Summaries of FY 1980 Engineering Research

U.S. Department of Energy
Office of Energy Research
Office of Basic Energy Sciences
Division of Engineering, Mathematical & Geosciences

March 1981

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FOREWORD

This report documents the basic Engineering Research program of the DOE Office of Energy Research. Dr. Oscar P. Manley is the Engineering Research program manager. This program is administered by the Division of Engineering, Mathematical and Geosciences in the Office of Basic Energy Sciences which is a major organizational unit of the Office of Energy Research (OER). The fiscal year 1980 operating funds managed under this program amounted to $2.3 million. Of the thirty-two projects constituting the program in 1980, eight were underway at DOE laboratories, fifteen at universities, seven at private sector laboratories, and two at other government agencies.

This report responds to a perceived need for this kind of compilation by university and other scientists, by congressional staff, and by staff of other executive departments when they are concerned with implementation and coordination of energy and other research projects and programs.

The OER basic Engineering Research program addresses engineering areas perceived as essential for progress in many energy technologies. Emphasis and high priority are accorded to projects and proposals with the objective of providing fundamental data and understanding for longer-range advances in energy processes and systems. The program complements the necessarily shorter-range focus of engineering reseach carried on in conjunction with DOE technology programs.

Currently identified, high priority, basic engineering research areas are: tribololgy, heat transfer, process control, instrumentation for hostile environments, elastoplastic deformations, engineering aspects of combustion, and resource recovery. Notable among projects underway in 1980 were projects dealing with: surface-fluid interactions in support of research in tribology and percolation, non-imaging optics for design of more efficient solar collectors, high temperature electronics for control systems in hostile environments, methods for solid-solid and solid-liquid separation for resource recovery, modeling of elastoplastic deformation and crack propagation in engineering structures, automatic on-line process analysis, automation of non-destructive testing of materials, combustion of lean fuel-air mixtures, heat exchange, and systems vibration and wear.

This is the first report of this type prepared for this program. To expedite publication, the approach taken was to have staff adapt summaries from project documentation submitted prior to and early-on in the fiscal year. The principal investigators have not been given the opportunity to review or approve the summaries as published. It has not been the intent to convey significant scientific results of the projects, but rather to indicate the area and scope of the research. For more detailed information about a given project, it is suggested that the investigators be contacted directly.

James S. Coleman, Director
Division of Engineering,
Mathematical and Geosciences
Office of Basic Energy Sciences

INTRODUCTION

The purpose of the report is to provide a convenient compilation of summaries of the individual research project (tasks) that constitute the OER basic Engineering Research program for fiscal year 1980.

The report is ordered alphabetically by institution with all of the project entries for an institution following the institutional-departmental heading. In a monotonically increasing sequence, each project entry begins with an underlined identification number. This is followed, reading across the page, by the project title, the funding level, and a coded sequence, e.g., 80-2. The first two digits of this sequence indicate the fiscal year in which the project was authorized; the digit following the hyphen indicates the anticipated duration of the project in years. If the anticipated term of the project is indefinite, the capital letter I follows the hyphen instead of a digit. If the funding period is other than twelve months, the number of months in the funding period appears immediately below the funding level. A funding level is paranthesized to indicate that it is a prior year obligation and that there was no obligation for support of the project in fiscal year 1980. The names of the investigators are given immediately below the project title; at the DOE laboratories, the first name listed is that of the designated "task manager". The summary description of the project completes the project entry. The indexes both refer to the project numbers rather than to page numbers.

The participating DOE laboratories in fiscal year 1980 were:

Argonne National Laboratory (ANL)
Idaho National Engineering Laboratory (INEL)
Lawrence Berkeley Laboratory (LBL)
Lawrence Livermore National Laboratory (LLNL)
Los Alamos National Scientific Laboratory (LANSL)
Oak Ridge National Laboratory (ORNL)
Pacific Northwest Laboratory (PNL)
Sandia National Laboratories, Albuquerque (SNL-A)

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ARGONNE NATIONAL LABORATORY
Components Technology Division
9700 South Cass Avenue
Argonne, Illinois 60439

1. ENGINEERING MODELS IN DYNAMIC PLASTICITY — $ 45,000 — 80-2

G. S. Rosenberg, R. A. Valentin

The general objective is to develop a rational continuum basis for describing the dynamic plastic deformation of metals subjected to short duration, high intensity loading. A phenomenological rather than microscopic approach guides the derivation of constitutive representations, while classical irreversible thermodynamics provides rationale for specific representations. To bridge the gap between theory and eventual engineering application, consideration is given to development of analytical methods which define upper bounds on deformation history in terms of easily measurable load and material parameters. To maximize the eventual utility of theoretical models, the relationship between derived constitutive representations and available conventional materials data is explored. Particular emphasis is placed on representing multidimensional effects in terms of uniaxial test data.

BATTELLE COLUMBUS LABORATORIES
Structures and Mechanics Research
Department
505 King Avenue
Columbus, Ohio 43201

2. DAMAGE ACCUMULATION BY CRACK GROWTH UNDER COMBINED CREEP AND FATIGUE — $ 42,000 — 80-2

Carl E. Jaske

This project was authorized to begin in September of 1980. The proposed research is made up of simultaneous experimental and analytical tasks. These will be interactive; the results of one will provide direct feedback to the other throughout the course of the program. Analytical work will be directed toward evaluating the sensitivity of the basic approach to important independent variables, establishing critical conditions for experimental work, and refining and/or modifying the methodology as required. Type 316 stainless steel will be used for the experimental studies because it is commonly employed in many high-temperature applications in the energy industry and because its mechanical properties have been well characterized in past experimental programs, eliminating the need for extensive background materials data development in the present study. Baseline crack growth data will be developed in terms of da/dt versus C* for creep and da/dN versus ΔJ for fatigue. Hold-time, creep-fatigue tests will be conducted on precracked specimens. Selected test conditions will be based upon analytical predictions of the approach. Both center-cracked and compact-tension geometries will be employed. Results of these experiments will establish confidence in the analytical approach that eventually evolves.

BIPHASE ENERGY SYSTEMS
2800 Airport Boulevard
Santa Monica, California 90405

3. TWO PHASE FLOW RESEARCH — $ 59,000 — 80-3
W. Amend, L. Hays

This project was authorized to begin in June of 1980. It is planned as a three year effort to carry out research on two-phase flow nozzles and their mass/momentum exchange interaction with the liquid phase film on a rotating separator. During the first year, the investigators will experimentally evaluate the analytically computed optimum nozzle length for a given scale of atomized particle. In addition, the optimum trade-off between atomization pressure drop (resulting in various particle sizes) and nozzle presure drop will be established for a constant overall energy input. The work will be carried out utilizing air and water at ambient temperature with a nominal mass ratio of 10:1. Experimental data will be obtained using the Biphase nozzle thrust/reaction table, which utilizes calibrated strain gage load cells to measure nozzle performance. In the second year work will go forward to determine experimentally the momentum exchange efficiency between a high energy two-phase jet flow and the liquid film formed on the inner surface of a rotating separator. Of particular importance are the effects of liquid film thickness and velocity relative to the impinging jet. The effect of nozzle jet impingement angle will also be quantified. Separator film thicknesses will be varied from 0.0 to 0.75 inch, whereas, the relative velocities will vary from 0 to 200 fps. The angle of incidence of the jet to the film will vary from 5^{o} to 30^{o}. Both the nozzle thrust table and the rotating separator will be used to measure the momentum transfer efficiency under the various operating conditions. The final year of the research will quantify the wave-making interactions between external disturbances and a rotating separator liquid film. Study of the effect of two-phase nozzle jet perturbation to the film will be carried out over a range of Reynolds numbers, Froude numbers, and relative scales of the disturbance to the film depth, in order to establish the the relevant wave making characteristics. All tests will be documented photographically to record the various wave heights and angles. The effect of Coriolis forces will also be quantified through consistent variation in the Rossby number.

CALSPAN CORPORATION
Advanced Technology Center
Environmental Systems Department
P. O. Box 400
Buffalo, New York 14225

4.	MITIGATION OF BIOFOULING USING SURFACE COATINGS Dennis W. Goupil	$ 65,000	80-3

This project was authorized to begin in September of 1980. It is concerned with the testing, development and application of improved nontoxic antifouling coatings for use in heat exchange condensers. A preliminary series of experiments is proposed to determine if the relationship between surface chemistry and biological adhesion that has been developed from studies of the fouling environment of the blood, the mouth, and the sea can be applied to the biofouling problems in power plants. The three year program will progress gradually from the testing of coatings subjected to water from laboratory aquaria (1st year) to field studies performed with saltwater (2nd year) and freshwater (3rd year). At the conclusion of the program, it is anticipated that the basic engineering research involved in the application of coatings to heat exchangers in both saltwater and freshwater will be completed.

CARNEGIE-MELLON UNIVERSITY
Department of Mechanical Engineering
Schenley Park
Pittsburgh, Pennsylvania 15213

5.	MODELING OF SPRAY COMBUSTION William A. Sirignano	($110,000) 24	79-2

Theoretical research is underway on the problem of spray combustion in a multi-dimensional, unsteady, turbulent, two-phase flow. The liquid is a multicomponent fuel with heavy hydrocarbon components such as found in the alternative coal-derived and shale-derived liquids. Therefore, in order to accurately predict vaporization rates and gas-phase mixture ratios, a large system of equations is required. The equations governing the gas enthalpy, gas velocity, and gas turbulent scales are parabolic. The subsystem of equations governing the liquid-phase properties (droplet velocity, droplet radius, droplet surface temperature, and droplet number density) are hyperbolic, with some tendency towards a parabolic character due to turbulent diffusion of the droplets. The research during the first year has concentrated on the study of a model system of equations. Physically meaningful multi-dimensional spray combustion cases will now be studied utilizing results from the study of the model equations.

CARPENTER ENVIRONMENTAL ASSOCIATES, INC.
198 Walnut Street
Northvale, New Jersey 07647

6. PLASMA JET EXTRACTION OF OIL SHALE — $ 50,000 — 80-1
Ali Cambel

This project was authorized to begin in September of 1980. The investigators will undertake an exploratory proof of concept study to determine whether or not plasma arc jets may be used to advantage in accelerating shale oil production. The project plan specifies a four stage study consisting of: 1) system design, 2) net energy analysis of the system design, 3) an environmental evaluation of the system design, and 4) a bench type laboratory experiment. In stage one, a systems study of how plasma arc jets may be incorporated into shale oil recovery will be completed; two basic configurations will be considered, solo and hybrid systems to augument existing schemes. Different configurations of arc jets will be considered as well as the use of different gases as feed stock. Systems diagrams will be made to predict yield per day. The entire proposed technology will be described and configuration diagrams will be presented. In stage two, a comparative net energy analysis will be performed. This will consist of two approaches: 1) a pure net energy analysis, and 2) a hybrid net energy analysis developed by Frantz and Cambel, consisting of net energy analysis and input/output analysis. The net energy ratio for the various configurations developed will be calculated. In the third stage, a mini-environmental assessment of the system design will be performed particularly to establish if sulphur and nitrogen may be deleterious. In the last stage, a laboratory bench experiment will be conducted to determine if hopes and predictions for the system can be realized. In order to be able to make a comparison, a modified Fischer assay will be conducted. This will consist of a tank wherein a 100-gram sample of oil shale is heated. The variables will be the time, the temperature and the yield. They will clearly be different because the plasma temperatures will be considerably higher than the 500^{o}C commonly used in a conventional Fischer assay. Use of a standard procedure, the Fischer assay, will give a good indication of the effectiveness of plasma jets in oil retorting and will yield definitive comparisons.

UNIVERSITY OF CHICAGO
Enrico Fermi Institute
5630 Ellis Avenue
Chicago, Illinois 60637

7. FUNDAMENTALS AND TECHNIQUES OF NONIMAGING OPTICS FOR SOLAR ENERGY CONCENTRATION — $ 75,000 — 80-1

Roland Winston, Joseph J. O'Gallagher

The objective of this project is to carry out research in broadly defined areas to explore the potential of nonimaging optics for solar energy concentration. The development of a new formalism, based on the geometric vector flux concept, and the resulting discovery of new concentrator designs have stimulated a continuing effort to provide a broader theoretical base in this new discipline. The research activities break down into two modes or phases, one essentially devoted to fundamental theoretical questions and one devoted to exploration of promising applications. The former provides a foundation to support new concepts and the latter provides motivation and direction to the theoretical effort. The work is organized in accordance with these divisions. In the mode of fundamental theoretical questions, the research areas are: 1) extension and development of the new formalism for the geometrical vector flux in nonimaging optics, 2) analysis of the properties of the evolution of the phase space distribution for radiation as it transits various concentrator designs, and 3) the conduct of additional optimization studies of existing CPC, and multi-stage concentrator designs. In the mode of exploring promising applications, the activities include: 1) continued measurements on a concentrator with large reflector gaps appropriate to developing a practical scale concentrator for use with an evacuated receiver, 2) carrying out selected surveys of the characteristics and directional distribution of diffuse radiation and the associated response to nonimaging concentrators using a variety of approaches, and 3) construction and optical testing of selected optimized cavity designs.

COLORADO SCHOOL OF MINES
Department of Chemical and
Petroleum-Refining Engineering
Golden, Colorado 80401

8. AN IMPROVED INSTRUMENT FOR THE MEASUREMENT OF THE THERMAL CONDUCTIVITY OF NONELECTROLYTE LIQUIDS — $ 45,000 — 79-2
E. Dendy Sloan, Michael S. Graboski

This is the second year of this two year project. The prime objective was to design and build an innovative transient hot wire thermal conductivity apparatus to measure the thermal conductivity of organic liquids at ambient conditions and at high temperatures and pressures. This objective has been accomplished. A second objective is to test the apparatus by comparing measured thermal conductivities of liquid toluene with the excellent data presented by Mani (1971). Toluene has been proposed as a reference standard substance for thermal conductivity measurements (Trump (1977). A third objective is to measure the thermal conductivity of two different oils obtained from coal liquefaction processes as a function of temperature and pressure. Work to accomplish the latter two objectives is well underway and progressing satisfactorily.

IDAHO NATIONAL ENGINEERING LABORATORY
Fuels and Materials Division
P. O. Box 1025
Idaho Falls, Idaho 83401

9. NDE SYSTEMS AND ANALYSIS — $ 75,000 — 79-3
D. E. Keefer, L. S. Beller

This program addresses the application of Synthetic Aperture Focusing Techniques (SAFT) to realization of the full resolution and sensitivity of ultrasonic techniques for imaging, inspection and process control. The approach is through finite-element, perturbation theory methods. The result is expected to be up to an order of magnitude improvement in usefulness of the ultrasonic techniques for inspection, imaging and process control purposes.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Chemical Engineering
Urbana, Illinois 61801

10. CONDITIONS FOR DROPWISE CONDENSATION ON ELECTROPLATED GOLD — $ 46,900 — 80-3

J. W. Westwater

Recently, certain noble metals, including gold, have been shown to promote dropwise condensation. This research project is aimed at gaining a better understanding of the mechanism underlying the enhanced dropwise condensation of water on gold films. It is hoped that improved understanding of this phenomenon can be translated into the utilization of baser metal surfaces for this purpose. The research may well contribute to a great improvement in the efficiency of boiling/condensation heat exchangers because dropwise condensation results in much higher heat transfer coefficients. Work is underway using electroplating for deposition of the gold surface. The deposition variables and their effects on promotion of dropwise condensation are being characterized. Steam at atmospheric pressure is the test vapor; and the condensing heat transfer coefficient is being measured on vertical flat circular test surfaces. Also work is underway on the surface analysis of the plated surfaces using electron microscopy and Auger electron spectroscopy. It is planned to extend the work to other methods of deposition in addition to electroplating.

ILLINOIS INSTITUTE OF TECHNOLOGY
Department of Mechanics and Mechanical
and Aerospace Engineering
Chicago, Illinois 60616

11. STUDY OF THE INTERACTIONS BETWEEN FRICTION, WEAR AND SYSTEM RIGIDITY — $ 72,000 — 79-2

S. Kalpakjian, V. Aronov, F. D'Souza

In this research project, the investigators have undertaken an interdisciplinary investigation to: 1) study the effect of vibrations on frictional mechanisms, 2) develop models of vibratory structure including contact stiffness, and 3) analyze self-excited vibrations caused by friction. The objective is an intensive investigation of wear processes in terms of interactions among friction, vibration and wear. The study is being carried out both experimentally and analytically. The design and construction of a versatile apparatus has been completed. This design has the capability of controlling the applied load, rigidity and damping of the total frictional system. Preliminary experiments indicate that the system, as designed and constructed, is appropriate for the study undertaken. Having completed the design and construction of the special apparatus and instrumentation, future studies will involve extensive experimentation concerning friction, wear and vibrations.

ILLINOIS INSTITUTE OF TECHNOLOGY
Department of Electrical Engineering
3300 South Federal Street
Chicago, Illinois 60616

12. METHOD OF VIBRATIONAL CONTROL IN THE PROBLEM OF STABILIZATION OF CHEMICAL REACTORS — $ 48,000 — 80-3

Semyon M. Meerkov

The intent of this research project is to develop a method to increase the stability area of complex nonlinear dynamic systems. The continuous stirred tank chemical reactor is being studied as a specific example of such a system. Work has begun to develop a nonclassical control technique, the vibrational control, which will convert unstable equilibrium positions into stable ones by means of parameter oscillation. In this first year, analysis of vibratile parameters in the reactor is underway; current work is considering pressure and flow. Also analyses are underway to determine the magnitude of the oscillations and the admissibility of frequencies from a practical technological point of view. As the analyses progress, work will begin on the derivation of equations containing a vibration parameter. Then an analysis of the effect of vibrational control on the reactor will be completed and an estimation made of the increase in the stability area.

UNIVERSITY OF IOWA
Division of Energy Engineering
Iowa City, Iowa 52242

13. CONVECTIVE AND RADIATIVE TRANSFER FOR TURBULENT FLOW IN ENERGY SYSTEMS — $ 55,000 — 79-3

Theodore F. Smith, Ching Jen Chen

The overall objective of this research is an examination of the interaction of convective and radiative heat transfer for turbulent flow of a radiatively participating gas through circular ducts. Within this objective, the specific aims are: 1) formulation of the conservation equations for mass, momentum, and energy transport in a manner suitable for the intended applications and for solution on a digital computer, 2) identification and development of appropriate models to describe turbulent and radiative transport properties, 3) development of solution techniques which are efficient, convenient, and accurate, 4) acquisition and analysis of velocity, temperature, and heat flux results in order to identify the contribution and significance of the various transport mechanisms, and 5) development of limiting cases and simplified models which would be suitable for engineering design studies. Results derived from this work are expected to provide a better understanding of the various energy transport mechanisms occurring in energy systems and to yield mathematical methods for evaluation of gas velocity and temperature profiles when convection and radiation are simultaneously considered. During 1980, separate turbulent and radiant energy models and a solution scheme have been developed. Work is beginning on the testing of each model and the numerical scheme for individual accuracy and capability before combined models are executed.

LAWRENCE BERKELEY LABORATORY
Energy and Environment Division
University of California
Berkeley, California 94720

14. IGNITION STUDIES — $110,000 — 79-3
Elton J. Cairns, A. K. Oppenheim, F. C. Hurlbut

This research project is a part of the Lean Engine Combustion Program. Its main objective is to acquire fundamental knowledge on the role of radicals in ignition of gaseous hydrocarbon-air mixtures. On the experimental side, studies will be made of effects of jets of radicals on ignition by means of electric sparks and photochemical irradiation as well as RF excitation. The theoretical studies carried out at the same time will concentrate upon the thermochemical aspects of ignition with particular attention attached to a specific treatment of the process emphasizing the detrimental effects of losses.

LAWRENCE LIVERMORE NATIONAL LABORATORY
Electronics Engineering Division
P. O. Box 808
Livermore, California 94550

15. CHEMICAL PROCESS MODELS AND CONTROL TECHNOLOGY — $130,000 — 79-3
E. K. Miller, Jack Frazer

The object of this research is to develop improved design methods for use in the chemical industry in order to increase productivity and efficiency in the laboratory, pilot plant, and production facilities. A laboratory bench-scale apparatus with a problem environment similar to that found in a commercial pilot plant is used. The goals are to be able to rapidly characterize complex chemical reactions, determine optimum operating conditions, and develop control algorithms for achieving optimality under adverse conditions.

LOS ALAMOS NATIONAL SCIENTIFIC LABORATORY
Energy Division
P. O. Box 1663
Los Alamos, New Mexico 87545

16. HEAT PIPE ENGINEERING — $ 75,000 — 79-3
C. R. Emigh, F. C. Prenger

Heat pipes offer unique advantages for efficiently transferring heat. This program extends and improves the existing description of heat transfer phenomena in heat pipes in order to achieve an improved engineering design code for heat pipes with liquid metal working fluids at temperatures ranging from 700-1800K. Substantial revision in heat pipe theory and reformulation of heat pipe design codes is being applied to the development of vertically oriented, gravity assisted heat pipes. Continued theoretical and experimental work is being directed towards improved understanding of the flow transition phenomena, turbulent flow in the heat pipe evaporator and the effect of long adiabatic sections on heat pipe performance.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
The Energy Laboratory
77 Massachusetts Avenue
Cambridge, Massachusetts 02139

17. PISTON RING FRICTION AND VEHICLE FUEL ECONOMY — $ 75,000 — 80-3
David P. Hoult, Joe M. Rife

This research project was authorized to begin in September of 1980. The project addresses the development of a physical model for piston ring-lubricant system design. The experimental base will come from a series of experiments to be conducted in a high speed photographic rig, a friction engine, and from flow visualization models. The expected result of this study is a model that will describe the fluid mechanics of lubrication and the motion of piston rings in sufficient detail to be used for design and performance analysis.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Center for Advanced Engineering Study
77 Massachusetts Avenue
Cambridge, Massachusetts 02139

18. FURTHER DEVELOPMENT OF THE METHODS OF THERMOECONOMICS — $ 68,000 — 79-3
Myron Tribus

This research project is concerned with the development of Thermo-economics--a new discipline in which the principles of thermodynamics, engineering economy, and optimization are applied to systems which convert or use energy. Thermoeconomics is similar in philosophy to conventional approaches to thermodynamic analysis. The system is divided into subsystems upon which energy, entropy, material, and economic balances are made. By developing a system of "transfer prices" the details of a subsystem may be analyzed, and trade-offs between capital investment and thermodynamic dissipation made in such a way as to insure an overall system improvement. The work accomplished in the first year includes: 1) development of a formalized procedure for thermoeconomic analysis, 2) the development of measures which serve to identify the largest potential economic improvements in a system, 3) formulation of a method for developing transfer prices which permit system decomposition, and 4) development of a method to use the resulting prices for system improvement by optimization. In this second year, work is underway to further refine the methods and illustrate how to apply them to systems of practical interest.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Laboratory for Manufacturing and
Productivity
77 Massachusetts Avenue
Cambridge, Massachusetts 02139

19. IMPROVEMENT OF RELIABILITY OF WELDING BY IN-PROCESS SENSING AND CONTROL — $105,000 — 79-3

Koichi Masubuchi, Henry M. Paynter, Frans Van Dyck

The objective of this research project is to improve the reliability of welding by developing "smart" welding machines. A smart welding machine will be equipped with sensors, artificial intelligence, and actuators for reducing welding errors by one or two orders of magnitude. Welding with a "smart" welding machine system, when it is developed, will result in a total manufacturing cost equal to or less than actual current manufacturing costs. For obtaining such results the smart welding machine will be integrated into a manufacturing system that prepares the edges, welds, inspects and repairs. The design of an Integrated Pipe Welding System and the construction of its critical components is the envisioned follow-on development effort to be based on results obtained in this study. The ultimate objective is the introduction of the integrated system into industry. Work in the first year has concentrated on basic study and development of prototype systems with significant development of concepts and equipment for in-situ sensors of the welding process and of models of the welding process. Work in this area is continuing at an accelerated pace.

UNIVERSITY OF MICHIGAN
Department of Mechanical Engineering
and Applied Mechanics
550 East University
Ann Arbor, Michigan 48109

20. LOSS CHARACTERISTICS OF CORD RUBBER COMPOSITES — $ 54,000 — 80-2

S. K. Clark, Farhad Tabaddor*

This is a joint research effort undertaken by investigators associated with the University of Michigan and the B. F. Goodrich Tire Company. The objective is to increase the understanding of the way in which internal losses in a cord-rubber composite depend on the loss characteristics of the constituents used to fabricate it, and by such understanding to make available to designers in the rubber industry knowledge which will enable them to assess such effects and to minimize them, where possible, within constraints imposed by other design requirements. The research plan calls for theoretical and computational studies and an associated experimental program. The theoretical studies will consider methods and techniques for calculating the loss characteristics of cord-rubber composites. The experimental program is designed to clarify the role of constituent materials in cord-rubber composite loss characteristics. Specifically, it will provide a means of evaluating different levels of analytical treatment and should also furnish valuable experimental data to the rubber industry for use by designers where applicable.

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*B. F. Goodrich Tire Company

NATIONAL ACADEMY OF SCIENCES
NRC Assembly of Mathematical and
Physical Sciences
Numerical Data Advisory Board
2101 Constitution Avenue
Washington, D.C. 20418

21.	SUPPORT OF STUDIES AND ACTIVITIES RELATED TO EVALUATION AND COMPILATION OF NUMERICAL DATA Gesina C. Carter	$ 15,000	80-I

The Department of Energy has joined with other federal government departments and agencies to support studies and other activities related to evaluation and compilation of numerical data which are carried on by the Numerical Data Advisory Board of the National Academy of Sciences. The Numerical Data Advisory Board has acquired responsibilities related to numerical data for the scientific and technical disciplines, for space and time dependent data, and for interdisciplinary and socio-technical areas, such as energy and environment. The Board functions to promote private initiative in data compilation, evaluation, and dissemination, and to enhance coordination between existing data programs.

NATIONAL BUREAU OF STANDARDS
Office of Standard Reference Data
Washington, D.C. 20234

22. SUPPORT OF CRITICAL DATA COMPILATIONS — $200,000 — 80-I
David R. Lide

The Office of Standard Reference Data of the National Bureau of Standards is administering a collaborative program for preparation of compilations of reference data for use by the science and engineering community. Proposals are being solicited from colleges and universities as well as from non-academic organizations, both non-profit and commercial. Support may be provided for salaries, computer costs, travel, and other services necessary to carry out the work proposed. In addition, the Office of Standard Reference Data provides technical assistance to projects funded under this program. Each project supported is expected to lead to a publishable data compilation containing recommended values and accuracy limits. Guidance for projects supported under this program requires integration with other reference data activities coordinated by NBS under the authority of the Standard Reference Data Act (Public Law 90-396) in order to meet standards of reliability and assure compatibility with other related data.

CITY UNIVERSITY OF NEW YORK
Department of Chemical Engineering
The City College
Convent Avenue at 138th Street
New York, New York 10031

23. TOPICS OF INTERFACE MECHANICS — $150,028 — 80-1
Benjamin Levich

This project was planned and proposed as an approach to a systematic investigation of the field of interface mechanics. In the first part of the effort, the investigators reviewed a possible approach to the question of the influence of surface active substances (SAS) on the motion of fluid-fluid interfaces. The necessity of applying separate analysis to each hydrodynamical problem, involving SAS, was emphasized. In this connection work went forward to investigate the influence of SAS on jets breakup, on transport phenomena through liquid-liquid interfaces, and on the motion of the interface when the Reynolds number is not small. Also a reexamination of the problems involving particles near surfaces was undertaken. In particular, the motion of particles near permeable surfaces was studied. In the second part, attention was focused on the unresolved problem of the motion of a three-phase boundary. This subject, which is important for numerous engineering problems, was reviewed, and effort was devoted to devloping a new approach to a solution of the problem of the moving contact line.

POLYTECHNIC INSTITUTE OF NEW YORK
Aerodynamics Laboratories
333 Jay Street
Brooklyn, New York 11201

24. ANALYSIS OF SHOCK IMPLOSION — $ 41,000 — 79-2
Eli A. Mishkin

In this project, research has been undertaken to extend the hitherto developed theory of a single strong imploding shock coming from infinity to: 1) develop the analysis of an imploding shock wave in a pellet of finite dimensions, 2) extend the analysis to a succession of several shocks, 3) consider cylinderical pellets, 4) consider the outside energies and the shape of the impinging power pulses, and 5) if possible, consider non-homogeneous pellets. Work has progressed in extension of the basic theory and in analysis of an imploding shock wave in a pellet of finite dimensions. A technical report has been published and another is being prepared for publication. The work has now turned largely to the analysis of a sequence of several imploding shocks.

OAK RIDGE NATIONAL LABORATORY
Chemical Technology Division
P. O. Box X
Oak Ridge, Tennessee 37830

25. SEDIMENTATION AND SOLID-SOLIDS SEPARATION — $ 75,000 — 80-3
Jack S. Watson, Sam D. Clinton

The objective of this program is to examine, in a fundamental manner, solid-solid and solid-liquid separation techniques for energy related applications. These applications include resource recovery from coal-conversion residues and low grade ores, as well as effluent control from power plants. Specific approaches to this problem include use of gravitational and magnetic forces, search for innovative techniques for aiding sedimentation, and study of effects of electric fields on particle aggregate.

PACIFIC NORTHWEST LABORATORY
Engineering and Physics Department
Battelle Boulevard
P. O. Box 999
Richland, Washington 99352

26. NONDESTRUCTIVE ENGINEERING EVALUATION — $ 75,000 — 79-3
M. D. Erickson, T. P. Harrington, P. G. Doctor

The purpose of this research task is to improve the performance of Nondestructive Evaluation (NDE) systems, reduce the labor intensity associated with NDE inspection, and to develop a multidisciplinary approach to NDE. The research methodology focuses on developing quantitative measurement with available techniques of pattern recognition in computer science. Specific models for NDE will be developed which are suitable for mini/micro computer implementation. In addition, the skills of fracture mechanics and economic analysis will be added to expand the capability of NDE to predesign analysis of structures considering both engineering and economic factors.

PENNSYLVANIA STATE UNIVERSITY
Department of Mechanical Engineering
University Park, Pennsylvania 16802

27. THE OFFSET STRIP FIN - A GENERALIZED UNDERSTANDING OF ITS PERFORMANCE CHARACTERISTICS — $ 46,000 — 79-2
Ralph L. Webb

This research project is concerned with the offset strip fin used in plate fin heat exchangers. The objective is identification of optimized fin geometries which will result in more efficient, lower energy consumption heat exchangers. The research underway seeks to establish the friction characteristics of offset fin arrays using idealized surface geometries which span geometric parameters of commercial interest. Work in design of the experimental apparatus has been completed and construction of the apparatus is progressing. When experimental data become available, work is to begin on a generalized correlation of the results which will permit the prediction of optimum surface geometries. The anticipated results would enable manufacturers to establish performance improvement goals.

SANDIA NATIONAL LABORATORIES, ALBUQUERQUE
Condensed Matter and Device
Physics Research Department
P. O. Box 5800
Albuquerque, New Mexico 87185

28. HIGH TEMPERATURE ELECTRONICS — $ 50,000 — 80-3
G. A. Samara, R. J. Chaffin,
I. J. Fritz, R. A. Kiehl

High resolution pressure measurements are needed in oil, gas, and geothermal acquisition. Quartz resonator pressure gauges based on the nonlinear elastic properties of quartz fill this need. Their resolution could be significantly enhanced at high temperatures if corrections can be made to account for the temperature dependence of the third-order elastic constants. This task focuses on characterizing this higher order effect in important engineering materials (quartz and $LiNbO_3$) from a practical and a fundamental viewpoint. The task also includes formulation of a detailed theory to relate the observed frequency shifts back to the fundamental third-order elastic constant and their temperature dependences. Another critical electronic component presently unavailable for high temperature electronics is the capacitor. The proposed task includes materials research on the identification and understanding of suitable, low conductivity, high dielectric constant materials (such as Si_3N_4, BN, SiO_2, and TiO_2) at temperatures up to 500°C. The long-range objective includes investigation of transistor and diode concepts suitable for high temperature operation.

SCIENTIFIC SYSTEMS, INC.
Suite 309-310
186 Alewife Brook Parkway
Fresh Pond Shopping Center
Cambridge, Massachusetts 02138

29.	ELECTRICAL COMPONENTS MODELING TECHNIQUES FOR EFFICIENCY AND STABILITY ANALYSIS J. Baillieul, R. Washburn	$ 74,500 24	80-2

The objective of this research project is to develop a theoretical framework for the design and control of pulse-width modulated and other energy conversion systems, and to identify and analyze stability problems for such systems. This project was authorized to start in September 1980. The planned research is organized into four tasks: 1) development of a control theory of bilinear systems in which the controls are switches, 2) study of n^{th} order pulse-width modulated linear systems, 3) study of distributed parameter models and associated control techniques for thyristors and similar high power electronic switches, and 4) study of the occurrence of chaotic behavior in pulse-width modulated systems. Availability of the theoretical framework which is the goal of this work would enable designers to develop power supplies which operate nearer to their theoretical efficiency limits.

SKF INDUSTRIES, INC.
Technology Services Division
1100 First Avenue
King of Prussia, Pennsylvania 19406

30.	LUBRICATION OF ENGINEERING SURFACES - II John I. McCool, Y. P. Chiu, Stuart S. Gassel	$120,000	80-2

This research project was authorized to begin in September of 1980. The objective is to perform follow-on research on the characterization of bearing surfaces for applications in the design of high performance traction drives, gears, bearings, etc. Within the current state-of-the-art, feasible and practical experimental and original analytic work is to be undertaken within the following three areas: 1) evaluation of the key assumptions regarding asperity deformation in contacting bodies; 2) assessment of the statistical error in the bispectral moments of anisotropic rough surfaces together with the compilation of additional reference values; and 3) experimental validation of the traction and film thickness predictions of TRIBOS, a previously developed computer code, expansion of its capabilities, and extension of the input data base.

SOUTHWEST RESEARCH INSTITUTE
Division of Engineering Sciences
6220 Culebra Road
San Antonio, Texas 78284

31. FEASIBILITY OF PHYSICAL SCALE MODELS FOR DETERMINING HYDRO-THERMO-MECHANICS OF HOT DRY ROCK GEOTHERMAL ENERGY EXTRACTION — $ 46,000 — 80-1

Franklin T. Dodge

This project was authorized to start in September of 1980. The objective is to evaluate the use of scale models as a tool for studying hydrofractured hot dry rock reservoirs. The planned research calls for: 1) completion of a similitude analysis of all relevant processes, using full-scale data, mathematical models, and physical reasoning, 2) formulation of "scaling laws"--the required interrelations between model and full-scale physical properties and process variables, 3) evaluation of the feasibility of satisfying the scaling laws--what materials are needed, how the fracturing process and the fluid losses can be simulated, and so on, and 4) formulation of a rationale to interpret scale-model test results. If the feasibility of scale models is demonstrated, more detailed studies, the construction of models, and the comparison of model test data to full-scale data will be proposed for later years' research.

UNIVERSITY OF WISCONSIN
Department of Chemical Engineering
1415 Johnson Drive
Madison, Wisconsin 53706

32. THE DEVELOPMENT OF PROCESS DESIGN AND CONTROL STRATEGIES FOR ENHANCED ENERGY EFFICIENCY IN THE PROCESS INDUSTRIES — $ 77,000 — 80-3

M. Morari, W. H. Ray, D. F. Rudd

This research project addresses the development of synthesis methods for the design of efficient and resilient (i.e., flexible, operable, and controllable) heat exchanger networks for applications in process industries. The design methods being developed include operability explicitly as one of the objectives. The process industries are a major consumer of energy and the improvement of energy efficiency is an important goal. The approach being taken involves two steps. The first is work to identify network structure/ resiliency relationships. When these conditions are identified, it will be easy to judge the practicality of the synthesized structures and to develop algorithms which synthesize practical structures. The second step is the development of a synthesis method for networks with good operability characteristics.

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