diagram and photographs illustrate the text.

BESSONOVA, E. N., et al., Investigation of the Mechanism of Earthquakes, Am. Geophys. Union, Soviet Research in Geophysics, in English translation, V. 4 (1960).

This book presents the results of work conducted by the Geophysics Institute of the Academy of Science, U. S. S. R. since 1948 on the investigation of fault-plane displacements. During this period a method was evolved that makes it possible to determine the mechanical type of fractures at the focus, the dip and strike of the fault plane, and the direction of the displacement and order of the relative intensity of the first shock.

By means of this method is was possible to investigate the displacement near the foci of earthquakes in the seismic regions of the U. S. S. R.

(the Garnskaya Oblast, northern Tien Shan, western Turkmenia, Kopet-Dag, and the Caucasus) and adjoining regions (Hindukush and the Pacific Ocean).

The first part contains the theoretical basis and a condensed description of the methodology with indicated references.

The second part presents summary data regarding displacements near earthquake centers of the various seismic areas of the U. S. S. R. Basic determinations, when possible in geological terminology, are given at the beginning of the second part, so that the reader who is interested only in the tectonic aspect of the matter might dispense with Part I.

Many of the methodological conclusions and results of interpretations are included.

BOGERT, B. P., "Hand Digitized Seismic Data," edited by VESIAC Staff, Rept. No. 4410-14-X, Institute of Science and Technology, The University of Michigan, Ann Arbor, Mich. (1962).

Sample short-period seismograms were hand digitized in an experiment to measure their quality against that of digitizations produced by electronic means. Several samples were hand digitized in two independent groups. The resulting playbacks were compared with each other, and with playbacks from electronic digitizations of the same records, to demonstrate coherence, R^2, for each comparison.

Cross-spectral analysis between the electronically digitized and the hand-digitized playbacks indicate that, although coherence is good up to 1.5 cps, it drops off rapidly at higher frequencies. At approximately 2.0 cps, hand digitization becomes unreliable when data are sampled at 10 samples per second. Coherence of hand digitization differs with the digitizer. Sampling high-frequency data at an increased number of samples per cycle of the folding frequency would improve the coherence between independent analyses. Some of the digitizing error at high frequencies may be due to the tracking difficulties with the optical system used by the investigators; it had a short lever-arm recording pen, and the equipment assumed an infinite lever arm.

The results point out the desirability of providing adequate electronic digitization capability.

BOGERT, B. P., "An Observation of Free Oscillations of the Earth," J. Geophys. Research, V. 66, n. 2, pp. 643-646 (1961).

The more extensive measurements by Benioff, Press, and Smith, by Ness, Harrison, and Slichter, and by Alsop, Sutton, and Ewing are supported by the results of spectral power analyses, made with an electronic computer, of seismograms obtained from the Chilean earthquake of May 1960 by a Columbia long-period vertical seismometer installed at Chester, New Jersey. Agreement is particularly good in the shorter period range (up to 17.7 minutes). It is interesting that peaks at 20.4 and 10.06 minutes correspond to the lowest purely radial mode $_0S_0$ and the next lowest mode $_1S_0$, respectively.

BOLT, B. A., "Machine Processing of Seismic Travel-Time Data," Bull. Seism. Soc. Am., V. 51, n. 2, pp. 259-267 (1961).

A method of constructing empirical travel-time curves from a sample of observed times has been programmed for computation on a high-speed data-processing machine. The method reduces to a uniform procedure analysis hitherto successful in obtaining the standard travel-time tables, and its speed of operation promises to facilitate the construction of regional tables. The program processes up to 500 observations of the phase under revision, taken from any number of selected earthquakes. The hypocenter and time of origin of each shock are first adjusted by an automatic procedure previously described, and the needed correction is applied to the observed times. The corrected times are then weighted relative to a provisional travel-time table, and the weights used to fit polynomials up to a specified degree. Sample characteristics are also computed to facilitate statistical treatment. Preliminary results, obtained using the program to process PKIKP times from 9 Aleutian shocks and a deep-focus New Zealand shock, are presented. These results supply additional evidence that, relative to the standard P tables of Jeffreys and Bullen, PKIKP times require the addition of about 1 1/4 seconds.

BOLT, B. A., "Revision of Earthquake Epicenters and Seismic Traveltime Curves Using the IBM 704 Computer," Earthquake Notes, V. 31, n. 3, pp. 25-26 (1960).

A program, coded for the IBM 704, is designed to reduce to a minimum by a least-squares method the differences between P travel times observed and P travel times calculated from standard tables.

BOLT, B. A., and BUTCHER, J. C., "Rayleigh Wave Dispersion for a Single Layer on an Elastic Half Space," Australian J. Phys., V. 13, n. 3, pp. 490-504 (1960).

Numerical solutions of the period equation for Rayleigh waves in the single surface layer were calculated using the SILLIAC computer at the University of Sydney. Values of the phase and group velocities for both the fundamental and first higher mode are tabulated against period for 11 two-layer models. The related models allow a sensitivity analysis of the effect of variation in the seismic parameters. Values of the elastic constants used in the calculations were chosen to fit the seismic velocities determined for the crust in Western Australia, so that the solutions are relevant to studies of the crustal structure of Australia.

BOLT, B. A., and DORMAN, J., "Phase and Group Velocities of Rayleigh Waves in a Spherical, Gravitating Earth," J. Geophys. Research, V. 66, n. 9, pp. 2965-2981 (1961).

Periods of spheroidal eigenvibrations, with spherical harmonic $n \geq 20$, have been computed for self-gravitating inhomogeneous spheres corresponding to a variety of earth models. The periods are used to deduce phase and group velocities for the fundamental and first higher modes of Rayleigh waves having periods less than 320 seconds. The

mathematical methods, program checks, and estimations of numerical precision used in the work are presented in detail. A comparison is made between phase and group velocities for different spherical models and with corresponding flat-earth velocities calculated for the same physical parameters by the Thomson-Haskell matrix method for a non-gravitating layered half-space. The comparison shows that the inclusion of gravity and sphericity increases the phase velocity by 0.25 km/sec (~5%) near T = 300 seconds and by 0.10 km/sec (~2.5%) near T = 150 seconds, where T is the period of the wave. In striking contrast, for 100 < T < 250 seconds, the group velocities for the spherical case remain within 1% of the corresponding velocities for the horizontally layered case. A group-velocity minimum occurs close to T = 220 seconds. The variation with depth of the relative amplitudes of the radial and horizontal displacements and the perturbed gravitational potential is shown graphically for one earth model where n = 30, 80, and 110. On the basis of a comparison with these theoretical results, recent observations of Rayleigh wave phase and group velocities, as well as measured periods of some spheroidal oscillations, are consistent with an earth's mantle having a density distribution similar to that of model A constructed by Bullen, and having P and S velocity distributions similar to those calculated by Gutenberg. A group-velocity dispersion curve which corresponds to the first higher mode (or first shear mode) of Rayleigh waves has also been computed for 20 < T < 150 seconds (500 > n > 40) for a continental model. Extrema of the curve which may be expected to produce relatively large amplitude arrivals occur at a velocity of 4.30 km/sec during a period of 60 seconds (a minimum) and at a velocity of 4.54 km/sec during a period of 25 seconds (a maximum). The period and velocity of the latter agree well with the period and velocity of the phase S_a described by Caloi and by Gutenberg and of the phase S_n of Press and Ewing.

BREKHOVSKIKH, L. M., Waves in Layered Media, Academic Press, New York (1960).

A systematic exposition of the theory of the propagation of elastic and electromagnetic waves in layered media is presented. The book is not restricted to Soviet work, but it does present a complete picture of Soviet research in this field. The following subjects are dealt with in turn: plane waves in layers; some applications of the theory of plane-wave propagation in layered media; plane waves in layered-inhomogeneous media; reflection and refraction of spherical waves; wave propagation in layers; the field of a concentrated source in a layered-inhomogeneous medium.

BROMAN, W. H. See Wottlin, W. O.

BRUNE, J. N. See Nafe, J. E.

BULLEN, K. E., "Seismic Ray Theory," in A. H. Cook and T. F. Gaskell, (eds.) The Earth Today, Interscience Publishers, New York, pp. 93-105 (1961).

Seismic ray theory is developed ab initio (apart from one or two standard elementary results) with special emphasis on the variables ζ and α, where $\zeta = d \log v/d \log r$ and $\alpha = 2/(1 - \zeta)$. The relations between travel time and distance are examined for a variety of types of velocity

distribution, including the case where α is constant and those where α and v change discontinuously, or rapidly but continuously, with increase of depth. The analysis is designed to provide an improved basis for working out in quantitative detail the effect on travel times of the various types of velocity variation likely to be relevant to the earth. In particular, it is hoped that the analysis will lead to the most effective use of ray theory in the current difficult problems of the structure of the earth's outer mantle.

Advantage has been taken of the opportunity to present a number of previous results involving ζ and α in revised form, as part of a wider logical development. Previous work on deriving seismic velocity distributions from travel-time data is generalized.

A terse account of the basic theory is given and no numerical applications have been included. References are given to papers containing applications.

BURGUNKER, M. E., Russian-English Dictionary of Earth Sciences, Telberg Book Co., New York (1961).

English counterparts are presented of those Russian terms which constitute the "hard core" of the nomenclature of tectonics, geomorphology, hydrology, paleogeography, and geophysics. A number of botanical, zoological, and ecological terms utilized by the earth scientist are included. In the choice of Russian terminology, the nomenclature in A. S. Barkov's Slovar-Spravochnik po Fizicheskoi Geografii (Dictionary and Manual of Physical Geography), Moscow, 1954, was treated as a yardstick for the type of vocabulary presented, because of the growing importance of such disciplines as paleobotany and ecology in the earth sciences. [From Author's Preface]

BUTCHER, J. C. See Bolt, B. A.

BYRNE, C. J., "Instrument Noise in Seismometers," Bull. Seism. Soc. Am., V. 51, n. 1, pp. 69-84 (1961).

Methods are developed to analyze the effects of thermal noise and seismic noise in masking small earth vibrations. The procedure is applied to a simple seismometer, seismometers with electronic and galvanometer amplifiers, and a seismometer with a shunt capacity.

A numerical example is worked out for the Benioff 1-second instrument. In the 0.1-10-second band, thermal noise is not limiting.

CALOI, P., "Seismic Waves from the Outer and the Inner Core," in A. H. Cook and T. F. Gaskell (eds.), The Earth Today, Interscience Publishers, New York, pp. 139-150 (1961).

New formulas for the determination of travel times of seismic waves in the interior of the earth are given. Applications of said formulas to the calculation of travel times of ScS-waves, recorded with exceptional clearness at Tolmezzo on the occasion of Aegean Isles shallow earthquakes (April-June 1957), are also given. The problem of the waves reflected by the inner core, using manifest examples of PKIKP-waves recorded at Tolmezzo, is discussed.

CARDER, D. S., MURPHY, L. M., PEARCE, T. H., and MICKEY, W. V., "Surface Motions from Underground Explosions" (with Appendix A), U. S. Coast and Geodetic Survey, Washington, D. C., Project 26.4 of Operation HARDTACK, Phase II on Contract No. AT(29-2)-746, AEC-DOD Rept. No. WT-1741 (1961).

Ground effects resulting from certain HARDTACK II underground explosions were measured by strong-motion and teleseismic seismographs from 2000 feet to distances of nearly 100 miles. In addition, many temporary seismographs were operated by a number of organizations to distances of nearly 2400 miles, and routine seismographs continued to operate on a worldwide basis. Some of the results are given. For safety purposes, predictions of ground effects, using formulas derived by the Coast and Geodetic Survey from pre-Rainier high-explosives tests and modified slightly as a result of the Rainier tests, hold with reasonable accuracy. However, slightly revised formulas are believed to be more applicable to all ground displacements in the distance ranges covered in this report. An energetic wave believed reflected from the surface near the source was recorded by some of the strong-motion seismographs. It is out of phase with the initial wave and follows it by about a quarter second. From the ground-effects standpoint, the Blanca shot was equivalent to a magnitude 4.8 earthquake, and seismic energy contained in a wave 0.8 km from the source is believed to contain about 0.4% of the yield energy. The Logan and Rainier shots were respectively equivalent to magnitude 4.5 and 4.1 earthquakes and corresponding seismic energies contained respectively 0.5% and 0.3% of the yield energy.

CARLSON, R. H., Nuclear Explosives and Landslide Dams, Sandia Corp., Albuquerque, N. Mex., SC-4403(RR), TID-4500, 15th Edition (1960).

The possibility of constructing a rockfall dam by triggering a rockslide with nuclear explosives is explored. Seismic forces created by a deeply buried nuclear-explosive charge could initiate the slide, or the direct energy of nuclear explosives could be used to fracture the rock which would make up the slide mass. Problems discussed include spillway construction, seepage control, and those problems unique to the utilization of nuclear explosives. Destruction of undesirable natural slide dams is also considered. Appendixes cover desirable locations for a slide dam, descriptions of naturally created slide dams, and a Russian technique for creating slide dams by direct high-explosive blasting. A cost comparision is made for a slide dam constructed by use of conventional and nuclear techniques. It is concluded that slide dams could be successfully created by means of nuclear explosives.

CHAO, T. C., "Meteorologiya i seysmologiya v kitaye" ("Meteorology and Seismology in China"), Priroda, n. 10, pp. 27-34 (1959).

Research in meteorology and seismology carried out by the Institute of Geophysics of the Academy of Sciences of the Chinese Peoples' Republic is discussed. Descriptions of more than 15,000 earthquakes in China are collected in a symposium entitled, "Chronological Tabulation of Chinese Earthquake Records." More than 8000 references were investigated in preparation of this list. "The catalog of earthquakes in China" was based on the above symposium. The data were systematized and supplemented with the material of contemporary instrumental observa-

tions. The catalog contains information on 1180 major earthquakes of the period from 1189 to 1955. First arrivals, epicenters, calculated intensity, and resulting destruction are given. Much seismic engineering work is being done, and construction of seismic instruments is on a large scale.

CHASZEYKA, M. A., "Studies of Surface and Underground Nuclear Explosions," Illinois Inst. of Tech., Armour Research Foundation, Final Report on Contract No. DA-44-009-ENG-3998 (1961).

The entire range of shock propagation, from the close-in phase to the elastic behavior, is studied. Under equations-of-state studies it is shown thermodynamically that the waste heat is the result of entropy changes and the absorption of thermal energy by the dense constituents in mixtures of solids and air.

Fluid thermodynamic properties of a gas-solid mixture are studied. An analytical solution for a spherical shock wave with constant compressed density is presented. An analytical expression is derived for the acceleration behind a spherical shock wave and compared with experimental results.

Cratering from surface and shallow-buried nuclear detonations is analyzed. The implications of the radiation phase of a nuclear detonation on cavitation in a camouflet-type nuclear detonation are covered.

High-explosive and nuclear detonations are analyzed on the basis of theoretical information and TNT field tests. Encouraging results are obtained for correlating high-explosive tests and nuclear detonations as bases for predicting nuclear-detonation effects.

For refraction at an interface, the paper gives a general graphical solution that overcomes the problems of mathematical analysis. This method is applied to a refraction at the earth's surface from a shallow-buried nuclear detonation.

CLOUD, W. K., and HUDSON, D. E., "A Simplified Instrument for Recording Strong Motion Earthquakes," Bull. Seism. Soc. Am., V. 51, n. 2, pp. 159-174 (1961).

A strong-motion earthquake recorder for the direct measurement of one point on the response spectrum curve is described, and results obtained with the instrument under field conditions are compared with those obtained by a standard spectrum analysis of accelerograph records. The device has the advantages of low initial cost and of low maintenance expense, and can thus be installed in relatively large numbers. A network of such instruments located at points with differing local geological conditions is proposed as a supplement to the U. S. Coast and Geodetic Survey strong-motion seismograph system.

COHEN, E. See Hassman, M.; Laing, E. B.

COX, E. F., "Microbarometric Pressures from Large High Explosive Blasts," J. Acous. Soc. Am., V. 19, n. 5, pp. 832-846 (1947).

Charges detonated for Army-Navy Explosives Safety Board tests in Idaho, October 1946, produced pressure waves recorded by subsonic frequency microbarographs at distances of 12.9 to 452 km. Observations

showed both normal and abnormal signals at 182 and 292 km, no clear abnormal signals at 141 or 89 km, no signals of any kind at 872 km. In the zone of normal audibility, average wave velocity between blast point and receiving station decreases slightly with increasing distance, and may increase slightly with charge weight; it is substantially the same as sound velocity. No consistent travel-time differences for the abnormal signals resulted from changing charge weight between 3.2 and 250 tons of TNT. Neither normal nor abnormal signal strengths were predictable from charge weight. The largest abnormal signal properly recorded was a 3-cycle wave train with peak-to-peak amplitude of 220 microbars received 182 km from a 125-ton blast. Interpolated to apex pressure perturbation, this signal amplitude eliminates shock-wave supersonic velocity as a logical explanation for abnormal audibility. Incident angles of abnorml rays are not calculable. However, if one assumes 182 km as the descent distance for rays starting out horizontally, neglects wind effects, and accepts the apex temperatures measured by balloons, rough calculations of lower stratosphere temperatures are possible. These establish 34 km as a minimum altitude at which ground temperature is reached.

COX, E. F., PLAGGE, H. J., and REED, J. W., "Meteorology Directs Where Blast Will Strike," Bull. Am. Meteorol. Soc., V. 35, n. 3, pp. 95-103 (1954).

Seismological exploration companies and Defense Department proving grounds are occasionally served with liability suits for damage wrought by explosions. Good forecasts of troposphere temperature and wind structure can be used to predict where shocks will strike, and with fair accuracy whether or not the shock will crack windows. Formulas are derived by which these predictions may be made.

DARBYSHIRE, J., and HINDE, B. J., "Microseisms," Research Applied in Industry, V. 14, n. 1, pp. 8-17 (1961).

The origin of microseisms is discussed briefly, and their use for detecting and tracing storms at sea is described. Emphasis is placed on recent work in England. Vertical and horizontal electronic seismographs have been designed and installed at the National Institute of Oceanography for the specific purpose of recording microseisms. The instruments have high magnification and a flat response for waves of periods between 2 and 10 seconds; a triple pen recorder is used. Since 1958, three seismographs have been used with automatic analysis by instruments. Examples of the tracking of specific storms from the instrumental records are given. Correlation coefficients are used not only to find the direction of approach of the storm but also the ratio of Rayleigh-wave activity to Love-wave activity. The distribution of this ratio over the North Atlantic shows that the ratio diminishes away from the recording station. This confirms the view that microseisms form as Rayleigh waves and are converted to Love waves in transit; thus the distribution of their ratio should be useful in studying the nature of the earth's crust.

DAVIS, P. D., Jr., "Automatic Marine Seismic Monitoring and Recording Device," Texas Instruments Inc., Dallas, Semi-Annual Technical Report No. 1 on Contract No. AF 19(604)-8368 (1961)

This report describes the research and construction of an automatic marine seismic monitoring and recording device for the period 15 March 1961-31 August 1961. Development work on various subassemblies has been completed, and laboratory testing of these assemblies is nearing completion. Laboratory tests of the system and local field tests will commence in September.

DEHLINGER, P., "Seismology in the U. S. S. R.," Intern. Geol. Rev., V. 3, n. 4, pp. 279-324 (1961).

This review establishes a perspective from which Soviet seismology can be viewed, and to summarize Soviet published literature in seismology as of about December 1959.

The Soviets are attempting to extend basic and applied knowledge in every phase of seismology. This approach has resulted in a systematic, well-coordinated, and all-inclusive program that incorporates sizable government agencies, a large number of highly trained scientists, and funds for operation which have been estimated to be considerably greater than those expended in the United States.

The major research and investigations in Soviet seismology are conducted at the Institute of Earth Physics (formerly the Geophysical Institute), and its field stations, of the U. S. S. R. Academy of Sciences. All phases of seismology are being studied at this Institute by a large staff of highly trained scientists, including more than 100 geophysicists, physicists, and mathematicians. The Institute also awards doctorate degrees in seismology. Other Soviet organizations are active in seismology, but to a lesser extent.

Among the main concerns of Soviet seismology are the study of the physical properties of various types of seismic waves propagated in different media, especially layered media; the determination of criteria for recording and identifying wave groups; and the development of instruments to record, analyze, and process data. Some of the most significant Soviet developments during the last fifteen years are mentioned.

For the purposes of this review, Soviet seismology has been grouped into four subjects: (1) theoretical and laboratory investigations, (2) earthquake seismology, (3) explosion seismology, and (4) instrumental seismology. Emphasis has been placed on principles, concepts, and techniques which the Soviets are using and developing.

DENOYER, J. M., "The Effect of Variations in Layer Thickness on Love Waves," Bull. Seism. Soc. Am., V. 51, n. 2, pp. 227-235 (1961).

A model is considered in which Love waves propagate perpendicular to the trend of a structure that is varying in thickness as a sine function of distance. The period equation for this model is obtained, and average values for phase and group velocities are found for several distance ranges. A method is proposed for finding relative amplitudes as a function of position along the structure for any specified period.

DERESIEWICZ, H., "The Effect of Boundaries on Wave Propagation in a Liquid-Filled Porous Solid," I: "Reflection of Plane Waves at a Free Plane Boundary (Non-Dissipative Case)," Bull. Seism. Soc. Am., V. 50, n. 4, pp. 599-607 (1960).

A general solution is deduced of the differential equations which describe the propagation of elastic waves in a nondissipative liquid-filled porous solid. The solution is then used to examine some of the phenomena which arise when each of the three body waves predicted by the field equations is, in turn, incident on a plane traction-free boundary. It is found, for example, that an obliquely incident wave of each type in general gives rise to reflected waves of all three types.

DIMENT, W. H., et al., "Crustal Structure from the Nevada Test Site to Kingman, Arizona, from Seismic and Gravity Observations," J. Geophys. Research, V. 66, n. 1, pp. 201-214 (1961).

The time of the first arrival of seismic waves generated by explosions at the Nevada Test Site and recorded along a 300-km line southeastward through Kingman, Arizona, is expressed as $T_0 = \Delta/5.2$, $T_1 = 0.34 + \Delta/6.15$, and $T_2 = 5.82 + \Delta/7.81$, where time is in seconds and the shot-detector distance (Δ) is in kilometers. Assuming constant velocities for the layers, the thicknesses are $H_0 = 1.7$ km, $H_1 = 26.7$ km, and $H_0 + H_1 = 28$ km (below a 1-km datum). The average Bouguer anomaly is about -120 milligals, and the average elevation is about 1.1 km.

Seismograms were examined for P waves indicating the presence of other discontinuities within and below the H_2 layer, but the separation between seismic stations was too great to establish the presence of such discontinuities. A questionable alignment of weak arrivals following the T_2 refraction time by less than 1 second may indicate the presence of a discontinuity below 28 km. Fair alignments of strong second arrivals in the range 200 to 400 km might be interpreted as direct P waves or channel waves in the H_1 layer.

DIX, C. H., "Elastic Pulse Reflection—Evaluation of Some Determinants," J. Geophys. Research, V. 66, n. 1, pp. 235-236 (1961).

The fourth-order determinants that occur in the theory of reflection are split into a sum (denominator) and difference (numerator) of two much simpler determinants. This makes the algebra much simpler. It also makes the form similar to that familiar for normal incidence.

DIX, C. H., "The Seismic Head Pulse, Reflection and Pseudo-Reflection Pulses," J. Geophys. Research, V. 66, n. 9, pp. 2945-2951 (1961).

The shapes of the seismic head pulse and of the ordinary reflection and pseudoreflection pulses are compared with the direct-pulse shape. The direct pulse is the step in the radial displacement potential. The method used is a variation of Cagniard's work together with suitable approximations and the results are similar to Cagniard's. The present treatment is simpler than Cagniard's and better adapted to direct numerical calculations for many important cases. A numerical example is given.

DORMAN, J. See Bolt, B. A.

DOW, W., "A Telemetering Hydrophone," Deep-Sea Research, V. 7, n. 2, pp. 142-147 (1960).

A deep telemetering hydrophone which transmits information acoustically through the water to a surface vessel is described and illustrated. The instrument has the advantage of requiring no electrical cable to the ship; it may be quickly hung on any suitable supporting line or wire, and can be made to operate completely free of the ship. Among other applications, the unit may be used to detect sounds reflected from subbottom strata. Luskin and others (1960) using a similar instrument have recorded seismic refraction arrivals in deep water. Tests are being planned that will combine the instrument with a repetitive pulse source, both submerged near the bottom in deep water.

DUCLAUX, F., Seismometrie théorique (Theoretical Seismometry), Gauthier-Villars, Paris (1960).

This book has chapters on the following topics: general principles of pendulum seismographs, horizontal pendulum, vertical pendulum, horizontal seismograph with mechanical amplification, standardization of a seismograph with mechanical amplification, general theory of electromagnetic seismographs, response of the electromagnetic seismograph to sinusoidal movements and to abrupt movement of the ground, apparatus without equivalent reaction to a given apparatus, principal types of electromagnetic seismographs, calculations of an apparatus having given properties, standardization of an electromagnetic seismograph, verification of standardization and functioning of an electromagnetic seismograph, and various questions of adjustment.

DWORNIK, S. E., and ORR, D. G., "Reflectance Studies of Vegetation Damage," U. S. Army Engineer Research and Development Laboratories, Ft. Belvoir, Va., Tech. Summary Rept. No. 2 (1961). Filed as USAERDL Tech. Memo. N-22-A.

This report presents data collected at the Nevada Test Site during the period 20-28 June 1961 in connection with research on means of detecting underground nuclear explosions. Reflectance curves were obtained from 42 samples excluding 3 samples from the March Field Trip (Mormon fea, sagebrush, rabbitbrush), and including one dead pinion and one living oak. A detailed list of samples is included in Appendix I of the report. Reflectance curves are contained in Appendix II.

EWING, J., and EWING, M., "A Telemetering Ocean-Bottom Seismograph," J. Geophys. Research, V. 66, n. 11, pp. 3863-3878 (1961).

Successful tests of a telemetering ocean-bottom seismograph have been made on three occasions. In all cases, the seismograph was resting on the ocean bottom or planted in the sediments, sending its information to the surface by frequency modulation of a supersonic beam. The use of cables connecting the instrument on the bottom to the recording ship was avoided so that the level of background noise would not be influenced by having a long cable shake the instrument. These first tests were designed to help determine what frequencies should be recorded, at what levels, and what method is best for transmitting the earth's vibrations in these frequencies to the recording instrument at the surface. Neither the instru-

ment nor the method used was optimal for obtaining all of the seismological data from the ocean bottom, but they have demonstrated the feasibility of ocean-bottom seismographs and have helped to determine the criteria for the more complicated instruments and methods of transmittal which will ultimately make up a worldwide system. Data from such a system are expected to settle the question of the origin and propagation of microseisms, provide detailed information about the sedimentary layer and about the earth's crust and upper mantle, and, most important of all, may greatly increase the radius over which a single station can monitor small earthquakes or explosions.

In the preliminary tests, body waves from one earthquake and several seismic refraction profiles were recorded. The earthquake record indicates reasonably good signal-to-noise ratio in the short-period range. The refraction profiles give indications from P and S waves of important regional and local variations in the character of the crust-mantle interface.

EWING, M. See Ewing, J.; Landisman, M.

FEOFILAKOV, V. D. See Rykunov, L. N.

FLANAGAS, W. G., and SHAFFER, L. E., "An Application of Nuclear Explosives to Block Caving Mining," U. of California, Livermore, Lawrence Radiation Laboratory, UCRL Rept. No. 5949 (1960).

Drilling and mining explorations at the site of the Rainier event (detonated at the Nevada Test Site of the U. S. Atomic Energy Commission) have revealed that it is possible to mine back into the area of a nuclear explosion by the use of commonly accepted mining methods. Therefore, it also appears possible to apply nuclear explosives in preparation for mining by a modified block-caving technique.

FOOSE, R. M., and HOY, R. B., "Identification of Possible Underground Nuclear Explosions by On-Site Inspection," Stanford Research Inst., Menlo Park, Calif., Operation Hardtack-II, Final Report (1959).

This report summarizes the results of investigations of techniques and methods to be used by an inspection team seeking evidence of clandestine underground nuclear explosions.

During the Hardtack II operations at the Nevada Test Site in 1958, SRI investigated the practical application of aerial observation and photoreconnaissance methods, and ground and underground inspection methods—including geologic mapping, recording postshot disturbances, and measuring postshot surface motions.

Information obtained by other agencies participating in the operation, which may be pertinent to the detection of underground nuclear explosions, has been assembled.

On the basis of information from the Hardtack II investigations, the inspection methods have been evaluated as to their applicability and limitations; appropriate revisions have been set forth regarding the role and operating methods of mobile inspection teams; clues have been tabulated of on-site human activity peculiar to the conduct of an underground nuclear explosion; and recommendations have been made regarding methods and equipment to be used for drilling to obtain a radiochemical sample.

FORBES, C. B., and HEALD, C. L., "Refraction Seismic Survey — Porpoise Area," VELA UNIFORM Porpoise — Project 7.4A, United ElectroDynamics, Inc., Pasadena, Calif. (1961).

Two short seismic-refraction profile lines were shot south of the Climax Granitic Stock in Nye County, Nevada, to map the southeast boundary fault and determine the relationships of the adjoining fault blocks. The purpose of the survey was to study the geologic structure in the vicinity of the proposed Porpoise site. Shot holes were drilled to depths ranging from 105 to 120 feet in alluvium, charge sizes varied from 40 to 600 pounds (charges in excess of 200 pounds were in multiple holes), and each survey line was laid out with geophones spaced at 135 feet. The results showed that slippage of the fault exceeds 750 feet, with down-throw to the southeast. The approximate dip of the fault plane was estimated as 55^{o}.

FREILING, E. C., "Fractionation I: High-Yield Surface Burst Correlation," AD 232 085, U. S. Naval Radiological Defense Laboratory, Research and Development Tech. Rept. USNRDL-TR-385 (1959).

This report describes the phenomenon of fractionation and explains its importance to various radiological and chemical problems. Data from four high-yield surface bursts over sea water and coral are correlated. The correlations appear to hold within a factor of 2 for even the worst cases, compared to observed fractionation factors as high as 100. Possible applications are discussed.

GILMAN, R., "Report on Some Experimental Long-Period Seismographs," Bull. Seism. Soc. Am., V. 50, n. 4, pp. 553-559 (1960).

The unexpected usefulness in research of the Press-Ewing seismograph system has stimulated further efforts to obtain even higher seismograph sensitivity in the period range beyond 100 seconds. A major difficulty has been in maintaining pendulum stability at long periods. This paper describes a stable long-period seismometer and gives results from several seismograph systems incorporating long-period pendulums and galvanometers.

GLOYNA, E. F. See Serata, S.

GRINE, D. R., "VELA UNIFORM — Dynamic Properties of Rocks," Stanford Research Inst., Menlo Park, Calif., Semi-Annual Technical Report, on Contract AF 19(604)-8419 (1961).

This is the first technical summary report on a project to produce information useful in prediction of effects of the medium on stress waves produced by underground explosions. Work is concentrated on determination of Hugoniot equations of state of two rock-forming materials: quartz, and calcite. It describes laboratory experiments on single crystals in various alignments, and on blocks of unusually fine-grained and homogeneous Eureka quartzite, Lococino sandstone, Yule marble, and Indiana limestone. Techniques for machining these rocks to small tolerances have been developed. Experimental methods used were: beveled-pellet method, plane-wave wedge method, and a two-dimensional wedge experiment. Results of laboratory shots on these rocks are tabulated: shock

velocity U (km/sec), particle velocity u (km/sec), stress σ (kb), and compression P_0/P. Particular attention is being given to all phenomena likely to be useful in understanding propagation of large-amplitude waves in rocks.

GUTENBERG, B., "Microseisms," Advances in Geophysics, V. 5, pp. 53-92 (1958).

This general discussion of the nature and causes of microseisms includes the following subjects: the definition, history, and classification of microseisms; instruments for the investigation of microseisms; artificial causes for microseisms; natural microseisms with periods less than 2 seconds, period 1-3 seconds, periods of about 4 seconds, periods of 4-10 seconds, and periods of 10 seconds to several minutes; and theory of microseisms. A list of 182 references is included.

HAGIWARA, T., HIRONO, T., HISANDA, T., KAWASUMI, H., et al., "East Asian Area Seismology and Earthquake Engineering Seminar Monograph Japan," UNESCO New York (1961).

This monograph was prepared as material to be used by the Survey Mission sent by UNESCO to East Asia during June and July 1961 to conduct a survey of seismology and earthquake engineering in the area. It contains more than 35 articles, with pictures and charts of installations, buildings, etc., as well as samples of tabulated data. The topics considered are: seismological observation, Tsunami observation, volcanological observation, prediction of earthquakes, earthquake dangers, laws and recommendations for aseismic structures, research organizations, and educational systems. The International Training Center on earthquake engineering recently established in Japan is also discussed.

HARKRIDER, D. G., and ANDERSON, D. L., "Computation of Surface Wave Dispersion for Multilayered Anisotropic Media," Calif. Inst. of Technology, Pasadena, Contract No. AF 49(638)-910.

With the program described in this paper it is now possible to compute surface-wave dispersion in a solid heterogeneous half-space containing up to 200 anisotropic layers.

Certain discrepancies in surface-wave observations, such as disagreement between Love- and Rayleigh-wave data and other independent evidence, suggest that anisotropy may be important in some seismological problems. In order to study the effect of anisotropy on surface-wave dispersion, a program was written for an IBM 7090 computer which will compute dispersion curves and displacements for Rayleigh waves in a layered half-space in which each layer is transversely isotropic. A simple redefinition of parameters makes it possible to use existing programs to compute Love-wave dispersion.

HASKELL, N. A., "A Static Theory of the Seismic Coupling of a Contained Underground Explosion," J. Geophys. Research, V. 66, n. 9, pp. 2937-2944 (1961).

According to the theory of Latter, Martinelli, and Teller, the amplitude of the distant seismic signal from a completely contained underground

explosion is determined by the permanent displacement produced in the neighborhood of the source. A static-equilibrium theory of this displacement is developed. A Coulomb-Mohr type of yield condition is used to determine the stresses in the near zone where the stresses are beyond the elastic limit. If the internal friction parameter that occurs in the Coulomb-Mohr yield condition is treated as a phenomenological constant, to be determined by the seismic data, it is possible to obtain reasonably good agreement with the relative amplitudes of the seismic signals observed in the Project Cowboy series of chemical explosions in cavities of various sizes in salt. The indicated value of the friction parameter is, however, appreciably less than the values usually observed in compression tests on unconsolidated materials. The theory is also consistent with the observed size of the cavity produced in tuff by the underground nuclear explosion Rainier, but an even smaller value of the friction parameter must be assumed.

HASSMAN, M., and COHEN, E., "Review of Blast Closure Systems," TISE-AEC No. NP-10507, pp. 233-274, Ammann and Whitney, New York.

Results are presented of studies made on existing self-acting blast and remote actuated blast closure systems and of analyses of available test data. Recommendations are made concerning the various structural and mechanical design parameters. Existing designs are reviewed critically. Limitations of protection afforded by remote actuated designs are presented. It is concluded that maximum system reliability is obtained through the use of self-acting blast-actuated valves which are not dependent upon external sensors and are suitable for multibursts. New valve concepts are developed and discussed, with designs presented which have inherent advantages over existing valves, for high-volumetric flow capacities and for combustion-type equipment. The delay-path concept is described. An appropriate method is developed for shock flow into plenums prior to valve closure. An orifice method of analysis is developed for flow into a chamber past a valve which is closing. These methods are checked against existing test data and proved to be conservative in all cases. Plenum chambers are sized to limit pressure build-up to 2 psi, using the approximate method, for all existing valves studied. Recommendations are made for improvement in valve design and installation.

HEALD, C. L. See Forbes, C. B.; Swain, R. J.

HEALY, J. H., and PRESS, F., "Two Dimensional Seismic Models with Continuously Variable Velocity Depth and Density Functions," Geophys., V. 25, n. 5, pp. 987-997 (1960).

A method for fabricating two-dimensional ultrasonic seismic models with variable velocity and density is described. The method is justified theoretically. It is tested by comparing the experimental and theoretical dispersion of Rayleigh waves in a model of a two-layered earth crust.

HENRIE, T. A., RENNER, R. A., OLSON, R. L.,LEONE, O. Q., and BAKER, D. H., Jr., "Problems in Recovering Thermal Energy from Molten Salts," U. S. Bureau of Mines, Rept. No. BM-RI-5812 (1960).

A study was conducted to determine the problems involved in recovery of thermal energy from molten salts. The study was conducted in

connection with Project GNOME which will be conducted in an underground salt deposit to determine the feasibility of recovering thermal energy from underground nuclear explosions.

HESS, W. N., and NORDYKE, M. D., "Throwout Calculations for Explosion Craters," J. Geophys. Research, V. 66, n. 10, pp. 3405-3412 (1961).

A study of the throwout from an explosion crater is discussed. Starting with particles in motion in the crater, the lip build-up is followed until all particles have landed. Working with experimental information from a 500-ton high-explosive explosion, calculation of the apparent crater and lip shape and characteristics was attempted. So far the calculations are only rough, and the data are preliminary. g and also the size of the crater were changed to try to see how craters on the moon would look.

HILL, G., "Still-Warm Cavern Yields Secrets of '57 Atom Blast," New York Times, V. 110, n. 37,788, p. 1 (July 10, 1961).

Radiation from the Rainier underground nuclear explosion of September 17, 1957, in Nevada, has so diminished in nearly four years that it is possible to enter and inspect the explosion cavern itself. Residual heat causes a temperature of 100°F at the upper end of the chamber. Particles of radioactive fused rock, of hardness 7 to 8 and as large as the Hope diamond, were formed. A tour of the cavern and tunnel to it is described.

HILLER, W. See Berckhemer, H.

HINDE, B. J. See Darbyshire, J.

HIRONO, T. See Hagiwara, T.

HISANDA, T. See Hagiwara, T.

HOCHSTRASSER, U., and STONELEY, R., "The Transmission of Rayleigh Waves across an Ocean Floor with Two Surface Layers," Part II: "Numerical," in A. H. Cook and T. F. Gaskell (eds.), The Earth Today, Interscience Publishers, New York, pp. 197-201 (1961).

This investigation obtains values of the wave velocity and group velocity of waves of Rayleigh type, following ocean paths corresponding to the structures indicated by experimental investigations using explosions at sea. Eight different models have been considered, with ocean depths 4 or 6 km, a sedimentary layer of depth 1 or 2 km, underlain by basic rocks of thickness 5 or 7 km; in all cases these structures were supposed to rest on ultrabasic rocks of great thickness.

The wave velocity was found for a series of values of the wave number by solving an 11-row determinantal equation; the computations were performed by the use of the SEAC electronic computer of the U. S. National Bureau of Standards, and from these values the corresponding values of the group velocity were obtained by numerical differentiation. The general agreement of these dispersion curves with observed values indicates that they should be useful in determining the ray track and time of passage of a train of Rayleigh waves crossing an ocean floor whose structure and depth vary from place to place.

HOFFMAN, G. A., "Thermoelectric Powerplants Utilizing Contained Nuclear Explosions," The RAND Corp., Santa Monica, Calif., Rept. No. RM-2490-1(RAND) on Contract No. AF 49(638)-700 (1960).

The problem of stationary thermoelectric power plants that would utilize the thermal energy released by detonating nuclear devices in a closed cavity surrounded by a heat exchanger is defined. The major obstacles to the realization of such a system are: the excavation of large (up to 1500 ft in diameter) cavities in rock and their preservation under lithostatic and explosive pressures; the definition of the shock phenomena from the detonation and the response and survival of the cavity and heat exchanger under the reflected shocks up to 3000 psi for very short durations; and the overall economic feasibility of the system, which may require a capital investment of $2 billion but might produce electric power at a cost competitive with that of conventionally produced power. The evaluation of these problems is prompted by the advantages of such a hypothetical system; the use of transient fusion pulses, with the energy being absorbed by a heated gaseous mass and slowly released to turbo-electric generators, seems an early, though unrefined, solution to the problem of exploiting fusion energy, and is far less complicated than the requirements for using a sustained fusion process. The results suggest that none of the obstacles is insurmountable.

HONSHO, S. See Nagumo, S.

HOOK, J. F., "Seismic Wave Propagation in Inhomogeneous, Isotropic Media—Outline of Method of Analysis," National Engineering Science Co., Pasadena, Calif. (1961).

This paper outlines a method for analyzing seismic-wave propagation in inhomogeneous media. Previously, it has been most difficult to treat such problems analytically because no method was available to separate the vector wave equation into its P, SH, and SV components. The Stokes-Helmholtz potential representation accomplishes this separation in homogeneous media, but fails in most cases of inhomogeneous media. The method outlined in this paper utilizes a generalization of the Stokes-Helmholtz representation to achieve separation in a number of interesting cases.

HOUSNER, G. W., "The Earthquake Ground Shock Problem and Its Relation to the Explosive-Generated Ground Shock Problem," TISE-AEC No. NP-10507, pp. 157-168, Calif. Inst. of Technology, Pasadena.

The problems of earthquake ground shock and explosive-generated ground shock are similar. This report covers applications of techniques and instruments (shock spectra, reed gauges, accelerometers) for solving the former to the latter. Some significant differences are more easily handled for explosive-generated ground shock than for those of earthquakes; these difficulties lie in the character of the spectra, the degree of ground coupling, the relative scale of phenomena, and the influence of soil properties. Some of the difficulties, however, are common to both.

HOY, R. B. See Foose, R. M.

HUDSON, D. E., et al., "Ground Accelerations Caused by Large Quarry Blasts," Bull. Seism. Soc. Am., V. 51, n. 2, pp. 191-202 (1961).

Ground acceleration-time measurements have been made within 2000 feet of two quarry blasts of total charge weight 185 tons and 673 tons. Ground accelerations were of a character and magnitude similar to those associated with damaging earthquakes. Complete response spectrum curves calculated from the acceleration records are presented. Direct comparisons are made, using identical instruments, between these results and previous similar measurements and calculations made of strong-motion earthquakes, high-explosive blasts, and the Rainier nuclear blast.

HUDSON, D. E. See also Cloud, W. K.

HUNKINS, K. L., "Seismic Studies of Sea Ice," J. Geophys. Research, V. 65, n. 10, pp. 3459-3472 (1960).

During the International Geophysical Year, elastic-wave propagation in sea ice was studied near Drifting Station Alpha in the central Arctic Ocean. Velocities of longitudinal and transverse waves in ice showed a marked seasonal change which is largely attributable to variations in ice temperature. With these velocity data, plus additional data on density, the calculation of various elastic constants of sea ice throughout the year can be made.

Flexural wave dispersion was investigated for different ranges, charge sizes, and ice parameters. Experimental results are in general agreement with theory. Thickness, as determined from the dispersion of flexural waves and from air-coupled flexural waves, is characteristically lower than that found by direct measurement.

Both longitudinal and flexural waves crossing leads suffer severe attenuation. Transmission across leads shortened the duration of the normal air-coupled flexural wave train.

JACOBS, J. M., SMELCER, N. K., and VORESS, H. E., "Bibliographies of Interest to the Atomic Energy Program," TISE-AEC No. TID-3043 (Rev. 1) (Suppl. 2) (1961).

This publication contains 442 references to bibliographies and literature surveys on various aspects of atomic energy and allied subjects, received during the period November 1959 to November 1960. References cited are to both reports and periodical literature. They are arranged alphabetically by issuing agency. Subject, author, and report-number availability indexes are provided.

KAPLAN, K., ZACCOR, J. V., and WILLOUGHBY, A. B., "A Device for Determining Dynamic Stress-Strain Relationships of Soils," TISE-AEC No. NP-10507, pp. 65-74, Broadview Research and Development Corp., Burlingame, Calif.

A device for the rapid determination of stress and strain in small soil samples under dynamic loading conditions is described. Stress in the sample can be built up to a constant value in times as short as a few tenths of a millisecond through multiple reflections of the input stress pulse between the two ends of the sample and can be maintained at this level indefinitely.

KAWASHIMA, T. See Nagumo, S.

KAWASUMI, H. See Hagiwara, T.

KISSLINGER, C., MATEKER, E. J., Jr., and McEVILLY, T. V., "SH Motion from Explosions in Soil," J. Geophys. Research, V. 66, n. 10, pp. 3487-3496 (1961).

Although not predicted by simple theory, prominent tangential horizontal motion is observed in almost all cases from both chemical and nuclear explosions. A series of experiments designed to clarify the factors that are significant in producing this motion has been carried out. The seismograms, recorded at small distances, clearly indicate the asymmetrical pattern of radiation of the SH motion in the source region, as contrasted with the symmetrical pattern for the radial and vertical motion. This radiation pattern is the most useful indicator of the nature of the generating mechanism. The combined effect of charge size and depth determine which of two wave forms will appear. The most prominent SH motion is in the form of Love waves, but this motion is much more pronounced for shallow shots that produce cratering, or at least surface cracking, than for completely contained shots. An examination of theoretical radiation patterns indicates that crack formation may contribute significantly to the generation of SH motion.

KOGAN, S. D., "Travel Times of Longitudinal and Transverse Waves, Calculated from Data on Nuclear Explosions Made in the Region of the Marshall Islands," Izvest. Akad. Nauk S. S. S. R., Ser. Geofiz., n. 3, pp. 246-253 (1960).

The Jeffreys-Bullen travel-time curve is compared with true travel-time curves for surface focus in the western part of the Pacific Ocean. The true curve of a P wave is 2 seconds less, of a PP wave 5 seconds less, and of a PcP wave 3 seconds less. That of a transverse wave is 4-5 seconds greater; and if corrections for longitudinal waves can be nearly completely explained by the absence of a granite layer in the Pacific Ocean region, then corrections for transverse waves are probably related to the values for the velocity of S waves in the upper part of the mantle, which are less than those currently accepted.

KOGAN, S. Ya., "On the Determination of the Energy of Seismic Waves of Arbitrary Form," Izvest. Akad. Nauk S. S. S. R., Ser. Geofiz., n. 5, pp. 426-430 (1960).

A formula is obtained for the calculation of the energy of Rayleigh surface waves of arbitrary form, using the displacement and the velocity of displacement of the ground at the point of observation. This formula is derived on the basis of a general expression of the density of flow of energy. By way of an example of this general expression, the formula of Zoeppritz-Wiechert for the longitudinal body wave is obtained.

KOOPMANS, L. H., "An Evaluation of a Signal-Summing Technique for Improving the Signal-to-Noise Ratios for Seismic Events," J. Geophys. Research, V. 66, n. 11, pp. 3879-3893 (1961).

For seismic events, formulas are derived for evaluating the improvement in the rms signal-to-noise ratio as a function of frequency. The

technique consists of summing the trace amplitudes recorded at a number of closely spaced seismometer stations. A modification whereby the signals are corrected for phase shift before summing is also studied. The theory is applied to noise data from a three-station network for the ranges of periods 6.7 to 20 seconds and 0.25 to 1 second. The signals in the short-period range are taken to be P and S body waves. Rayleigh waves are used in the long-period range. Improvement comparable to and occasionally in excess of that expected for uncorrelated noise is indicated for the modified technique in the short-period range, whereas little improvement is obtained in the long-period range for the given station spacing and noise conditions.

KOVACH, R. L., and PRESS, F., "Rayleigh Wave Dispersion and Crustal Structure in the Eastern Pacific and Indian Oceans," Geophys. J. Roy. Astron. Soc., V. 4, pp. 202-216 (1961).

Rayleigh-wave dispersion data are presented for a number of earthquakes having their epicenters in the Easter Island area and recorded at Pasadena, California. The dispersion data differ in a small but significant way from those obtained for Pacific Ocean basin paths. When the seismic refraction data of Raitt are used to compute theoretical Rayleigh-wave dispersion curves, discrepancies with the observed Easter Island-Pasadena data are found, and these are resolved by the addition to the assumed theoretical model of a modified low-velocity zone in the upper mantle. This modification consists of lowering the mean shear velocity in the upper mantle to 4.5 km/sec. A theoretical model compatible with the compressional velocities obtained by seismic refraction measurements and the dispersion data is shown to be possible. Such a model does not require changing Poisson's ratio from the usual value, with consequent reduction of the shear velocities in the upper mantle. The model is developed by reducing the thickness of the layer with compressional velocity 8.2 km/sec to the minimal thickness required to give a refraction arrival. The mean shear velocity of 4.5 km/sec implies a "soft" upper mantle along the path from Easter Island to Pasadena. Dispersion data also show that the mean thickness of unconsolidated sediments between Easter Island and Peru is 0.57 km.

Rayleigh-wave dispersion data are also presented for Indian Ocean shocks recorded at Wilkes Station, Antarctica. Within the limits of observational error, the Indian Ocean data are in agreement in the period range from 37 to 25 seconds, with the theoretical model assumed for the Easter Island-Pasadena data.

KUHN, V. V., "The Peculiarities of Seismic Waves in Media with Vertical Interfaces," Izvest. Akad. Nauk S. S. S. R., Ser. Geofiz., n. 5, pp. 434-442 (1960).

The results are presented of a study on three-dimensional liquid-solid models of the pecularities of seismic waves in media with vertical interfaces in the presence of a covering layer. An analysis is made of the dependence of the relative intensity of head and diffracted waves on the thickness of the covering layer and the ratios of the velocities and densities at the vertical boundary. Some examples are adduced of the comparison of the results of the study of media with vertical interfaces obtained both from models and in experimental field work.

LAING, E. B., and COHEN, E., "Design Below Ground Arch and Dome Type Structures Exposed to Nuclear Blast," TISE-AEC No. NP-10507, pp. 188-223, Ammann and Whitney, New York.

The discussion covers some of the problems encountered in the design of hardened shallow-buried and earth-mounded arch- and dome-type structures. Design equations for determining idealized loadings, frequencies, response values, and stresses are proposed. Effects of change of arch curvature, nonrigid subgrade, arching, and compatability of edge displacements are discussed.

LAVER, F. J. M., Waves, Oxford Univ. Press, London (1959).

The types, form, and behavior of waves are discussed in 18 chapters. The first three chapters deal with the general nature of a wave and some of the different kinds of waves. The next nine chapters discuss the behavior of waves, including speed and force; echoes, reflections, and interferences; shadows; mixing and separating; and vertical and horizontal motion. Specific types of waves are discussed in four chapters: water, sound, earthquake, and electromagnetic waves. The book is concluded with a chapter on waves in general and a list of references.

LEET, L. D., "Ground Vibrations from Trinity Tests," U. S. Atomic Energy Comm. Rept. No. 2844 (1945).

An analysis of records of the 100-ton shot of May 7, 1945, combined with those of extensive tests of vibrations from quarry blasting, show that there is no possibility whatever of damage to property from ground vibrations caused by either the 100-ton shot, a 5000-ton shot, or a 50,000-ton shot.

It is recommended that vibration measurements in towns near blast areas be made inside buildings to permit determination of the effect, if any, of airborne concussion, as well as ground vibrations, on the buildings.

LEET, L. D., Vibrations from Blasting Rock, Harvard Univ. Press, Cambridge, Mass. (1960).

The process of blasting rock involves a series of preparatory steps and a complicated sequence of events during and after detonation of the explosive. The size, depth, and separation of the drill holes, and their separation from a free face, influence the results. Rocks respond to explosives in ways governed by their mineral components and history of formation. Of great importance are joints, bedding planes, foliation, and variation in their properties brought about by weathering. Joints are especially important since they are surfaces along which the rock is actually broken before any blasting takes place.

When an explosive buried in rock is detonated, a small volume of rock in the immediate vicinity is shattered by compression. When the pressure front reaches a rock-air boundary, it is reflected back into the rock as a tension front. The combined effect of pressure and tension at the rock-air boundary is to rupture the rock. In the rest of the rock, the pressure front rapidly decays into elastic waves which constitute the vibrations that sometimes shake structures and people.

The effectiveness of an explosive in breaking rock depends on the total energy it releases, the rate at which this energy is released, and the efficiency with which it is transmitted to surrounding rock. These factors are not controlled by any single property of the explosive, but on the other hand total energy is a very useful characteristic by which to rate explosives relative to each other.

LEET, L. D., "Vibrations from Construction Blasting," Explosives Eng., V. 38, n. 1, pp. 13-19 (Jan.-Feb. 1960); n. 2, pp. 47-53 (Mar.-Apr. 1960).

The process of blasting rock involves a complicated series of steps before and after the blast, and the problems encountered in various types of blasting operations vary widely. The factors important to the results are: size, depth, spacing of holes; distance from any free rock face; the location of explosives in the hole; and the quantity of explosives required to break a specified volume of rock. This paper reports on the effects of explosions on rocks, the cratering encountered, and ground displacements as determined by a Leet seismograph. Some effect of explosion vibrations on structures is also discussed.

LEONE, O. Q. See Henrie, T. A.

LINKOV, E. M., and TRIPOLNIKOV, V. P., "A Magnetoelectronic Seismograph," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 2, pp. 164-165 (1961).

The magnetoelectronic seismograph, which is of a simple construction, has a high sensitivity that is not dependent on amplitude. This high sensitivity makes it possible to use the seismograph to transmit seismic signals by radio. The seismograph can be used for magnetic recording and for the electron-beam and galvanometric registration of seismic waves, as well as for measurement of tiltings of the earth's surface.

LOMBARD, D. B., "The Hugoniot Equation of State of Rocks," U. of Calif., Livermore, Lawrence Radiation Laboratory, UCRL-6311 (1961).

In considering peaceful applications for nuclear explosions detonated underground, one is concerned with the action of strong shocks which proceed from the center of detonation into the surrounding medium. The propagation of such shocks and their effect on the medium are directly related to the useful purposes to which nuclear explosives can be put. Furthermore, in planning experimental explosions it is highly desirable to predict with good accuracy the effects of the shock. Predictions are based partly on a knowledge of the Hugoniot equation of state.

For these reasons, the equations of state of several common rocks have been measured by Alder's group at Livermore. Plane hydrodynamic shocks were produced by conventional high-explosive techniques and transmitted to pellets of the rock by aluminum plates. Shock times of arrival at aluminum and rock surfaces, and free-surface velocities were recorded by an argon flash-block technique and a sweep camera. This method has been discussed by various authors. Shock velocity and free-surface velocity are measured in these experiments.

Measurements have been made at pressures ranging from 70 kb to 900 kb. Rock salt, granite, tuff, marble, dolomite, limestone, basalt, and

other rocks have been studied; several points on the P-V curve for each have been measured. Particularly interesting data for granite and basalt have been obtained. Further work is in progress.

The desirability of making in situ peak pressure measurements on shocks generated by actual nuclear explosions has led to the development of an instrument which employs pin-contractors to measure shock velocity and free-surface velocity at locations in the rock medium not far from the explosion. The instrument has performed satisfactorily in high-explosive tests. It is hoped that shock stresses from below 100 kb to over 1 Mb can be measured in this fashion.

LONG, R. P., "Evaluation of Methods of Installation of the Wiancko-Carlson Earth Pressure Gage, "Ballistic Research Laboratories, Aberdeen Proving Ground, Md. (1958).

This report is the first phase of a study of the Wiancko-Carlson earth pressure gage to find a method of installation which will give accurate results and can be accepted as a standard.

In this phase of study, an applied load was point concentrated and also uniformly distributed to the gage. The two sets of records were compared. Then force was distributed over the gage placement. Three gage positions were used. The gage was also examined to determine if there were any weakness in the construction.

The results show that there is little variation between point concentrated and uniform loading for the increasing pressure curves, that a flush-mounted gage will give equal distribution of force over the gage placement, that additional data are required on gages mounted above and below the surface of the gage placement before any definite conclusions can be reached, and that the hinge of the gage must be protected at all times.

MATEKER, E. J., Jr. See Kisslinger, C.

MATHEWS, J., "Static Deformation of a Plastic Medium," The RAND Corp., Santa Monica, Calif., Research Memorandum, under U. S. Atomic Energy Comm. Contract No. AT (11-1)-135 (1961).

This report presents static solutions for the displacement and stresses in a plastic medium surrounding a spherical cavity in which a hydrostatic pressure exists. Various cases are presented, including that in which the pressure "unloads" the plasticity caused by the formation of the cavity. Numerical examples are presented at the end of the report.

MATTHIAS, R. H. See Snay, H. G.

McDONAL, F. J., ANGONA, F. A., MILLS, R. L., SENGBUSH, R. L., Van NOSTRAND, R. G., and WHITE, J. E., "Attenuation of Shear and Compressional Waves in Pierre Shale," Geophys., V. 23, n. 3, pp. 421-437 (1958)

Attenuation measurements were made near Limon, Colorado, where the Pierre shale is unusually uniform from depths of less than 100 feet to approximately 4000 feet. Particle-velocity wave forms were measured at distances up to 750 feet from explosive and mechanical sources. Explos-

ives gave a well-defined compressional pulse which was observed along vertical and horizontal travel paths. A weight dropped on the bottom of a borehole gave a horizontally traveling shear wave with vertical particle motion. In each case, signals from three-component clusters of geophones rigidly clamped in boreholes were amplified by a calibrated, wideband system and recorded oscillographically. The frequency content of each wave form was obtained by Fourier analysis, and attenuation as a function of frequency was computed from these spectra.

For vertically traveling compressional waves, an average of six determinations over the frequency range of 50-450 cps gives $\alpha = 0.12f$. For horizontally traveling shear waves with vertical motion in the frequency range 20-125 cps, the results are expressed by $\alpha = 1.0f$. In each case attenuation is expressed in decibels per 1000 feet of travel and f is frequency in cps. These measurements indicate, therefore, that the Pierre shale does not behave as a viscoelastic material.

McEVILLY, T. V. See Kisslinger, C.

MEIDAV, T., "Nomograms to Speed up Seismic Refraction Computations," Geophys., V. 25, n. 5, pp. 1035-1053 (1960).

Nomographic solutions of a number of equations commonly employed in seismic refraction work are presented. The equations solved are: (1) depth to a second layer, by means of the critical distance formula; (2) the critical angle and offset distance formulas; (3) true velocity of bedrock from the apparent up- and down-dip velocities; (4) depth to a second layer by means of the intercept-time formula. This last solution is also applied to (a) finding the throw of a fault, and (b) depth to an irregular second layer at each seismometer beyond the critical distance. Geometry of each of the nomograms is explained. Procedure for using each of the nomograms is described.

MELTON, B. S., "Useful Concepts for the Engineering Design of Seismographs," Earthquake Notes, V. 31, n. 3, pp. 26-27 (1960).

The important conclusions resulting from theoretical and experimental studies of electromagnetic seismographs are listed. They are given without proof to indicate the present possibilities and advisable practices that can lead to good seismograph design.

MICKEY, W. V., "Operation Plowshare, Project Scooter, Surface Motion from a Cratering Shot in Desert Alluvium," U. S. Dept. of Commerce Rept., U. S. Coast and Geodetic Survey, Washington 25, D. C. (1961).

A 1,000,000-pound high-explosive tamped shot in desert alluvium produced transient displacements on the alluvial fill out to 14,000 feet, which were about four times larger than comparable shots in tuff with the detector on bedrock. The accelerations were from 5 to 8 times as large as the predicted values but with a systematic convergence to the scaling curve with increasing distance. Maximum displacements were in the surface-wave group. Stations on bedrock recorded displacements very close to predicted values.

MICKEY, W. V. See also Carder, D. S.

MILLS, R. L. See McDonal, F. J.

MORRIS, R. H. and SCHNEIDERHAN, R. C., "Operation Hardtack, Phase II, Earth Motion Studies, Project 26.5 (UCRL)," Edgerton, Germeshausen and Grier, Inc. Rept. No. ITR 1706 (1959).

EG&G, Inc., performed earth motion photography for UCRL (Project 26.5) on the seven tunnel shots in Area 12. This report contains the camera-instrumentation and target-array details pertinent to Project 26.5 and the results obtained from surface-motion measurements on the Blanca and Neptune shots.

MURPHEY, B. F., "High Explosive Crater Studies: Desert Alluvium," Sandia Corp., Albuquerque, N. Mex., Rept. No. SC-4614(RR) (1961).

Crater dimensions were determined for 23 explosions of 256-pound spherical TNT charges buried in desert alluvium. As opposed to previous work covering depths of burst as great as 6 feet, the work presented in this report extends knowledge of apparent crater radius and depth to depths of burst as great as 30 feet. Optimum depth of burst for apparent crater radius was near 10 feet and for apparent crater depth near 8 feet. Photography illustrated a very great slowing down of the surface motion between depths of burst of 9.5 and 15.9 feet. Crater contours, profiles, and overhead photographs are presented as illustrations.

MURPHEY, B. F., "High Explosive Crater Studies: Tuff," Sandia Corp., Albuquerque, N. Mex., SC-4574(RR), TID-4500, 16th Ed. (1961).

Spherical charges of TNT, each weighing 256 pounds, were exploded at various depths in tuff to determine apparent crater dimensions in a soft rock. No craters were obtained for depths of burst equal to or greater than 13.3 feet. It was deduced that rock fragments were sufficiently large that charges of greater magnitude ought to be employed for crater experiments intended as models of nuclear explosions.

MURPHY, L. M. See Carder, D. S.

NAFE, J. E., and BRUNE, J. N., "Observations of Phase Velocity for Rayleigh Waves in the Period Range 100 to 400 Seconds," Bull. Seism, Soc. Am., V. 50, n. 3, pp. 427-439 (1960).

Phase velocity as a function of period has been determined for Rayleigh waves in the period range 100 to 400 seconds. The results were derived from a study of seismograms from the southeastern Alaska earthquake of July 10, 1958, and from published data on the Assam earthquake of August 15, 1960. The method depends on measurement of the travel time of wave crests along an arc of known length, with proper correction for change of period with distance. For observations of a single Rayleigh-wave train at a single pair of observing stations, crest identification is uncertain, and so too is the resulting curve of phase velocity versus period. A set of phase velocity curves may be computed, each one corresponding to a different choice of crest identification. Only one of these is consistent with the data from several earthquakes and several pairs of observing stations. In the present work, high precision in phase-velocity measurement is achieved by using the observations of the Assam earthquake's Rayleigh

waves R_3 and R_5 at Pasadena. Data from the southeastern Alaska earthquake are used to resolve the ambiguity resulting from uncertainty in crest identification. The fine phase-velocity curve is estimated to be accurate to better than 1% in the range of periods 100 to 400 seconds.

NAGUMO, S., KAWASHIMA, T., and HONSHO, S., "Model Experiment on Rayleigh Wave" (in Japanese with English Abstract), Busuri-Tanko, V. 12, n. 3, pp. 129-133 (1959).

The propagation of a Rayleigh wave in a semi-infinite elastic medium was studied in a two-dimensional model. It was found that the wavelength of a Rayleigh wave on the surface becomes longer with an increase in the shot depth; the wavelength is approximately twice the shot depth. The underground propagation of a Rayleigh wave is illustrated; the wave front of maximum amplitude seems to be inclined to the surface. The reciprocity of the Rayleigh wave between source and detector is ascertained within the error of the experiment.

NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL, "A Report to the Public on the Biological Effects of Atomic Radiation" (based on the 1960 Summary Reports of the National Academy of Sciences, Committee on the Biological Effects of Atomic Radiation) (1960).

Abstracts are given of the summary reports of six committees (see below) including (p. 9-10) report of the Committee on Disposal and Dispersal of Radioactive Wastes.

NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL, "The Biological Effects of Atomic Radiation" (summary Reports from a Study by the National Academy of Sciences) (1960).

In June 1956 the National Academy of Sciences published the first summary reports of the findings and recommendations of six committees established to study the biological effects of atomic radiations. These committees cover the fields of genetics, pathology, meteorology, oceanography and fisheries, agriculture and food supplies, and the disposal and dispersal of radioactive wastes. The present volume contains new summary reports, bringing the findings of the committees up to date, to 1960. The summary reports will be followed by reports in detail on a number of special problems. [From Foreword]

The report of the Committee on Disposal and Dispersal of Radioactive Wastes (pp. 57-66) deals with the following topics: present status of radioactive waste disposal; problem areas now under investigation; cost of radioactive waste management; magnitude of future management problem, federal-state relationships; international aspects; effects of waste management operations on man's overall radiation exposure.

NESS, N. F., et al., "Observations of the Free Oscillations of the Earth," J. Geophys. Research, V. 66, n. 2, pp. 621-629 (1961).

Free oscillations of the earth excited by the Chilean earthquakes of May 1960 were recorded with high precision at Los Angeles by a LaCoste-Romberg tidal gravimeter. Spectral analysis of 4.6 days of record sampled at 1-minute intervals shows that the spheroidal modes of type ${}_0S_?$, where

ℓ - 2, 3, 4, ..., 40, 41, were excited at periods in almost all cases within 1% of the theoretical predictions of Alterman, Jarosch, and Pekeris, based on the Gutenberg earth model. In addition, the first and second overtones for several modes have been identified. The Gutenberg model of the earth is in slightly better accord with the observations than is the Bullen model B.

Upper and lower limits for the Q's of these modes have been derived from the observations. These, in general, are of order 200 to 400, but the fundamental dilatational mode $_0S_0$ with a period of 20.46 minutes, for which shear stresses are absent, has a Q of at least several thousand and was observed even during quiet periods a month after the Chilean earthquakes. Three of the low-order modes are split, an effect which is ascribed to the earth's rotation.

NORDQUIST, J. M. See Aki, K.

NORDYKE, M. D., "Nuclear Craters and Preliminary Theory of the Mechanics of Explosive Crater Formation," J. Geophys. Research, V. 66, n. 10, p. 3439 (1961).

Four nuclear craters have been produced at the Nevada test site. Three were from 1.2-kiloton nuclear explosions in desert alluvium, a sand-gravel mix, and the fourth was from a 115-ton nuclear explosion beneath the sloping side of a bedded tuff mesa. Comparison of these craters with high-explosive craters in alluvium shows that, within experimental error, the craters produced by subsurface nuclear explosions are quite comparable with those produced by equal yield chemical explosions. Experimental data from these nuclear and chemical explosive cratering programs and theoretical machine calculations of the behavior of underground explosives make it possible to construct a picture of the major mechanisms that contribute to the formation of explosion craters. These mechanisms include compaction and plastic deformation of the medium immediately surrounding the explosion, spalling of the surface above the explosion by the tensile wave generated at the free surface of the ground, and acceleration of the fractured material overlying the explosion cavity by the gases trapped in the cavity, before and during their escape. The role that each mechanism plays changes with the scaled depth of burst of the explosive and to some extent with material. The contribution that each makes is outlined for four typical craters representing surface, shallow, optimum, and deep burial depths. For surface burial, plastic deformation and compaction are the principal actions; for shallow burial depth, spall is the dominant feature; for optimum depth, gas acceleration becomes the most important mechanism; and for deep burial, subsidence into the cavity produced by plastic deformation and compaction is the major factor. The differences to be expected between explosion craters and craters resulting from impact explosions, such as those produced by meteors are examined. The relative contribution of each of these mechanisms is also estimated for apparent crater depth vs. depth of burst.

NORDYKE, M. D. See also Hess, W. N.

NUCKOLLS, J., "Theory of Underground Explosions," U. of Calif., Livermore, Lawrence Radiation Laboratory, UCID Rept. No. 4344 (1960).

A qualitative description of the theory of underground explosions as applied to Project Cowboy is presented. The theory constitutes an approximate steady-state analysis of the cracked-elastoplasto-hydrodynamic model used in the Underground Nuclear Explosion Code. This model differs from the elasto-hydrodynamic model presented previously in that the material between the elastic and plastic regions is treated as an elastic solid with radial cracks rather than as a fluid. A critical analysis of the theory is included.

NUTTLI, O. W., "The Effect of the Earth's Surface on the S Wave Particle Motion," Bull. Seism, Soc. Am., V. 51, n. 2, pp. 237-246 (1961).

This paper is concerned with the determination of the particle motion of the earth's surface due to the incidence of a plane S wave of arbitrary polarization and incidence angles. It is assumed that the earth's surface may be represented by a plane surface.

For angles of incidence less than $\sin^{-1}(b_o/a_o)$, where a_o and b_o are the P and S wave velocities at the earth's surface, all three components of ground motion will be in phase, and the resultant motion is linear. For angles of incidence greater than $\sin^{-1}(b_o/a_o)$, all three components of ground motion will in general be out of phase, with the resultant motion describing some three-dimensional figure. The epicentral distance at which the motion changes from linear to nonlinear depends upon the wave length of the S wave and the slope of the travel time curve at that distance.

NUTTLI, O. W., and WHITMORE, J. D., "An Observational Determination of the Variation of the Angle of Incidence of P Waves with Epicentral Distance," Bull. Seism, Soc. Am., V. 51, n. 2, pp. 269-276 (1961).

Apparent angles of incidence of the P wave were obtained from the seismograms of the Galitzin-Wilip instruments at Florissant. The "half-periods" of these waves varied from 1 1/2 to 3 1/2 seconds, and the epicentral distances from 16.5^o to 103.2^o. The data indicate that the velocity of P waves at the earth's surface is approximately 8 km/sec. This suggests that these P waves "do not see" or are not affected by the earth's crust, although the crustal thickness is known to be approximately 35 km. P wave data from five other stations for the Alaska earthquake of July 1958 support the conclusions obtained from the Florissant data.

OGURTSOV, K. I., "The Improvement of Accuracy in Asymptotic Approximations for the Intensity of Waves Propagated in a Laminated Elastic Medium," Izvest. Akad. Nauk. S.S.S.R., Ser. Geofiz. n. 2, pp. 142-145 (1961).

For short intervals of time including the instant when a front arrives at the point of observation, the known exact solution is in the form of a series. In the present paper, an approximate solution is obtained by retaining the first two terms of this series (previously only one term was retained). The conditions for which the second term may not be neglected are investigated. The formulas obtained are simplified for the case when the direction of propagation of certain of the seismic waves is inclined at

a small angle to the interface. A method of simplification is pointed out for the case when the direction of propagation of the waves can be inclined at a small angle to the normal.

OLIVER, J. E., et al., "Crustal Structure of the New York-Pennsylvania Area," J. Geophys. Research, V. 66, n. 1, pp. 215-225 (1961).

Phase velocities of Rayleigh waves in the period range from 15 to 45 seconds were determined from seismograms of the Waynesburg-Ottawa-Palisades tripartite array. A theoretical model, compatible with these data and with previously published seismic-refraction data of Katz, consists of a low-velocity sedimentary layer overlying two crustal rock layers which in turn overlie the earth's mantle. The total crustal thickness is about 37 km.

Calculations of Rayleigh-wave dispersion for a variety of theoretical models show that small variations in elastic properties from place to place may cause significant errors in the determination of total crustal thickness if such variations are neglected when the phase-velocity method is used independently. The error is considerably less if supplementary data are used in conjunction with phase-velocity data, as was done in the example cited above.

OLSON, R. L. See Henrie, T. A.

ORR, D. G. See Dwornik, S. E.

PANASSENKO, G. D., "On Determining the Elements of a Seismic Ray from the Data of a Single Station," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 4, pp. 361-366 (1960).

An evaluation is given of the errors in determining the azimuthal angle and the coefficient of the horizontal component of the displacement vector for a three-component seismographic set-up as a function of the azimuthal angle. It is shown that the probability of these errors in relation to the least error at an azimuthal angle of 45^{o} grows rapidly, as a function of the azimuthal angle. Conditions are given which guarantee a given accuracy in determining the azimuthal angle and the modulus of the horizontal component.

A four-component system for an assembly of seismographs is proposed. Its advantage over the three-component system is shown. Examples are discussed of determination from a four-component assembly of seismographs of a general type (D. P. Kirnos) of the azimuthal angle, and the apparent angle of emergence of a seismic ray. Records were used from the seismographic station "Apatity".

PASECHNIK, I. P., "Seismic Method of Detecting and Identifying Nuclear Explosions," (1960); Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 6, pp. 545-551 (1961).

The seismic method is at the present time the only method of detecting and identifying underground nuclear explosions. This article describes the quantitative characteristics of the noise level at very-low-, average-, and high-noise stations for various periods. Parameters for the seismic apparatus, as recommended at the meeting of experts in 1958-1959, are presented.

PEARCE, T. H. See Carder, D. S.

PETERSON, P., "Checking the Performance of Electrodynamic Seismometers," Bull. Seism. Soc. Am., V. 50, n. 4, pp. 561-562 (1960).

The performance of electrodynamic seismometers slowly deteriorates as the magnets age and the hinges become strained. This deterioration can be determined by the extremely simple measurement of the d-c sensitivities of the seismometer and galvanometer. The change in the theoretical synchronous magnification can be calculated.

PLAGGE, H. J. See Cox, E. F.

PODYAPOLSKI, G. S., and VASSILEV, Yu. I., "A Rayleigh-Type Wave at a Non-Free Surface," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 9, pp. 859-868 (1960).

The paper adduces some experimental data and theoretical explanations of a specific low-frequency wave originating at a sharp interface; this wave is similar to a Rayleigh wave at the free boundary of a half space.

POPOV, I. I., "Dispersion of Long-Period Love Waves in the Continental and Oceanic Crust along the Path Indonesia-Crimea," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 10, pp. 970-973 (1961).

This paper examines the Love wave records obtained at the seismological station "SIMFEROPOL" which has a special long-period horizontal electrodynamic seismograph.

PRESS, F., "The Earth's Crust and Upper Mantle," Science, V. 133, n. 3463, pp. 1455-1463 (1961).

Refinements of seismic methods are being used to study the density and layering of the earth. The reality of the Conrad discontinuity, crustal layering under the continents, mechanism of isostatic compensation of topographic highs, the merger between "continental" and "oceanic" crustal layering sequence, and the significance and distribution of the low seismic velocity layer in the upper mantle are being investigated. Improvements in technique, such as correlation refraction shooting, the detailed analysis of surface waves, and gravity observations, are discussed. A combination of these seismic methods and direct drilling may help explain the connection between the seismic and physicochemical layering in the crust and mantle. The International Geophysics Committee has established an "Upper Mantle Project" to help coordinate these researches.

PRESS, F. See also Healy, J. H.; Kovach, R. L.

REED, J. W. See also Cox, E. F.

RENNER, R. A. See Henrie, T. A.

RICHARDS, T. C., "Motion of the Ground on Arrival of Reflected Longitudinal and Transverse Waves at Wide-Angle Reflection Distances," Geophys., V. 26, n. 3, pp. 277-297 (1961).

The horizontal and vertical motions of the surface of the ground on the arrival of reflected longitudinal and transverse waves from an elastic discontinuity are determined theoretically, with special reference to those parameters encountered in exploring for limestone structures in the foothills of western Canada by wide-angle reflection techniques. The results, which cover a wide range of possible overburden velocities, are expressed by means of curves from which the displacement for any practical elastic contrast, depth, and observation distance may be readily determined. Properties of these curves are examined empirically. The theory assumes plane waves in determining the amplitude ratios at the structural- or free-surface discontinuities, and spherical waves in deriving spread factors. Corrections to the curves on account of a nonuniform overburden velocity are considered in the case of a typical central foothills well. The evidence for PP and PS in model, and to a less extent in field work, and the significance of phase changes on reflection are discussed. It is concluded that the horizontal geophone should prove to be a useful additional tool in wide-angle reflection surveys in disturbed foothill zones. Here, it could confirm or refute the arrival of a reflection registered by the vertical geophones in the many cases where doubt exists.

RINEHART, J. S., "Model Experiments Pertaining to the Design of Underground Openings Subjected to Intense Ground Shocks," TISE-AEC No. NP-10507, pp. 169-197, Mining Research Laboratory, Colorado School of Mines, Golden, Colo.

In these experiments explosives were detonated above openings precast in five brittle rocklike modeling materials. The shapes of the openings and the depths from a free face were varied. The results of some two hundred tests which provide an excellent insight into the nature of failures are described.

RINEHART, J. S., "On Fractures Caused by Explosions and Impacts," Quart. Colo. School Mines, V. 55, n. 4 (1960).

This report presents in a relatively elementary manner the solutions to a large number of problems connected with fracturing, occurring under impulsive loads, such as might be generated by explosions and impacts. Little attention is given here to practical applications, the intent being the laying down of sets of basic rules and the completion of a large number of illustrative exercises.

Many attributes of the character of transient stress disturbances and the laws which govern their movement through materials are delineated, with considerable emphasis being given to reflections at boundaries and transmittal through layered media. These laws are the foundation upon which the remainder of the report rests.

The way in which momentums and energies become distributed and partitioned within an impulsively loaded body, and a clear account of spalling and its many ramifications are presented.

The movement of a transient disturbance is strongly affected by abrupt changes in the physical properties of the medium through which it is traveling. The fundamental character of these effects is outlined and in particular the limitations which nature, in real materials, places on man's ability to influence these movements.

The peregrinations of transient stress disturbances can be markedly influenced by encounters with free surfaces. A number of representative encounters and situations are depicted. Several factors which determine the constantly changing shape of a transient stress pulse are discussed. The requisite background material for the discussion of spalling in real materials is given.

ROSENBAUM, J. H., "Shockwave Propagation in Shallow Water," I, AD 111 909 U. S. Naval Ordnance Laboratory, White Oak, Md., Rept. No. 4353 (1956).

The propagation of an acoustic pulse from a point source in a shallow layer of water is treated. The signal emitted by the source is an exponentially decaying step wave; both the source and the receiver are located in the water layer. The bottom is a semi-infinite half-space whose acoustic properties are assumed to be the following: (a) an ideal liquid, (b) an ideal solid, (c) a surface exhibiting constant normal resistive impedance.

Mathematical expressions are presented for all three cases, which are exact solutions of the acoustic problems and which are applicable for relatively moderate ranges and recording times. The final expressions are given in a form suitable for numerical work.

RYKUNOV, L. N., and FEOFILAKTOV, V. D., "A Piezoelectric Emitter of Single-Stroke Ultrasonic Pulses for Modeling Seismic Waves," Izvest. Akad. Nauk. S.S.S.R., Ser. Geofiz., n. 2, pp. 131-136 (1961).

The free vibrations excited in a pack of 45° Z-cut ammonium dihydrogen phosphate (ADP) plates by electric pulses are made up of two superimposed modes (vibration means) at different frequencies and cause different kinds of deformation of the plates. The characteristics of these deformations make it possible to eliminate one of the modes so as to produce an oscillator characterized by one natural frequency.

The vibrations excited in this oscillator by square electric pulses of varying duration were examined, and on this basis an emitter was designed to radiate elastic ultrasonic pulses of various forms and, in particular, a single-stroke pulse.

SATO, Y. et al., "Love Waves in a Heterogeneous, Spherical Earth, Part I: Theoretical Periods for the Fundamental and Higher Torsional Modes," J. Geophys. Research, V. 65, n. 8, pp. 2395-2398 (1960).

Free periods of torsional oscillation have been calculated for the Jeffreys-Bullen and Lehmann I earth models. Results are given for the first nine radial modes and for azimuthal modes up to n = 44. The calculation allows for sphericity, an arbitrary number of discontinuities, gradients within each shell, and a liquid core.

SAVARENSKY, E. F., et al., "On The Determination of the Energy of Elastic Waves Generated by Earthquakes," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 5, pp. 419-425 (1960).

The paper examines the question of the determination of the energy of seismic body waves from the data of distant stations, taking into consideration the nonuniformities in the emission by the focus. A device for

the evaluation of the density of the energy by the seismogram is suggested. An example is presented of the determination of the energy of the earthquake of January 3, 1957.

SCHNEIDERHAN, R. C. See Morris, R. H.

SCHWIND, J. J., et al., "PS Converted Waves from Large Explosions," J. Geophys. Research, V. 65, n. 11, pp. 3817-3824 (1960).

Four seismograms obtained during 1958 and 1959 from large quarry blasts at Promontory and Lakeside, Utah, and the Blanca underground nuclear explosion near Mercury, Nevada, were studied to ascertain whether converted PS-type waves were recorded and could be used in an analysis of the earth's crustal layering, as proposed by Andreev in 1957.

The method of analysis consisted in computing theoretical times of arrival for PS converted waves based on crustal layering and velocities in the area as determined from refraction seismic studies by Berg, Cook, and Narans, by plotting the radial horizontal component versus the vertical component of velocity of ground motion over appropriate time intervals, and by comparing amplitudes and frequencies of the PS converted waves with the amplitude and frequency of the parent P wave.

Arrivals, provisionally interpreted as PS converted waves, were detected on the traces of both the radial horizontal-component seismometers (2 cps natural frequency) and the vertical-component seismometers (2 cps). The amplitude of the PS converted waves was usually several times greater than that of the first arrival of the P wave. The successively later arrivals of PS converted waves from successively deeper horizons showed progressively greater ground-velocity amplitudes, as found by Andreev on earthquake seismograms, but some variance from this generalization was found. The frequencies of arrival of the various PS converted waves were approximately the same as those of the parent P wave: between 5 and 10 cps.

The crustal layering, which was determined by using the times of arrival of the PS converted waves, compared favorably with that given by Berg, Cook, and Narans for this area. The computed depths of successive layers are given.

SENGBUSH, R. L. See also McDonal, F. J.

SERATA, S. and GLOYNA, E. F., "Principles of Structural Stability of Underground Salt Cavities," J. Geophys. Res., V. 65, n. 9, pp. 2979-2987 (1960).

The principles of structural stability of underground salt cavities and the significance of the principles as they relate to other cavities are discussed. The theory of plasticity is applied to the evaluation of stress and strain conditions of the salt cavities. The concept of a yielded zone which develops around the cavities is introduced, and a theoretical development of the extent and stress distribution of the zone is illustrated through the use of ideal spherical and cylindrical cavities under uniform triaxial compression. Applicability of the concept to actual conditions, such as cavity irregularities, brittleness of formation and nonhydrostatic loading, is discussed.

SERBIN, H., "The Intense Stress Field Produced in the Elastic Earth by a Bomb Blast at the Surface," The RAND Corp., Santa Monica, Calif., Rept. P-1210 (1957).

A theory is presented for the free stress field in the earth developed by a bomb blast at the surface. The theory is based on the assumption that the earth is an elastic solid. The analysis is confined to the intense stress field developed shortly after the burst. Stresses and displacements are calculated in explicit form and can be compared with test data when such is available.

SERIFF, A. J. See Wottlin, W. O.

SEVIN, E., SHENKMAN, S., and WELCH, E., "Ground Shock Isolation of Buried Structures," Armour Research Foundation, Illinois Inst. of Technology, Chicago, Final Report on Contract AF 29(601)-2586 (1961).

This work is the second year's study of the isolation of buried structures from ground shock. The previous year's work is reported in AFSWC-TR-59-47, "Ground Shock Isolation of Buried Structure," Small aluminum cylinders (2 inches in diameter and 8 inches long) were embedded in dry Ottawa sand and subjected primarily to the ground-shock components of a high-explosive charge. Accelerometers mounted on the models were used to measure the motions of the models.

Various devices were then employed on or about the models to alleviate the induced motions as compared to the unisolated response. These isolation devices consisted of open and closed cell polyester urethane foams and loose and dense sand contained in a stovepipe. In addition, variations in model response with changes in overall bed density were investigated. A concomitant analytical study was also conducted to explore certain aspects of the model response including kinematics of model motion, the structure-soil interaction problem, and isolation model response.

The study demonstrated that model accelerations generally increase with increasing bed density and that the effectiveness of isolation systems must be measured relative to the characteristics of the overall bed. It is also shown that the high-frequency components of model response are important for models placed close to the charge. The study reinforced previous conclusions regarding the validity of testing procedures and the effectiveness of soft foam isolation.

SHAFFER, L. E. See Flanagas, W. G.

SHENKMAN, S. See Sevin, E.

SHURBET, D. H., "Determination of Sedimentary Thickness in the Mexican Geosyncline by Rayleigh Wave Dispersion," J. Geophys. Research, V. 66, n. 3, pp. 899-902 (1961).

Dispersion of short-period Rayleigh waves is studied in an effort to measure sedimentary rock thickness in the Mexican geosyncline. The measurement is approximate, but the study indicates uniformity of crustal structure over a very large area, including the Mexican geosyncline.

Therefore the study suggests an economical method of measuring crustal thicknesses over the entire area. The study indicates that the average sedimentary thickness across the Mexican geosyncline is about 8 km.

SIDOROV, A. A. See Tarkhov, A. G.

SIMPSON, S. M., Jr., "Initial Studies on Underground Nuclear Detection with Seismic Data Prepared by a Novel Digitization System," Mass. Inst. of Technology, Final Rept. No. 1 on Contract AF 19(604) 7378 (1961).

A semiautomatic paper-record digitization system, developed under the above contract has been applied to a number of seismic records resulting from the Logan and Blanca nuclear shots. Data for twenty-seven of these records digitized at 1/20-second increments and for thirty-four earthquake records adapted from digitizations of Bruce Bogert are presented, and are also available as a magnetic-tape library.

Rough measures of microseismic noise amplitude show inverse correlation with distance from the nearest ocean. Two spectral estimations near the coast show narrow lines at 1, 1.4, and about 2.9 cps in the vertical, whereas, at a three-component inland station the noise was primarily concentrated below 1 cps, with small peaks at higher frequencies appearing on the horizontals only, suggestive of Love waves. A test on this three-component record, narrowband filtered at 1/4 cps, failed to show the presence of Rayleigh waves, a possible explanation being barometric coupling to the vertical instrument.

The predictability of microseisms may provide a technique for improving signal-to-noise ratio of first motions. Tests show that microseismic energy is 99% to 40 or 50% predictable from its past where prediction distance varies from 1/20 second to 3 seconds. This yields possible signal-to-noise amplitude ratio improvements up to a factor of 2.

An ideal filter which discriminates perfectly between Rayleigh waves and P waves has been designed but not tested. Tests of phase-shift operators designed to compensate for phase distortion in the Benioff short-period recording system suggest that signal-to-noise amplitude-ratio improvements by factors of 2 to 3 may be realized in the first motion.

SMELCER, N. K. See Jacobs, J. M.

SMITH, F. L., and YOUNG, T. R., "Nuclear Explosives and Mining Costs," U. of Calif., Livermore, Lawrence Radiation Laboratory, UCRL Report No. 5928 on Contract No. W-7405-eng-48 (1960).

An interesting application of nuclear energy to mining operations is the proposed use of nuclear explosives to shatter a buried ore body so that the ore may be leached in situ. This method offers intriguing possibilities for profitable mining of low-grade deposits that would not repay the cost of mining by conventional means. Cost estimates indicate that the nuclear method would be less expensive than the block-caving method currently used, especially for very large ore deposits.

SNAY, H. G., and MATTHIAS, R. H., "A Theory of the Propagation of Shock-waves and Their Formation by Explosions," U. S. Naval Ordnance Laboratory, White Oak, Md., Rept. No. 2195 (1951). AD 129 685

A set of simultaneous ordinary differential equations is derived for the peak pressure and time factor of shock waves. These equations satisfy the Rankine-Hugoniot conditions and the partial differential equations of fluid dynamics. No particular assumptions are made as to the nature of the medium, so the equations hold for any gas or liquid. For application to explosion phenomena, expressions for the initial conditions are found for the interface between the explosion products and the surrounding medium (which in this case is the place where the shock wave is formed). Relationships are derived for two cases: (1) that the shockwave is observed at a fixed point (applicable to the measurement of air-blast waves); (2) that the point of observation moves with the medium (applicable to shock-wave measurements in water).

SNODGRASS, D. T. See Swain, R. J.

STAUDER, W., "S Waves: Alaska and Other Earthquakes," Bull. Seism. Soc. Am., V. 50, n. 4, pp. 581-597 (1960).

Techniques of S-wave analysis are used to investigate the focal mechanism of four earthquakes. In all cases the results of the S-wave analysis agree with previously determined P-wave solutions and conform to a dipole with moment or single couple as the point model of the focus. Further, one of the two nodal planes of P is selected from the S-wave data as the fault plane. Small errors in the determination of the angle of polarization of S are shown to result in scatter in the data of a peculiar character which might lead to misinterpretation. The same methods of analysis which in the present instances show excellent agreement with a dipole with moment source are the methods which in a previous paper required a single-force-type mechanism for a different group of earthquakes.

STAUDER, W., "S Waves and Focal Mechanisms: The State of the Question," Bull. Seism. Soc. Am., V. 50, n. 3, pp. 333-346 (1960).

The questions usually discussed with respect to the use of S waves in determining the character of an earthquake focus concern the ambiguity of the fault-plane solution from P waves and the problem of a single couple vs. a double couple as the model of an earthquake focus. Recent papers on the subject of the earthquake mechanisms bring forward more basic questions concerning the adequacy of focal models. The theory of point sources and previous applications of S waves to mechanism studies are reviewed as guides to further investigation.

STAUDER, W., "Three Kamchatka Earthquakes," Bull. Seism. Soc. Am., V. 50, n. 3, pp. 347-388 (1960).

Three earthquakes, two with previously determined fault-plane solutions, are selected in order to study the relation between the S waves and the source mechanism. The S waves are observed at favorable epicentral distances at stations distributed in all quadrants about the epicenter. The

earthquakes are of a focal depth of 40 to 60 km and belong to the aftershock sequence of the great earthquake of November 4, 1952. The direction of first motion and the plane of polarization of S are determined by the construction of particle-motion diagrams.

In the case of the two earthquakes for which the fault-plane solutions have been published, no correspondence is found between the observed S-wave data and the character of the S motion expected on the basis of the given nodal planes of P, whether the source be considered as a single couple or as a double couple. For the third earthquake it is found that the first motion of P is compressional along all rays leaving the focus downward and that the S waves are strongly SV polarized. No faulting mechanism can explain this distribution of the motion in the initial P and S phases. The motion is explained as corresponding to that generated by a simple force acting almost vertically downward. Graphical and analytical techniques of analysis determine the trend of the force at the source to be N 12^{o} W, with a plunge of 85^{o}. A reconsideration of the other 2 shocks shows that these, too, are better explained by a simple force than by a faulting mechanism.

STAUDER, W., and ADAMS, W. M., "A Comparison of Some S-Wave Studies of Earthquake Mechanisms," Bull. Seism. Soc. Am., V. 51, n. 2, pp. 227-292 (1961).

Graphical and analytical techniques for using S waves in focal mechanism studies are compared. In previous applications the analytical technique has shown little or no agreement with the results of fault-plane solutions from P waves, whereas for other groups of earthquakes the graphical methods have shown good agreement between the S waves and the P-wave solutions. It is shown that the graphical and analytical techniques are identical in principle and that, when the graphical methods are applied to the same three earthquakes to which the analytical technique had been applied, the identical results are obtained.

Closer examination of the graphical presentation of the data, however, shows that the disagreement between the S waves and the fault-plane solutions from P is largely apparent. The discrepancy follows upon the peculiar scatter in the S-wave data and the chance occurrence of observations of S at stations located along closely parallel planes of polarization of S. Once this is understood, it is seen that the direction of polarization of S waves is in substantial agreement with the methods of analysis of focal mechanisms from P waves, and that the data are consistent with a simple dipole as the point model of the earthquake focus.

STONELEY, R. See Hochstrasser, U.

SULLIVAN, W., "Scientists Told of A-Test Clues," New York Times, V. 110, n. 37,692 (April 5, 1961).

A detectable variation in the normal, although weak, flow of electric currents through the earth's crust, caused by some unrelated but violent electrical disturbance, is suggested as a possible means of monitoring for buried nuclear explosions.

SWAIN, R. J., HEALD, C. L. and SNODGRASS, D. T., "Shear and Compressional Velocity Measurements, Project Hobo," U. of Calif., Livermore, Lawrence Radiation Laboratory, UCRL Rept. No. 5993 on Contract No. W-7405-eng-48 (1960).

Three groups of 100-foot holes were drilled vertically downward from the floor of U 12e main tunnel and U 12e.03 drift at the Nevada Test Site. Distances between the holes in each group varied from 13 to 375 feet. One hole in each group was used as a "shot hole," the others for seismometers to record the energy generated in the shot hole. Two types of recordings were made, one for dilatational or longitudinal P-waves and one for transverse or shear S waves. Simultaneous recordings were made on photographic paper and on magnetic belts, with a minimum of three specimen records at each hole for each type of recording. The magnetic belts were transcribed to 1/2-inch IRIG tape for computer use. Rock density measurements were also made in the holes. From these data Poisson's Ratio, Bulk Modulus, Rigidity Modulus, and Young's Modulus were computed. Elastic constant values obtained in situ were found to be much higher than those determined by soil laboratory tests on small rock samples. The data obtained are considered to be of exceptionally high accuracy.

SWIFT, L. M., and WELLS, W. M., "Postshot Disturbances and Surface Motions — Operation Hardtack II," Stanford Research Inst., Menlo Park, Calif., Final Rept. WT 1740 on Project 26.1, Operation Hardtack II (1960).

Postshot earth disturbances and surface displacements were measured as functions of time after two deep underground nuclear detonations, using the magnetically recorded output of geophones and the sight readings of simple liquid-level gauges to evaluate the applicability of these measurement methods for making detailed location of deep underground bursts after their general location has been established by other means. The low yield of one shot and the unexpectedly high noise interference precluded establishing the limits of the geophone listening technique. However, the records obtained from the geophones and the liquid-level gauges indicate that these techniques show some promise for second-stage detection of underground bursts. Further tests of the techniques are recommended after modifications in instrumentation are made to reduce the noise interference in the geophones and to reduce the error in the liquid-level gauges.

TARKHOV, A. G. and SIDOROV, A. A., "The Mathematical Processing of Geophysical Data," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 10, pp. 965-969 (1961).

Different methods of mathematical processing should be applied to the results of geophysical observations in order to lessen the influence of the various types of interference. In addition to the calculation of the arithmetic and geometric means, the use of the so-called method of inverse probability has been recommended. It is shown, by applications to actual material, that the ratio of anomaly to interference can be increased. Directions for possible further investigations are indicated.

TRIPOLNIKOV, V. P. See Linkov, E. M.

TROITSKAYA, V. A., "Effects in Earth Currents Caused by High-Altitude Atomic Explosions," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 9, pp. 877-881 (1961).

Initial results are adduced of an analysis of short-period oscillations of the earth's electromagnetic field, caused by high-altitude atomic explosions in the South Atlantic (operation "Argus") and near Johnston Island in the Pacific Ocean. The data analyzed were collected during the IGY in the Arctic, middle, and Antarctic latitudes. They consisted of rapid round-the-clock recordings of terrestrial currents, made with a feed of 30 mm/minute.

TRYGGVASON, E., "Crustal Structure of the Iceland Region from Dispersion of Surface Waves," Seism. Inst., Univ., Uppsala, Sweden, Scientific Rept. No. 3 on Contract No. DA-91-591-EUC-1637 (1961).

A number of Icelandic records of earthquakes originating in the Mid-Atlantic Seismic Belt between 52° and 70° N lat have been investigated. The surface waves on these records are chiefly in the period interval 3-10 seconds, and are first-mode Love waves and Rayleigh waves. The surface wave dispersion shows that a surface layer having an S-wave velocity about 2.7 km/sec covers the region. It is about 4 km thick on the Mid-Atlantic Ridge south of Iceland and in western Iceland, about 3 km thick, or even thinner, in central Iceland, and about 7 km thick northwest of Iceland. An intermediate layer with an S-wave velocity of about 3.6 km/sec covers the island and extends several hundred kilometers off the coasts. Its thickness is similar to that of the surface layer, according to surface wave data. Below these layers there is a thick layer where the S-wave velocity is about 4.3 km/sec, and the surface waves do not indicate any layer of higher wave velocity. The discontinuity above the 4.3-layer corresponds to the Mohorovicic discontinuity under the continents. The upper mantle wave velocities in this region are significantly lower than those generally found under the continents.

TRYGGVASON, E. See also Båth, M.

VAN DORN, W. G., "Some Characteristics of Surface Gravity Waves in the Sea Produced by Nuclear Explosions," J. Geophys. Research, V. 66, n. 11, pp. 3845-3862 (1961).

Low-frequency dispersive gravity waves produced by nuclear explosions at Bikini, Marshall Islands, were recorded at four distant island stations. A comparison of these wave measurements with those predicted by linear theory shows that they agree closely in the nature of the dispersion and in the rate of amplitude decay with distance. The wave system associated with the large tsunami of March 9, 1957, is also considered. The dispersions for both types of disturbance were virtually identical, as predicted by the theoretical argument that the dispersion of a centered wave system is independent of the nature of the source disturbance. In analyzing the rate of amplitude decay, it was necessary to correct the observations for enhancement due to scattering by the islands upon which the recording stations were located; this showed that even relatively small islands are effective as scatterers. These experiments show rather conclusively that tide-gauge records of tsunami-like disturbances grossly misrepresent the characteristics of the wave systems in the open sea.

VAN NOSTRAND, R. G. See McDonal, F. J.

VASSILEV, Yu. I. See Podyapolsky, G. S.

VESIAC (staff), "A Consideration of H.I.S. Thirlaway's 'Depth of Focus Discrimination within the Crust at First-Zone Distances,'" Univ. of Mich., Inst. Sci. and Tech., Ann Arbor, Mich., Rept. No. 4410-12-X, Special Advisory Rept. No. 1 on Contract SD-78 (1961).

The critical comments of several outstanding authorities are gathered, reviewed, and summarized in this Special Advisory Report on H. I. S. Thirlaway's paper "Depth of Focus Discrimination within the Crust at First-Zone Distances." The original paper and the accompanying illustrations are reproduced in their entirety.

VOLAROVICH, M. P., et al., "Investigation of the Attenuation of Elastic Waves in Rock Specimens," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 8, pp. 793-797 (1961).

A device has been developed for the investigation of the attenuation of elastic ultrasonic waves in small rock specimens; it is intended for conduction experiments made under high uniform pressures. The amplitude coefficient of attenuation is determined by the use of multiple reflections of ultrasonic pulses of a certain frequency in cylindrical specimens.

Values are obtained for the attenuation coefficient of longitudinal ultrasonic waves in some rock specimens.

VORESS, H. E. See Jacobs, J. M.

VOSKRESENSKY, Y. N., "Some Types of Diffracted Waves Detected by the Adjustable Directional Receiver Method," Izvest. Akad. Nauk S.S.S.R., Ser. Geofiz., n. 2, pp. 125-130 (1961).

As a result of operations using the ADR method in Bashikiriya, new data are obtained on the recording of the $P_{12}P_{21}$ and $P_{112}P_{21}$ type waves which develop as a result of diffraction of nonhomogeneities in the shallow rigid interlayer (caused by the distortion) and return to the shot point. The $P_{12}P_{21}$ and $P_{112}P_{21}$ waves possess equal apparent velocities, which follow with a small time interval Δt and create oscillations of considerable duration. These waves, superimposed on useful reflected waves, contribute to the complication of seismic recordings. The experiments indicated that these waves can be accurately separated by using the spectra of the superimposed oscillations.

The $P_{12}P_{21}$ and $P_{112}P_{21}$ waves in this region are separated by applying the ADR method with its specific separating ability. The results of field recordings show close agreement with theoretical data and geological considerations in operations. Further application of the ADR method will allow the $P_{12}P_{21}$ and $P_{112}P_{21}$ type waves to be separated more frequently and used in geological interpretations.

WATT, P. A., "The Application of a d-c Amplifier to Seismic Recording," Bull. Seism. Soc. Am., V. 50, n. 3, pp. 471-476 (1960).

A d-c chopper-stabilized amplifier is being used to amplify seismic signals from a Willmore short-period geophone to a level suitable for direct recording on a 0-1-ma pen recorder. The overall magnification of the system is approximately 10,000, and the amplification of the d-c amplifier is 60 v/mu. The frequency response of the amplifier is d-c to 75 cps.

WELCH, E. See Sevin, E.

WELLS, W. M. See Swift, L. M.

WHITE, J. E. See McDonal, F. J.

WHITMORE, J. D. See Nuttli, O. W.

WILLOUGHBY, A. B. See Kaplan, K.

WOOD, C. A., "Plot Seismic Data with Electronic Computers," World Oil, V. 148, n. 5, pp. 131-133 (1959).

The large number of repetitious operations involved in plotting seismic data make it a likely possibility for some type of automation. A method is presented here for preparing point-plotted cross-sections by use of a digital computer and an accounting machine that has been modified to function as a plotting device. The time required in this experimental stage is at present slightly greater than that required to plot the same sections by hand. The computer method is much more accurate, however, and the time involved should be reduced considerably by research in programming.

WOOD, H. O. See Anderson, J. A.

WOTTLIN, W. O., SERIFF, A. J., and BROMAN, W. H., "Seismic Observations by Shell Development Company of the Pre-Gnome Explosions—Data," Shell Development Co., Houston, Texas (1959).

Three buried high-explosive charges fired by the United States Atomic Energy Commission in Eddy County, New Mexico, as part of their Pre-Gnome experiment, were observed with seismic-particle velocity detectors. Charges of 180, 750, and 6200 pounds of explosive were fired 1200 feet below the surface. Seismic observations were made at the surface and at depths of 710 feet and 250 feet, at 28,600 feet from the shothole, with instruments sensitive to frequencies between about 8 and 100 cycles per second. The instruments were calibrated so that actual ground motions could be measured. Normal refraction records were also made at the surface at 29,000 feet and 105,000 feet. The actual records are reproduced, and instrument calibration, location, and timing data are given.

YOUNG, T. R. See Smith, F. L.

ZACCOR, J. V. See Kaplan, K.

Appendix A

REPORTS AND ARTICLES SPONSORED BY THE VELA UNIFORM PROGRAM

BÅTH, M., and TRYGGVASON, E.: "Deep Seismic Reflection Experiments at Kiruna," Seism. Inst., Univ., Uppsala, Sweden, Contractors Scientific Report No. 4 on Contract No. DA-91-591-EUC-1637 (1961).

BOGERT, B. P., "Hand Digitized Seismic Data," edited by VESIAC Staff, Rept. No. 4410-14-X, Institute of Science and Technology, The University of Michigan, Ann Arbor, Mich. (1962).

DAVIS, P. D., Jr.: "Automatic Marine Seismic Monitoring and Recording Device," Texas Instruments Inc., Dallas, Semi-Annual Technical Report No. 1 on Contract No. AF 19(604)-8368 (1961).

DWORNIK, S. E., and ORR, D. G., "Reflectance Studies of Vegetation Damage," U. S. Army Engineer Research and Development Laboratories, Ft. Belvoir, Va., Summary Rept. No. 2 (1961).

FORBES, C. B., and HEALD, CL.: "Refraction Seismic Survey—Porpoise Area," VELA UNIFORM Porpoise—Project 7.4A, United ElectroDynamics, Inc., Pasadena, Calif. (1961).

GRINE, D. R., "VELA UNIFORM—Dynamic Properties of Rocks," Stanford Research Inst., Menlo Park, Calif., Semi-Annual Technical Report, on Contract AF 19(604)-8419 (1961).

HARKRIDER, D. G., and ANDERSON, D. L., "Computation of Surface Wave Dispersion for Multilayered Anisotropic Media," California Institute of Technology, Pasadena, Contract No. AF 49(638)-910.

SIMPSON, S. M., Jr., "Initial Studies of Underground Nuclear Detection with Seismic Data Prepared by a Novel Digitization System," Mass. Inst. of Tech., Final Rept. No. 1 on Contract AF 19(604) 7378 (1961).

TRYGGVASON, E., "Crustal Structure of the Iceland Region from Dispersion of Surface Waves," Seism. Inst. Univ., Uppsala, Sweden, Scientific Rept. No. 3 on Contract No. DA-91-591-EUC-1637 (1961).

VESIAC (Staff), "A Consideration of H.I.S. Thirlaway's 'Depth of Focus Discrimination within the Crust at First-Zone Distances,'" Univ. of Mich., Inst. Sci. and Tech., Ann Arbor, Mich., Rept. No. 4410-12-X, Special Advisory Rept. No. 1 on Contract SD-78 (1961).

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