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HEARING

BEFORE THE

COMMITTEE ON HUMAN RESOURCES

UNITED STATES SENATE

NINETY-FIFTH CONGRESS

FIRST SESSION

ON

JAMES A. KRUMHANSL, OF NEW YORK, TO BE AN ASSISTANT
DIRECTOR OF THE NATIONAL SCIENCE FOUNDATION

NOVEMBER 2, 1977

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[Redacted area]

NOMINATION

WEDNESDAY, NOVEMBER 2, 1977

U.S. SENATE,
COMMITTEE ON HUMAN RESOURCES,
Washington, D.C.

The committee met, pursuant to notice, at 9:45 p.m. in room 4232, Dirksen Senate Office Building, Senator Jennings Randolph, presiding pro tempore.

Present: Senators Randolph, Pell, Stafford, and Chafee.

Senator RANDOLPH. A pleasant morning to our guests and those who will testify.

The nomination the committee considers this morning is the nominee of the President, James Krumhansl. I believe that the Director of the National Science Foundation is with us here today and I think it is very appropriate that he have the opportunity to introduce you.

We will have that introduction as we continue with your nomination hearing. Thank you very much, Richard, for coming along.

INTRODUCTORY STATEMENT OF RICHARD C. ATKINSON, DIRECTOR, NATIONAL SCIENCE FOUNDATION

Dr. ATKINSON. Thank you, Mr. Chairman and members of the committee.

I have a formal statement here that I would like introduced into the record.

Let me simply say that Dr. Krumhansl is the President's nominee for a senior management position at the National Science Foundation. He comes to the Foundation from Cornell University where he has been a longtime member of the faculty as a professor of physics. He has had broad experience both in the academic community and in the industrial community, where he served as the director of research for two large industrial firms.

His scientific expertise is not limited to physics. He is really a renaissance man in terms of his range of scientific interests. Most of his work has been in electrical engineering, applied mathematics, materials science and theoretical physics, and he has a broad range of other scientific interests.

Dr. Krumhansl has also received a number of honors. He has been a National Science Foundation senior fellow. He has been a Guggenheim fellow, a Fulbright lecturer and a visiting fellow at All Souls College at Oxford. He has been the editor of the *Journal of Applied Physics* and *Physical Review Letters*, and he is now a fellow of the American Physical Society and a member of the governing board of the American Institute of Physics.

Mr. Chairman, Dr. Krumhansl comes to the Foundation at an exciting time. I look forward to working with him. I am confident of his ability to manage effectively NSF programs, both in terms of good scientific judgment and in terms of good managerial judgment.

Thank you, Mr. Chairman.

Senator RANDOLPH. Thank you very much, Dr. Atkinson.

I think it is not inappropriate to say that our Committee on Environment and Public Works had many contacts with the National Science Foundation and we look upon your presentation—in fact it is an endorsement, as I understand it, of the nominee designate, is that correct?

Dr. ATKINSON. A very strong endorsement, Mr. Chairman. And let me add, the Foundation is very proud of its record in the environmental area and we thank you for your comment.

Senator RANDOLPH. There is a letter addressed to our chairman, Senator Williams, from the chairman of the Subcommittee on Health and Scientific Research of this Committee on Human Resources. Edward M. Kennedy in his letter of November 1 indicates that Senator Kennedy has every reason to believe that Dr. Krumhansl will work very closely with the subcommittee he chairs in this full committee and, without objection, I will place that letter along with Mr. Atkinson's formal statement and the biographical sketch of Dr. Krumhansl in the record at this point.

[The material referred to follows:]

STATEMENT BY
DR. RICHARD C. ATKINSON, DIRECTOR
NATIONAL SCIENCE FOUNDATION
BEFORE THE
COMMITTEE ON HUMAN RESOURCES
UNITED STATES SENATE

November 2, 1977

Mr. Chairman and Members of the Committee:

I am privileged to introduce to you the President's nominee for a senior management position in the National Science Foundation. He is Dr. James A. Krumhansl, a professor of physics at Cornell University, nominated to be an Assistant Director of NSF for Mathematical and Physical Sciences, and Engineering. The directorate operates more than 40 programs in these fields, primarily through support of individual projects in basic research.

Dr. Krumhansl is unusually well qualified to serve in the leadership of the directorate. He is both a physicist and an engineer, and his experience encompasses both academic and industrial research. His own research interests lie in electrical engineering, applied mathematics, materials science, and theoretical physics. He has directed research at two large industrial firms, and he has been a consultant to industry.

In a sense, Dr. Krumhansl is one of the Foundation's own; he was an NSF Senior Fellow in 1966-67. He also has been a Guggenheim Fellow, a Fulbright Lecturer, and a Visiting Fellow at All Souls College, Oxford. He has edited the Journal of Applied Physics and the Physical Review Letters. He is now a Fellow of the American Physical Society and a member of the Governing Board of the American Institute of Physics.

Mr. Chairman, Dr. Krumhansl comes to the Foundation at an exciting time. The mature disciplines in physics, chemistry, mathematics, and engineering have developed a large body of scientific knowledge that enables scientists to ask more penetrating questions about the nature of the universe. I look forward to working with Dr. Krumhansl, and I am confident of his capabilities for the management of NSF's programs in basic research and engineering.

NATIONAL SCIENCE FOUNDATION

WASHINGTON, D.C. 20550

JAMES ARTHUR KRUMHANSL

Dr. James Arthur Krumhansl has been a professor of physics at Cornell University since 1959. He has been an active researcher in academic and industrial circles since 1943, with emphasis in the fields of theoretical solid state physics, materials science, applied mathematics, and electrical engineering. In addition to teaching physics, he is a professor of applied physics and a member of the Materials Science Center and the Center for Applied Mathematics at Cornell.

Dr. Krumhansl's main scientific interest in recent years has been in theoretical physics, particularly its application to materials and structural properties. He also has been interested in macroscopic engineering properties of polycrystalline aggregates and scattering theory and ultrasonic non-destructive testing. Earlier he had concentrated his research interests in network theory and synthesis, electromagnetic theory and microwave application, information theory and communications systems, and catalysis.

Dr. Krumhansl was born August 2, 1919, in Cleveland, Ohio. He earned a bachelor of science degree in electrical engineering at the University of Dayton in 1939. The following year he was awarded a master of science degree at Case Institute of Technology (now Case-Western Reserve University) in Cleveland. He earned a doctor of philosophy degree in physics at Cornell in 1943.

He was appointed an instructor at Cornell in 1943 and served until 1944 when he took a position as senior staff scientist with Stromberg Carlson Company in Rochester, New York. In 1946 he returned to the academic world to become an assistant professor and then associate professor at Brown University for two years.

Dr. Krumhansl returned to Cornell in 1948 as an assistant professor for two years before he was promoted to associate professor in 1950. In 1954 he joined the Union Carbide Company Research Center in Parma, Ohio, as assistant director and later associate director of research until 1959 when he was named full professor at Cornell. From 1960 to 1964 he was director of Cornell's Laboratory for Atomic and Solid State Physics.

He was a Guggenheim Fellow at Cornell from 1959 to 1960. Dr. Krumhansl was a National Science Foundation Senior Postdoctoral Fellow at Oxford University from 1966 to 1967. He also was a Fellow of the American Physical Society, chairman of its Division of Solid State Physics in 1968 and a councillor from 1970 to 1974. He was a Fulbright Lecturer in Yugoslavia in 1976. He has been a member of the governing board of the American Institute of Physics since 1973.

Dr. Krumhansl has published widely in his field and has been editor of the Journal of Applied Physics and the Physical Review Letters and associate editor of other journals. He is a member of advisory boards of several research laboratories and a consultant for many of the nation's leading corporations. He also is a member of many professional organizations, including the American Association of University Professors, the American Association for the Advancement of Science, the American Association of Physics Teachers, the American Association of Petroleum Geologists, and Sigma Xi, the national scientific fraternity.

Dr. Krumhansl has interests in outdoor sports, music, and wines and their making. He is married and has three children.

July 1977

Biographical Data (Professional):

James A. Krumhansl

Title(s) of Positions(s) at Cornell:

Professor of Physics, Professor of Applied Physics, Member: Materials Science Center (Cornell), Center for Applied Mathematics (Cornell).

Fields of Teaching and Research:

Theoretical Solid State Physics, Materials Science, Applied Mathematics, Electrical Engineering.

Present Additional Responsibilities:

Editor: Physical Review Letters, 1974 - present.
 American Physical Society: Finance Committee, Advisor to Council.
 American Institute of Physics: Governing Board, 1975 - present,
 Chairman, Publishing Policy Committee.
 National Science Foundation: Physics Advisory Panel, 1975 - present.

Previous Professional Appointments:

- (a) at Cornell: Instructor, 1943-44; Asst. Professor, 1948-50; Assoc. Professor, 1950-54; Professor, 1959-present. Director, Laboratory of Atomic and Solid State Physics, 1960-64.
- (b) in government or industry: Senior Staff Scientist, Stromberg Carlson, 1944-46; Assistant-Associate Director of Research, Union Carbide (Parma) Research Center, 1954-59.
- (c) in other educational institutions: Brown University, Assistant-Associate Professor, 1946-48.

College and University Faculty Committee Responsibilities at Cornell:

Miscellaneous service on Graduate Field Committees, Materials Science Center Executive Committee, Faculty Council of Representatives, Planning - Review Committee (Senate), various ad hoc committees.

Previous Professional Activities or Awards:

Guggenheim Fellow, 1959-60 (Cornell).
 National Science Foundation Sr. Postdoctoral Fellow, 1966-67 (Oxford)
 All Souls College (Oxford), Visiting Fellow, 1977-78.
 Fulbright Lecturer, 1976

Editorial:

Journal of Applied Physics, Editor, 1957-61; Reviews of Modern Physics, Assoc. Editor (Solid State), 1968-73; Solid State Communications, Editorial and Board, 1964-present.

American Physical Society:

Fellow; Chairman, Division of Solid State Physics, 1968-69; APS Councillor, 1970-74; Chairman, Long Range Planning Study, American Physical Society, 1972-73; Member, various APS committees.

James A. KrumhanslContinuation of Previous Professional Activities or Awards:

- American Association for Advancement of Science, Fellow.
- Member: Materials Research Council (ARPA) (Also, CoFounder)
 Materials Advisory Board (NAS) Committees.
 Visiting Committees, Oak Ridge National Lab.
 Visiting Committee; Solid State, Argonne Lab.
- Consulting: Union Carbide, General Atomic, Xerox, IBM, General Electric,
 Ford, Los Alamos.

Main Scientific Interests

- 1940 - 1943 Network Theory and Synthesis
- 1940 - 1943 Electromagnetic Theory and Microwave Applications
- 1942 - 1946 Information Theory and Pulse Communication Systems. (Including Circuit Development).
- 1946 - 1948 Applied Mathematics (Statistics, Numerical Analysis for Computer Development).
- 1948 - Solid State Theory.
- 1954 - 1960 Chemical Physics, particularly carbon physics and chemistry.
- 1956 - 1960 Catalysis
- 1956 - 1960 Graphite Manufacture and Engineering Applications.
- 1960 - 1963 Contributions to point defect scattering in theory of thermal conductivity.
- 1960 - 1967 Second sound in solids; first definite statement of observational conditions; methods for solving Boltzmann equation.
- 1963 - 1967 Contributions to continuum mechanics; microscopic basis of couple-stress elasticity.
- 1960 - 1963 General theory of thermoelectric energy conversion.
- 1966 - 1974 Theory of disordered systems.
- 1965 - 1975 Molecular hydrogen as a quantum crystal; high pressure equation of state and metallic hydrogen transition.
- 1973 - Structural phase transitions, statistical mechanics of non-linear dispersive systems, solitons.
- 1972 - Macroscopic engineering properties of polycrystalline aggregates.
- 1974 - Scattering theory and ultrasonic non-destructive testing.
- 1974 - Non-Linearity in General (Mathematics, Engineering, Field Theory).

PUBLICATIONS

J. A. Krumhansl

"Barkhausen Noise and Magnetic Amplifiers. I. Theory of Magnetic Amplifiers," J. Appl. Phys. 20, 432 (1949), with R. T. Beyer.

"Barkhausen Noise and Magnetic Amplifiers. II. Analysis of the Noise," J. Appl. Phys. 20, 582 (1949), with R. T. Beyer.

"The Evaluation of Lattice Sums for Cubic Crystals," Phys. Rev. 92, 569 (1953), with J. Hove.

"The Calculation of F Center Energy Levels," Phys. Rev. 89, 1154 (1953), with N. Schwartz.

"Lattice Vibration Specific Heat of Graphite," J. Chem. Phys. 21, 1663 (1953), with H. Brooks.

"Band Structure of Graphite," J. Chem. Phys. 21, 2238 (1953), with J. Carter.

"Theoretical Calculations of F-Center Energy Levels," Phys. Rev. 93, 245 (1954).

"Interpretation of the Strain Broadening Components in X-ray Diffraction Patterns," J. Appl. Phys. 26, 1057 (1955), with J. C. Bowman and J. R. Stock.

"Lattice Vibration Specific Heat of Graphite," Tenth Annual Calorimetry Conference, University of Minnesota, September 16-17, 1955.

"Weak Temperature Dependence of 'Van Vleck' Paramagnetic Susceptibility in Semiconductors," Bull. Am. Phys. Soc (II) 1, 117 (1956), with H. Brooks.

"Excitation Transfer in Crystals," Symposium on Color Centers, Argonne National Laboratory, October 31 - November 2, 1956.

"Photoexcitation in Ionic Crystals," Editor R. G. Breckenridge, et al., "Photoconductivity Conference," J. Wiley and Sons, Inc., New York, 1956, p. 450.

"Intrinsic Magnetic Susceptibility of Solids - Van Vleck Paramagnetic Susceptibility," Symposium on the Physics of Semiconductors, National Bureau of Standards, Washington, D.C., Oct. 24-26, 1956.

PUBLICATIONS

J. A. Krumhansl

- 2 -

"Temperature Independent Paramagnetic Susceptibility in Semiconductors," Brown University, Nov. 5, 1956.

"Temperature Independent Paramagnetic Susceptibility in Semiconductors," Alfred University, Alfred, N. Y., Nov. 13, 1956.

"Temperature Independent Paramagnetic Susceptibility in Semiconductors," Scientific Laboratory, Ford Motor Co., Dearborn, Michigan, Dec. 10, 1956.

"Electronic Specific Heat of Graphite," Bull. Am. Phys. Soc., (II) 1, 289 (1956), with W. DeSorbo and J. C. Bowman.

"National Carbon Research and Solid State Physics," Press Preview Day, National Carbon Research Laboratories, Cleveland, Ohio, Sept. 17, 1956.

"Solid State Physics and Catalysis," Union Carbide Corporation Catalysis Conference, South Charleston, W. Va., April 23-4, 1957.

"The Solid State," Editor H. Eyring, et al., "Annual Review of Physical Chemistry," Annual Reviews, Inc., Palo Alto, Calif., 1957, Vol. 8, page 77.

"A Review of Compound Semiconductors," University of Minnesota, May 17, 1957.

"Lattice Vibrations and Low Temperature Thermal Properties of Graphite," Third Biennial Carbon Conference, University of Buffalo, June 17-21, 1957.

"X-ray and Low Temperature Thermal Conductivity Study of Defects in Graphite," Conference on Industrial Carbon and Graphite, London, England, Sept. 24-26, 1957, with J. C. Bowman and J. T. Meers.

"Energy Band Structure of Lithium by a Modified Plane Wave Method," Phys. Rev. 109, 30 (1958), with E. Brown.

"Criteria for Mixing and the Mixing Process," 14th Annual Tech. Conf. of Society of Plastic Engineers, Detroit, Mich., Jan. 28-31, 1958, with J. T. Bergen and G. W. Carrier.

PUBLICATIONS

J. A. Krumhansl

- 3 -

"The Low Temperature Specific Heat of Graphite," submitted to Physics and Chemistry of Solids on Feb. 25, 1958, with J. C. Bowman. J. Phys. Chem. Solids 6, 367 (1958).

"High Temperature Thermal Conductivity in Solids," Thermoelectric Processes in Solids Symposium, Chicago, Ill., March 26, 1958.

"Lattice Vibrations of Layer Lattices and Elastic Constants," Bull. Am. Phys. Soc., (II) 3, 123 (1958).

"Elastic Constant and Specific Heat of Graphite," Harvard University, May 16, 1958.

"The Use of Chemical Potentials in Photoconductivity," International Conference on Solid State Physics in Electronics and Telecommunications, Brussels, Belgium, June 2-7, 1958, with H. D. Messer.

"Thermal Conductivity of Semiconductors," 1958 International Conference on Semiconductors, Rochester, N.Y., Aug. 18-22, 1958.

"Weak Temperature Dependence of 'Van Vleck' Paramagnetic Susceptibility in Semiconductors," Electronic Properties of Metals at Low Temperatures, Hobart College, Geneva, N. Y., Aug. 25-29, 1958.

"Thermal Conductivity in Semiconductors," Conference on Thermoelectricity, Washington, D.C., Sept. 3-4, 1958, with M. Bettman and W. S. Williams.

"Thermal and Electric Properties of Semiconductors," Erie Section of I.R.E., Erie, Pennsylvania, Oct. 21, 1958.

"Magnetic Susceptibility of Solids," J. Appl. Phys. 30, 1183 (1959).

"Dispersion Relation for Second Sound in Solids," Phys. Rev. 133, A1411 (1964), with R. A. Guyer.

"Boltzmann Equation in a Phonon System," Phys. Rev. 136, A1397 (1964), with C. Horie.

PUBLICATIONS

J. A. Krumhansl

- 4 -

"D15. The Scattering of Lattice Vibrations by Vacancy Type Defects," Lattice Dynamics, Proceedings, of the International Conference held at Copenhagen, Denmark, August 5-9, 1963. Pergamon Press, 1964.

"G1. Conference Summary: Mainly Experimental, "Lattice Dynamics, Proceedings of the International Conference held at Copenhagen, Denmark, August 5-9, 1963. Pergamon Press, 1964.

"Thermal Conductivity of Insulating Crystals in the Presence of Normal Processes," Proceedings of the Physical Society, Great Britain, 85, 921 (1965).

"Scattering of Long-Wavelength Phonons by Point Imperfections in Crystals, "Phys. Rev. 140, A1812, (1965), with J. A. D. Matthew.

"Solution of the Linearized Phonon Boltzmann Equation, "Phys. Rev., Vol. 148, No. 2, 766-778, 12 August 1966, with R. A. Guyer.

"Theory of Displaceable Point Defects in Crystals, "Phys. Rev. Letters 16, 1105 (1966), with M. Gomez, S. P. Bowen, and J. Matthew.

"Thermal Conductivity, Second Sound, and Phonon Hydrodynamic Phenomena in Nonmetallic Crystals," Phys. Rev., Vol. 148, No. 2, 778-788, 12 August 1966, with R. A. Guyer.

"Phonon Physics," Reprinted from "Perspectives in Modern Physics," Essays in Honor of H. A. Bethe, Edited by R. E. Marshak. Interscience Publishers.

"Solution of the Linearized Phonon Boltzmann Equation," Phys. Rev. 148, 766 (1966), with R. A. Guyer.

"Thermodynamics of Energy Conversion Systems," Nuovo Cimento.

"Lattice Vibrations in Solids," Jour. Appl. Phys.

"Physical Properties of an Off-Center Impurity in the Tunneling Approximation. I. Statics, "Phys. Rev. 153, 1009 (1967), with M. Gomez and S. P. Bowen.

"Solid Molecular Hydrogen as a Quantum Crystal", Phys. Lett. 28A, 263 (1968) with S. Y. Wu.

PUBLICATIONS

J. A. Krumhansl

- 5 -

"Elastic Strains in Imperfect Crystals," Localized Excitations in Solids (Plenum Press, 1968), with T. H. Merrett and R. J. Elliott.

"Asymptotic Descriptions of Defect Excitations," Localized Excitations in Solids (Plenum Press, 1968).

"Asymptotic Description of Localized Lattice Modes and Low-Frequency Resonances," Phys. Rev. 166, 856 (1968), with J. A. D. Matthew.

"Effect of Force-Constant Changes on the Incoherent Neutron Scattering from Cubic Crystals with Point Defects," Phys. Rev. 175, 841 (1968), with Katja Lakatos.

"Atomic Tunneling in Solids," Tunneling Phenomena in Solids, Plenum Press, 1969, p. 551.

"Some Considerations of the Relation Between Solid State Physics and Generalized Continuum Mechanics", Iutam Symposium Freudenstadt, Stuttgart 1967, Mechanics of Generalized Continua.

"Effect of Force-Constant Changes on the Coherent Neutron Scattering from Face-Centered Cubic Crystals with Point Defects," Phys. Rev. 180, 729 (1969), with Katja Lakatos.

"Pair Effects and Self-Consistent Corrections in Disordered Alloys," Phys. Rev. 181, 1006 (1969), with R. N. Aiyer, R. J. Elliott, and P. L. Leath.

"Heat Pulses in NaF: Onset of Second Sound," Phys. Rev. Letters 24, 100 (1970), with T. F. McNelly, S. J. Rogers, D. J. Channin, R. J. Rollefson, W. M. Goubau, G. E. Schmidt, and R. O. Pohl.

"Pair Effects in Random Lattices; A Generalized C.P.A. and Its Equivalence to Diagrammatic Expansions", Phys. Lett. 36A, 111 (1971) with B. G. Nickel.

"Self-Consistent Average Green's Function in Random Lattices: A Generalized Coherent-Potential Approximation (n) and its Diagrammatic Equivalents", Phys. Rev. B 4, 4354 (1971) with B. G. Nickel.

PUBLICATIONS

J. A. Krumhansl

- 6 -

"Triplet Correlation in Liquid Argon by Monte Carlo Method: Low Densities", J. Chem. Phys. 56, 2034 (1972) with S. S. Wang.

"Superposition Assumption. I. Low Density Fluid Argon", J. Chem. Phys. 56, 2179 (1972) with S. S. Wang.

"High-Pressure Behavior of Solid H₂, D₂, He³, He⁴, and Ne²⁰", Phys. Rev. B 5, 4180 (1972) with E. L. Pollock, T. A. Bruce and G. V. Chester.

"Quantum Theory of the Equation of State for Solid Hydrogen", Phys. Rev. B 5, 4155 (1972) with S. Y. Wu.

"Superposition Assumption. II. High Density Fluid Argon", J. Chem. Phys. 56, 4287 (1972) with S. S. Wang.

"Pair Potential in Liquids from the Exact Born-Green Equation. I. Model Testing," J. Chem. Phys. 57, 4202 (1972), with S. S. Wang.

"It's a Random World," reprinted from AMORPHOUS MAGNETISM, edited by Henry O. Hooper & Adrian M. deGraaf, Plenum Publishing Corporation, 227 West 17th Street, New York, N. Y. 10011

"The Short-Range Interaction Between Hydrogen Molecules," Phys. Rev. A 9, 1852 (1974) with H. Beck and A. K. McMahan.

"The Theory and Properties of Randomly Disordered Crystals and Related Physical Systems," Reviews of Modern Physics, Vol. 46, No. 3, July (1974) with R. J. Elliott and P. L. Leath

"Macroscopic engineering properties of polycrystalline materials: Elastic properties," J. App. Phys. 46, 1875 (1975) with J. E. Gubernatis.

"Dynamics and Statistical Mechanics of a One-Dimensional model Hamiltonian for Structural Phase Transitions," Phys. Rev. B 11, 3535 (1975) with J. R. Schrieffer.

"Stochastic Theory of 'Spin-Phonon Relaxation,'" with R. Pirc, Phys. Rev. B 11, 4470 (1975).

"Mean Field and Exact Results for Structural Phase Transitions in 1-D and Very Anisotropic 2-D, 3-D Systems," with A. R. Bishop, Phys. Rev. B 12 2824 (1975).

"Potential Energy and Force Constants of a Potassium Chloride Molecule from Extended Huckel Calculations", with Kristl B. Hathaway, Journal of Chemical Physics, 63, 4313, 1975.

"Extended Huckel Calculation of Repulsive Interactions in Noble Gases" with Kristl B. Hathaway, Journal of Chemical Physics, 63, 4308, 1975.

"The Elasticity of Polycrystals and Rocks", with E. Domany, J. E. Gubernatis, Journal of Geophysical Research 80, 4851, 1975.

- "Molecular Dynamics Simulation of Model For (one-dimensional) structural Phase Transitions," Solid State Communications, 17, 1975 with T. R. Koehler, A. R. Bishop, and J. R. Schrieffer.
- "Theory of the Scattering of Ultrasound By Flaws," Ultrasonics Symposium Proceedings, 1975 Ultrasonics Symposium Proceedings, IEEE Cat. #75 CH) 994-4SU with J. E. Gubernatis, E. Domany, and M. Huberman.
- "Microscopic Derivation of Domain Walls", presented at the Puerto Rico conference and submitted to the Journal of Ferroelectrics, with E. Domany and A. R. Bishop.
- "Weakly-Pinned Fröhlich-Charge-Density-Wave Condensates: A New, Nonlinear, Current Carrying Elementary Excitation"; Physical Rev. Letters 36, 432 (1976) with M. J. Rice, A. R. Bishop and S. E. Trullinger.
- "Classical Particle-like Behavior of Sine-Gordon Solitons in Scattering Potentials and Applied Fields", Phys. Rev. Lett. 36, 1411 (1976), with M. B. Fogel, S. E. Trullinger, A. R. Bishop.
- "Dynamics of Sine-Gordon Solitons in the Presence of Perturbations", Phys. Rev. B 15, 1578 (1977) with M. B. Fogel, S. E. Trullinger, A. R. Bishop and J. A. Krumhansl.
- "Solitons in a Coupled Linear Chain System", Phys. Rev. Lett. 38, 778 (1977) with B. Horowitz and E. Domany.
- "Self-Consistent Calculations of Elastic Constants of Polycrystalline Graphite", with R. E. Smith, G. B. Spence, J. E. Gubernatis and J. A. Krumhansl, Carbon 14, 185 (1976).
- "Quantum Corrections to Domain Walls in a Model (One-Dimensional) Ferroelectric", A. R. Bishop, E. Domany and J. A. Krumhansl, Phys. Rev. B14, 2966 (1976).
- "Solitary Structures in Nonlinear Fields", Sanibel Conference, January 1977, J. A. Krumhansl.
- "Formal Aspects of the Theory of the Scattering of Ultrasound by Flaws in Elastic Materials", J. E. Gubernatis, E. Domany and J. A. Krumhansl, J. of Applied Physics, 48, 2804 (1977).
- "The Born Approximation in the Theory of The Scattering of Elastic Waves by Flaws", J. E. Gubernatis, E. Domany, J. A. Krumhansl and M. Huberman, J. of Applied Physics, 48, 2812 (1977).

HARRISON A. WILLIAMS, JR., N.J., CHAIRMAN
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United States Senate

COMMITTEE ON HUMAN RESOURCES

WASHINGTON, D.C. 20510

November 1, 1977

Honorable Harrison A. Williams
 Chairman
 Committee on Human Resources
 U. S. Senate
 Washington, D.C. 20510

Dear Mr. Chairman:

I am pleased to have this opportunity to comment on the nomination by the President of Dr. James Krumhansl to be Assistant Director for Mathematics, Physics and Engineering at the National Science Foundation.

Dr. Krumhansl has had a distinguished career in physics during which he has had the opportunity to serve in both academic and industrial research efforts. He brings to the leadership team at the N.S.F. an outstanding perspective on the resources and talents which exist in the disciplines for which he will be responsible.

I am confident that Dr. Krumhansl will work closely with our Committee and the Subcommittee on Health and Scientific Research as we continue our efforts to assure that the national receives a full return on the funds it invests in basic research.

With every good wish,

Sincerely,



Edward M. Kennedy, Chairman
 Subcommittee on Health and
 Scientific Research

Senator RANDOLPH. I think there is continuing in the committee, Dr. Krumhansl, the review of your financial holdings. I am advised that the review is incomplete, but that because we were having this hearing in reference to Mr. Biddle's nomination, that we could move forward on your nomination hearing as well. We will, perhaps through the committee staff, be contacting you further in reference to your financial statement. I just mention that so as to indicate that today's hearing process will suffice, but that you may be hearing from the committee staff members in reference to your financial statement, if necessary.

Would you proceed now, sir?

**STATEMENT OF JAMES A. KRUMHANSL, OF NEW YORK, NOMINEE
TO BE AN ASSISTANT DIRECTOR OF THE NATIONAL SCIENCE
FOUNDATION**

Dr. KRUMHANSL. I would be happy to supply any data in discussion or in writing which your committee requires. Thank you very much.

Senator RANDOLPH. If you wish to comment on your statement—it is not a long statement. Whatever you desire. If you choose to summarize, the entire statement will be made a part of this record.

Dr. KRUMHANSL. I would first like to say how honored I am to be here, how enthusiastic I am to become acquainted with your committee and with any of the agencies in Washington with which I will be associated in my new responsibilities if confirmed.

I would like to read my statement.

Senator RANDOLPH. It is certainly appropriate.

Dr. KRUMHANSL. I am honored to appear before you as a presidential nominee to an assistant directorship of the National Science Foundation. This is a tremendous opportunity for service, both to my fellow citizens at large and to those who are colleagues in science, in the common purpose of best achieving our national and professional goals.

The National Science Foundation has a justly deserved reputation for success in fostering scientific investigation and in strengthening science education. I aspire to join the ranks of those whose efforts and dedication have achieved this distinction in the administration of public funds for these purposes and to assist in whatever way I can to promote the progress of science through the Foundation's programs.

Not all branches of science stand in the same relation to the world in which we live. Before we reap we must sow and regularly seek new strains. The areas within my proposed purview, the mathematical and physical sciences, and engineering, reach to widely separated horizons. They extend from the fascinating and elusive mysteries of elementary particle physics on the one extreme, a true frontier, to the challenge on the other hand of sensitively selecting and supporting research studies which especially help technology to make practical use of the science resource which has been developed.

I see my responsibilities as to assure that the Foundation continues getting the very best understanding of fundamental science possible from its investment and at the same time, maintaining an awareness of the opportunities for use of scientific knowledge by technology and by society generally.

I have always found science and technology and their uses to be stimulating. My early training and industrial employment were in

electrical engineering, and I witnessed the communications revolution as it developed through radar research in World War II.

As a university teacher in physics, applied mathematics, and materials science, I have participated in the evolution of the scientific research resource in colleges and universities and I believe this is a very important national asset.

As an industrial research administrator in the chemical industry and former consultant to other industries, I have witnessed interplay between technical, commercial, and societal priorities. And, finally, as an editor of professional journals, I have realized the importance of communication in science and to the world around us. Those experiences have been personally exciting. I hope now that they will serve to make me continually aware of the issues and needs in the national support of mathematics, physical sciences, and engineering.

I will be fully committed to using my background in the scientific, educational, and industrial communities to achieve the common aims of the Foundation and my colleagues in science. Through further service to science I want to bring a richer life to those about me.

That's my formal statement and, if I can summarize, I am deeply committed to my profession and to its use by those around us.

Senator RANDOLPH. Thank you, Dr. Krumhansl.

We just checked through the number of publications. There are 89 that you have had published to your credit.

Dr. KRUMHANSL. I have lived awhile in this business. If one keeps busy and one communicates then it counts up.

Senator RANDOLPH. These go back to 1949.

Dr. KRUMHANSL. That's correct.

Senator RANDOLPH. It seems to me you get more prolific as the years move on.

Dr. KRUMHANSL. I don't know that I should comment on age, retirement, and such questions.

Senator RANDOLPH. You have one here, "Theoretical Calculations of F-Center Energy Levels." Because we have been working on energy in the Senate could you take a moment to give us just a few words about what you were doing in that publication?

Dr. KRUMHANSL. I am happy to have the opportunity because here is a very technical title. I should tell you about the origin of F-Centers. The F comes from the German word "farben," color. It was found in some of the salt mines of Germany that sometimes the salt crystals would be transparent and sometimes they would be colored.

The curiosity of scientists 40 or 50 years ago directed itself to the origin of that coloration. Next act: 30 years later. The subject: solid state physics takes shape and the theory develops. That theory allows us to understand that electrons at specific positions in the crystal lattice may produce a coloration.

If I can go directly to the question you asked, what relation may this have to the energy problem? The point is that the origins of the modern development of photovoltaic cells for solar energy conversion can be traced directly to an understanding of solid state physics, involving the theory of F-Centers. Thus one of the major contenders for solar energy devices, the photovoltaic cell, can trace its parentage to early fundamental research on the subject of F-Centers.

Senator RANDOLPH. Thank you very much. You have been a very busy man, is that right?

Dr. KRUMHANSL. That's right.

Senator RANDOLPH. You liked your work?

Dr. KRUMHANSL. I like work.

Senator RANDOLPH. I sometimes think as I meet different types of people how some are maybe overenthusiastic, some are very enthusiastic, some are perhaps less enthusiastic but I knew the moment you spoke today that you have had a very genuine input in the science field and you want to continue. This position would give you a great opportunity; is that right?

Dr. KRUMHANSL. That is certainly correct. That is the challenge.

Senator RANDOLPH. Doctor, how do you think the research proposals that come from industrial scientists should be reviewed? How should these be evaluated by you? Should the criteria be different from the industrial scientists than from the researcher, let's say, within the academic world? Just comment, would you?

Dr. KRUMHANSL. I believe—in part these are my personal opinions—I understand the importance of the concept of providing support for good science wherever it may be. Your question concerns a mechanical but subtle mechanical question; that is, how proposals shall be evaluated.

I think there should be a balance between some questions of urgency or relevance and quality; I don't think that one should ever compromise the quality of the science in the review process.

Senator RANDOLPH. I think that leads into the next question. There is perhaps a current emphasis within the Foundation on what we would call a joint or mutual industry and university venture or ventures in basic research. Would you happen to have a little further comment?

Dr. KRUMHANSL. Yes; I believe this is a very exciting concept. I may be prejudiced. In part, my reason for that answer is that I have been imbedded in one of those experiments myself and it has been a very successful experiment. In fact, with the committee's permission, may I digress into some thinking that I was doing last night as to how I might illustrate some aspects of science as a resource. May I have a minute or so?

We see the advertisement, "Diamonds Are Forever." My feeling is that good science is forever and for everywhere. Again, an anecdote: About 100 years ago Lord Rayleigh wondered why the sky was blue. He thought about this and conjectured that it was due to scattering of light by inhomogeneities, fluctuations in the atmosphere. From that, there developed through mathematics, through a generation of nuclear physics, through the understanding of the scattering of radio waves in World War II in radar a whole set of applications which today employs scattering concepts as the method or strategy for experiments. It is part of the theoretical underpinning of modern medical diagnosis in scattering of ultrasound and ultrasound imaging (so we now can replace X-ray diagnosis by ultrasound diagnosis). We can apply the scattering of sound to oceanography in the detection of structure and determination of the properties of our undersea environment and so on.

My point is that good science lasts a very long time and good science can be used everywhere if one is sensitive to how science does couple with applications. A healthy interplay between industry and basic science is something to which I think we can point as having had many success stories and as something which we should continue to cultivate.

Senator RANDOLPH. John?

Senator CHAFFEE. Mr. Chairman, thank you.

I am delighted to be here and have this opportunity to meet Dr. Krumhansl. First, I want to state that I have a tilt bias in his direction—I guess a bias means a tilt, so that is redundant. I have a bias in his direction because he taught at Brown University in the forties. So I start out with a presumption in your direction.

Second, I would like to convey the regrets of your Senator, Senator Javits who—if you were here during the previous testimony you will have heard the statement of Senator Stafford that Senator Javits could not be here due to a very important engagement in New York City—sends his regrets and wishes that he could be here to support this nomination.

Third, I have had the privilege of sitting on the board of a major university where complaints of all kinds come forward but we have never heard any complaints about the National Science Foundation. That is unusual for an organization that is so widespread. You would think you would hear griping that there had been unfairness, or they are a failure in one place or another undeservedly.

That hasn't proven true, so it seems to me, looking at it from the outside, and the inside now to some degree, that the Science Foundation is doing a superb job. I think, Dr. Atkinson, you deserve a lot of credit, and have a big job to carry on what appears to have been a superb tradition for this country.

I must confess, I am not aware that the Science Foundation did support industrial research. Could you explain, between the two of you, just how that would work out? For example, let's say that RCA is doing a significant piece of research and if the Science Foundation contributed how would they contribute and what would happen, for instance, with the ensuing patents that might result?

Dr. ATKINSON. Senator, this is a complicated area. In our applied research effort we have had a tradition of supporting work in industry and in universities. The basic research efforts have been almost entirely confined to the support of research in universities. On the other hand, there is much concern about the strength of our industrial science base, and with this concern in mind, the Foundation is now reviewing the whole issue of what its relation should be to industry in the support of industrially based research. The National Science Board has a report now in final draft form, and it will be reviewing the draft at its next board meeting. The Board will attempt to look forward to what the Foundation's role should possibly be in an expanded program of support for industrially based research.

But, it is a complicated issue and it is one that doesn't have a simple answer.

Senator CHAFEE. I can easily see that. I know it is a thorny area but I would commend you for the effort you are taking to resolve this, because we are all looking to the future of the Nation and how the Nation can do best. I don't think because science has primarily been in the universities, that we should overlook the efforts being made in more applied science in the corporations.

Somehow, if we can be of assistance while protecting ourselves or seeing the public is protected as far as any profits that ensue from such research, I think we ought to make that effort.

I know the chairman is involved in something else, so perhaps I can defer it—how do you work it now in your universities where, for instance, you are doing some research that is of interest to a private corporation? Wouldn't they make direct subsidies to help that research in the university laboratory?

Dr. KRUMHANSL. I think there are several parts to the answer to that. Scientific communication is very fast, so one of the ways in which the information becomes available to the industrial laboratories is just through the journals. As it happens, I have been editor up until this time—and I will relinquish that editorship—of a journal called the "Physical Review Letters." It appears weekly.

In principle, we can publish a manuscript within 3 weeks of its submission, and average perhaps 8 weeks. This means that work supported by the National Science Foundation, which is public property, can be put into print and distributed to any user in a very, very short time, and quite effectively. That's one answer.

The other answer is that indeed, in the case of very, very well-focused interests some industries do make connection with a research project by providing supplementary funding, or by their staff, as scientific colleagues, talking directly to those doing the work.

Senator CHAFEE. Mr. Chairman, I have taken a little bit too much time, but I just want to say this—which has nothing to do with this committee but has to do with a general area—that I am ill at ease about the extent of financial disclosure by nominees for posts. We as Senators are subjected to it. That is the trend of the time.

We have got to tell everything we own or owe. But there is something that makes me very ill at ease about requiring people that come before us or any other committee to reveal all their assets. I think the result might well be that we discourage good people from taking jobs which have enough drawbacks to them in themselves, having to move their families, the temporary nature of it, the excessive, often, reduction in income and the subjecting themselves to a good deal of criticism of all types—by adding the burden of excessive financial disclosure.

I know we discussed this briefly the other day in the committee, but somehow I hoped that if there is financial disclosure that it could be limited to the committee and not broadcast to the world at large. I just wanted to get that off my chest, Mr. Chairman.

Senator RANDOLPH. Thank you, John.

Off the record.

[Discussion off the record.]

The hearing of Dr. Krumhansl will now be concluded. There are certain questions, seven in number provided by Senator Kennedy which because of the time situation I shall not ask. These will be given to you to respond to them in writing. Would that be agreeable?

[The questions and responses referred to appear at the end of the hearing.]

Dr. KRUMHANSL. Yes, quite agreeable.

Senator RANDOLPH. We would be very happy to have your responses.

We thank you, Dr. Atkinson for coming with Dr. Krumhansl. I have long felt that by and large the expenditures of funds in scientific research and development, the pure and unpure as we call it, generally these have been not just expenditures. They have been investments. The investment sometimes is not noted at the beginning, but the result is not just the dollar on the dollar spent—the dollar received—but the investment very often has paid great dividends for humanity as a whole. I think we can subscribe to the hope that in the future this will continue to be so.

[The prepared statement of Dr. Krumhansl and material referred to follows:]

Statement by
Dr. James A. Krumhansl
Nominee for Assistant Director,
Mathematical and Physical Sciences, and Engineering
National Science Foundation

Mr. Chairman and Senators

I am honored to appear before you as a Presidential Nominee to an Assistant Directorship of the National Science Foundation. This is a tremendous opportunity for service, both to my fellow citizens at large and to those who are colleagues in science, in the common purpose of best achieving our national and professional goals.

The National Science Foundation has a justly deserved reputation for success in fostering scientific investigation and in strengthening science education. I aspire to join the ranks of those whose efforts and dedication have achieved this distinction in the administration of public funds for these purposes and to assist in whatever way I can to promote the progress of science through the Foundation's programs.

Not all branches of science stand in the same relation to the world in which we live. Before we reap we must sow and regularly seek new seed strains. The areas within my proposed purview, the Mathematical and Physical Sciences, and Engineering, reach to widely separated horizons. They extend from the fascinating and elusive mysteries of elementary particle physics on the one extreme to the challenge on the other hand of sensitively selecting and supporting research studies which especially help technology to make practical use of the science resource which has been developed. I see my responsibilities as to assure that the Foundation continues getting the very best understanding of fundamental science possible from its investment, at the same time maintaining an awareness of the opportunities for use of scientific knowledge by technology and by society generally.

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- 3 -

the evolution of the scientific research resource in colleges and universities; this is a very important national asset. As an industrial research administrator in the chemical industry, and former consultant to other industries, I have witnessed interplay between technical, commercial, and societal priorities. Finally, as an editor of professional journals, I have realized the importance of communication in science and to the world around us. Those experiences have been personally exciting and I hope now that they will serve to make me continually aware of the issues and needs in the national support of Mathematics, Physical Sciences, and Engineering.

I will be fully committed to using my background in the scientific, educational, and industrial communities to achieve the common aims of the Foundation and my colleagues in science. Through further service to science I want to bring a richer life to those about me.

NATIONAL SCIENCE FOUNDATION

WASHINGTON, D.C. 20550

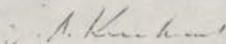
October 31, 1977

The Honorable Harrison A. Williams, Jr.
Chairman
Committee on Human Resources
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

I should like to confirm for the record that, in accordance with standard National Science Foundation policy, while serving as Assistant Director of the Foundation I will disqualify myself from any participation in the consideration of proposals from Cornell University, my home institution.

Sincerely yours,



J. A. Krumhansl

NATIONAL SCIENCE FOUNDATION

WASHINGTON, D.C. 20550

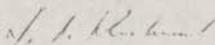
October 31, 1977

The Honorable Harrison A. Williams, Jr.
Chairman
Committee on Human Resources
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

The President recently transmitted my name to your Committee for confirmation as Assistant Director for Mathematical and Physical Sciences, and Engineering of the National Science Foundation. If confirmed by the Senate, I will be willing to respond to any requests to appear and testify before any duly constituted committee of the United States Senate. I am honored that the President has considered me for this appointment and stand ready to contribute to any hearings where my testimony would be considered useful.

Sincerely yours,



J. A. Krumhansl

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D. C. 20550

November 1, 1977

OFFICE OF THE
DIRECTOR

The Honorable Harrison A. Williams, Jr.
Chairman
Committee on Human Resources
United States Senate
Washington, D. C. 20510

Dear Mr. Chairman:

For those concerned with my proposed appointment to the National Science Foundation, the following describes my relation with my immediately previous employer, Cornell University. I am on leave for 2 years with extension allowed as deemed suitable at that time. I will receive no compensation or pension contributions from Cornell during the term of this appointment.

Respectfully,

A handwritten signature in cursive script that reads "James A. Krumhansl".

James Arthur Krumhansl

COMMITTEE QUESTIONS FOR DR. KRUMHANSL

- 1) COULD YOU IDENTIFY WHAT YOU CONSIDER TO BE THE MOST EXCITING NEW DEVELOPMENTS TO BE EXPLORED BY YOUR DIRECTORATE IN THE NEXT FEW YEARS?

- 2) WHAT CAN AND SHOULD THE NATIONAL SCIENCE FOUNDATION DO TO ENCOURAGE INTER-DISCIPLINARY APPROACHES TO SCIENTIFIC PROBLEMS?

- 3) WHAT BENEFITS AND OR PROBLEMS DO YOU FORESEE STEMMING FROM THE CURRENT EMPHASIS WITHIN THE FOUNDATION ON JOINT UNIVERSITY-INDUSTRY VENTURES IN THE PERFORMANCE OF BASIC RESEARCH?

- 4) HOW DO YOU THINK RESEARCH PROPOSALS FROM INDUSTRIAL SCIENTISTS SHOULD BE REVIEWED AND EVALUATED BY YOUR DIRECTORATE. SHOULD THE CRITERIA BE DIFFERENT FROM THOSE WHICH APPLY TO ACADEMIC RESEARCHERS? AND FOR WHAT REASON?

- 5) DO YOU THINK THE CURRENT BALANCE BETWEEN PROBLEM ORIENTED AND BASIC RESEARCH NEEDS TO BE REVISED? IN WHAT WAY?

- 6) HOW DO YOU INTEND TO COORDINATE THE EFFORTS OF YOUR DIRECTORATE WITH THE OTHER BASIC RESEARCH DIRECTORATES? WITH THE SCIENCE APPLICATIONS DIRECTORATE?

- 7) WHAT CAN AND SHOULD THE FOUNDATION DO TO ENHANCE THE POSSIBILITY OF USEFUL "SPIN OFFS" FROM THE BASIC RESEARCH IT SPONSORS?

RESPONSES TO QUESTIONS

SUBMITTED BY

• HONORABLE EDWARD M. KENNEDY
CHAIRMAN, SUBCOMMITTEE ON HEALTH AND SCIENTIFIC RESEARCH
COMMITTEE ON HUMAN RESOURCES

TO

JAMES A. KRUMHANSL
NOMINEE FOR
ASSISTANT DIRECTOR FOR MATHEMATICAL AND
PHYSICAL SCIENCES, AND ENGINEERING
NATIONAL SCIENCE FOUNDATION

November 11, 1977

Question #1

- Q. Could you identify what you consider to be the most exciting new developments to be explored by your directorate in the next few years?
- A. The Mathematical and Physical Sciences, and Engineering Directorate presently has research programs in mathematics, computer science, physics, chemistry, materials science, and engineering. It is my personal view that in all of these we are in a period of burgeoning accomplishment and opportunity. I may also emphasize in passing that these sciences not only have substance and direct applications in themselves, but also augment the science base in other directorates at NSF or the mission agencies by supporting basic research and providing new techniques or facilities.

Among the promising developments being explored by scientists with MPE support are the following:

- Mathematicians are beginning to find that they can use the modern computer not simply as a computational device, but also as an aid to the development of concepts in analysis. This development will profoundly influence the classes of problems they are able to attack. They will be able to use the computer as a tool for testing conjectures and even for suggesting mathematical problems.
- The idea of Computational Complexity has developed into a profound concept with important practical consequences. For example, very recent studies in the theory of complexity have led to the design of encrypting techniques which give experts the ability to authenticate electronic messages as they would signatures and legal documents. In addition, encrypting techniques prevent tampering and are easy to use. This critical development will assist in the widespread adoption of electronic computer communications in commerce, government and other aspects of civilian life. There are broad implications with the introduction of new scientific concepts such as computer complexity. In this instance, for example, national security concerns have been raised because computer complexity opens the possibility of developing new codes that cannot be broken by intelligence services.

- ° In High Energy Physics, we have been expanding rapidly our understanding of elementary particles. In just a few years our intuitive feelings that quarks are real entities have been clarified significantly. As a truly vital endeavor at the frontiers of science, particle physics continues to justify significant attention. In the intermediate physics range relatively inexpensive new techniques for accelerating heavy nuclei to high energies are disclosing important new features in the interaction of compound nuclei. In the low energy range not only do we continue to find new insights into atomic and molecular physics for use in chemistry, atmospheric science, and plasma physics -- but also there are exciting ideas directed toward testing elementary particle interactions which complement the high energy studies.
- ° Chemical catalysts are an exciting area of research. They not only play a crucial economic role in the chemical industry, but also, and perhaps more significantly, involve nearly all of the processes of life. New experimental techniques continue to improve our insight into the molecular mechanisms involved in chemical catalysts; major steps toward comprehending the heterogeneous catalytic process are being made. Related work bears on using catalysts to replace the expensive metals of the platinum group in exhaust gas pollution control. The evolution of the laser as a research tool will be pursued with keen interest by chemists. Purely intramolecular processes can be studied in a collisionless gas or a molecular beam. Further, laser studies of the condensed phases of matter have been informative about ordinary chemical processes in liquids. In view of the significant progress made in the statistical mechanics of liquid structure and dynamics, comparable progress in the understanding of photochemical process in liquids is foreseeable, and of potential interest in solar energy studies.
- ° In materials science, basic studies of the properties of superfluid systems (particularly Helium 3) will continue to produce new ideas on the structure of matter. New materials of chemical, electronic, and technological importance are being developed -- notably ternary compound superconductors and "low-dimensional" materials.

Question #1

3.

- Engineering is a broad topic, heavily supported and practiced in industry. Yet there are important basic questions of a generic nature. For example, how do solutions of engineering problems scale between large and small systems? New ideas for research on this topic are being supported by NSF. Applications include the design of large earth dams or concrete structures from experiments with scale models, investigation of jets and plumes such as those formed in the outfall from sewage disposal plants, and the verification of mathematical scaling relations which can be afforded by use of a large centrifuge for the dynamic testing of scale models in geomechanics. Another promising area in engineering is research on advanced automation which deals with the behavior of adaptive, digital control, and sensor systems. The objective is imitation and enhancement of some of man's capabilities such as those inherent, for example, in an eye-arm-wrist-hand-finger system directed by rudimentary brain capacity. Closely related is automatic extraction of information from images and other sensory inputs, which relates, for example, to the design of prosthetic devices.

- One old topic which is surfacing anew to challenge all of the divisions of the directorate is that of turbulence. New mathematics, computer simulation, laser diagnostics, engineering hydrodynamic studies, information from blood circulatory experiments, and other developments are stimulating some of the best scientists to new efforts on this old and ubiquitous problem of turbulence.

I hope that these selected topics convey some sense of what I firmly believe to be true -- that mathematics, the physical sciences, and engineering are in a fertile and exciting period.

Question # 2

Q. What can and should the National Science Foundation do to encourage interdisciplinary approaches to scientific problems?

A. I would like to make two general points. First, in my thirty-five years of professional experience in science, I do not recall a period when there has been such a spontaneous eruption of interdisciplinary awareness in the scientific and engineering communities through curiosity, recognition of mutually common conceptual problems, and new techniques as now. This is truly fortunate. Second, the National Science Foundation can play an important role in encouraging this interdisciplinary work, while at the same time ensuring that quality is maintained.

The National Science Foundation already does many things to encourage interdisciplinary approaches to scientific problems. Projects are jointly funded within the structure of the Foundation. Our Materials Research Laboratories program is a major effort to provide a research environment which fosters an interdisciplinary approach to selected problems. Many of our sponsored facilities, which are designed to serve a multiplicity of users, such as synchrotron radiation sources or the new submicron electronics materials facility also provide such encouraging environments. Personally, I would say that the Foundation should encourage interdisciplinary activities when a proposal makes it clear that the approach is well matched to the problem, and of course, that the problem is an important one.

Science itself, as a body of knowledge, is not really disciplinary *per se* but rather, it strives for generality and completeness. Disciplines emerged, in part, because the problem of complete knowledge is so large that individuals tend to select manageable problems and to develop specialized techniques for their pursuit. As a result, there emerged not only an increasing body of knowledge, but also a body of professional, skilled practitioners who can make a collective judgment as to the quality and validity of a new result through publication, criticism, and discussion. NSF has a role to play by encouraging communications and understanding between the practitioners of the various disciplines. With open channels of communication, interdisciplinary studies are a natural development for creative research scientists. We would not wish to enter into an era of interdisciplinarianism for the sake of interdisciplinarity at the risk of losing the value of such discussion, criticism, and validation.

Question #3

Q. What benefits and/or problems do you foresee stemming from the current emphasis within the Foundation on joint university-industry ventures in the performance of basic research?

A. The Foundation has supported productive joint university-industry programs within both the basic research programs and the former RANN program. This certainly is a good thing to do when a particular topic is ripe for joint exploitation; clearly this cannot be an across-the-board activity, but the NSF simply must provide a mechanism to respond to those who identify timely topics. Currently there is discussion within the Foundation as to how best to attack complications such as patents and proprietary information.

I personally feel that the long-range health of science makes it appropriate to protect a large block of resources for universities because of their educational involvement. A program looking to the health of basic research in industry could be separate, and separately funded, as I now see it. A mechanism which provides for the easy exchange of people between industry and academe is appealing for that is a proven method for transfer of ideas, perspective, and technique.

Question #4

Q. How do you think research proposals from industrial scientists should be reviewed and evaluated by your directorate? Should the criteria be different from those which apply to academic researchers? And for what reason?

A. As stated above I think any large scale basic research program involving industry should be a separately funded program. However, within that context, I would feel that research proposals should be evaluated in much the same way that proposals are currently evaluated in our basic research programs. Scientific excellence should be the major criterion and peer review should be the major tool. The selection of reviewers and advisory panel members might have to be given special consideration. There should be no special "sheltering" in such a program, however.

Question #5

- Q. Do you think the current balance between problem-oriented and basic research needs to be revised? In what way?
- A. Because I have been at the Foundation such a short time and our applied research activity is undergoing such a major reorganization, I would like to withhold judgment on this issue for the present time. It is my personal opinion that the greatest national good would come about if the mission agencies were to build up (or rebuild) stronger basic research programs in those areas where new knowledge will foreseeably bear upon their future operational problems.

Question #6

- Q. How do you intend to coordinate the efforts of your directorate with the other basic research directorates? With the Science Applications Directorate?
- A. A satisfactory coordination mechanism, especially at the program officer level, is already in place among the basic research directorates at NSF. For example, our synchrotron radiation sources are funded by the Division of Materials Research, but they are used by investigators supported by chemistry and biology grants as well. A similar situation will apply to several other facilities now being developed.

Our Science Applications Directorate is so new that it is hard for me to say now what would be the best method of coordinating our programs. It seems essential that my program staff maintain communications with this Directorate. Perhaps, at the beginning, each Research Directorate could appoint an individual to serve as Science Liaison member to the Science Applications Directorate to facilitate communications and permit Directorates to learn from each other.

Question #7

- Q. What can and should the Foundation do to enhance the possibility of useful "spin-offs" from the basic research it sponsors?
- A. I believe that nearly every element of the Mathematical and Physical Sciences and Engineering Directorate has research with some "spin-off" potential. I will encourage awareness of opportunities.

As to mechanisms, first, all work supported within the basic research program is published so that potential spin-offs are always there to be captured by those who can use the research results. Second, NSF-developed or -sponsored workshops are among our initiatives to "spread the word" more rapidly, and in a more timely fashion. I believe that it also happens that an individual program officer recognizes the potentiality of a spin-off and he simply pushes it until someone catches it.

Senator RANDOLPH. Thank you very much. This hearing is over.
[Whereupon, at 11 :30 a.m. the committee adjourned.]



