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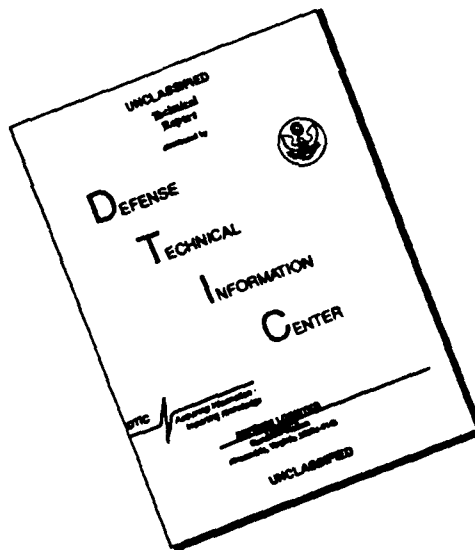
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## REPORT DOCUMENTATION PAGE

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| 12. PERSONAL AUTHOR(S)<br>B. Kellogg                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |       |          | WORK UNIT NO.                                                                                 |  |                          |
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| FIELD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | GROUP | SUB. GR. | Numerical analysis, finite elements, continuation, scattering                                 |  |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |       |          |                                                                                               |  |                          |
| 19. ABSTRACT (Continue on reverse if necessary and identify by block number)<br>The purpose of the report was to provide additional equipment for a computational laboratory dedicated to research in numerical analysis and applied mathematics. The report summarizes the equipment acquired and the research being presently carried out in the laboratory. The research is on topics in boundary integral equations, adaptive finite elements, numerical methods for a scattering problems, continuation methods, and very accurate arithmetic calculations.<br>(KR) — |       |          |                                                                                               |  |                          |
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**AFOSR-TR- 89-1729**

Final Report

Grant AFOSR 83 0286

1 September 1983 - 31 January 1985

Title

RESEARCH EQUIPMENT

Principal Investigator

R. Bruce Kellogg

University of Maryland  
College Park, MD 20742

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Final Report for Equipment Grant AFOSR-83-0286, Sept. 1, 1983 - Jan. 31, 1985

The purpose of the grant was to provide additional equipment for a computational laboratory dedicated to research in numerical analysis and applied mathematics. The initial funding for the laboratory was provided by the National Science Foundation.

The funds provided by this grant were used to acquire an additional computational node, and additional memory, communications capabilities, and graphics capabilities for the laboratory. A detailed list of the equipment acquired by this grant is as follows.

| ITEM                                                  | AMOUNT      |
|-------------------------------------------------------|-------------|
| Apollo DN500 -1MB<br>computational node               | \$25400     |
| Winchester disk for an Apollo node                    | 5350        |
| Hewlett Packard pen plotter<br>and graphics terminals | 7724        |
| 3 CRTs, cable Source                                  | 2118        |
| 3 print terms Federal                                 | 3000        |
| 5 Password modems                                     | 1758        |
| power equalizer                                       | 310         |
| printer ribbons, diskettes                            | 410         |
| symbolic manipulation program<br>and UNIX             | 2734        |
| textronix terminal emulator and<br>PLOT10 software    | 1811        |
| miscellaneous, shipping charges, etc.                 | 358         |
| <br>TOTAL                                             | <br>\$55817 |

Following are brief descriptions of the research being carried out in the computational laboratory.

1. The purpose of the grant was to provide additional equipment for a computational laboratory dedicated to research in numerical analysis and applied mathematics. The initial funding for the laboratory was provided by the National Science Foundation.

Chief, Project

Project: Implementation of the spline-trigonometric method

Investigator: Douglas N. Arnold (Department of Mathematics)

A method designed by the investigator for the numerical solution of boundary integral equations is being implemented and tested. The method is a Galerkin method with spline trial functions and trigonometric test functions. Among the issues being investigated are the proper numerical quadrature procedures to use with the spline-trig method, the use of the fast Fourier transform in the implementation, the dependence of the convergence on the shape of the domain, and the local convergence behavior. At present a first version of the code has been written.

This work is partially supported by the National Bureau of Standards.

Project: Numerical methods for scattering

Investigators: R. B. Kellogg (IPST)

A. K. Aziz (IPST)

Numerical methods are being investigated for the solution of time harmonic scattering problems for moderately high frequencies, between the high frequency region where geometric optics techniques prevail and the low frequency region where the usual finite element and finite difference techniques are appropriate. The present stage of the investigation involves the testing, on a model problem, of some modified finite element schemes that incorporate rapidly oscillating functions into the finite element subspace.

This result is supported in part by the navy, through the IR fund of NSWC.

Project: Path following algorithms.

Investigator: R. B. Kellogg (IPST)

Numerical methods are being developed and studied for the solution of  $n$  equations in  $n + 1$  unknowns. A path following program has been written, and is being tested on various problems using the Apollo system. The present stage of the project involves using the program to follow curves generated by the reduced solution of a rather complicated singular perturbation problem for a system of differential equations, with several boundary layers. The problem arises in the modelling of certain transport processes in physiology.

Project: Adaptive approaches and a-posteriori estimates for solving differential equations

Investigator: Ivo Babuska

The work is partially supported by ONR Contract No. 00014-85-K-0169 and NSF Grant DMS-8315316

- 1) The p and h-p versions of the finite element method.

The theory of the p and h-p versions of the finite element method in one and two dimensions was developed. The practical applicability of the theoretical conclusions was tested by the numerical treatment of relatively large scale problems of structural mechanics. The results have been already used in the commercial p-version finite element program PROBE (Noetic Technologies, Inc.). The numerical results are part of two Ph.D. theses awarded in 1985.

- 2) Numerical solution of linear and nonlinear boundary value problems for ordinary differential equations.

The theory of the factorization method was developed and a general program was written. The program was tested on various problems of an engineering character as, for example, the problem of the stability of a towed underwater cable. The results are related to the Ph.D. theses awarded in 1984.

- 3) Adaptive finite element solution for nonlinear problems.

The previous work, which resulted in the design and implementation of the adaptive solver FEARS for linear partial differential equations, is being extended to the design of the nonlinear solver NFEARS.

Project: Level-index arithmetic

Investigators: F. W. J. Olver (Research Professor, IPST) and

D. W. Lozier (Adjunct Professor, IPST).

The level-index ( $\ell i$ ) number system is being investigated as an alternative to the floating-point system for internal use on computers. In this system a nonnegative real number  $x$  is represented as its generalized logarithm  $\ell + \ell n^{(\ell)} x$ , where  $\ell n^{(\ell)} x$  is the  $\ell$ th iterated logarithm of  $x$ , the integer  $\ell$  being determined by the condition  $0 \leq \ell n^{(\ell)} x < 1$ . The main advantage of the  $\ell i$  system would be to eliminate overflow and underflow problems. The Apollo will be used to simulate the  $\ell i$  system in software in order to test the performance of the system on various standard algorithms in numerical analysis, particularly ones that are known to be prone to overflow or underflow. A compiler is nearing completion.

This work is supported in part by the U. S. Army Research Office, Durham under Contract DAAG 29-84-K-0022.

Reference: C. W. Clenshaw and F. W. J. Olver "Beyond floating point", J. A.C.M. 31, 319-328 (1984).