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NAVAL POSTGRADUATE SCHOOL
Monterey, California

A SUMMARY OF THE

FOUNDATION RESEARCH PROGRAM

March 1978

Report for the Period

1 July 1976 to 30 September 1977

NAVAL POSTGRADUATE SCHOOL
Monterey, California
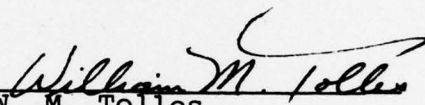
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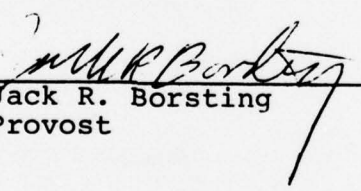   Provost

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Naval Research, Arlington, Virginia 22217 and the Chief of
Naval Development, Washington, DC 20360.

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Foundation Research Program	Finite Element	Fatigue Testing
Equatorial Waves	Military Health Care	Transonic Engine
Air Pollution	Lasers	Flow

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)* Thirty-eight summaries of Independent Research/Independent Exploratory Development work carried out under funding to the Naval Postgraduate School Foundation Research Program. This research was carried out in the areas of Mathematics, Administrative Science, Operations Research, National Security Affairs, Physics & Chemistry, Electrical Engineering, Meteorology, Aeronautics, Oceanograhpy, and Mechanical Engineering. A tabulation in the appendix I identifies area of research and the principal investigator. The category of independent research or independent exploratory research is also identified for each research task.

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I. Introduction

The principal thrust of the research and exploratory development program at the Naval Postgraduate School (NPS) stems from its mission:

> To conduct and direct advanced education of commissioned officers, and to provide such other technical and professional instruction as may be prescribed to meet the needs of the Naval Service; and in support of the foregoing to foster and encourage a program of research in order to sustain academic excellence.

In fulfillment of the research and development program objectives and within the above constraints, the Naval Postgraduate School

> Initiates and conducts scientific and applied research (6.1) of a long-range nature in areas of special interest to the Navy.
>
> Conducts exploratory development (6.2) deriving from scientific program areas or in other areas specifically requested by the Navy.

In addition, NPS performs scientific research and exploratory development, where uniquely qualified, for other agencies of the Department of Defense and, in defense related efforts, for other Federal Government agencies. NPS also furnishes consulting services for the Navy and, where specifically qualified, for other agencies of the Department of Defense and in defense related efforts for other Government agencies.

II. Background on the NPS Research Program

The Navy has developed the Naval Postgraduate School as an academic institution which uses university educational methods to address the special graduate education requirements of the Navy. The Superintendent of the Naval Postgraduate School is a Rear Admiral of the line of the Navy. He is supported by a dual management structure, part military and part civilian. The faculty, mostly civilian, is responsible for the academic programs and, in support of these, conducts an active research effort. The military staff specifies the educational needs of the Navy, in terms of curricula, and provides administrative logistic support.

At the Naval Postgraduate School, as in other academic institutions, the faculty is organized into departments. The department represents a resource center of faculty members with allied disciplinary specialization. Currently, the departments at the Naval Postgraduate School include Computer Science, Mathematics, Administrative Science, Operations Research, Physics and Chemistry, Electrical Engineering, Meteorology, Aeronautics, Oceanography, Mechanical Engineering, and National Security Affairs. Inter-disciplinary groups which have effective departmental status include Acoustics, Anti-Submarine Warfare, Electronic Warfare and Command, Control and Communication (C3).

Research and development projects are largely conducted by the individual faculty members on a project basis. Projects typically originate from proposals prepared either by individual faculty members, or by groups of faculty members from the same or different departments.

The research program is divided administratively into two parts. First is the Sponsored Research Program. This program includes projects awarded by sponsoring agencies to an individual principal investigator. The principal source of funds is the various commands and laboratories of the Naval Material Command. The sponsored program constitutes about 80% of the total NPS research program. The Foundation Research Program is based on a grant from the Chief of Naval Research and the Chief of Naval Development. This program is administered internally by a Research Council. The Council meets periodically to review faculty proposals, allocate funding, and review results of completed projects.

Appendix I identifies each project by title and category or type funding (Research - 6.1 and Exploratory Development - 6.2). The 6.1 category was funded by the Chief of Naval Research, Arlington, Virginia 22217 and the 6.2 category was funded by Chief of Naval Development, Washington, DC 20360.

This report summarizes the FY 1977 Foundation Research Program.

Title: Computational Basis Functions For Optimal
                Approximations

Investigator: R. Franke, Associate Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: The objective of the study was to investigate
                the feasibility of using the representers of
                point evaluation functionals as basis functions
                for the computation of optimal approximations.
                The main purpose, but not the only application,
                is to construct interpolation functions for
                data in two independent variables at scattered
                points. Other basis functions useful for com-
                putational purposes were to be developed.

Summary: The objective was to investigate the computation
                of optimal approximations in Sard corner spaces.
                Construction of basis functions suited for com-
                putation was proposed.

                The use of the natural basis functions (repre-
                senters of point evaluation functionals) was
                investigated by computing condition numbers
                pf coefficient matrices for random sets of
                points. Two schemes for generating basis func-
                tions which are zero in certain regions were
                developed.

                The use of the natural basis functions for
                computation of optimal approximations are
                possible in some cases. For large sets of data
                where smooth approximations are required, it
                is desirable to use local methods.

Publications: R. Franke, "On the Computation of Optimal
                Approximations in Sard Corner Spaces", to
                appear in SIAM J. on Numer. Anal.

                R. Franke, "On the computation of Optimal
                Approximations in Sard Corner Spaces",
                Technical Report, NPS 53Fe76121, December 1976.

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Title: Convergence of the Method of Parallel Displace-
                 ments for Unconstrained Minimization in the
                 Non-Quadratic Case

Investigator: I. B. Russak, Associate Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: To establish the convergence characteristics
                 of the method of parallel displacements (des-
                 cribed below) in the non-quadratic case when
                 using exact derivatives and numerical derivatives.

Summary: Problems in optimization occur very frequently
                 in military applications, e.g., optimizing with
                 respect to time to intercept the parameters of
                 a missile interceptor system. Furthermore, since
                 constrained optimization problems can often be
                 stated in terms of unconstrained ones, then
                 methods for solving the latter are very important.
                 The method of parallel displacements is a powerful
                 tool for solving unconstrained optimization prob-
                 lems and understanding its convergence character-
                 istics is necessary for successful application
                 to actual problems. In describing the method of
                 parallel displacements we shall refer to the
                 function $f(X)$ where: i) $f(X)$ is of class C^2,
                 ii) X is an N dimensional vector, iii) $f(X)$ is
                 strictly convex.
                 The method of parallel displacements will now
                 be described:

Starting with the N + 1 initial points $X_{1,1} X_{1,2}$

$\ldots, X_{1,N+1}$ which do not lie in an N-1 dimensional

plane, set $P_1 = X_{1,N+1} - X_{1,N}$. For $j = 1,\ldots,N$,

let X_{2j} be obtained as follows:

$$X_{2j} = X_{1j} + \alpha_{1j} P_1 \quad j = 1,\ldots,N$$

where

$$\alpha_{1j} = \frac{-P_1^T f'(X_{1j})}{P_1^T f''(X_{11}) P_1}$$

with f', f", ^{T} denoting respectively, the first
and second derivatives and the transpose. Set
$P_2 = X_{2,N} - X_{2,N-1}$ and

$$X_{3j} = X_{2j} + \alpha_{2j}P_2 \quad j = 1,\ldots,N - 1$$

where

$$\alpha_{2j} = \frac{-P_2^T f'(X_{2j})}{P_2^T f''(X_{11})P_2} \quad .$$

Continue this process in the same manner with
$P_3 = X_{3,N-1} - X_{3,N-2}$ to get points $X_{4,j}$
$j = 1,\ldots,N-2$.

After N steps we obtain a point $\overline{X} = X_{N+1,1}$.
This completes one cycle of the method. The
point $\overline{X}$ so obtained can be shown to provide a
minimum of f if f is quadratic with a positive
definite Hessian at its minimum point. If f
is not quadratic, then we set $X_{1,1} = \overline{X}$ and
repeat the procedure.

Convergence of the method (i.e., of the sequence
of points $\{\overline{X}\}$ generated above) to a relative
minimum of f has been established for the non-
quadratic case when using exact derivatives and
assuming a bounded third derivative for f. It
remains to prove convergence when the assumptions
on f are weakened and the exact derivatives
are replaced by numerical derivatives. In addi-
tion the rates of convergence remain to be estab-
lished.

Publications: None.

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Title: Necessary Conditions for Problems Involving
                Higher Derivative Bounded State Variables

Investigator: I. B. Russak, Associate Professor, Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: To develop necessary conditions for a minimum
                in the general control problem of Bolza with
                state inequality constraints in which the control
                enters in the second derivative of the constraint
                (described below).

Summary: A class of problems was investigated which in-
                cludes the types found in a wide variety of
                applications such as in determining optimal ship
                routing and optimal missile trajectories. A
                particular example of the former is to find the
                route requiring minimum fuel for a ship which
                is required to reach a specified destination
                while satisfying conditions on propulsion limi-
                tations and also avoiding land masses. In this
                problem, propulsion is the control variable so
                that constraints on ship's position appear as
                state constraints (type iii in the problem def-
                inition) in which the control enters in the
                second derivative of the constraint.

The class of problems which has been investigated
is described below:

Minimize the integral

i) $I_0(a) = g_0(b) + \int_{t^0}^{t^1} L_0(t,x(t),\dot{x}(t),u(t))dt$

in the class of trajectories

a: $x^i(t)$, $\dot{x}^i(t)$, $u^k(t)$, b^σ

  $i = 1,\ldots,N$ $k = 1,\ldots,K$ $\sigma = 1,\ldots,r$ $t^0 \leqq t \leqq t^1$

which satisfy:

ii) $\ddot{x}^i = f^i(t,x(t),\dot{x}(t),u(t))$ $i = 1,\ldots,N$

iii) $\psi^\alpha(t,x(t)) \leqq 0$ $\alpha = 1,\ldots,m'$ $\psi^\alpha(t,x(t))=0$

                                    $\alpha = m' + 1,\ldots,m$

iv) $\theta^\eta(t,x(t),\dot{x}(t),u(t)) \leqq 0$ $\eta = 1,\ldots,L'$

      $\theta^\eta(t,x(t),\dot{x}(t)u(t)) = 0$ $\eta = L' + 1,\ldots,L$

v) $I_\gamma(a) \overset{\leq}{=} 0$ $\gamma = 1,\ldots,p'$ $I_\gamma(a) = 0$

   $\gamma = p' + 1,\ldots,p$

vi) $x^i(t^s) = X^{is}(b)$ $\dot{x}^i(t^s) = \dot{X}^{is}(b)$ $i=1,\ldots,N$

   $t^s = T^s(b)$ $s = 0,1$

where

$$I_\gamma(a) = g_\gamma(b) + \int_{t^0}^{t^1} L_\gamma(t,x(t),\dot{x}(t),u(t))dt$$

   $\gamma = 1,\ldots,p$

Necessary conditions are obtained for a solution
to the above class of problems. Important
features of this work are in : i) relaxing the
solvability assumption on the state constraints
while still permitting the solution trajectory
to have an infinite number of intervals on the
boundary, ii) extending the maximum principle
to a larger set than previously realized,
iii) developing modified forms of the relation
$\dot{H} = H_t$ and of the transversality relation usually
obtained in problems of this type and iv) proving
a condition concerning $\dot{u}(t^1)$, the derivative
of the multiplier functions at the final point.

Publications: None.

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Title   Analysis of Methods For Estimating Reliability
                 Bounds

Investigator: A. L. Schoenstadt, Associate Professor of
                 Mathematics.

Sponsor: Foundation Research Program (6.1)

Objective: The study investigated the accuracy of bounds
                 on the reliability of a system, composed of
                 a serial arrangement of independent, exponential
                 failure law components, produced by two well-
                 known, but different methods - the Lieberman-
                 Ross Method and the Mann-Grubbs Method. The
                 methods differ primarily in that the Lieberman-
                 Ross method is a statistically exact procedure,
                 whose bounds depend on the order in which fail-
                 ure data is recorded, while the Mann-Grubbs
                 method is an approximately optimum procedure,
                 whose bounds do not depend on data order. This
                 is a continuing project.

Summary: Both analytic and simulation methods were used
                 to compare the estimated bounds produced by
                 both methods, using identical data. In each
                 instance, whichever method produced the lower
                 upper bound on the hazard rate, without pro-
                 ducing a false bound, was judged superior. It
                 was shown that the Mann-Grubbs method generally
                 produced superior bounds, except when very
                 restrictive assumptions were made on the order
                 in which failures were recorded, or on the size
                 of the sample in relation to the relative com-
                 ponent hazard rates.

Publications: A. L. Schoenstadt, "A Comparison of the Lieberman-
                 Ross and Mann-Grubbs Methods," Technical Report,
                 NPS 53ZH76091, September 1976.

Title: The Calculation of e^{At} With Some Applications

Investigator: E. Stewart, Professor of Mathematics

Sponsor: Foundation Research Program (6.1)

Objective: The aim of this research was to obtain simple techniques for calculating e^{At} where A is an n x n - matrix. The results of this work were to give these techniques in differential equations courses where e^{At} becomes a natural part of a solution to a system of simultaneous linear, first order differential equations.

Summary: After obtaining the eigenvalues of a matrix A(n x n), e^{At} is then obtained as the solution of an initial value problem for an nth order differential equation with constant coefficients. In the process of obtaining the unique solution under the given initial conditions, n matrices must be determined. These matrices turn out to be pairwise orthogonal and idempotent or nilpotent and these properties characterize the matrices. Using these properties formulae are obtained for calculating e^{At}. The three possible cases are:

    a) A has simple eigenvalues.

    b) A has one eigenvalue of multiplicity n.

    c) A has various eigenvalues of multiplicities one or more.

Applications are then given for obtaining solutions to various linear systems of differential equations.

Publications: None

Title: Derivation of Critical Planning Properties of
                  The Process Associated With Generating Demands
                  For Health Care

Investigator: D. Whipple, Associate Professor of Administra-
                  tive Sciences

Sponsor: Foundation Research Program (6.2)

Objectives: To develop analytically the major parameters
                  involved in the generation of demands for health
                  care resources given the significant agency
                  relationship of the physician for the patient.
                  These will be used to analyse the budgetary
                  process used in the Military Health Services
                  System (MHSS) under its present structure and
                  to recommend changes where applicable.

Summary: An economic mathematical programming optimi-
                  zation model previously developed by the
                  investigator will be modified and extended
                  to develop testable hypotheses concerning the
                  probable outcome of various parametric changes
                  in the structure of the MHSS in terms of cost
                  by the physician-agent and the patient. These
                  outcomes will be analysed in light of present
                  or suggested organizational change initiatives
                  in the MHSS, and recommendations for empirical
                  policy research mode.

Conference
Presentations: D. Whipple, "Development of Mangement Incen-
                  tives to Accompany Capitation Budgeting in
                  U. S. Military Health Care Delivery System",
                  presented at the 10th Annual Health Systems
                  Research Symposium in Miami, November 1-2,
                  1976, also chaired a session.

                  D. Whipple, "The Contribution of Non-Physician
                  Providers to the Search for a More Equitable
                  and Efficient Health Care Delivery System",
                  presented at the American Association for the
                  Advancement of Sciences, San Francisco, June
                  12-15, 1977, also chaired session.

D. Whipple, "Structural Change in the U. S.
Military Health Care Delivery System: Goal
of Cost Containment", presented at the North
American-European Comparative Health Systems
Evaluation Congerence, Milan, Italy, September
11-15, 1977.

Publications: None

Title: Investigation of a Sequential Median Test

Investigator: D. R. Barr, Professor of Operation Research

Sponsor: Foundation Research Program (6.2)

Objective: To assess properties of a sequential test based
                on sample medians, including expected sample
                size and operating characteristics.

Summary: Empirical evidence was obtained through simulation
                which demonstrates potential usefulness of the
                proposed test. This evidence suggested the sample
                number has asymptotic geometric distribution;
                efforts were undertaken to demonstrate this
                analytically, but to date have not been sucessful.

Publications: None.

Title: Analysis of a Class of Binary Trees Arising From
                  Certain Applications in Sorting and Information
                  Retrieval

Investigators: G. G. Brown, Associate Professor of Computer
                  Science and Operations Research

                  B. O. Shubert, Associate Professor of Operations
                  Research

Sponsor: Foundation Research Program (6.1)

Objective: Combinatorial examination of a class of Binary
                  Trees with the view of providing information useful
                  in analysis of algorithms based on this widely
                  used storage structure.

Summary: Exact and asymptotic results are given for equally
                  likely trees and those grown by binary insertion
                  tree sorts applied to random strings of key symbols.
                  Tabulations are now available on the results. Two
                  observations are noteworthy. First, the universally
                  held belief that randomly grown trees will become
                  misshapen and require frequent pruning or reorgan-
                  ization to avoid excessive access path lengths
                  in subsequent use is false. Second, the degree
                  to which randomly grown trees depart from balanced
                  symmetric structure provides an excellent new
                  nonparametric hypothesis test for randomness of
                  sequences.

Publications: G. G. Brown and B. O. Shubert, "On Random Binary
                  Tree," Technical Report NPS55Bw76061, (July 1976).

Title: Lanchester-Type Models of Warfare (Monograph)

Investigator: J. G. Taylor, Associate Professor of
                        Operations Research

Sponsor: Foundation Research Program (6.1)

Objective: To continue writing a monograph on Lanchester-
                        type (i.e. differential-equation) models of
                        warfare. The monograph will be a state-of-
                        the-art summary as well as an introduction to
                        analytical models of combat attrition and
                        will attempt to integrate and synthesize
                        widely scattered results and modelling ideas.

Summary: The writing of the monograph was continued,
                        with the outline of the book undergoing
                        major revision. Substantial portions of the
                        first three chapters were written, and the
                        the first chapter on background and intro-
                        duction (i.e. the general nature of combat
                        models) was revised. The initial portions
                        of the book have been largely tutorial in
                        nature, and consequently numerous examples
                        have been given to illustrate many points
                        about various basic Lanchester-type models.
                        Additionally, some previously pending re-
                        lated research (to ultimately be incorporated
                        into the monograph) was completed, and also
                        an invited address entitled "State-of-the-
                        Art Summary of Lanchester Theory" was deliv-
                        ered at the 15th Army Operations Research
                        Symposium.

Conference
Presentations: J. G. Taylor, "Concentration of Forces in
                        Some Lanchester-Type Combat Models," pre-
                        sented at the Western Section of ORSA 1976
                        Meeting, Los Angeles, CA, 16-17 September
                        1976.

                        J. G. Taylor, "State-of-the-Art Summary
                        (Lanchester Theory)," presented at the
                        Annual U.S. Army Operations Research Sym-
                        posium, Fort Lee, VA, 27-29 October 1976.
                        (invited by program committee).

J. G. Taylor and G. G. Brown, "Further Canonical Methods in the Solution of Variable-Coefficient Lanchester-Type Equations of Modern Warfare: A New Definition of Power Lanchester Functions", presented by J. G. Taylor at the Miami Joint ORSA/ TIMS National Meeting, Miami Beach, FL, 3-5 November 1976. Abstract in ORSA Bulletin.

Publications: J. G. Taylor and G. Comstock, "Force-Annihilation Conditions for Variable-Coefficient Lanchester-Type Equations of Modern Warfare", Naval Research Logistics Quarterly 24, 349-371 (1977).

J. G. Taylor, "Predicting Battle Outcome with Liouville's Normal Form for Lanchester-Type Equations of Modern Warfare", Opsearch 14, 185-203 (1977).

J. G. Taylor, "Optimal Commitment of Forces in Some Lanchester-Type Combat Models", Technical Report, NPS55-77-2, January 1977.

J. G. Taylor and G. G. Brown, "Numerical Determination of the Parity-Condition Parameter for Lanchester-Type Equations of Modern Warfare", Technical report, NPS55-77-10, March 1977.

J. G. Taylor, "Error Bounds for the Liouville-Green Approximation to Initial-Value Problems", Technical report, NPS55-77-29, June 1977.

Theses Directed: Herbert H. Mauerer (Captain, West German Army), "Design Considerations for Lanchester-Type Models of Warfare (LATMW)", Master's Thesis September 1976.

Title: Convexity in an Inventory Model

Investigator: P. W. Zehna, Professor of Operations Research

Sponsor: Foundation Research Program (6.2)

Objective: The Hadley-Whitin Q-r models in inventory theory
                 have been widely used by practioners for some
                 time now in spite of questions regarding their
                 validity. The purpose of this research was to
                 extend the author's investigations in these matters
                 to hopefully characterize the proper solutions.

Summary: Beginning with some recently completed research
                 in the backorders case, the author was able to
                 successfully complete the research and give a
                 full characterization of the solutions. Continuing
                 with the lost sale case, one that had not been
                 previously studied, the investigator was able to
                 show that, while the situation was not as bad in
                 this case, a similar anomaly existed and again,
                 it was possible to completely characterize the
                 solution in this new case also.

Publications: P. W. Zehna, "Solutions in Hadley-Whitin Q-r Models"
                 submitted to the Naval Logistics Quarterly.

                 Lenna, Peter W., "Solutions in Hadley-Whitin
                 Q-r Models:, Naval Postgraduate School Technical
                 Report NPS 55-78-4, January, 1978.

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Title: Canadian Armed Forces Unification: The Effects
After Ten Years

Investigator: D. P. Burke, Assistant Professor of National Security
Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To update, through research in Canada, a previous
study by the principal investigator on the unification
of the Canadian Armed Forces.

Summary: Ten years have passed since the abolition of the
Canadian Army, Navy and Air Force and the creation
of a single service in their place. Most of the
dire effects on morale and efficiency which were
predicted by opponents of the step have not occurred.
Severe budgetary stringency (which was relieved
somewhat by unification) has had a much more serious
effect, and preference in promotion and assignment
given to French Canadians is of much more immediate
concern, at least to English speakers. However,
the expectations of the authors of unification have
also been partly disappointed. With the 1976 creation
of Air Command, institutions which parallel each of
the old services now exist in the new, and the terms
"army", "navy" and "air force" are again in daily
use. Significant savings in overhead have been made,
but flexibility in personnel policy is seriously
hampered by the persistence of regimental and corps
organization in the new Service. There is no serious
sentiment in the Forces or the Government for a
return to a three-service organization.

Publication: None

Title: The Use of Expert Opinion in Congressional Roll Call Analysis

Investigator: E. J. Laurance, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To experiment with quantified judgment techniques in assessing Congressional behavior.

Summary: One of the methods commonly used to assess Congressional behavior regarding defense policy is the construction of scales based on roll call votes on defense issues. Typically, these are constructed using Guttman scaling or factor analysis, both of which assume that all votes in the scale are of equal importance. This research involved experimenting with several types of weighting techniques which relied on the judgments of experts knowledgeable of the defense issues involved. Techniques such as paired comparison and constant sum were used to construct weighted scales and compared with scales constructed in a purely statistical manner.

Publications: None

Title: The CENTO Alliance: Status and Prospects

Investigator: R. H. Magnus, Assistant Professor of National
                Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To determine the current status of the alliance
                among its member and associated states. What should
                be the policy of the United States towards it?

Summary: Although there are differences in the perceptions
                of the member and associated states, there still
                remains a common core of agreement on the utility
                of the alliance centered around a shared antagonism
                towards Soviet activities in the area. Regional
                members would, in general, like to see the alliance
                take a more active role in regional issues. The
                Untied States has consistently resisted these pres-
                sures. In view of the increasing importance of
                the resources of the Persian Gulf for the United
                States, it is recommended that the alliance should
                be, at least, maintained and, quite possibly,
                strengthened.

Publications: None

Title: The USSR, Eastern Europe and Eurocommunism

Investigator: J. Valenta, Assistant Professor of National
                  Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To write a paper on Soviet and East European
                  perceptions of and responses to Eurocommunism
                  in Western Europe.

Summary: The research of this paper was conducted and
                  concluded. The paper drew extensively on
                  Soviet and European sources. After the paper
                  was completed an invited address entitled
                  "Eurocommunism in Eastern Europe" was delivered
                  at the 1977 Annual Convention of the American
                  Association for the Advancement of Slavic
                  Studies, Washington, DC.

Publications: J. Valenta, "The Impact of Eurocommunism on
                  Eastern Europe," Problems of Communism,
                  March-April 1978 (forthcoming).

                  J. Valenta, "The USSR and Eurocommunism,"
                  The USSR and Eastern Europe, T. Rakowska
                  and A. Gyorgy (eds.) (Indiana University
                  Press, forthcoming, 1979.)

Title: The Soviet Intervention in Czechoslovakia, 1968

Investigator: J. Valenta, Assistant Professor of National
                  Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To finish writing a revised manuscript on
                  the Soviet intervention in Czechoslovakia
                  in 1968. The manuscript will be a comprehen-
                  sive study analyzing the Soviet management of
                  the Czechoslovak crisis of 1968. It will also
                  be a test of the bureaucratic politics paradigm
                  as a methodological tool to be used in explain-
                  ing Soviet foreign policy behavior.

Summary: The first chapter on the bureaucratic politics
                  model was revised and substantial portions of
                  the following three chapters were rewritten.
                  The monograph was completed and sent to the
                  publisher. Also, an invited address entitled
                  "Bureaucratic Politics and Soviet Foreign
                  Policy" was delivered at the Annual Convention
                  of the American Association for the Advancement
                  of Slavic Studies, Washington, DC, October, 1977.

Publications: J. Valenta, Anatomy of a Decision: Soviet Inter-
                  vention in Czechoslovakia, 1968, manuscript in
                  which Johns Hopkins University Press has expressed
                  great interest and is now considering for pub-
                  lication.

                  J. Valenta, "Soviet Intervention in Czechoslovakia,"
                  in Ivan Volgyes (ed.), Czechoslovak Political
                  Tradition (Festschrift for Professor J. Korbel),
                  Columbia University Press, forthcoming, 1978.

Title: The Soviet-Cuban Intervention in Angola

Investigator: J. Valenta, Assistant Professor of National
                  Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To continue writing a monograph on the Soviet
                  and Cuban intervention in Angola in 1975. The
                  monograph will be an analytical research summary
                  of the external and internal factors which in-
                  fluenced the Soviet-Cuban management of the
                  Angolan crisis of 1975. It will likewise be a
                  useful introduction to further research testing
                  the formation of a probable pattern for the pre-
                  diction of future Soviet and Cuban military
                  involvement in Africa.

Summary: The writing of the monograph, which draws exten-
                  sively on Soviet, Cuban and African sources,
                  has been compiled and substantial portions of
                  the manuscript will be published. Furthermore,
                  some previously pending related research was
                  completed.

Publications: J. Valenta, "The Soviet-Cuban Intervention,
                  1975," in David Albright (ed.) The Great Powers
                  in Africa (Westview Press, forthcoming, 1978).

                  J. Valenta, "The Angolan Intervention, 1975,"
                  Studies in Comparative Communism, forthcoming,
                  winter 1979 (The editor-in-chief of the journal
                  requested the paper which is now being consid-
                  ered for publication.)

Title: Investigation of Nuclei Giant Multipole Resonances by Inelastic Electron Scattering

Investigators: F. R. Buskirk, Professor of Physics
J. N. Dyer, Professor of Physics
R. Pitthan, Assistant Professor of Physics

Sponsor: Foundation Research Program (6.1) and National Science Foundation Grant

Objective: The inelastic electron scattering experiments with ^{58}Ni, ^{60}Ni and ^{238}U were undertaken with excitation energies up to 40 MeV. The present measurements combined with earlier work on ^{208}Pb, ^{197}Au, ^{165}Ho and ^{89}Y form part of a survey of the systematics of the giant resonances in medium and heavy nuclei.

Summary: The Nickel experiments (^{58}Ni and ^{60}Ni) were performed at 102 MeV and scattering angles of 45, 60, 75 and 90 degrees. One striking result concerns the giant dipole resonance, which in (γ,n) experiments is much smaller for ^{58}Ni compared to ^{60}Ni. Our experiments, which measure the total El strength, not just the (γ,n) channel, show precisely the opposite result, namely that ^{58}Ni has the larger El strength. If (e,e') and (γ,n) results are to be reconciled, either the (γ,p) experiments are wrong or some other channel, possibly (γ,D) must be present and large in ^{58}Ni, but small in ^{60}Ni.

The Uranium experiments, 87.5 MeV at angles of 45, 60, 75 and 90 degrees were undertaken to extend our survey to an extremely heavy nucleus, which is not only deformed, as is ^{165}Ho, but fissionable. The established resonances were seen including the split dipole resonance. Unexpected results for both the isoscalar and isovector quadrupole modes were the small strengths corresponding to about half the sum rule in both cases. Also these states were not as broad as one would expect for a deformed nucleus.

The resonance highest in energy, at 28.4 MeV or 176 $A^{-1/3}$ MeV, fits and E3 angular distribution and corresponds to 90% of the sum rule. Possibly this state corresponds to the ones seen in ^{197}Au,

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^{208}Pb and ^{165}Ho, which were not identified at the time. If these are the same state, it may be noted that the energy expressed in $A^{-1/3}$ units shifts from 175 $A^{-1/3}$ for the deformed fissionable to 195 $A^{-1/3}$ MeV for spherical nuclei.

Publications: R. Pitthan, R. R. Buskirk, E. B. Daley, J. O. Shannon and W. H. Smith, "Giant Resonances and Bound Collective States Observed in the Scattering of 92.5 MeV Electrons from the Closed-Neutron-Shell Nucleus ^{89}Y Between Excitation Energies from 2.0 to 55 MeV", Physical Review C16,970 (1977).

R. Pitthan and F. R. Buskirk, "Isospin of the Fine Structure Between 8 and 12 MeV in ^{208}Pb and its Implication for the Multipole Assignment of the 8.9 MeV Resonance", Physical Review C16, 983 (1977).

R. Pitthan, J. S. Beachy, F. R. Buskirk and S. J. Kowalick, "Resonant Octupole Strength at 13 MeV in ^{58}Ni and ^{60}Ni and the Character of the 53 $A^{-1/3}$ State in Heavy Nuclei", (submitted).

J. S. Beachy, S. J. Kowalick, F. R. Buskirk and R. Pitthan, "Difference in El Strength of ^{58}Ni (T=1) and ^{60}Ni (T=2) at Deuteron Threshold", (submitted).

W. A. Houk, R. W. Moore, F. R. Buskirk and R. Pitthan, "Evidence for an Isovector Octupole Resonance at 28.4 MeV and Other Giant Resonances in ^{238}U", (submitted).

Title: Laser Produced Plasmas

Investigators: A. W. Cooper, Professor Physics

                F. Schwirzke, Associate Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: In the continuing project, the interaction is
                investigated between intense laser pulses and
                targets. The dynamics of the laser produced
                plasma and self-generated magnetic fields are
                studied.

Summary: Experimental evidence has been found that
                magnetic fields are generated in the steepened
                front of a fast moving plasma plume which
                is interacting with a background plasma. A
                laser produced plasma expands in z-direction
                normal to the target surface with a velocity
                of about 10^7 cm/sec. If the laser produced
                plasma flows into a photo-ionized background
                plasma of sufficient density, shock heating
                at the front will produce a temperature gra-
                dient in z-direction. Magnetic fields in
                azimuthal direction are then generated long
                after laser shutoff by the cross product of
                the radial density gradient and the electron
                temperature gradient in z-direction. The lo-
                cation of the peak magnetic field coincides
                with the steepest gradient in the shock front.
                Very basically, spontaneous magnetic fields
                should be generated whenever a shock is pro-
                duced by a plasma streamer.

Conference
Presentations: F. Schwirzke, "Spontaneous Magnetic Fields
                in Laser-Impact Craters", presented at the
                Eighteenth Annual Meeting of the Divison of
                Plasma, American Physical Society, 15-19
                November 1976, San Francisco, CA. (abstract
                published in Bulletin American Physical
                Society 21, 1029 (1976), paper co-authored
                with A. W. Cooper).

F. Schwirzke, "Spontaneous Magnetic Field
Generation in Shock Waves", presented at
the Nineteenth Annual Meeting of the Divi-
sion of Plasma Physics of the American
Physical Society, 7-11 November 1977,
Atlanta Georgia (Abstract published in Bull-
etin of the American Physical Society, 22
1160 (1977), co-authored with A. W. Cooper.

Title: Computer Simulation of Sputtering by Molecules

Investigator: D. E. Harrison, Jr., Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: To examine the containment and interaction
                of collision cascades when the sputtering of
                a copper crystal by a diatomic ion is simulated
                in the computer.

Summary: Most of the time was devoted to the develop-
                ment of a new generation of the computer pro-
                gram which has been the basis of this line of
                research. The computer results have now been
                interpreted to indicate that the interaction
                of collison cascades is much more prevalent
                and important than previously assumed. The
                research will continue.

Publications: None

Title: Magnetic Noise in and near The Ocean

Investigator: O. Heinz, Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: The objective is to obtain improved long term
                data on the magnetic noise on the ocean floor,
                within the ocean and immediately above the sur-
                face. By using a combination of total field
                magnetometers and VLF receivers it is planned
                to cover the frequency range from mHz to KHz.

Summary: Using a Cs vapor optically pumped magnetometer,
                we are currently measuring the spectrum of the
                geomagnetic field fluctuations in two frequency
                bands: 0.1 Hz to 25 Hz and 1 Hz to 256 Hz.
                This work is being done at our field site at
                La Mesa Village in Monterey. At the same time
                measurements were initiated from the Research
                Vessel Acania using a self contained VLF Re-
                ceiver and tape recorder which was lowered into
                Monterey Bay. Measurements were taken at 50
                feet intervals (during descent and ascent) and
                the instrument package was placed on the ocean
                floor at a depth of 300 feet for about 15 min-
                utes. Since both of these measurements are still
                in their initial phases no results are available
                at this time.

Publications: None.

Title: Spectroscopic Data Center: Compilation of
               Short Ultraviolet (XUV) Spectra

Investigator: R. L. Kelly, Professor of Physics

Sponsor: Foundation Research Program (6.1), and
               National Aeronautics and Space Administration

Objective: It is planned to maintain, on a continuing
               long-term basis, a complete and critical com-
               pilation of atomic and ionic spectrum lines
               with wavelengths below 2000 Angstroms, for the
               first 36 elements.

Summary: The published literature is searched and re-
               levant publications obtained. The observed
               spectrum lines are compared on a line-by-
               line basis, with those predicted from the
               known atomic energy levels (a complete file
               of energy levels is maintained). Those lines
               satisfying established criteria are retained
               in the files. The published intensities are
               normalized, and multiplet numbers are added.
               Approximately 70,000 lines are presently
               stored in the files.

Publications: None

Title: Elastic Waves in Crystals

Investigator: J. R. Neighbours, Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: The objectives of this research are two-fold. First, to formulate a vector relation similar to the Poynting vector in electromagnetism for describing the flow of elastic energy in an anisotropic crystal. Second, to investigate the reflection of an elastic wave at the boundary between two anisotropic media.

Summary: Elasticity is a fourth rank tensor, a relation between two second order tensors. However, as a result of various symmetries, the elastic constants are describable by a symmetric 6 x 6 array rather than by 81 components. Thus they can be represented as a matrix and transformed accordingly.

Propagation of elastic waves is similar to optical birefrengence except that elastic waves can also have longitudinal polarization and might properly be called a case of trirefrengence.

Progress on this project has been to carefully formulate the matrix transformation in coordinates rotated with respect to the primary stress reference axes, and to find the solutions to the eigenvalue problem in the rotated coordinates. A computer program in BASIC has been written for this purpose. From the eigenvalues, both wave velocity and wave slowness (similar to an index of refraction surface) surfaces have been constructed. So far these calculations have been confined to cubic, hexagonal and orthorhombic crystals. Many real crystals have been investigated and the special pure mode directions have been tabulated.

A related problem is the sensitivity of the elastic constants to inversion. The elastic

constants are the coefficients when the stresses
are expressed as linear functions of the strains.
An alternative formulation is of the strains
in terms of the stresses. The product of the
two matrices is the unit matrix, and different
types of experiments measure components of one
or the other of the matrices. In order to com-
pare different types of measurements, it is
desirable to know how the elements of one matrix
vary with respect to variation of a single ele-
ment of the other. A program has been written
for this purpose and many real crystals have
been investigated.

This project is now being actively carried out
on an extracurricular basis.

Publications: None

Title: Homogeneous Catalysis by Palladium Complexes

Investigator: R. A. Reinhardt, Professor of Chemistry

Sponsor: Foundation Research Program (6.1)

Objective: Determination of rate laws for the oxidation
                  of the olefin <u>trans</u>-2-butene by several pal-
                  ladium (II) complexes. This research was in-
                  itiated in late 1975 and continued to the end
                  of calendar year 1976.

Summary: The experiments were conducted by use of gas
                  chromatography to analyze for both reactant
                  olefin and product ketone. Early results using
                  $PdCl_4^{2-}$ as oxidant, gave results in accord
                  with published data on the system obtained by
                  a totally different technique. Preliminary re-
                  sults on the $PdBr_4^{2-}$ - olefin system, though
                  showing internal inconsistencies, showed prom-
                  ise of ultimately yielding reliable results
                  and these formed the basis of a paper presen-
                  ted before the Northwest Regional Meeting of
                  the American Chemical Society in Reno, Nevada,
                  June 1976.

                  Continued studies, however, were unable to
                  improve the discrepancies. In particular, the
                  analyses for reactant and product could not
                  be reconciled with material balance in the sys-
                  tem. In addition, data of a given run would
                  show wide scatter, and, in many cases, replicate
                  runs gave differences in computed rate param-
                  eters far outside any tolerable error.

                  It can be surmised that the difficulties are
                  inherent in the experimental method, which
                  is thus inappropriate for the system. A real
                  possibility is loss through vaporization of
                  the extremely volatile substrate olefin at
                  varying rates during the course of a run. It
                  is not proposed to continue the investigation.

Publications: None.

Title: Frequency Response of Cold Wires Used for
Atmospheric Turbulence Measurements in the
Marine Environment

Investigators: G. A. Schacher, Associate Professor of Physics

G. W. Fairall, Assistant Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: The purpose of this project is to determine
the effect of sea salt deposition on the
frequency response of platinum wires used for
measuring thermal turbulence. These wires
are operated at ambient temperature, are very
small (~ 2 μ diameter), and their small time
constant allows them to follow temperature
changes as rapid as several kilohertz. When
they are operated in the marine environment
spray and aerosols deposit sea salt on the
wires. This salt can form a film which could
alter the wires' frequency response.

Summary: We have developed methods for coating the wires
and measuring their frequency response in con-
trolled conditions in the laboratory. The
salt is deposited by spraying a fine mist of
salty water over the wires and allowing the
droplets to evaporate on the wires. This is
accomplished in a large chamber 4ft high by
1½ft diameter. The salted wire is tested in
an airstream which contains a "white" spectrum
of temperature fluctuations, and its response
is determined with a spectrum analyzer.

Development of the system to create the white
temperature spectrum has been completed and
the salted temperature wires have been tested.
the results show that the frequency response
of the wires can be significantly affected
as low as 10 Hz, but only with amounts of salt
that are far in excess (about 100 x) of that
normally encountered in experiments at sea.
The experimental portion of the work has been
completed and comparison with theory is under-
way.

Publications: None

Title: Interval Modulation of a Sinusoidal Carrier

Investigator: G. Myers, Associate Professor of Electrical
                          Engineering

Sponsor: Foundation Research Program (6.2)

Objective: This work is concerned with radio commu-
                          nications. This research investigated use
                          of a modulated interval, between bursts of
                          a sinusoidal carrier, to convey the infor-
                          mation in a message waveform. We called
                          this form of modulation "interval modula-
                          tion" (IM).

Summary: IM produces a delay between bursts of the
                          sinusoidal carrier. This delay is propor-
                          tional to the amplitude of the modulating
                          message waveform. Thus, IM is unlike AM,
                          PM, or PM where the amplitude, frequency
                          or phase of a sine wave vary in accordance
                          with a message waveform.

                          The research resulted in mathematical des-
                          criptions of the IM carrier in the time
                          domain and frequency domain. Early in the
                          investigation, we completed the design of
                          an IM modulator and demodulator. We then
                          built and tested these circuits. The tech-
                          nique was then verified by transmitting
                          voice and music signals through the system.
                          The quality of the recovered signals was
                          excellent.

Conference
Presentations: G. Myers, "Interval Modulation (IM) of a
                          Sinusoidal Carrier", Technical Conference,
                          SIEEM 77, Monterey, Mexico, September 77.

                          G. Myers, "Symposium on Spread Spectrum
                          Communications", Naval Postgraduate School,
                          September 1976.

Publications: G. Myers and E. L. Kilborn, Jr., "Interval
                   Modulation (IM) of a Sinusoidal Carrier",
                   Technical Report, NPS62Mv77031, February
                   1977.

Thesis Directed: E. L. Kilborn, Jr., "Interval Modulation
                   (IM) of a Sinusoidal Carrier", Master's
                   Thesis, December 1976.

Title: Researches in Digital Filters

Investigator: S. R. Parker, Professor of Electrical
                  Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To extend previous work on one dimensional
                  filters to the multidimensional case in the
                  general areas of synthesis, stability, and
                  limit cycles.

Summary: A direct technique for expressing the impulse
                  response of a multidimensional digital filter
                  in terms of the coefficients of the transfer
                  function is presented. This approach poten-
                  tially leads to a synthesis procedure for re-
                  cursive two dimensional signal processing.

                  An adaptive recursive digital filter has been
                  developed and compared favorably with the
                  optimal filter. The feedforward and feedback
                  gains of the filter are adjusted adaptively to
                  minimize a least square performance function
                  on a sliding window average basis for gradient
                  calculations.

Publications: S. R. Parker, L. Souchon, "Synthesis of N
                  Dimensional Recursive Digital Filters by
                  Taylor Series Expansion", IEEE Transactions
                  on Circuits and Systems, Vol CAS24, No. 1,
                  January 1977, pp 28-34.

Title: Computer Aided Acoustical Imaging

Investigator: J. P. Powers, Professor of Electrical Engi-
                  neering

Sponsor: Foundation Research Program (6.2)

Objective: This work is part of a continuing effort to
                  explore the use of computer processing of co-
                  herent (both amplitude and phase information
                  present) data to generate images of objects
                  from transmitted or reflected ultrasonic
                  fields. The short term objective was to con-
                  struct an experimental system to record the
                  complex data fields of an ultrasonic wave for
                  computer processing. Additionally it was
                  desired to explore the presentation of the
                  data on a computer driven video display for
                  presentation of the data or resulting image.

Summary: The first acoustic images using this system have
                  been obtained. The data aquisition system has
                  been built and successfully tested. Prelimi-
                  nary acoustical images have been displayed on
                  a Ramtek Gx-100 television display with 16
                  gray levels (limited by the display refresh
                  memory capability). The data acquisition sys-
                  tem consists of a logarithmic compressive am-
                  plifier with 60db of dynamic range, a phase
                  detector, and a high accuracy positioning and
                  recording system. Testing and calibration of
                  the hardware implementation of these devices
                  shows acceptably high degrees of accuracy and
                  repeatability. The data is recorded on analog
                  tape. After digitization of the recorded data
                  and subsequent demultiplexing of the channels
                  the data has been successfully stored in mem-
                  ory of PDP 11/40 computer for subsequent dis-
                  play or processing. Using the Ramtek Gx-100
                  display driven by a PDP 11/40, interactive
                  display capability has been developed to allow
                  the operator to call up displays of amplitude,
                  phase or intensity data. He also has the capa-
                  bility to change the quantization levels, the
                  gray scale assignment and to assign various
                  pseudocolor values to the data. This inter-
                  active capability was designed and tested dur-
                  ing the research period using both computer
                  generated and experimentally recorded data.
                  Future efforts include further expansion of this

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interactive display capability, refinements
in the data acquisition system and investiga-
tion of more experimental objects to assess
the overall capabilities of the system.

Publications: J. P. Powers, "Computer Simulation of Linear
Acoustic Diffraction, Acoustical Holography,"
Vol. 7, L. W. Kessler, Ed., Plenum Press, New
York, 1977, pp. 193-205.

J.P. Powers, Lt. R. T. O'Bryon, Lt. J. W.
Patton, "Ultrasonic Imaging System Incorporat-
ing Computer Aided Coherent Processing", Ab-
stracts, Ninety-fourth Meeting of the Acousti-
cal Society of America, Miami Beach, 12-16
December 1977, in J. Acoustical Society of
America, 62 (Supplement 1): S22, 1977.

Title: Sampled Analog Signal Processing

Investigator: T. F. Tao, Professor of Electrical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: To develop theory, design procedure and applications of sampled analog recursive filters using charge transfer devices.

To investigate the limitations and sensitivities of sampled analog signal processing.

Summary: Signal processing can be generally separated into four categories:

Filter	Recursive
	Nonrecursive
Spectral	Fourier Type
Analyzers	Non-Fourier Type

They can be implemented either digitally using computers, integrated circuits or in sampled analog ways using charge transfer devices. Sampled analog signals differ from digital signals because their amplitudes are not digitized. They are similar because both types of signals are sampled. This study is concerned with two aspects of sampled analog signal processing.

(1) Sampled Analog Recursive Comb Filters:

Theory, design procedure and applications of sampled analog recursive filters have been investigated. It was found that recursive filters using sampled analog delay lines behave in many ways simliar to the digital recursive filters but with one major difference. Because a charge transfer delay line usually has delay of multiple sampling periods, the frequency characteristics of a sampled analog recursive filter has $N/2$ comb teeth below the Nyquist frequency. It is a comb filter. It was found that theories and design procedure

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developed for digital recursive comb filters can be used for sampled analog recursive comb filters if two modifications are made: filter coefficients vary with frequency, charge transfer delay lines have delays of multiple sampling periods. Two types of comb filters have been studied: canceller type and integrator type. Their applications as MTI radar canceller and pulse-repetition-frequency sorter have been demonstrated.

(2) Sampled Analog Discrete Fourier Transforms:

Two algorithms have been used to implement sampled analog discrete Fourier transforms: Chirp Z Transform and Prime Transform. Both algorithms use the transversal filter which can be easily implemented using charge transfer devices. This study investigated the advantages and limitations of these two sampled analog discrete Fourier transforms in comparison with the digital FFT (fast-Fourier-transform) algorithm.

<table>
<tr><td>Publications:</td><td>S. Holmes, "Hardware Signal Processor Development-Session Summary", <u>Proceedings 9th Asilomar Conference on Circuits, Systems, and Computers</u>, pp. 289-299 (1976).</td></tr>
</table>

S. Holmes, M. Pollack and J. Campbell, "Sensitivity Study of Sampled Analog Signal Processing", <u>Proceedings 19th IEEE Midwest Symposium on Circuits and Systems</u>, pp. 430-439, (1976)

L. Saetre, S. Holmes and A. Ejaz, "Recursive CTD Comb Filter and Its Application to MTI Radar Signal Processing", <u>Proceedings 1976 GOMAC Conference</u>, (Government Microcircuit Applications Conference), pp. 246-249 (1976).

J. Campbell, T. F. Tao and M. Pollack, "Sensitivity Study of Chirp Z Transform and Prime Transform as Sampled Analog Discrete Fourier Transform Algorithms", <u>Proceedings of 10th Asilomar Conference on Circuits, Systems and Computers</u>, pp. 372-38- (1976)

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T. F. Tao, S. Holmes A. Ejaz, F. Piazza,
L. Saetre and B. Freund, "Theory and Applications of Sampled Analog Recursive CTD
Comb Filters", Proceedings NASA/JPL Conference on Charge Coupled Device Technology
and Applications, pp. 1-10, (1976)

Theses Directed: J. Campbell, "Sensitivity Study of the
Chirp Z Transform and the Prime Transform
as Sampled Analog DFT Algorithms", Master's
Thesis, December 1976

A. Ejaz, "Theory of Sampled Analog Recursive Comb Filters and Their Canceller
Applications", Engineer Degree, December,
1976.

F. Piazza, "Theory and Applications of CTD
Recursive Comb Filters", Master's Thesis,
December 1976.

Sklivanos, "Sensitivity Study of Sampled
Analog Tapped Delay Line Transversal Filters," Master's Thesis, September 1976.

Title: Aerodynamic Stabilization of Gaseous Dis-
                  charges

Investigator: Oscar Biblarz, Associate Professor of Aero-
                  nautics

Sponsor: Foundation Research Program (6.2)

Objective: The main objective is to define practical
                  aerodynamic means for stabilizing discharges
                  for electrical laser. Other applications in
                  cold plasma chemistry are also envisaged.
                  A particular objective was to become ac-
                  quainted with supersonic flow and vortex
                  flows as stabilizing agents and, furthermore,
                  to examine the theoretical aspects of aero-
                  dynamic stabilization. This is one part of
                  a continuing project.

Summary: The work undertaken complements the activi-
                  ties in turbulence stabilization which have
                  been underway at the Naval Postgraduate
                  School. First-hand experience with super-
                  sonic flow and vortex-flow equipment was ob-
                  tained. The problem of analyzing the effects
                  of turbulence in a discharge was given some
                  perspective, and the classical or Schottky
                  solution for the positive column in a flow
                  discharge was re-examined in the light of the
                  stability problem. The program will continue
                  with more studies with turbulence.

Conference
Presentations: O. Biblarz, E. Wassertrom and Y. Crispin,
                  "Stabilization of Flow Discharges by Super-
                  sonic Flows", presentation at the 30th Annual
                  Gaseous Electronics Conference, 18-21 Oct.
                  1977, Palo Alto, CA, (abstract in conference
                  record and in bulletin of the American Phys-
                  ical Society.

Publications: O. Biblarz, J. L. Barto, and H. A. Post, "Gas
                  Dynamic Effects on Diffuse Electrical Dis-
                  charges in Air", Israel Journal of Technology,
                  Vol. 15, No. 1-2.

                  O. Biblarz, J. L. Barto, and H. A. Post,
                  "Gas Dynamic Effects of Diffuse Electrical
                  Discharges in Air", 19th Israel Annual Con-
                  ference on Aviation and Astronautics, Tel
                  Aviv-Haifa, March 2-3, 1977, (full paper on

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conference record).

Y. Khait and O. Biblarz, "Influence of Turbu-
lence on diffuse Electrical Gas Discharges
Under Moderate Pressures". Paper submitted
to the Journal of Applied Physics .

O. Biblarz, "Aerodynamic Stabilization of
Gaseous Discharges", Technical Report, NPS-
67Bi77111, 1 November 1977.

Title: Acoustic Variability and Air-Sea Exchange

Investigators: W. W. Denner, Associate Professor of Oceano-
                   graphy
                   K. L. Davidson, Associate Professor of Mete-
                   orology
                   T. M. Houlihan, Associate Professor of Mecha-
                   nical Engineering
                   J. V. Sanders, Associate Professor of Physics
                   E. B. Thornton, Associate Professor of Oceanography

Sponsor: Foundation Research Program (6.1)

Objective: To better understand the relationship between
                   air-sea interaction and the variability of
                   underwater sound propagating through the upper
                   layers of the ocean.

Summary: This project is an ambitious one preparing to
                   make simultaneous measurements of air-sea ex-
                   change, ocean sound velocity microstructure
                   and acoustic variability in the upper layers
                   of the ocean. An experimental setup has been
                   designed for high frequency measurements in
                   shallow water. Preliminary designs have been
                   considered for open ocean measurements. Avail-
                   able equipment has been calibrated and tested,
                   necessary new equipment ordered. Analysis of
                   results obtained in a previous experiment
                   conducted by one of the Investigators (Dr.
                   Denner) off New Zealand has been completed and
                   the results submitted for publication. A cor-
                   relation between surface heating and mixing
                   and acoustical variability are shown. More
                   carefully controlled experiments such as this
                   effort are clearly justified. This work is es-
                   sential to understanding the performance of
                   Navy acoustical weapons such as the torpedo and
                   mine.

Publications: W. W. Denner, B. G. Rickard and A. C. Kibble-
                   white "A temperature Microstructure Probe",
                    Marine Sciences Communications, Vol 3 (1)
                   P 61-91. 1977

                   W. W. Denner, B. F. Rickard and A. C. Kibble-
                   white "A Study of Temperature Microstructure
                   in Coastal Waters, submitted to Deep Sea
                   Research.

W. W. Denner, B. F. Richard and A. C. Kibble-
white, "Temperature Microstructure and its
Influence Upon the Propagation of Ultransonic
Sound in the Sea", submitted to <u>Deep Sea
Research</u>.

Title: Biochemical Modelling of Marine Ecosystems
                  And Acoustic Prediction

Investigator: Eugene D. Traganza, Associate Professor of
                  Oceanography

Sponsors: Foundation Research Program (6.1),
                  Office of Naval Research, and
                  Fleet Numerical Weather Central

Objective: To utilize biochemical measurements of
                  plankton in models which link them with
                  environmental and acoustic properties of
                  the ocean.

Summary: Marine Ecosystems include many kinds of
                  organisms which affect sound in the sea,
                  ranging in size from microscopic plankton
                  in the surface layers to midwater fishes
                  and ubiquitous whales. Marine organisms
                  may either be sources of noise which can
                  mask the sounds of submarines or form dis-
                  continuities in the physical medium which
                  intercept and reradiate or "scatter" acous-
                  tic signals, an effect which can confuse
                  Naval weapons systems or seriously reduce
                  the active detection range of sonar. One
                  hypothesis is that zooplankton estimates
                  can be useful in predictive models of
                  "sound scattering" by virtue of their im-
                  portance in marine ecosystems. The eco-
                  system is the most suitable level of bio-
                  logical organization for application of
                  systems analysis techniques and should
                  lend iself to acoustic modelling.

                  A major problem with modelling marine eco-
                  systems is that understanding has been se-
                  verly limited by the inadequacy in assessing
                  zooplankton biomass, production or trophic
                  level and the consequent lack of a compre-
                  hensive knowledge of regional and seasonal
                  relationships with environmental parameters.

The first objectives of this study have
been:

(1) to evaluate the general feasibility
of the zooplankton-sound scattering hypoth-
esis.
(2) to evaluate devices for collecting
statistically significant numbers of samples
of zooplankton of different sizes.
(3) to evaluate the potential of making
rapid biochemical measurements of zooplank-
ton biomass in samples which may also contain
phytoplankton and detritus.
(4) to compare the seasonal variation of
biochemically assayed biomass of size groups
with zooplankton biomass predicted by an
ecosystem model of the Monterey upwelling
region.

Future objectives include (1) addition of
biochemical methods which will distinguish
which zooplankton are herbivorous and (2)
comparison of seasonal/regional sound scat-
tering with modelled and measured variation
of phytoplankton, zooplankton and scattering.

A summary of progress so far is as follows:

(1) A background study produced a "volume
reverberation"-zooplankton regression model
of the North Atlantic and North Pacific
oceans (Traganza and Stewart, 1973; Solomon,
1975; Stewart, 1972) which indicated that
regional and seasonal sound scattering can
be quantitatively associated with the dis-
tribution of zooplankton.
(2) The background, preliminary results,
and the preliminary analytical scheme for
relating herbivorous zooplankton to an eco-
system model were reviewed (Traganza and
Graham, 1975).
(3) A carbon method was developed in this
study which has proven to be highly suc-
cessful measure of total biomass of "net
zooplankton" and has received a wide inter-
national response from other investigators
(Traganza, Radney and Graham, 1976; Radney,
1975).

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(4) Field and laboratory studies of the
adenosine triphosphate (ATP) content of
zooplankton indicated that it may be pos-
sible to distinguish between living and
dead biomass in a sample of zooplankton
pending development.
(5) A size sampling in situ net system
(SSISNET) was developed and tested in
wind tunnel experiments at NPS(Mitchke,
1976).
(6) Initial attempts have been made to
simulate seasonal variation of plankton
and nutrient levels in the Monterey eco-
system (Pearson, 1975 and Hendrickson,
1976) on the basis of cumulative historical
trends of key forcing functions including
light, wind, temperature and depth of the
mixed layer.

New developments: Fifteen stations were
occupied along a transect from Gibraltar
to Dakar, Africa to Puerto Rico. A newly
constructed SSISNET containing two stan-
dard 30 cm nets in series was used to col-
lect 50 Meter samples of the 333 to 1800-
μm zooplankton in the upper 350 meters of the
water column. The ATP content of these sam-
ples showed distinct maxima at the same
geographic locations which showed distinct
dissolved methane maxima. The ATP and meth-
ane maximum did not always occur at exactly
the same depth, but both were in or near
the thermocline. The results suggest that
the biological production of dissolved meth-
ane may occur in situ in the pelagic eco-
system. A possible mechanism may be the
presence of methane bacteria in the digestive
tract of herbivorous zooplankton.

Publications:
E. D. Traganza, and K. J. Graham, "Carbon/
Adenosine Triphospate Ratios in Marine Zoo-
plankton", Deep Sea Research, 24 10 pp, 1977.

E. D. Traganza, J. C. Radney, and K. J.
Graham, "A Convenient Method For The Deter-
mination of Carbon In Marine Net Zooplankton",
Marine Chemistry, Vol 7: 110-119, 1976.

Theses Directed: D. E. Henrickson, "An Evaluation Of A Computer
Simulation Model Of Plankton Dynamics In
Monterey Bay", Master's thesis, September 1976.

R. P. Mitchke, "Design And Wind Tunnel Test
Of A Size Sampling In Situ Net System,
(SSISNET)", Master's thesis, September 1976.

R. T. Pearson, "A Computer Simulation Model
Of Seasonal Variations In Ocean Production
For A Region Of Upwelling", Master's thesis,
September 1976.

Title: Metered Studies Of The California Counter-current

Investigators: J. B. Wickham, Associate Professor of Oceanography
S. P. Tucker, Associate Professor, Oceanography

Sponsor: Foundation Research Program (6.1)

Objective: The objective for this study was to gather and test equipment to be used in a large-scale direct metering of currents and water mass properties of The California Counter-current. This effort was a part of continuing studies by these investigators of the California Countercurrent. It extends the previous work by use of direct measurements and continuous recording of currents and continuous recording of water mass properties. The ultimate objective is to document the form and variation of the countercurrent on a variety of time scales.

Summary: Foundation support has been used in the following activities:

1. Calibration of 4 Aanderaa current meters in towing tank at Scripps Institution of Oceanography.
2. Visit to Oregon State University laboratory for demonstrations and discussion about deployment, recovery and maintenance of moored buoys and current meters.
3. Bench testing of acoustic and timed releases to be used in metering project.
4. Field testing of seven acoustic releases in water depths between zoo and zoom.
5. Research into sources of supply and characteristics of equipment to be ordered for metering program and into procedures for mooring operations.
6. Studies of recent theoretical models of eastern boundary currents, these to serve as the basis for appropriate design of out sensing array (or antenna).

Publications: None

Title: Studies in Applied Mechanics

Investigator: J. E. Brock, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To develop and submit for publication several studies in the field of Applied Mechanics.

Summary: Several such studies were brought to completion, papers written up and submitted, and of these most have been accepted for publication. Other studies continue. Nine separate investigations are briefly described in the following numbered paragraphs.

(1) This study reports on the very close agreement between theory and experiment for behavior of a uniform cantilever beam excited in flexural vibrations by the sudden release of a lateral load at the tip. An experimentally generated trace of flexural stress vs. time at a point on the beam appears so spiky and grassy that analytical agreement appears unlikely. However, a computer generated graph, employing the complete eigensolution using the Bernoulli-Euler-Navier model of a beam, agrees in fine detail with the experimentally determined graph.

(2) The oblateness of the earth can be represented to a very high degree of accuracy by a simple model consisting of one positive and two negative mass particles located on the polar axis. At points exterior to the earth's surface, the geopotential exerted by this model is almost exactly the same as that exerted by the actual earth. This permits constructing very simple computer programs for the behavior of earth satellites, and, in particular, facilitates a demonstration of the phenomena of advance of perigee point and motion of the line of nodes.

(3) Snap-through behavior of structural elements is important in technology. For example, ship's plating behaves in this fashion, this behavior being called "panting." The phenomenon is difficult to treat analytically. This study treats a particularly simple case so that the student has ready access to a

complete illustrative example.

(4) A simple experiment is described which illustrates plastic bending and permits confirmation of the theoretical moment-curvature relation for a rectangular cross section.

(5) Although elastic buckling of a single strut-like element, with specified end conditions is well understood and relatively easily presented to students, the buckling behavior of structures is not at all well understood and is frequently mishandled in textbooks and in the general literature. Professor R. E. Newton and the writer have previously written on this subject. The present study traces the evolution of a simple structure as a spring-like element is modified so as to introduce a non-linear behavior and shows that quite unexpected phenomena are associated with the modified structure. The analysis is surprise-ingly difficult.

(6) In a recent publication in the Journal of Applied Mechanics the authors treated a very special problem involving estimating the gravest vibration frequency of a torsional system. The present study shows that the Dunkerley-Mikhlin estimates are immediately at hand for a significant generalization of the problem. It also provides an alternate treatment, using the Hamilton-Cayley theorem and Chebychev polynomials, for the special case treated by the earlier authors.

(7) The literature does not seem to afford a simple example of a complete solution for the Euler buckling of a practically realizable nonuniform strut. This study supplies such an example. The eigenfunctions are modified Gegenbauer polynomials.

(8) Several studies are still under way on the general subject of plastic behavior of structural plates. A general theorem has been formulated which permits obtaining upper bounds without the necessity of specifying or constructing a moment field. This theorem has yielded many of the classical results and has been used to treat the problem of an elliptical

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plate with a concentrated load in a general position near the center of the plate. The theorem seems to lend itself to use with a computer optimizing program such as COPES which is implemented at the NPS computer center and it is anticipated that some analyses will be made using this facility.

(9) The writer presented the Dunkerley-Mikhlin formulas in a paper to the Journal of Applied Mechanics. The present paper provides a more elegant derivation based on the idempotency of the filtering matrix. Another physical example is presented illustrating the power of the method.

Publications: John E. Brock, "An experiment on the Vibration of Cantilevers," accepted for publication by IJMEE (International Journal of Mechanical Engineering Education).

John E. Brock, "A Simple Model of Oblate Earth," Accepted for Publication by IJMEE.

John E. Brock, "Simple Snap-through Behavior of a prismatic Bar,"Accepted for publication by IJMEE.

John E. Brock, "Buckling of Simple Elastic Structures -- a Complicated and Deceptive Subject," Accepted for publication by IJMEE.

John E. Brock, "Lower Bounds for Gravest Torsional Frequencies," Accepted for publication by the Journal of Applied Mechanics.

John E. Brock, "An Euler Buckling Eigensystem for a Nonprismatic Strut," Submitted to the Journal of Applied Mechanics.

John E. Brock, "An Improved Derivation of the Dunkerley-Mikhlin Formula, "The Shock and Vibration Bulletin, No. 47, Part 2, (September 1977), pp. 17-18.

John E. Brock, "A Simple Laboratory Experiment in Plastic Bending," Accepted for publication by IJMEE.

Title: Holographic Nondestructive Test NDT

Investigator: A. E. Fuhs, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To determine the suitability of holographic
                  nondestructive test as a means of locating weld
                  flaws in piping.

Summary: Real time holography is used to obtain fringe
                  patterns. Fringe patterns are interpreted in
                  terms of surface displacement. Flaws in piping
                  welds have anomalous surface displacements.
                  To check sensitivity a finite element computer
                  code is used to predict surface displacement.
                  Pipes with manufactured cracks are test speci-
                  mens.

                  The holography system has been assembled. Hol-
                  ograms have been made. Test specimens have been
                  assembled including the following: stainless
                  steel piping with manufactured cracks for cor-
                  relation with finite element computer code,
                  reject piping from Mare Island shipyard, and
                  aircraft components with known fatigue cracks
                  obtained from NARF Alameda. The finite element
                  computer code is 85 per cent complete.

Publications: A. E. Fuhs, B. W. Hannah and W. L. King, Jr.,
                  "Technical Comment on 'Extensions of Dual-Plate
                  Holography Interferometry'," AIAA Journal,
                  pp. 725-727, 1977. (Accepted for publication
                  in AIAA Journal, February 1978)

Title: Shaped Charges For Neutralization of Buried
                Mines

Investigator: A. E. Fuhs, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: To develop a technique to neutralize buried
                mines. The technique is to be used by EOD
                officers and crew.

Summary: Mines may be buried at depths from a few inches
                to 6-8 feet. The buried mines are detected and
                located by magnetic means. Error in location
                may be comparable to buried depth. Some means
                of placing an explosive charge near the mine
                is required. A shaped charge can open a large
                hole through which a charge can be rammed.

                An assembly of charges was designed, built,
                and tested. The assembly of charges consisted
                of a 2-inch diameter shaped charge with ½ lb
                HE located on top of a cylinder containing
                liquid explosive. The cylinder had a coaxial
                tube which allowed passage of the metal jet
                from the shaped charge. It was found that the
                liquid explosive spray lined the hole; it was
                also found that the cylinder for the liquid
                explosive was rammed down the hole. As a
                result of these early tests, a series of tests
                is being planned using solid explosive located
                below the shaped charge. A time delay deto-
                nator will be used for the solid explosive.

Publication: None

Title: Melting of Ice Subjected to Turbulent Flow of Sea
                Water

Investigators: A. E. Fuhs, Professor of Mechanical Engineering
                R. Stolfi, Associate Professor of National
                Security Affairs
                W. W. Denner, Associate Professor of Oceanography
                R. Bourke, Associate Professor of Oceanography
                P. Wang, Associate Professor of Mathematics
                LT W. Clifford, USN, Graduate Student in Naval
                Engineering
                LT R. Erman, USN, Graduate Student in Naval
                Engineering
                Dr. O. Griffin, Naval Research Laboratory

Sponsor: Foundation Research Program (6.1)

Objective: To determine the rate of regression of fresh-water
                ice subjected to turbulent flow of sea water.
                Further, to develop an analytical model which allows
                prediction of the ice melting rate and heat trans-
                fer rates.

Summary: Large blocks of ice with dimensions 16 x 4 x 2 feet
                are frozen. The ice blocks are instrumented with
                thermocouples to measure gradients in the thermal
                boundary layer and in the ice. The blocks are
                towed at speeds of 0.7 to 1.2 knots. Weights are
                obtained before and after towing. Measurements
                are made of the dimensions of the ice block before
                and after towing.

                As of November 28, 1977, three blocks of ice have
                been towed in Monterey Bay. Nusselt numbers for
                heat transfer have been obtained. The regression
                rate has been correlated using the computer code
                of Dr. Owen Griffin. Ice ripples have been observed
                and measured. The observations of ice ripples
                correlate well with existing theories. Temperatures
                in the base flow region have been determined. A
                thermal boundary layer profile has been obtained.

Conference
Presentations: Allen E. Fuhs, Warren W. Denner, Matthew Kelleher,
                  William Clifford, Reginald Erman, Russel Stolfi,
                  Robert H. Bourke, and Peter C. C. Wang, "Self
                  Propelled Iceberg." Paper presented by Allen E.
                  Fuhs at the First International Conference on
                  Iceberg Utilization for Fresh Water Production,
                  Weather Modification and Other Applications, Ames,
                  Iowa, October 2-6, 1977. Paper to be published
                  in Proceedings.

                  Russel Stolfi, Allen Fuhs, Peter Wang, Robert
                  Bourke and Lieutenants Reginald Erman, William
                  Clifford, USN, "Ice Moving in Sea Water." Paper
                  presented by R. Stolfi at the First International
                  Conference on Iceberg Utilization for Fresh Water
                  Production, Weather Modification and Other
                  Applications, Ames, Iowa, October 2-6, 1977. Paper
                  to be published in Proceedings.

Title: Warm Working of Eutectic and Eutectoid alloys to produce Fine Microstructures

Investigator: T. R. McNelley, Assistant Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: Production of fine, spherodized microstructures in Al-Cu and Al-Mg alloys by warm working and evaluation of subsequent mechanical properties, especially ambient temperature properties.

Summary: The objectives of this research were met. Fine two-phase microstructures were produced in both an Al-Cu alloy and several Al-Mg alloys. Subsequent mechanical characterization of these alloys has revealed that excellent mechanical properties can be developed in Aluminum-Magnesium alloys containing 11% to 14% magnesium by weight. Flow-stress values up to 90,000 psi were obtained, for example, in one alloy. This has lead to a focusing of this research primarily on the Al-Mg system; some additional practical factors concerning this system are that these alloys are less dense than conventional aluminum alloys, and the alloys being studied also exhibit superplasticity at warm temperatures. Research will now focus on the processing and related mechanical properties of these Al-Mg alloys.

Publications: None.

Theses Directed: A. L. Cipriani, "An Investigation of the Mechanical Properties of Warm-Rolled Aluminum-17.5 weight percent Copper alloy," Master's Thesis, December 1976

F. G. Ness, "High Strength to Weight Aluminum-18 Weight percent Magnesium alloy through Thermomechanical Processing," Master's Thesis, December 1976

T. L. Glover, "Effects of Thermo Mechanical Processing on Aluminum-Magnesium, Alloys Containing High Weight Percentage Magnesium" Master's Thesis, December 1977

C. P. Bingay, "Microstructural Response of
Aluminum-Magnesium Alloys to Thermomechanical
Processing," Masters Thesis, December 1977

Title: Microgalvanic Aspects of Seawater Corrosion
                    (MASC)

Investigators: J. Perkins, Associate Professor of Materials
                    Science
                    K. J. Graham, Chemist, Physics and Chemistry
                    Department

Sponsor: Foundation Research Program (6.1)

Objective: To determine environmental effects on sea-
                    water corrosion of structural materials of
                    Navy interest, with an emphasis on the cor-
                    relation of electrochemical factors with
                    corrosion rates and with corrosion product
                    distribution, micromorphology and base metal
                    microstructural features.

Summary: Of constant concern to the Navy is the pro-
                    blem of seawater corrosion of ships' struc-
                    tural materials. Also, fouling of seawater
                    piping systems by marine organisms is a
                    serious problem. Unfortunately, the solutions
                    to these two coincidental problems are not
                    always compatible. For example, one method
                    of control of biological fouling involves the
                    addition of growth inhibitors such as hypo-
                    chlorite ion to the seawater prior to entry
                    into the piping system. Moderate levels of
                    hypochlorite ion are known to effectively
                    control biological growth. However, increases
                    in hypochlorite ion concentration also typi-
                    cally lead to increases in corrosion rate.
                    Also, the units which electrochemically produce
                    the ionic growth inhibitor tend to develop
                    very high concentrations of hypocholorite near
                    the generator, which is not diluted until
                    downstream in the condensers.

                    This problem is currently being studied
                    through a combination of electrochemical
                    techniques, corrosion rate determinations,
                    and direct microscopic observation techni-
                    ques. The effects of varying concentra-
                    tions of inhibitor ion and of other seawater
                    constituents on the corrosion rates of
                    various piping materials and marine fastener
                    materials is being considered. Specimens
                    are being evaluated potentiostatically in
                    known environments, with the data from these

experiments being correlated with microscopic
observables using scanning electron micro-
scopy and microbeam energy dispersive X-ray
spectroscopy.

Work accomplished during this time period
has included experiments involving aluminum
structural alloys, MILSPEC zinc and develop-
mental aluminum sacrificial anodes, and
several copperbased alloys. Current work in
concentrating on cupronickel alloys and brasses.

Publications: J. Perkins. W. H. Leubke, K. J. Graham and
J. M. Todd, "Anodic Corrosion of Zinc Alloys
in Seawater", Journal of the Electrochemical
Society, 124, (1977), 819-826.

J. Perkins, K. J. Graham, G. A. Storm, J. S.
Locke and J. R. Cummings, "Effect of Velocity
on Corrosion of Galvanic Couples in Seawater",
NACE Unit Committee T-7C "Symposium on Marine
Corrosion", to be presented at CORROSION/78,
NACE, Houston, Texas, March 6-10, 1978.

J. Perkins, J. S. Locke, and K. J. Graham,
"Effects of Dissimilar Metal Coupling, Po-
tential Distribution, and Temper condition
on Galvanic Corrosion of 5086 Aluminum Alloy
in Synthetic Seawater", NPS Technical Report,
NPS-69Ps-78-001, January 1978.

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The Soviet Intervention In Czechoslovakia, 1968	J. Valenta	6.1
The Soviet Intervention In Angola	J. Valenta	6.1
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Spectroscopic Data Center: Compilation of Short Ultraviolet (XUV) Spectra	R. L. Kelly	6.1
Elastic Waves in Crystals	J. R. Neighbours	6.1
Homogeneous Catalysis by Palladium Complexes	R. A. Reinhardt	6.1

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Microgalvanic Aspects of Seawater Corrosion (MASC)	J. Perkins K. J. Graham	6.1

PROGRAM REVIEW

The Foundation Research Program is monitored
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