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Series: Bromley, D. Allan, Files
Subseries: Correspondence Files

OA/ID Number: 62016
Folder ID Number: 62016-006

Folder Title:
Invitations: Speech (1) [6 of 11] [1991]

Stack:	Row:	Section:	Shelf:	Position:
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"CORRESPONDENCE TRACKING"

TYPE: INFORMATION/SPEECH DOCUMENT NUMBER: 9121021

****

FROM: HOXIE, R. Gordon: CENTER FOR THE STUDY OF THE PRESIDENCY

TO: DR. BROMLEY

DATE OF CORRESPONDENCE: 04/03/91

SUBJECT: INFORMATION REGARDING THE HARRY J. SIEVERS MEMORIAL LECTURE 04/25/91 AND APPRECIATION FOR ACCEPTANCE OF THE INVITATION.

****

ASSIGNED TO:

ACTION REQUIRED:

****

SENDER'S DUE DATE: OSTP DUE DATE:

DATE COMPLETED:

****

COPIES TO: D. Allan Bromley
Steve Olson

****

WHITE HOUSE TRACKING #: CONTACT PERSON:

REMARKS:

DATE RECEIVED: 04/08/91 FILE: P. Speech ~~FOLLOW-UP~~

9121021

CENTER FOR THE STUDY OF THE PRESIDENCY
208 EAST 75TH STREET - NEW YORK, N.Y. 10021 - 212 249-1200 - FAX 212 628-9503

OFFICE OF THE PRESIDENT

RECEIVED
91 APR 8 A10:49
OFFICE OF THE DIRECTOR

April 3, 1991

Dr. D. Allan Bromley
Assistant to the President
for Science and Technology
Old Executive Building, Room 358
Washington, DC 20506

Dear Allan,

Very much all of us are looking forward to your delivering the Harry J. Sievers Memorial Lecture on April 25, 1991, jointly sponsored by Fordham University and the Center for the Study of the Presidency. Herewith is a copy of the invitation that is being mailed to our Center members. As I discussed with Steve Olson, the lecture is scheduled at 5:30 p.m. in the McNally Amphitheater of the Fordham School of Law, at 140 W. 62nd Street in Manhattan, with a reception following in the adjacent atrium.

The usual format has been a lecture of approximately 25 minutes duration with a question period of equal length. President O'Hare and I are planning a small dinner in your honor immediately following. Should you find it better to return to Washington, I am sure that would be possible. Alternately, it would be my pleasure to have you as my guest overnight at the Metropolitan Club, 1 East 60th Street. Indeed, I would appropriately request the President's Suite for you should you be able to accept that part of the invitation.

As I advised your office earlier, it is my understanding that Fordham University desires to confer an honorary degree upon you. By now you should have received Father O'Hare's confirming letter in this regard.

May I again reiterate our appreciation for your having accepted this invitation, as we did the invitation for the Austin Conference, October 27, 1990. Your splendid essay, based upon that address, is featured in the Spring 1991 issue of the Center's Presidential Studies Quarterly which will be available at the lecture. Like your Austin address, your essay is truly outstanding.

Among old friends who will be joining us for the lecture, reception, and dinner is William T. Golden, member of the Center's Board of Trustees, who joins in all good wishes.

Sincerely yours,

Gordon

R.Gordon Hoxie

Enc: Invitation for the 1991 Sievers Memorial Lecture
cc: William T. Golden

"INVITATION FOR DR. BROMLEY"

TYPE: INVITATION-SPEECH DOCUMENT NUMBER: 9120992

****

SPEECH: YES NO

FROM: CHANDLER, Colby H.: BUSINESS-HIGHER EDUCATION FORUM

DATE OF EVENT: 06/28/91

LOCATION OF EVENT: UNIVERSITY OF CALIFORNIA, SANTA BARBARA, CA

TIME OF EVENT:

SUBJECT: INVITATION TO BE THE LUNCHEON KEYNOTE SPEAKER AT THE FORUM'S UPCOMING SUMMER 1991 MEETING.

****

RSVP: 04/17/91

CONTACT PERSON: DON M. BLANDIN

CONTACT NUMBER: 202/939-9345

****

INVITATION ACCEPTED? [redacted] NO

****

COPIES TO: Thomas Ratchford
Dr. Phillips

REMARKS:

DATE OF LETTER: 04/02/91 DATE RECEIVED: 04/03/91

FILE: P- INVITATION-[redacted] Speech

9120992



Business-Higher
Education Forum

RECEIVED

91 APR 3 P5:07

OFFICE OF THE
DIRECTOR

April 2, 1991

D. Allan Bromley
Assistant to the President for
Science and Technology
358 Old Executive Office Building
Washington, DC 20500

Dear Dr. Bromley:

On behalf of the Executive Committee of the Business-Higher Education Forum, I am pleased to invite you to make a major presentation at the Forum's upcoming Summer 1991 Meeting.

The meeting will be hosted on June 27-29 by the University of California, Santa Barbara, with overnight accommodations at the Four Seasons Biltmore. We would like you to deliver the luncheon keynote on Friday, June 28, but would hope you could join us for the entire meeting as well.

Forum members — about 90 chief executives from leading U.S. corporations, colleges and universities — would be interested in your insights into new directions in U.S. science and technology policy. Your remarks would perfectly complement our morning session, when we will take an extended look at how corporations and universities — working on their own and cooperatively — can do a better job of educating innovation managers. We have asked several leading corporate and university executives, such as Motorola's George Fisher and MIT's Paul Gray, to join us in discussing this cutting-edge, cross-disciplinary issue.

Your remarks and our session on Educating Innovation Managers will continue a longstanding Forum focus on issues of science, technology, innovation and competitiveness. As you might know, the Forum first called national attention to the competitiveness problem in 1983 and since then has published several followup reports dealing with particular aspects of the issue, including education and training, and technology transfer from universities to industry. (I have enclosed some background on our past and current projects.)

I think you will find the meeting to be a welcome combination of substantive discussion and friendly socializing. Attendance is limited to Forum members, their spouses and a handful of select guests, such as yourself.

Executive Committee

Colby H. Chandler
Forum Chairman (1990-92)
Retired Chairman and Chief Executive Officer
Eastman Kodak Company

William H. Danforth
Forum Chairman-Elect (Chairman, 1992-94)
Chancellor
Washington University

David Pierpont Gardner
Forum Immediate Past Chairman (Chairman, 1988-90)
President
University of California

Robert H. Atwell
President
American Council on Education

James K. Baker
Chairman and Chief Executive Officer
Arvin Industries, Inc.

B. R. Inman
Admiral
U.S. Navy (Retired)

Steven C. Mason
President and Chief Operating Officer
The Mead Corporation

Donald E. Petersen
Former Chairman and Chief Executive Officer
Ford Motor Company

John J. Phelan, Jr.
Retired Chairman and Chief Executive Officer
New York Stock Exchange, Inc.

Barbara S. Uehling
Chancellor
University of California, Santa Barbara

Joe B. Wyatt
Chancellor
Vanderbilt University

Past Chairmen
(1978-1988)*

Edward Donley
(1986-88 Term)
Chairman
Air Products and Chemicals, Inc.

Rev. Theodore M. Hesburgh, C.S.C.
(1984-86 Term)
President
University of Notre Dame

Robert Anderson
(1982-84 Term)
Chairman of the Board and Chief Executive Officer
Rockwell International Corporation

Wesley W. Posvar
(1980-82 Term)
President
University of Pittsburgh

James E. Olson
(1978-80 Term)
Vice Chairman of the Board
AT&T

*affiliation at time of Forum Chairmanship

Don M. Blandin
Forum Director

Judith T. Irwin
Forum Associate Director

One Dupont Circle Suite 800 Washington, D.C. 20036
Telephone: (202) 939-9345 FAX: (202) 833-4723
In affiliation with the American Council on Education

I have asked Forum Director Don Blandin to follow up this letter with a phone call in the near future to determine if you will be able to join us. Please feel free to get in touch with Don or me if you have any questions. On behalf of the Forum, I look forward to welcoming you to Santa Barbara.

Sincerely,

Colby Chandler

Colby H. Chandler
1990-92 Forum Chairman

Retired Chairman and Chief
Executive Officer
Eastman Kodak Company

Enclosures: About the Business-Higher Education Forum
Membership List



Business-Higher
Education Forum

ABOUT THE BUSINESS-HIGHER EDUCATION FORUM

The Business-Higher Education Forum, founded in 1978 by the American Council on Education, is a nonprofit, nonpartisan organization of approximately 90 academic and corporate chief executives. Their goals are to address issues of mutual concern to the corporate and higher education communities and to build consensus on how the two sectors can collaborate more effectively for the benefit of all society. To carry out its agenda, the Forum holds semiannual meetings, convenes occasional roundtables, publishes policy reports and conducts public-education campaigns.

MEMBERSHIP

Membership is by invitation of the Executive Committee, and the number is limited — equally divided between the two sectors. The relatively small size promotes collegiality and helps build consensus.

The chairmanship rotates between academic and corporate members every two years. Colby H. Chandler (Retired Chairman and CEO, Eastman Kodak Company) is the 1990-92 Chairman. He will be succeeded by William H. Danforth (Chancellor, Washington University) in the 1992-94 term. Previous chairmen have included: David P. Gardner (University of California); Edward Donley (Air Products and Chemicals, Inc.); Rev. Theodore M. Hesburgh, C.S.C. (University of Notre Dame); Robert Anderson (Rockwell International Corporation); Wesley W. Posvar (University of Pittsburgh); and the late James E. Olson (AT&T).

THE PROCESS

The Forum has always been a principals-only organization. Outside experts and observers are regularly invited to attend the semiannual meetings, but most of the discussions center on face-to-face, frank exchanges among Forum members themselves. Furthermore, task forces of Forum members take the lead in preparing the organization's reports.

Much of the Forum's effectiveness stems from this strong sense of ownership in the organization and its work. Indeed, one of the most important developments that has occurred in the Forum's first decade are the strong and enduring friendships that have grown as a result of participation in the group. These bonds extend well beyond the Forum meetings into the daily lives of many members.

MAJOR PAST PROJECTS

The Forum is very selective in identifying issues for debate and action. Issues must be important to both sectors and to the nation as a whole. They must lend themselves to consensus. And they must be actionable — through a series of pragmatic public and

One Dupont Circle Suite 800 Washington, D.C. 20036 (202) 939-9345 FAX: (202) 833-4723

private initiatives. Within those parameters, the Forum has focused on several key areas: competitiveness, human resources development, research and development, health care and international relations.

Competitiveness
In 1983, for instance, the Forum was the first private-sector group to alert the nation to the economic competitiveness challenge, with publication of *America's Competitive Challenge: The Need for a National Response*. Subsequent reports on the role of the business schools (1984), the commercial development of space (1986) and R&D cooperation (1988) addressed specific competitiveness issues, and a unique collaboration with Members of Congress (1985-1986) produced a blueprint for change that has been implemented by federal and state policymakers.

American Potential: The Human Dimension
In recent years, the Forum has been focusing particular attention on the human resources aspects of competitiveness. In 1988, the Forum published *American Potential: The Human Dimension*, which tried to build consensus among all parties on the steps needed to more fully develop the talents of the American people. Specific recommendations called for a comprehensive re-examination of the basic education and skills needed by U.S. students; renewed attention to training and retraining the workforce; and a special effort to expand scientific and technical expertise.

Three Realities: Minority Life in the United States
In June 1990, the Forum released a report that takes a fresh look at the opportunities and obstacles facing American minorities. Prepared by a task force co-chaired by Steven C. Mason (The Mead Corporation) and Clifton R. Wharton, Jr. (TIAA-CREF), the report includes recommendations for business and higher education leaders to implement in their own institutions.

MAJOR CURRENT PROJECTS

Help Wanted: A Citizen-Education Campaign on Closing the Skills Gap
The Forum has joined with The Public Agenda Foundation on a three-year project to help Americans understand the threat that lagging competitiveness poses to their standard of living and to suggest changes — especially in developing a skilled workforce — to address those concerns. A six-week public-education campaign, scheduled to get under way in Spring 1991 in the first "flagship" city, Nashville, will be conducted with the active participation of local TV stations, radio stations, newspapers and Forum members. The campaign (including a newspaper supplement and ballots, television documentary and ads, talk shows and town meetings) will be directed specifically to the general public. Additional campaigns are planned for Fall 1991 in Hartford, Indianapolis, Phoenix and Seattle, and in Winter 1992 in the state of Louisiana. The joint project will culminate in a nationwide campaign in 1992, with participation by ABC TV affiliates, the Network for Public Debate (major newspapers and TV/radio stations in communities across the country), the National Issues Forum (a consortium of over 1,000 universities, libraries and other local groups), Forum members and the Business Roundtable. The joint venture has published a report, *Crosstalk: The Public, the Experts and Competitiveness,* which summarizes the major gaps in public and expert understanding of competitiveness and education issues.

Coalition for Democracy and Enterprise
The Coalition for Democracy and Enterprise, co-chaired by Rand Araskog (ITT Corporation) and Arnold Weber (Northwestern University), was established to give the Forum's university and corporate members a mechanism for providing technical assistance

to Central and Eastern Europe. Based on two days of workshops and meetings in Poland in late November 1990, plus extensive discussions during the past 10 months with leading experts in the U.S. and Central and Eastern Europe, the Coalition hopes to focus on three inter-related areas: *management training* (including MBA-like courses to retrain Polish faculty members; executive short courses to train middle and senior managers in fields from accounting to marketing; internships and business exchanges; and training for university administrators); *business incubator centers* (which provide a wide range of assistance to start-up firms); and *technology transfer*. Near-term priorities for the Coalition are to raise funds from members, foundations and government sources, continue negotiating with Polish leaders in the Council of Ministers, the Ministry of Industry and the Ministry of National Education.

Anderson Medal
In November 1990, the Forum announced that St. Louis-based Partnerships for Progress won the first Anderson Medal, honoring exemplary three-way partnerships of businesses, higher education institutions and the public schools to improve the performance of American students. The award is named after the Forum's 1982-84 Chairman, Robert Anderson (former Chairman and Chief Executive of Rockwell International Corporation). The award was presented during ceremonies at the Winter 1991 Forum Meeting. Nine other local partnerships and two national programs (Coalition of Essential Schools and Cities in Schools) also were cited.

National Education Goals
The Forum is participating, both on its own and through the Business Coalition for Education Reform, in the effort by the National Governors' Association and President Bush to establish and implement national education goals.

Global Outreach Efforts
To identify areas of mutual concern with foreign business and higher education leaders, the Forum continues to cooperate with three organizations which it helped to found — the Corporate-Higher Education Forum in Canada (1983), the European University-Industry Forum (1988) and the Australian Business/Higher Education Round Table (1990). Forum members also are vigorously pursuing outreach efforts with their peers in several Asian nations and Mexico.

SEMIANNUAL MEETING ROUNDTABLES

During its semiannual meetings, the Forum focuses on a wide range of topics. The following begins to suggest the diversity of issues examined during meetings.

Future Meetings. Among topics to be addressed during the Summer 1991 Meeting (June 27-30, Santa Barbara, California) will be the issue of educating innovation managers. The Forum is considering holding the Summer 1992 Meeting in cooperation with European industry and academic leaders in Brussels.

Environment and Economic Development. The Winter 1991 Meeting focused extensively on environmental issues, with a look at several models of cooperation involving businesses, universities and government agencies, plus a keynote address by Dr. Peter Raven (Missouri Botanical Garden) that put the issue in perspective, and a tour of Biosphere 2.

Urban Education. Following up on its *American Potential* report, the Winter 1989 Meeting featured an "Urban Education Roundtable," with major presentations by such

leaders as Albert Shanker (American Federation of Teachers), Forum member Lamar Alexander (The University of Tennessee) and Owen Butler (Procter & Gamble Co.).

Front-Line School Reform. The Summer 1990 Meeting took a close-up look at the Rochester schools, where one of the nation's most comprehensive education-reform efforts is under way. Five of the principal participants made presentations.

Science and Technology. The Summer 1989 Meeting had several sessions on science and math education, including presentations by Forum member Donald Kennedy (Stanford University), former U.S. Education Secretary Shirley Hufstedler (Hufstedler, Miller & Beardsley) and Project 2061 Director F. James Rutherford (Project 2061, American Association for the Advancement of Science). The Winter 1990 meeting featured a roundtable on the future of U.S. technology.

Global Interdependence. The Forum has been using its semiannual meetings to discuss the emergence of new regional alliances. The Summer 1988 Meeting was devoted exclusively to the Pacific Rim. The Winter 1989 Meeting explored the possibility of a North American Alliance, including the United States, Canada, Mexico and perhaps one or more South American countries. The Summer 1989 Meeting addressed the implications for American business and higher education of "EC 92," the planned economic integration of the European Community. The Winter 1990 Meeting featured a major address by former U.N. Ambassador Jeane Kirkpatrick on "Communism in Turmoil." At the Winter 1991 Meeting, author Hedrick Smith discussed the future of reform in the Soviet Union.

Health Care. During the Winter and Summer 1990 Meetings, experts such as Rep. Willis Gradison (R-Ohio), Samuel Thier (Institute of Medicine, National Academy of Sciences), Dallas Salisbury (Employee Benefit Research Institute) and Frank Young (U.S. Department of Health and Human Services) briefed Forum members about the various dimensions of America's health-care challenge. Following up on those sessions, the Forum recently circulated a primer on issues such as cost, access and quality, focusing on the implications for businesses and universities.

Ethics Roundtable. The March 1989 roundtable focused on ways in which corporate, higher education and foundation leaders can promote more ethical behavior within their own institutions. The roundtable was part of a planned series of joint ventures between Forum members and chief executives of major U.S. philanthropic foundations.

GOVERNANCE AND FINANCING

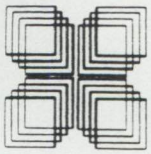
The Forum is governed by an 11-member Executive Committee, with membership divided between corporate and academic members. The organization is supported by membership dues and project grants from philanthropic foundations. The Forum is affiliated with the American Council on Education, which represents more than 1,500 post-secondary, degree-granting institutions and more than 250 education associations.

For further information, please contact:

Don M. Blandin, Forum Director
(202) 939-9345
FAX (202) 833-4723

March 1991

March 29, 1991



Business-Higher
Education Forum

Members of the
Business-Higher Education Forum

Corporate Members

Rand V. Araskog, Chairman and Chief Executive, ITT Corporation

*James K. Baker, Chairman and Chief Executive Officer, Arvin Industries, Inc.

Donald R. Beall, Chairman of the Board and Chief Executive Officer, Rockwell International Corporation

Robert A. Burnett, Chairman of the Board, Meredith Corporation

Frank V. Cahouet, Chairman, President and Chief Executive Officer, Mellon Bank Corporation

****Colby H. Chandler, Retired Chairman and Chief Executive Officer, Eastman Kodak Company

A.W. Clausen, Chairman, Executive Committee, BankAmerica Corporation

John L. Clendenin, Chairman, President and Chief Executive Officer, BellSouth Corporation

K.T. Derr, Chairman of the Board, Chevron Corporation

Edward Donley, Chairman, Executive Committee, Air Products and Chemicals, Inc.

William T. Esrey, Chairman and Chief Executive Officer, United Telecommunications, Inc., and Chairman and Chief Executive Officer, US Sprint

Louis V. Gerstner, Jr., Chairman and Chief Executive Officer, RJR Nabisco, Inc.

Joseph T. Gorman, Chairman, President and Chief Executive Officer, TRW Inc.

Thomas C. Graham, Vice Chairman - Steel and Diversified Group, USX Corporation

Philip M. Hawley, Chairman of the Board and Chief Executive Officer, Carter Hawley Hale Stores, Inc.

Winston R. Hindle, Jr., Senior Vice President, Digital Equipment Corporation

Irvine O. Hockaday, Jr., President and Chief Executive Officer, Hallmark Cards Incorporated

Larry D. Horner, Partner, KPMG Peat Marwick, and Former Chairman, KPMG International

*Admiral B.R. Inman, U.S. Navy (Retired)

Allen F. Jacobson, Chairman and Chief Executive Officer, 3M Company

Henry E. Kates, President and Chief Executive Officer, Mutual Benefit Life

Forum Corporate Members (Continued)

Donald R. Keough, President, Chief Operating Officer and Director, The Coca-Cola Company

Thomas G. Labrecque, Chairman and Chief Executive Officer, The Chase Manhattan Corporation and The Chase Manhattan Bank, N.A.

Paul E. Lego, Chairman and Chief Executive Officer, Westinghouse Electric Corporation

Kenneth A. Macke, Chairman and Chief Executive Officer, Dayton Hudson Corporation

Richard B. Madden, Chairman and Chief Executive Officer, Potlatch Corporation

Jon C. Madonna, Chairman & Chief Executive, KPMG Peat Marwick

John P. Mascotte, Chairman of the Board and Chief Executive Officer, The Continental Corporation

*Steven C. Mason, President and Chief Operating Officer, The Mead Corporation

Richard D. McCormick, President and Chief Executive Officer, U S WEST, Inc.

Kenneth H. Olsen, President, Digital Equipment Corporation

A.J.F. O'Reilly, Chairman, President and Chief Executive Officer, H.J. Heinz Company

*Donald E. Petersen, Former Chairman of the Board and Chief Executive Officer, Ford Motor Company

*John J. Phelan, Jr., Retired Chairman and Chief Executive Officer, New York Stock Exchange, Inc.

Harold A. Poling, Chairman of the Board and Chief Executive Officer, Ford Motor Company

James J. Renier, Chairman of the Board and Chief Executive Officer, Honeywell Inc.

Frank H. Richardson, President and Chief Executive Officer, Shell Oil Company

Charles S. Sanford, Jr., Chairman of the Board and Chief Executive Officer, Bankers Trust Company

Vincent A. Sarni, Chairman and Chief Executive Officer, PPG Industries, Inc.

C.J. Silas, Chairman and Chief Executive Officer, Phillips Petroleum Co.

Raymond W. Smith, Chairman of the Board and Chief Executive Officer, Bell Atlantic Corporation

John W. Teets, Chairman, President and Chief Executive Officer, Greyhound Dial Corporation

Randall L. Tobias, Vice Chairman of the Board, AT&T

Lawrence A. Weinbach, Managing Partner and Chief Executive, Arthur Andersen & Co., S.C.

Clifton R. Wharton, Jr., Chairman and Chief Executive Officer, TIAA-CREF

Kay R. Whitmore, Chairman, President and Chief Executive Officer, Eastman Kodak Company

David R. Whitwam, Chairman of the Board, President and Chief Executive Officer, Whirlpool Corporation

John W. Woods, Chairman of the Board and Chief Executive Officer, AmSouth Bancorporation

William S. Woodside, Chairman, Sky Chefs, Inc. (Former Chairman and Chief Executive Officer, Primerica Corporation)

Academic Members

*Robert H. Atwell, President, American Council on Education

Thomas A. Bartlett, Chancellor, Oregon State System of Higher Education

Derek Bok, President, Harvard University

Johnnetta B. Cole, President, Spelman College

William H. Cunningham, President, The University of Texas at Austin

***William H. Danforth, Chancellor, Washington University

James J. Duderstadt, President, The University of Michigan

Joseph D. Duffey, Chancellor, University of Massachusetts at Amherst, and President, University of Massachusetts (President-Designate, American University, effective July 1, 1991)

Thomas Ehrlich, President, Indiana University

Paul A. Elsner, Chancellor, Maricopa Community Colleges

**David P. Gardner, President, University of California

E. Gordon Gee, President, The Ohio State University

William P. Gerberding, President, University of Washington

Hanna Holborn Gray, President, The University of Chicago

Paul E. Gray, Chairman of The Corporation, Massachusetts Institute of Technology

Vartan Gregorian, President, Brown University

Stanley O. Ikenberry, President, University of Illinois

George W. Johnson, President, George Mason University

Thomas H. Kean, President, Drew University

Eamon M. Kelly, President, Tulane University

Donald Kennedy, President, Stanford University

Charles B. Knapp, President, The University of Georgia

Peter Likins, President, Lehigh University

C. Peter Magrath, President, University of Missouri

Rev. Edward A. Malloy, C.S.C., President, University of Notre Dame

G. Dennis O'Brien, President, University of Rochester

Rev. Leo J. O'Donovan, S.J., President, Georgetown University

Benjamin F. Payton, President, Tuskegee University

J.W. Peltason, Chancellor, University of California, Irvine

Chase N. Peterson, President, The University of Utah

Wesley W. Posvar, President, University of Pittsburgh

Frank H.T. Rhodes, President, Cornell University

Robert M. Rosenzweig, President, Association of American Universities

Steven B. Sample, President, State University of New York at Buffalo
(President-Designate, University of Southern California, effective March 31, 1991)

Benno C. Schmidt, Jr., President, Yale University

Betty L. Siegel, President, Kennesaw State College

John Brooks Slaughter, President, Occidental College

Michael I. Sovern, President, Columbia University

C. D. Spangler, Jr., President, The University of North Carolina

*Barbara S. Uehling, Chancellor, University of California, Santa Barbara

Arnold R. Weber, President, Northwestern University

*Joe B. Wyatt, Chancellor, Vanderbilt University

Charles E. Young, Chancellor, University of California, Los Angeles

**** Chairman, 1990-92
*** Chairman, 1992-94
** Immediate Past Chairman (Chairman, 1988-90)
* Executive Committee Members

"INVITATION FOR DR. BROMLEY"

TYPE: INVITATION-SPEECH DOCUMENT NUMBER: 9120968

****

SPEECH: YES NO

FROM: EVERHART, Thomas E. and Gordon E. Moore

DATE OF EVENT: 05/31/91

LOCATION OF EVENT: CALTECH, PASADENA, CALIFORNIA

TIME OF EVENT: 03:00PM

SUBJECT: INVITATION TO PARTICIPATE IN THE INSTALLATION CEREMONY OF INTEL/DARPA TOUCHSTONE PROGRAM DELTA SYSTEM AND SPEAK ON "WHAT HIGH PERFORMANCE COMPUTING MEANS FOR AMERICAN SCIENTIFIC EFFORTS."

****

RSVP: 04/16/91

CONTACT PERSON: DR. PAUL MESSINA

CONTACT NUMBER: 818/356-3732

****

INVITATION ACCEPTED? [redacted] NO

****

COPIES TO: Dr. Wong

REMARKS: 4/5/91 - Regretted to Rick Johnson! 503/696-7086 MR

DATE OF LETTER: 03/20/91 DATE RECEIVED: 04/02/91

FILE: P- INVITATION-SPEECH

9120968

RECEIVED

91 APR 2 P12:26

OFFICE OF THE DIRECTOR

CALIFORNIA INSTITUTE OF TECHNOLOGY

Pasadena, California 91125

Thomas E. Everhart
President

(818) 356-6301
FAX (818) 449-9374

March 20, 1991

Dr. D. Allan Bromley
Assistant to the President for
Science and Technology
Old Executive Office Building
Washington, D. C. 20506

Dear Dr. Bromley:

On behalf of the California Institute of Technology, Intel Corporation, and members of the Concurrent Supercomputing Consortium (CSC), we would like to invite you to participate in the installation ceremony of the world's fastest computer--the Intel/DARPA Touchstone Program DELTA System. Knowing your interest in this project, we would very much like you to speak, perhaps on the topic, "What High Performance Computing Means for American Scientific Efforts." We feel it would be a good opportunity to showcase American technological leadership in the area of supercomputing. We have asked California Representative George Brown, Chairman of the Science and Technology Committee, to serve as Master of Ceremonies.

The ceremony will take place Friday, May 31, at 3:00 p.m. at Caltech. Proposed attendees include CSC representatives, select industry leaders, key members of the business and supercomputer press, and government representatives, including some from the agencies who will be utilizing the computer (DARPA, DOE, NASA, NSF, and NIH). A dinner will follow the dedication at 7:00 p.m.

The supercomputer being installed at Caltech is the Intel Touchstone DELTA System, from Intel Corporation's Supercomputer Systems Division. As an advancement of Intel's iPSC/860 supercomputer, the DELTA System is a limited production model, capable of handling massive computational problems. We have taken the liberty of enclosing some additional background on the supercomputer and the Concurrent Supercomputing Consortium.

Fourteen of the nation's most prominent research institutions have joined to form the Concurrent Supercomputing Consortium. Researchers from these institutions will focus their energy, talent, and computational resources to address some of the most demanding, scientific and engineering challenges facing the world today.

We appreciate your consideration of this invitation, and we certainly hope it will be possible for you to join us at Caltech on May 31. If it would assist your staff to have a direct contact on the details of the program, they should feel free to contact Dr. Paul Messina. Dr. Messina is the Executive Director of the CSC, and he or his assistant, Mary Maloney, can be reached at (818) 356-3732.

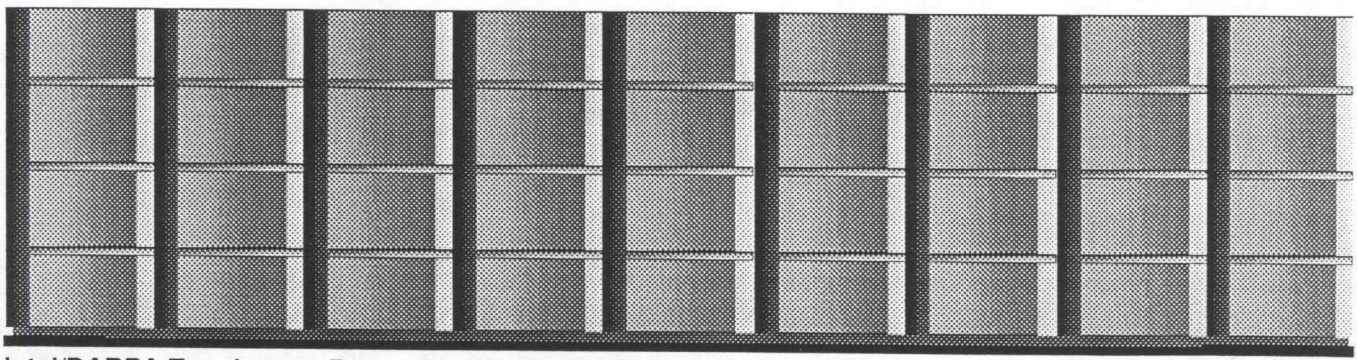
Sincerely,

Thomas E. Everhart
President

Gordon E. Moore
Chairman, Intel Corporation

Transcription of remarks by members of the Concurrent Supercomputing Consortium

Supercomputing '90 Press Conference
New York, NY USA
November 13, 1990



Intel/DARPA Touchstone Program's DELTA System

CONCURRENT SUPERCOMPUTING CONSORTIUM
PRESS BRIEFING
November 13, 1990

This document is comprised of the transcribed remarks of members of the Concurrent Supercomputing Consortium, as recorded during a press briefing held on the morning of November 13, 1990 at the Supercomputing '90 Conference. The briefing was held to publicize the formation of the Consortium and its acquisition of the Intel/DARPA Touchstone Program's DELTA limited-production supercomputer – at 32 GFLOPS, the world's fastest supercomputer. This document includes the recorded statements of each of the members of the Consortium and concludes with a brief Q&A.

CONCURRENT SUPERCOMPUTING CONSORTIUM REPRESENTATIVES IN ATTENDANCE

Argonne National Laboratory	Rick Stevens
Caltech	Tom Prince, Paul Messina
Jet Propulsion Laboratory	Carl Kukkonen
Center for Research on Parallel Computation	Ken Kennedy
DARPA	Gil Weigand
Lawrence Livermore National Laboratory	Robert Borchers
Los Alamos National Laboratory	Ann Hayes
Oak Ridge National Laboratory	Bob Ward
Pacific Northwest Laboratory	Thom Dunning
Purdue University	John Steele
National Aeronautics and Space Administration	Paul Smith
Intel	Justin Rattner

Paul Messina
Director of the Caltech Concurrent Supercomputing Facilities
and
Executive Director of the Concurrent Supercomputing Consortium

Thank you for coming so early this morning to hear about what we feel is an exciting development in the field of computational science. We're here to announce the formation of the Concurrent Supercomputing Consortium, an unprecedented collection of leading research institutions and government agencies that will use the Intel DELTA Touchstone System, a parallel supercomputer more powerful than any existing computer, to tackle some of the most challenging scientific and engineering problems facing the world today — problems such as global warming, the structure of viruses, and nuclear waste clean-up. These studies require huge computational resources, and we will use parallel computers to carry them out. The members of the Consortium are convinced that concurrent computation is the only approach that can obtain the required performance levels.

Now how was it that fourteen institutions of this type, including universities, national labs and government agencies, decided completely on their own to form a consortium for this purpose? Well, all of us have been heavily involved in computational science, that is, in developing and using computational techniques for making advances in science and engineering. Over the last few years, we have all invested time in developing methods for using parallel computers, based on our expectation that parallel architectures would be the only ones capable of providing the vast computational resources needed. While there is still a lot of research to be done on making these systems easier to use, many of us have already been using parallel computers for scientific and engineering applications.

So a few months ago, we all found ourselves poised to take advantage of the promise of parallel computers, but none of us on our own were able to acquire a system that would be significantly faster than existing conventional computers. In April, a few of us started discussing the concept of forming a consortium to pool our resources so that we could take the next step to get the payoff from our investment in learning how to use parallel computers. Within weeks, the word spread among our community, and we met at Caltech in June to discuss the formation of such a consortium to address large-scale computational problems using parallel computers. We found the prospects of sharing our intellectual resources through the consortium to be very attractive. We feel we can learn from each other and share our expertise in software more easily through the Consortium than would otherwise be the case.

In other words, the Consortium seemed to form itself spontaneously. It seemed to be an idea whose time had come. If I had set out to gather such a large and distinguished group of institutions into a consortium, I don't think I would ever have chosen such an ambitious list. Well, as you know, the first machine we chose to acquire is the Intel Touchstone DELTA System. Its architecture is familiar to us – a MIMD architecture with powerful processors, each with a large memory and an interconnection network that can accommodate a large number of processors. The configuration we're getting has 528 numeric processors, with a combined peak speed of 32 GigaFLOPS and over 8 Gigabytes of memory.

Paul Messina
Executive Director of the Concurrent Supercomputing Consortium (Continued)

Incidentally, the DELTA interconnection scheme uses mesh routing chips designed by Caltech Professor Chuck Seitz, who also designed a computer architecture on which Intel's first concurrent computer was based.

In the spring of 1991, the Touchstone Program DELTA System will be installed at the Caltech Concurrent Supercomputing Facilities. It will be accessible to all Consortium members by connections to existing national computer networks, principally NSFnet and the Department of Energy's ESNET. To facilitate program development, most partners are acquiring Intel iPSC/860 Systems, a current product. To get an early start in developing programs for the DELTA, CSC itself will be using a 64-node iPSC/860 that was delivered to Caltech yesterday. So we are getting started now.

In keeping with our emphasis on real-world applications that require the power of the DELTA, we expect to limit the number of users per site to only a handful and, the vast majority of the time, to a few very large jobs.

So in summary, we feel we've formed a consortium whose members want to solve challenging computational problems, who are making the transition to parallel computing as a tool to solve those problems, and whose initial computer system, the Touchstone DELTA, will provide unprecedented amounts of memory and computational speed.

Now the Consortium representatives seated here would like to present their perspectives on the Consortium and mention some of the applications they plan to run on the DELTA System. The first to speak will be Tom Prince from Caltech.

Tom Prince
Associate Professor of Physics
Caltech

At Caltech, my colleagues and I have been successfully using parallel computers for several years to attack a wide range of scientific problems. The Intel DELTA System will be a giant step forward in our ability to do parallel supercomputing. Its memory size and speed will allow us to perform calculations that were unthinkable with the former generation of parallel computers. For instance, understanding the human brain is the fundamental challenge of neurobiology. With 100 billion complex components, the human nervous system is perhaps the most complex device known to man. Simulations of this nervous system require vast resources, in terms of both computer memory and speed, and Caltech biologists are extremely eager to apply the capabilities of the DELTA to this problem.

I, myself, am an astrophysicist who works with neutron stars and black holes. My work done on the previous generation of parallel computers led directly to the detection of nine new radio pulsars, which are spinning neutron stars. Our exciting discovery of these fundamentally interesting objects was a direct result of the increased computational power of the previous generation of parallel computers. The DELTA is even more of a step forward and provides an even greater increase in computational capabilities. With the power of the DELTA, we will be able to carry out some of the most sensitive astronomical pulsar searches ever attempted.

I have mentioned just two of the many applications we wish to undertake at Caltech using the DELTA. Other projects involve sequencing the human genome, simulation of chemical reactions from first principles, and computational fluid dynamics. In summary, we at Caltech, are very excited about the new computational capabilities of the Intel DELTA System, and we are enthusiastic about the formation of the Concurrent Supercomputing Consortium, which brings together this powerful group of researchers to use this new machine.

Rick Stevens
Computational Scientist
Argonne National Laboratory

I think this is the most exciting machine since the first Cray, and I think that's the main reason why Argonne was so excited to be involved with this project. Argonne has also, in the last few years, enjoyed a very fruitful, strong, collaborative relationship with Caltech, including sharing resources over distributed networks, and we believe this concept of a distributed computing facility is workable and has been very productive for us.

For Argonne's computational scientists, this system is a major opportunity to explore larger, more complex problems. For the computer scientist at Argonne, it's a chance to demonstrate that massive parallelism can be used in a broad class of applications. Among the applications that will be investigated at Argonne is global climate modeling. The DELTA machine will provide the ability to do very high resolution studies that are not possible to do on existing architectures. We'll investigate models of high temperature of super conductivity. We'll do predictions of the secondary and tertiary structures of RNA, and we'll also investigate applications of this large system to parallel automated reasoning systems. We'll also use the system to solve symbolic problems in mathematics and science. For us, this machine is incredibly exciting because of its large memory size, and because its processors, individually, are incredibly fast.

Ken Kennedy
Professor of Computer Science
Rice University
and
Director of the Center for Research on Parallel Computation

The Center for Research on Parallel Computation is a National Science Foundation Science and Technology Center with the goal of making parallel computation truly usable for scientists and engineers, and the primary strategy is to do that by progress in algorithms and software. The participating institutions in our Center are, in addition to Rice University, Caltech, Argonne, Los Alamos National Laboratory, the University of Tennessee and Oak Ridge National Laboratory, and Syracuse University. So in a sense, I can claim all of the things said by the previous three speakers.

An important part of our strategy is to obtain access to the most powerful parallel computers of the day to try out our methods in a real testbed on real applications. To that end, we are delighted to be involved in the Concurrent Supercomputing Consortium. We believe that the Touchstone Program represents one of the most plausible approaches to building a TeraFLOP computer, which is a major goal of the proposed High Performance Computing Initiative, and we're very happy, therefore, to make it our principle target machine of the asynchronous distributed MIMD class. Now, CRPC researchers will use the DELTA not only as the vehicle for applications in reservoir engineering, geophysical computing, weather modeling, molecular dynamics, to name a few in addition to the ones named by the previous speakers, but also as a testbed for our research in advanced software environments for parallel computing.

Robert Borchers
Associate Director for Computation
Lawrence Livermore National Laboratory

About three years ago at Livermore, we appointed a group to study the architectures currently available in parallel computing in the hopes of moving real production computing applications such as we've run for years at Livermore on parallel architectures, and the group came back and recommended that we look at multiple instruction, multiple data machines like the Intel/Touchstone DELTA. We then appointed a project leader. Many of you have known Eugene Brooks, who invented the term "killer micros" and decided that we really needed access to a machine of significant capability such as this machine represented here. So we'll be Consortium members using this machine, as well as in-house machines, to move a number of production-level applications to this type of architecture. And let me give you two or three examples.

One, there is a project currently underway at Livermore to intercompare the major global climate models in order to try and understand the warming predictions, which differ rather significantly, and that project is underway. And out of that will come an understanding of the kinds of global climate models that allow us to make reasonable projections of the effects of CO_2 on the atmosphere. And it's our intent then to transfer one of these models to this architecture in order to attain high-resolution performance and run long-term climate modeling.

Secondly, we have a group who is very interested in doing three-dimensional fluid flow calculations using adaptive mesh techniques. Those techniques look very applicable to this architecture and are useful in things such as oil basin modeling, enhanced recovery, contaminant flow, and forest median, and things of that kind.

Finally, we have a group under the leadership of Linda Petzell and Tony Skjellum, who actually graduated from Caltech, to try to develop tools and algorithms to port applications to these machines. And, of course, we are very much interested in what Ken Kennedy and his group are doing in that area as well. So we've used this Consortium as an opportunity to really see a bunch of people who are interested in doing large-scale production computing and move those applications onto the next generation of parallel architectures.

Ann Hayes
Facilities Manager of the Advanced Computing Laboratory
Los Alamos National Laboratory

Los Alamos National Laboratory is indeed pleased to be a part of this distinguished Consortium. Los Alamos National Laboratory has a very long history of bringing the first supercomputers into its workplace. In fact, since 1981, we've been involved with parallel machines on both using them and acquiring experimental machines for looking at new problems. Recently, the Advanced Computing Laboratory was formed at Los Alamos to focus these efforts, and it's our charter to look at all promising new architectures, primarily parallel machines.

The trade-offs between different types of architectures really intrigue us. We feel that the DELTA machine will certainly expand the opportunity that we have to look at very large applications at Los Alamos. We're anxious to see how a problem such as ocean modeling and human genome sequencing will perform on this machine.

As data communication speeds increase and the latencies become more and more transparent to the user, the idea of computing on machines such as the DELTA at sites halfway around the country will become more and more commonplace to the scientists of the United States. And we're very anxious to be a part of this Consortium and use this machine.

Bob Ward
Division Director for the Engineering, Physics, and Math Division
Oak Ridge National Laboratory

Oak Ridge has been interested in parallel computing for many years. In the early 1980's, we looked at basic scientific algorithms, how they may perform on various parallel architectures. Since the mid 1980's, we've been looking at applications, placing them on various architectures, and seeing how they perform. You may know that Oak Ridge has had a 128-node Intel iPSC/860 for almost a year now. That machine is currently saturated, and we are certainly looking forward to running on the DELTA machine to again get more information out of the applications that we are running. We're running plasma physics codes. We're running global climate modeling, high temperature superconductivity, fundamental physics codes, and other various codes at Oak Ridge, and we're looking forward to running them on the DELTA and improving their performance.

Thom Dunning
Associate Director,
Molecular Science Research Center
Pacific Northwest Laboratory

The Pacific Northwest Laboratory is delighted to be a member of the Concurrent Supercomputing Consortium. We expect the Consortium to become a significant force for advancing the state of the art in scientific computing. A strategic objective of PNL is to forge a continuous series of activities linking basic research with applications of technology in pursuit of specific goals of the Department of Energy. There's no problem today more important to the Department than the restoration of the environment at its sites. The computational initiative that has been established at PNL to exploit the Intel DELTA Touchstone Program machine will support the full range of activities in PNL's environmental portfolio. In the molecular area, which is my own research area, we will be using the Intel DELTA to better understand the detoxification of contaminants by enzymes in the environment and the binding of contaminants to minerals in the soil. In the environmental sciences program, the DELTA will be used to model the transport of contaminants through the environment, both in the soil and in the ground water, as well as the chemistry of polluted atmospheres.

In the Environmental Restoration in Water Management Program, the DELTA will be used to characterize the contaminant plumes resulting from leakage of nuclear waste storage tanks on the DOE sites, as well as the vitrification of nuclear waste for long-term storage. Modeling natural systems with complex interactions between physical, chemical, and biological processes is certainly one of the more challenging problems that we will encounter during this decade. It will be one of the grand challenges of this decade. The massive computational power offered by the Intel DELTA will allow us to begin these studies now, not in the future.

John Steele
Director, Computing Center
Purdue University

Purdue University is very excited to be a part of this activity and to be able to make this unique type of computing resource available to our research faculty. We believe that highly parallel computers, such as the DELTA and its successors, represent the way high-performance computing will be done in the future. At Purdue, we plan to use the DELTA supercomputer, first and foremost, to develop new computational techniques and software tailored to the DELTA's unique parallel architecture. Purdue's scientists and engineers will then apply the DELTA to major research problems in several areas. Purdue engineers will use the DELTA to attack computational fluid dynamic problems that arise in the design of high-performance aircraft. Purdue biological scientists will use the DELTA to extend and expand their studies of the structure of viruses. These scientists were previously able to determine the structure of a human virus that causes the common cold. The more powerful DELTA System will permit them to extend their research to other more complex viruses and begin to investigate and work in the very exciting area of synthesizing drugs that might sometime combat those viruses.

Paul Smith
Program Manager
National Aeronautics and Space Administration

High-performance computing is essential to NASA's progress in science and engineering and is needed to support many phases of NASA's research and development program. NASA will use the DELTA as part of our agency's High Performance Computing Initiative — an ambitious program to accelerate the computing research capabilities required to maintain U.S. aeronautical and space science leadership in the 21st century. We will begin to use the DELTA for research problems as soon as it becomes available at Caltech. These research problems will be in the computational air sciences, the earth and space sciences, and for use in space for remote exploration and scientific experimentation in space.

Five NASA centers will be involved: The Ames Research Center, The Jet Propulsion Laboratory, The Goddard Space Flight Center, The Langley Research Center, The Lewis Research Center, and our research communities. This Consortium will provide a great step forward in achieving NASA's high-performance computing goals.

Carl Kukkonen
Director of the Center for Space Microelectronics Technology
Jet Propulsion Laboratory

The Jet Propulsion Laboratory is both a NASA Center and a Division of Caltech. At JPL, we have extensive experience in using parallel supercomputers, and we believe that the Intel DELTA provides a very effective route for solving some of the complex problems for the nation's space program. At JPL, we will use the DELTA for space science and for global modeling of the earth's atmosphere and oceans. We're going to be calculating data relating to the greenhouse effect and ozone depletion. We'll also produce movies to visualize the scientific data that our Galileo and Magellan space missions are taking from Jupiter and Venus.

Gil Weigand
Program Manager responsible for the Touchstone Program United States Defense Advanced Research Projects Agency (DARPA)

Speaking for DARPA, I'd like to say that we're very pleased to see this Consortium of nationally prominent scientific and engineering institutions form, and are gratified that they have chosen to use computer system technology developed through DARPA.

The basic research in scalable parallel computing that was done in the early 80's at Caltech, the subsequent successful transfer of this new computing technology to industry in the mid-80's time frame, the development of a new generation of parallel computing systems by Intel's Supercomputer Systems Division, and finally, the formation today of a consortium of the nation's leading scientific and engineering institutions to use this new technology to unlock new answers in science and engineering, is really a remarkable achievement. But it's also a splendid example of the principles of the High Performance Computing Program being used in practice. And DARPA has supported this process every step of the way.

High-performance computing is important to the Department of Defense. We are moving to a more computationally-based approach in our R&D. Size and complexity of problems such as weather prediction, air defenses, polar aircraft design, submarine defense, or just basic technologies such as turbulence, combustion, and electronics, require a huge amount of computational power. Specifically, our membership in this Consortium will give us the capability to provide a few of our computationally critical programs a huge increase in computing power and, thus, move significantly to a success at an earlier time frame. Also, on a much broader base of Defense Research and Development activities, this increase in power will allow us to accelerate our paradigm shift from a physical laboratories approach to a computationally-based laboratories approach in areas such as electronics, turbulence, and combustion.

Justin Rattner
Intel Fellow
Director of Technology
Intel Corporation's
Supercomputer Systems
Division

This is an exciting day for computing and for science, and it's one that Intel's proud to be part of. The Intel DELTA System we plan to install at Caltech next spring is the latest result of Intel's three-year Touchstone Program. Jointly sponsored by DARPA and Intel, this $27 million R&D program is aimed at raising supercomputer performance 50-fold before the program completes late next year.

Let me give you some of the facts and figures about the DELTA System. DELTA is a highly parallel concurrent supercomputer. It harnesses the power of 528 of Intel's most powerful chips, the i860 microprocessor. DELTA is based on a MIMD message-passing multicomputer architecture that was pioneered by Caltech under both DARPA and DOE sponsorship and developed commercially by Intel and others. I should point out that members in the Consortium have extensive experience with this type of architecture and will find it easy to move their existing software to the architecture.

The heart of any multicomputer, or for that matter, any parallel computer, is its internal communications network. DELTA has one of the most advanced networks ever developed for this type of machine. It's based on a new VLSI chip developed by Professor Charles Sietz of Caltech, and this network allows the DELTA processors to communicate with few delays at unprecedented speeds. In addition to the 528 processors that form DELTA's computational core, an additional 42 processors are available to provide high performance input/output and network connectivity.

And now for some of the figures I promised you — DELTA is peak rated at 17 billion instructions per second. It'll perform 32 billion arithmetic operations per second or floating point operations per second. This is equivalent to adding or multiplying 64 billion fifteen-digit numbers in one second. The communication network for DELTA, that I just spoke of, can transfer up to 16 billion bytes of information in one second, which makes it easily 10 times the performance of the entire Manhattan telephone network.

DELTA contains, as Paul mentioned, 8.8 billion bytes of main memory, an additional 45 billion bytes of disk storage, including 256 million bytes of disk cache. And lest you think that DELTA is a paper tiger, let me mention that the 64-processor DELTA prototype that was constructed as part of our Touchstone Program has been running at Intel's Portland, Oregon facility since September. The construction of the 570-processor DELTA System for the CSC is already underway. It should be partially operational next month and fully operational in January. After roughly three months of check-out and acceptance testing in Oregon, the DELTA will be shipped and installed at Caltech in Pasadena in late March or early April of 1991. We fully expect the DELTA will be producing new scientific knowledge for the Consortium beginning next summer as the fastest installed computer of its kind in the world.

Carolyn Marsen
Federal Computer Week

How much did the DELTA cost, and what has each member of the Consortium contributed?

Justin Rattner: The DELTA System is a limited production system. If it was to be made available commercially, we estimate that it would be priced in the range of $15-20 million.

Paul Messina: The Consortium has agreed not to discuss the financial contribution of each member.

Tom Hoffman
Information Week

Are there any plans for commercial availability of the system down the road?

Justin Rattner: As I said, the DELTA is a limited production system. Only a small number of machines are currently planned to be built. Intel's motivation is to contribute to the scientific efforts that have been outlined this morning by the Consortium and to gain the knowledge we need to define our future products based on this technology development. So we are not announcing new products or forecasting new products at this time, but focusing on what we hope to learn that will allow us to build better products in the future.

Jim Maggid
Maggid Research

One of the statements was that these machines will be used for a new class of problems, and old problems won't be run faster. It's the things that couldn't be done. If you look at the cost/performance of computers made out of microprocessors, which is what this is, in 10 years this will be an affordable desktop machine, maybe a million dollar machine or something in that range. I'd like to ask the Consortium members to give us an idea of what it would be like to have this kind of capability accessible to not just the "select few" in their organizations but to the broad base in their organizations at some future date.

Paul Messina: I'd like to have such a machine on my desk all to myself. I think having such a tremendously powerful parallel computer widely distributed to scientists would cause a major revolution in computational science and engineering.

For additional information:

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News Clippings Related to the Concurrent Supercomputing Consortium's Acquisition of the Intel Touchstone Delta System

From the Caltech Concurrent Supercomputing Facilities
California Institute of Technology
Mail Code 158-79
Pasadena, CA 91125
(818) 356-3732

The New York Times

Date: 11-13-90
Page: C1
Jump page: C4
BUSINESS DAY

Consortium To Buy Intel Computer

By JOHN MARKOFF

A consortium of 14 United States research institutions led by the California Institute of Technology is scheduled to announce today that it will purchase a custom-designed supercomputer from the Intel Corporation to help solve a series of scientific "grand challenges."

The project, known as the Concurrent Supercomputing Consortium, is one of the most significant endorsements to date of a style of computing known as parallel processing, which chains together many processors and breaks up problems to solve them more quickly.

The machine, whose design is an outgrowth of several research projects backed by the Defense Advanced Research Project Agency, or Darpa, will be used in areas like modeling global climate changes and complex chemical reactions; visualization of scientific data from the Magellan and Galileo spacecraft, and military research.

Fastest Systems Available

Supercomputers, described as the fastest systems available at any particular time, are used for scientific research and engineering design. The market for supercomputers has been growing rapidly in recent years and they are now widely used in industries as diverse as petroleum, aerospace, pharmaceuticals, media and entertainment.

Analysts said that the research leading to the development of the new massively parallel machine is a vindication for the defense agency and for the value of its research for United States high-technology companies. The agency has been criticized by some in the Administration for supporting research designed to back specific technologies and companies threatened by international competition.

"This represents an absolute triumph for Darpa and its work in supercomputers," said James Magid, a computer industry analyst at Needham & Company.

The machine, called the Delta System, is based on an array of 528 Intel i860 microprocessors, which are designed to perform mathematical operations at high speed. The design of the new computer is based in part on the work of a research group led by a Caltech computer scientist, Charles Seitz. The group has developed a specialized chip that is used to route information efficiently among different processors.

Intel officials said that once the machine is installed at Caltech in the spring it would be the world's fastest computer, but the claim drew skeptical reaction from a number of the company's competitors.

"We're thinking of it as a yawn," said Charles M. Grassl, a competitive analyst at the Cray Research Corporation. "Has it been tested? We think it's a paper announcement at this point."

Cray, which makes the machines that are generally credited with being the world's fastest, has been increasingly beset by contenders claiming to outperform its systems. Cray has acknowledged the importance of parallel computing and has recently raised the priority of its effort in that area.

Billions of Operations a Second

Intel officials said that the peak performance of the Delta would be 32 gigaflops, or billions of mathematical operations a second, but the company has not yet released more widely recognized performance measurements.

Exact cost figures for the new computer were not made public, but Intel executives said a commercial version of such a system would cost $15 million to $20 million. When it is installed in the spring, the new computer will be used for experiments involving high-speed computer networks connecting different laboratories.

The Delta computer will be focused on the largest problems that are beyond the scope of conventional computing, said Paul Messina, a computer scientist who is director of the project at Caltech. "We don't see this as an experimental machine; we have applications that are ready and waiting to use," he said.

Consortium members are Argonne National Laboratory; California Institute of Technology; Jet Propulsion Laboratory; the Center for Research in Parallel Computation; Darpa; Intel's Supercomputer System division; NASA's Office of Aeronautics, Exploration and Technology; the National Science Foundation; Pacific Northwest Laboratory; Lawrence Livermore National Laboratory; Los Alamos National Laboratory; Oak Ridge National Laboratory; Purdue University, and Sandia National Laboratories.



California Institute of Technology

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World's Most Powerful Computer To Be Installed At Caltech; Consortium Of Leading U.S. Research Institutions Formed To Tackle Massive Computational Challenges

PASADENA -- A new supercomputer, faster and more powerful than any existing computer, will be installed next spring at the California Institute of Technology. The announcement was made this morning (Tuesday, November 13, 1990) at a news briefing in New York City held in conjunction with the opening of the largest U.S. supercomputing event -- Supercomputing '90.

Fourteen of the nation's most prominent research institutions have joined to form the Concurrent Supercomputing Consortium. Through these institutions, researchers will focus their energy, talent, and resources to address some of the most demanding computational and scientific challenges facing the world today.

To support these researchers, the Concurrent Supercomputing Consortium is acquiring the Touchstone Delta System, the world's fastest computer, from the Supercomputer Systems Division of Intel Corporation. The Delta System, which is an advancement of Intel's iPSC/860 supercomputer, is a limited production model, capable of handling massive computational problems. This power comes from the fact that 528 numeric processors work simultaneously to provide a peak speed of 32 gigaFLOPS -- 32 billion floating-point operations per second.

"I am delighted that the most powerful computer in the world will be housed at Caltech, where faculty have been using concurrent computers for science and engineering applications since the early 1980s," said Caltech president Thomas E. Everhart. "I know that a number of research groups at Caltech and at other consortium members are simply itching to get their fingers on this machine, which will be able to tackle scientific problems that otherwise could not even be attempted."

Andrew S. Grove, president and chief executive officer of Intel Corporation, added, "Intel is proud that the Concurrent Supercomputing Consortium has chosen our system to support the consortium's assault on some of the world's important scientific challenges. This is also a milestone for us. For several years, we have been enhancing the performance of our parallel supercomputers; now we are seeing their move into the mainstream of high-performance computing."

The Delta System is the result of a research collaboration between Caltech and Intel that dates from the 1984 founding of Intel's Supercomputer Systems Division. In an example of effective technology transfer, Intel quickly incorporated the results of pioneering Caltech research in multicomputer design and programming into prototypes and products. Both the basic research at Caltech and the accelerated development of prototype systems at Intel are funded by DARPA, the Defense Advanced Research Projects Agency.

According to Gil Weigand, the DARPA program manager responsible for Touchstone, "DARPA has led the technology development in the area of concurrent computer systems for many years. We are gratified to see DARPA's support produce such monumental results. Delta is going to significantly extend computational capabilities in a number of areas important to the Department of Defense; quite frankly, as a consortium member, we are very eager to get our hands on it."

The Concurrent Supercomputing Consortium

The Concurrent Supercomputing Consortium brings together some of the world's leading researchers and scientists, who will use the Delta System to advance their efforts in addressing a wide range of scientific problems. Through the Concurrent Supercomputing Consortium, researchers from the geographically scattered member institutions will have access to the Delta system, which will be physically located in Caltech's Concurrent Supercomputing Facilities, in Pasadena.

The consortium's partners will be:

Argonne National Laboratory
California Institute of Technology
Caltech's Jet Propulsion Laboratory
The Center for Research in Parallel Computation (a National Science Foundation Science and Technology Center)
Defense Advanced Research Projects Agency (DARPA)

Intel Corporation's Supercomputer Systems Division
NASA
National Science Foundation (NSF) programs in computational science and engineering
Pacific Northwest Laboratory

Additional members of the consortium will include:

Lawrence Livermore National Laboratory
Los Alamos National Laboratory
Oak Ridge National Laboratory
Purdue University
Sandia National Laboratories

In addition, researchers at other institutions will have access to the Touchstone Delta System by working through consortium members.

Paul Messina, director of Caltech's Concurrent Supercomputing Facilities, has been named executive director of the newly formed consortium. According to Messina, "The types of computational problems being tackled by the consortium members led us to a unanimous decision. We needed more computing power than anyone has ever harnessed. It will be quite challenging and exciting to work with the members of the consortium to make the most efficient use of this special machine. The Touchstone Delta is allowing researchers to conceive of projects so large that they will take many hours of dedicated processing time, even with the machine's enormous speed. It is particularly gratifying that the government agencies that have supported concurrent computing research over the years -- the Defense Advanced Research Projects Agency, the Department of Energy's Applied Mathematical Sciences program, the National Aeronautics and Space Administration, and the National Science Foundation -- are all involved in supporting the consortium."

The operation of the Concurrent Supercomputing Consortium will be managed by a Policy Board containing representatives from each consortium member. The first chairman of the Policy Board will be Caltech astrophysicist Thomas A. Prince, associate professor of physics. According to Prince, "The Delta System is perhaps the most powerful computational tool ever developed. This level of power gives us the ability to investigate some of today's most intriguing scientific questions."

Members of the consortium will use the Delta System for various large-scale computations, including, for example: modelling and simulations of global climate change, which will help develop a better understanding of the impact of environmental issues such as acid

rain, increasing CO_2 concentrations, deforestation, and ozone-layer depletion; calculating the rates of chemical reactions from the first principles contained within the complex Schrödinger equation; visualization of scientific data returned from the Magellan and Galileo spacecraft; high-fidelity aerospace vehicle simulations; pattern recognition of DNA sequences within the human genome; re-engineering of enzymes for enhanced biodegradation; and modelling of molecular processes in natural and contaminated systems to better understand the behavior of contaminants in the environment.

Added Prince, "I myself am going to use the Delta to search through very large volumes of radiotelescope data for the faint and complex signatures of binary pulsars. Study of these exotic objects should contribute to our understanding in several important areas of astrophysics, including gravitation and general relativity."

The Delta System From Intel

The Touchstone Delta System from Intel is an advanced message-passing multicomputer with a unique mesh interconnect scheme. An advancement of Intel's iPSC/860 supercomputer, the Delta System incorporates Intel's i860 and 386 processors along with a custom mesh-routing chip developed by a Caltech research group led by Charles Seitz, professor of computer science.

"The Delta is a significant performance milestone for multicomputers," said Seitz. "This performance is achieved by combining two recent advances in microelectronic technology: the numeric performance of Intel's i860 microprocessor and the communication performance of the Caltech mesh-routing chips."

The Touchstone Delta System will have a peak speed of 32 gigaFLOPS (32 billion floating point operations per second), classifying it as the fastest computer in the world. It achieves its tremendous speed through concurrency. The Delta System employs many high-speed, cost-effective microprocessors, interconnected with a communication network that allows them to work together to solve enormous computational problems. The speed of computation grows proportionately as more microprocessors are added. Concurrent computation was reduced to practice at Caltech and other research institutions in the late 1970s and 1980s.

"Intel has made a serious commitment to parallel supercomputing technology," said Robert

Rockwell, general manager of Intel Corporation's Supercomputer Systems Division. "We plan to play an active role in the consortium, and we will be working closely with many of the member organizations as they acquire production iPSC/860s for application development at their own sites. The experience we gain from the application of the Delta System to today's most computationally demanding problems will help us refine our next generation of Intel supercomputers."

Justin Rattner, director of technology for the Supercomputer Systems Division of Intel Corporation, and principal investigator for the Touchstone project, added, "The Delta System is a milestone for both science and computer technology. Conventional supercomputers simply can't deliver the performance we need to understand the world's critical scientific challenges. Our only viable solution is the continued development of multicomputer systems based on the most powerful microprocessor technology available; technology that will double in performance every two years for the next ten years. The demand for a system as powerful as the Delta has convinced me that we have crossed the threshold of a new era for computing and science."

Adds Stephen Squires, chief scientist of DARPA's Information Sciences and Technology Office, "When we initiated the Strategic Computing Program in the early 1980s and invested in basic research at Caltech, one of our dreams was to enable U.S. industry to move to a new high-performance computing technology base. The Caltech and Intel Corporation collaboration that produced the new technology for the consortium is an excellent example of the principles of the Federal High Performance Computing Program being used in practice. We are very pleased to see the process working and believe that this will have specific impact on future Department of Defense and national capability."

About Caltech

Caltech, which will celebrate its centennial beginning on January 1, 1991, has an enrollment of some 1,800 students, and a faculty of about 275 professorial members and more than 425 research members. The Institute has more than 17,000 alumni.

Over the years, 21 Nobel Prizes have been awarded to faculty members and alumni. Twenty-nine Caltech faculty members and alumni have received the National Medal of Science. On the Caltech faculty are 53 members of the American Academy of Arts and Sciences, and on the faculty, Board of Trustees, and professional staff there are 66 members of the National

Academy of Sciences and 35 members of the National Academy of Engineering.

About Intel

Intel is an international manufacturer of microcomputer components, modules, and systems. Intel employs more than 20,000 people worldwide, has 90 sales offices in 25 nations, and also sells through electronics distributors in 34 countries.

Intel Corporation's Supercomputer Systems Division -- based in Beaverton, Oregon -- develops, manufactures, and markets parallel supercomputers.

Intel's parallel supercomputers are widely used in traditional supercomputer fields such as aerospace, defense, and petroleum, as well as emerging markets such as atmospheric, oceanic, and environmental modelling, financial analytics, and pharmaceutical design.

[iPSC/860, i860, and 386 are registered trademarks of Intel Corporation.]

Note to editors: Two 8 X 10 color prints are available to illustrate this story. One is a micrograph of the mesh-routing chip developed by Caltech's Charles Seitz. The other is a mechanical prototype of the configuration of the entire Touchstone Delta System.

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NATION

Call This a Super-Duper Computer

$15M machine is the fastest ever

By Joshua Quittner
STAFF WRITER

A group of national laboratories, universities and federal agencies have bought what is expected to be the fastest supercomputer ever built, and their scientists are teaming up to solve some of the world's most complex scientific problems.

The scientists, who call themselves the Concurrent Supercomputer Consortium, were expected to announce today that the consortium members have purchased Intel Corp.'s Touchstone Delta System, valued at $15 million. The computer, to be installed this spring at the California Institute of Technology in Pasadena, can perform a frenetic 32 billion calculations per second, its designers said — 4 billion calculations a second more than the fastest supercomputer available.

With that kind of speed, scientists hope to help map human genes, extrapolate the global climate a hundred years from now and design an "aerospace plane" capable of traveling 25 times the speed of sound. The computer will enable scientists to better understand acid rain, deforestation and ozone-layer depletion, and will help researchers visualize data returned from the Magellan and Galileo spacecraft.

"We can use it to correct the lens for the Hubble telescope," said Mike Bernhardt, a spokesman for Intel's supercomputer division. "On the fastest supercomputer available today, it would take well over a year to do the computations. With the new system, it could be done in 45 to 50 days."

"I think it's going to be an exciting machine. Exciting science is going to come out of it," said Tom Prince, an astronomer and astrophysicist at Caltech who hopes to use the computer to search for binary pulsars — collapsed, rapidly spinning stars.

The Intel Corp. machine is the latest benchmark in the field of parallel computing, in which hundreds — sometimes thousands — of microprocessors are linked to create a single supercomputer. Greater attention — as well as huge federal grants — is being showered on supercomputer development, as computation begins to eclipse experimentation and revolutionizes the world of science.

And increasingly, parallel supercomputers are becoming the computers of choice for scientists, who prefer them to the more conventional and expensive serial computers, which rely on single, powerful processors.

While the Delta System is expected to be the fastest computer in the world when Intel technicians at the company's supercomputer plant in Beaverton, Ore., power it up on Christmas Eve, the computer will undoubtedly be obsolete within a year, its designers said. Intel believes it can produce a supercomputer at least three times as fast by the end of 1991.

And companies in the forefront, like Thinking Machines of Cambridge, Mass., are racing to complete a supercomputer that will be capable of achieving a trillion calculations a second by the end of the century.

Paul Messina, director of Caltech's Concurrent Supercomputer Facility and the executive director of of the supercomputer consortium, said that for the consortium, buying the supercomputer in the face of such rapidly changing technology was similar to the predicament faced by an individual consumer who wants to buy a personal computer. "There's always something more appealing, cheaper, faster on the horizon," Messina said. "You just have to jump sometimes," he said, adding that the machine "will be an interesting machine for a good three years."

Parallel supercomputers are effective tools in massive computations because of their ability to distribute pieces of calculations between each of the microprocessors that are arrayed.

The Delta System harnesses 528 microprocessors — far smaller than previous, "massively parallel" supercomputers that relied on as many as 64,000 microprocessors. Delta's greater speed comes from more powerful microprocessors and a unique "mesh routing system," which rapidly relays operating instructions and data between each of the processors. In previous technologies, processors had to interrupt their work to pass messages.

The Delta System is "just the next point on the curve. It means there will be vast new kinds of problems that can be solved," said Stephen Squires, chief scientist of the federal Defense Advanced Research Projects Agency's Information Technology and Sci-

see next page...

ence Office.

Squires' agency, which was born in the shadow of Sputnik, acts as kind of a national watering can, nurturing private and academic research and development of high-performance computing with more than $100 million in grants a year.

The agency has given nearly $13 million to Thinking Machines with the hopes of a trillion-calculation-per-second computer, which Squires said he hopes to see by 1996. In the meantime, Intel's Delta System is an "intermediate result which is good enough for people to want to use it," he said.

The consortium includes scientists from Caltech; Purdue University; NASA; the federal Defense Research Advanced Projects Agency and the National Science Foundation; Argonne, Lawrence-Livermore, Pacific Northwest, Oak Ridge, Sandia, and Los Alamos national laboratories; the Jet Propulsion Laboratory at Caltech and Intel itself.

Evolution of a Supercomputer

The Touchstone Delta System that Intel has developed can do 32 billion calculations per second. In 1980, the number of tasks performed by a computer per second was 100 million, while in 1988, 1 billion tasks could be performed per second. In the future, computers will be able to do a trillion calculations per second. Here is a synopsis of what supercomputers have been used for in the past and what scientists hope they can use them for in the future.

1980
- Simulate the wings of an airplane.
- 48-hour weather prediction.
- Oil reservoir modeling, detecting where underground reserves are and their size.

1988
- 72-hour weather prediction.
- Three-dimensional modeling of how superheated gases behave.

1991
- Modeling global climate change.
- Studying water pollution in ground water and surface water.
- Visualization of scientific data from the Magellan and Galileo spacecraft.
- Pattern recognition of DNA sequences.
- Designing an aerospace plane capable of traveling 25 times the speed of sound.
- Military applications, like designing parts of submarines, tanks and airplanes.

1996
- Computer modeling of human vision.
- More precise global climate modeling.
- Understanding the force that holds the nuclei of atoms together.

SOURCE: Intel

How They Compare

How long different computers take to do a scientific calculation.*

- SUPERCOMPUTER: 1 minute
- MINISUPERCOMPUTER: 30 minutes
- MAINFRAME: 3 hours
- COMPUTER WORKSTATION: 15 hours
- PERSONAL COMPUTER: 96 hours

* - Based on speed ratings for floating-point math operations.

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TECHNOLOGY

Intel to Supply A Supercomputer To Group of Labs

By Stephen Kreider Yoder
Staff Reporter of The Wall Street Journal

SAN FRANCISCO—Intel Corp.'s supercomputer division said it won a contract to supply what it termed the world's fastest computer to a group of government and university laboratories.

The deal is a coup for Santa Clara-based Intel, which is trying to make a name for itself in high-performance computers using its own chips. The market for supercomputers, multimillion-dollar machines built to process huge numbers of calculations at an extremely high speed, has been dominated by companies such as Cray Research Inc.

Called the Touchstone Delta System, the new Intel machine uses so-called parallel-processing technology to lace together 528 of its i860 microprocessor chips so that they do calculations simultaneously. The machine produces a peak speed of 32 gigaflops, or billions of floating-point operations a second. Today's fastest machines run at peak speeds in the mid-20s of gigaflops.

Robert Rockwell, general manager for Intel's supercomputer division in Beaverton, Ore., wouldn't disclose the machine's exact price, valuing it at $15 million to $20 million. The machine was built in part with technology gained from the Defense Advanced Research Projects Agency, or Darpa, he said.

Mr. Rockwell said Intel will install the machine early next year at the California Institute of Technology in Pasadena for use by 14 institutions that are expected to announce today their formation of a group named Concurrent Supercomputing Consortium. The group comprises some of the nation's top research institutions, including Lawrence Livermore National Laboratory, the National Aeronautics and Space Administration, the National Science Foundation, Purdue University and Caltech.

A Caltech spokesman said the group plans to use the machine for scientific problems—such as simulating global climate changes and translating into pictures the masses of data sent by the Magellan and Galileo space probes—that haven't been practical to solve with slower machines.

THE SPANG ROBINSON REPORT ON

High Performance Computing

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The Delta Consortium

One of the biggest pieces of news to come along was the announcement of the formation of the **Concurrent Supercomputing Consortium**, a group of the largest and most savvy supercomputer users in the country led by Caltech. The consortium's founding was announced at *Supercomputing '90*, along with word that it would acquire the Touchstone Delta prototype, arguably the most powerful computer system in the world at 32 double precision GFLOPS peak performance. A Cray Research competitive analyst called Delta "a yawn," but there is plenty of reason to think he was whistling past the graveyard. **Karen Gullo** covered the consortium story in New York, and we interviewed Touchstone project director **Justin Rattner** and kicked the Delta system tires in Beaverton, OR. Our reports lead off this issue.

Supercomputing '90 triggered a rash of major company and product announcements as witnessed by our Company and Product news columns in this issue. The significant new product story was the heavy emphasis on software. Major software announcements were made by CONVEX, Intel, BBN Advanced and others touting new and improved operating systems, compilers and development environments. (We will have a full report on *Supercomputing '90* in the January issue.) On the company side, the lead story is the demise of Myrias Research, which folded early last month after several years of failing to convince users that the Myrias technology worked as well as Myrias said it did.

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Concurrent Supercomputing Consortium Formed

by Karen Gullo, Associate Editor

Intel's Big Apple Welcome

It was a typical New York story at the IEEE Supercomputing '90 conference last month: When trucks toting Intel Corp.'s exhibit pulled up at the service entrance of the Hilton Hotel in midtown Manhattan, a half dozen security guards appeared and asked the truckers if they needed help unloading. Glad to have the assistance, they let the men carry inside boxes containing computer workstations, software and other gear. Six boxes into the job, the "guards," and the boxes, were nowhere in sight. The truckers looked inside, but were told by hotel officials that there were no guards assigned to the service entrance.

Imagine the thieves' surprise when they found that they were the proud owners of two Resource Manager front ends for Intel's Delta system, assorted software and almost all the company's product literature. One of the boxes contained press releases announcing a new supercomputer and the formation of a new research consortium, which the company had kept under wraps for weeks. "I kept combing the blocks around the hotel, looking in garbage cans for the press releases," said one Intel press officer. "We didn't want news of the consortium to leak out."

Thieves Didn't Squeal

Though the contents of the boxes were never found, the thieves apparently kept their mouths shut and the parallel processing research consortium was announced on the first morning of the conference, as scheduled.

(The company arranged for new equipment to be delivered overnight to the conference.)

While the consortium probably doesn't mean much to the New York thieves, it's a major development in the world of supercomputing. A dozen national laboratories, universities and government agencies have teamed up to purchase the Touchstone Delta massively parallel system from Intel. The group, known as the Concurrent Supercomputing Consortium, will use the system for attempting to solve "grand challenge" large-scale computations, such as global climate simulations, visualization of space data, and pattern recognition of DNA sequences in the human genome.

Consortium Members

Members of the consortium include Argonne National Laboratory, California Institute of Technology, Caltech's Jet Propulsion Laboratory and Center for Research in Parallel Computation, Defense Advanced Research Projects Agency

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(DARPA), Intel's Supercomputer systems division, NASA, various NSF programs, Pacific Northwest Laboratory. Additional members include Lawrence Livermore Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Purdue University and Sandia National Laboratories.

The Delta, a product of the DARPA-funded Touchstone project, will be a 528-processor system capable of a peak speed of 32 GFLOPS. The system is worth between $15 million and $20 million, according to Intel. (The accompanying article describes the Delta system in detail.) Each consortium member is kicking in money, although officials declined to specify how much everyone is contributing. Pooling funds was a major factor in the group's formation, although it wasn't the only consideration, according to Paul Messina, director of the California Institute of Technology's Concurrent Supercomputing Facilities, where the system will be housed.

Big News

The consortium is big news on several fronts. It's the strongest endorsement yet for highly parallel computing from the most active supercomputer users in the country. Parallel computation research centers already exist at several universities, including Caltech, but the consortium will bring the technology to a very prestigious group whose members rely mostly on Crays for tackling big problems.

"This sends a real message out to the industry," said Paul Messina, director of Caltech's Concurrent Supercomputing Facilities and executive director of the consortium. "Traditional vector machines, what Cray, CDC and the Japanese have concentrated on, are not the wave of the future. They will still be used heavily for many years, but for doing more and more routine stuff. Parallel systems are needed for the really big problems."

A Yawn? Wake Up!

A Cray Research official called the Delta "a yawn" in an article published in the New York Times the day of the announcement. But it's doubtful that Cray, and for that matter, IBM, don't recognize that the Delta consortium gives a significant boost to highly parallel computing. The project will provide much-needed experience in building and running parallel applications and train a new generation of scientists to use parallel architectures. This will extend from the members out into private industry. "This will help spread the word," said Messina. "Each member tends to have some connection to industry, and you have a lot of technology transfer potential."

Support for the research consortium from DARPA seems to indicate that despite the flap over former director Craig Field, the agency is still committed to promoting strategic technologies and joint industry projects. Field resigned from DARPA after he was removed from his post by administration officials who apparently disapproved of Field's support and funding of joint industry projects in HDTV and gallium arsenide.

Meet the Chief

Sources that work with DARPA on parallel computing project say that agency officials have actually shown more interest in their industrial research partners than they had previously. "Now they want to come and

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meet the CEO, and they ask us if they're being responsive to us," said one source.

It's tough to say how big a role DARPA plays in the consortium—Messina says the agency is not the biggest contributor of funds, nor is it the smallest. But the agency is largely responsible for Delta, which is part and parcel of the DARPA-funded Touchstone project. Interestingly, DARPA is funding another parallel computer project, called Mega, at Thinking Machines, itself a product of DARPA funding. Observers say it's not unusual for DARPA to fund more than one project in the same field of research, but it will be interesting to see what might happen if pressure on DARPA builds up in the administration again. Gil Weigand, the DARPA program manager responsible for Touchstone, said the two project will co-exist. "The time scale on both projects are different," he said. "Mega was started a year ago, and we're looking for a prototype in the 100 Gigaflops range."

May Stretch Resources

The development of Delta breaths new life into the first phases of Touchstone project, which began last year, but may stretch resources at the supercomputer division, and efforts to move into the projects next phase, to the limit. Intel had rolled out the Gamma prototype systems to Oak Ridge National Lab and NASA Ames and then announced a commercial version, the iPSC/860, shortly after. "In late April we said we would only build a few machines," said Justin Rattner, director of technology for the supercomputer systems division at Intel. "We told DARPA that in a very painful meeting that I remember vividly." But in late May, Messina contacted Rattner and asked if the company would be interested in building a large system to be used by a group of users that Caltech had assembled. "I said, 'Are you kidding?'" Rattner remembers.

He's a bit concerned that Delta might delay the next phase of Touchstone, called Sigma, because of the demand on resources at Intel. About 20 researchers are dedicated to the Touchstone project, and will be shared between the two systems projects. But Rattner felt it would be worthwhile to build Delta "for the opportunity to learn to build a machine of that scale and to be part of the scientific effort that was outlined by Paul and the consortium members."

Lots of Skeptics

"One of the reasons we decided to join this effort is that we felt on the scientific side that highly parallel computing still had something to prove, certainly in the multicomputer category," said Rattner. "You still find lots of skepticism." Big strides in performance can't be achieved in vector machines -- the next generation might promise a two- or three- fold increase in performance, but grand challenge projects need 10 times the speed of existing supercomputer. "We felt that the projects outlined by the consortium were the sorts of things we could expect to see in the 10 to 15 Gigaflop range," said Rattner.

"You're going to get a lot of attention with that, because it's an order of magnitude beyond what you can expect for a conventional supercomputer. We had the order of magnitude in price performance for a while, but an order of magnitude in raw performance had not been demonstrated," he said. "I hope Delta is the first to do that."

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Use Existing Networks

Consortium members will access the Delta, which will be housed at Caltech, through existing high-speed research networks. Members will eventually benefit from the 5 Gigabit network project under development with funds from DARPA and the National Science Foundation. Messina estimates that within a year or so perhaps as many as two-thirds of the partners will use the ultra high-speed network.

Touchstone Delta: Super Super

Fastest Computer System Yet

When Intel Supercomputer Systems Division delivers the Touchstone Delta prototype to Cal Tech in the second quarter of 1991, it will be clearly, if temporarily, the fastest computer system in the world with a peak performance of 30 double precision gigaflops. Clearly, because no other vendor can claim performance at that level in the same time frame, and temporarily, because the 100 gigaflop peak performance range is in sight for the 1992-93 period, from Intel and others.

DARPA Support

The Touchstone project, initiated in 1988 and projected for a four-year life, is being carried out at Intel Supercomputer Systems Division (nee Intel Scientific Computers) in Beaverton, OR, under the direction of Intel Fellow Justin Rattner. The project is funded at about $28 million, with about one-fourth of the funding coming from the Defense Advanced Research Projects Agency (DARPA), and the balance from Intel corporate money. The ultimate aim of the project is to "Demonstrate by late 1991 the technology for systems with over

Touchstone Chronology

IOTA

Internal prototype: mid '88
Field prototype: late '88, delivered to U. of Wisconsin and U. of Virginia
Production model: iPSC/2 with CFS, early '89

GAMMA

Internal prototype: 9/89
Field prototype: 1/90, delivered to Oak Ridge National Laboratory and NAS, NASA-Ames, both 128 nodes
Production model: iPSC/860, 6/90 (about 30 systems delivered to date)

DELTA

Internal prototype: 9/90
Field prototype: 2Q91, to be delivered to Cal Tech for Parallel Supercomputing Consortium
Production model: No production model planned

SIGMA

Internal prototype: 12/91
Field prototype: 6/92, destination unknown
Production model: Not committed

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2,000 processors, 150 gigaflops peak 64-bit performance, 64 gigabytes of main memory and 0.5 terabyte of on-line storage," Rattner said.

The Delta prototype, which we describe in greater detail later, is not the first manifestation of Touchstone. It is, in fact, the third of a series of four phases of the project. The prior phases were:

- ✔ IOTA: Addition of the Concurrent File System (CFS) to the iPSC-1.
- ✔ GAMMA: The prototype for the iPSC/860.

The final phase will be SIGMA, the prototype that will provide the demonstration of objectives described above.

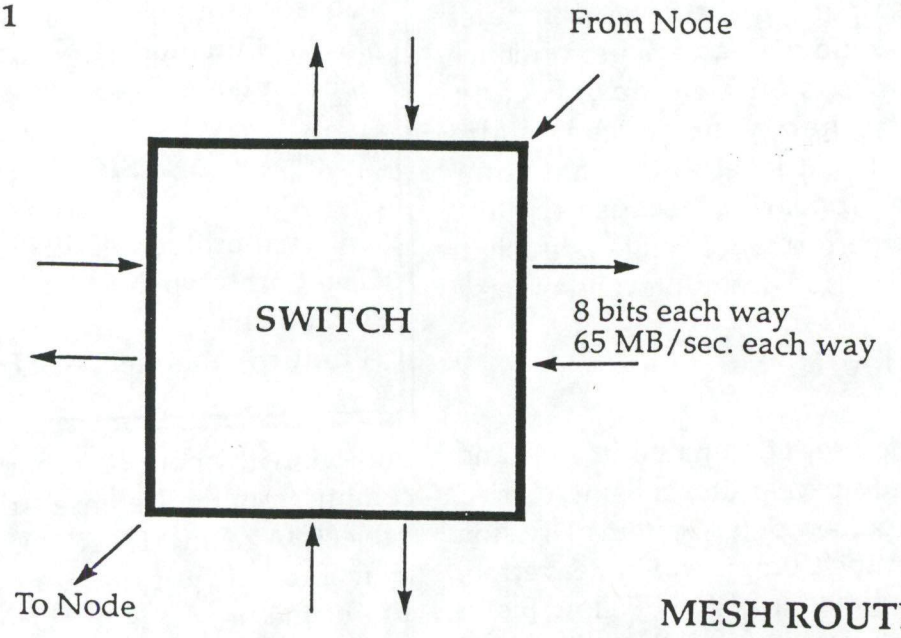
The Delta system retains the distributed memory - message passing architectural philosophy of its predecessors, but many architectural details have changed to enhance realizable performance and remove some of the bottlenecks inherent in the original hypercube design.

New Internal Network

Perhaps the most significant change is the substitution of the mesh router for the original hypercube network. Based on a chip designed by Cal Tech professor Charles Seitz, the mesh router connects all system nodes through a two dimensional network. **Figure 1** below diagrams the router chip.

From the diagram it is apparent that the chip offers byte-wide full duplex operation. The paths can run as fast as 65 MB/sec in each direction simultaneously, but Delta will operate the mesh at a more conservative 28 MB/sec. The significance is that network latency will be reduced by more than a factor of ten, in comparison with the iPSC/860.

Figure 1



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No More Front End

Distributed memory systems typically operate with a front-end computer to manage the user interface, networking and similar services. The Delta prototype eliminates the front end, and instead provides service nodes to handle user logins, system configuration. The number of service nodes can be expanded to any level, but the Delta that will be delivered to Cal Tech will have six, predominantly to limit the number of logins. Designer Rattner points out that while in theory the Delta architecture would support time-sharing use, it is an inefficient use of the system design.

In another departure from the older hypercube architecture, made possible by the interconnect topology, the number of nodes is not limited to a power of two, and in fact can be any number. The Delta field prototype is designed with 568 nodes in total, including 528 numeric nodes, 32 mass storage nodes with 1.4 GB of storage each, six service nodes and two Ethernet nodes.

Numeric nodes carry both 386 and i860 processor chips, giving programmers access to both instruction sets. Normally, the 386 processors control input-output, execute the operating system kernel, interface with the internal network and other housekeeping functions, but some programs, such as LISP and Ada, currently execute only on the 386 instruction set. Mass storage nodes and service nodes use only the 386. Numeric nodes can be equipped with up to 16 MB of DRAM; the Delta field prototype will be configured with a total of 8.768 GB of main memory.

Three Times Faster

While the numeric nodes can generate peak performance of nearly 32 gigaflops, achievable performance will depend upon the efficiency with which the system can be utilized. Rattner believes that 50 percent efficiency is within reach for a significant spectrum of applications, which would suggest realizable performance of better than 15 gigaflops, or nearly three times the best performance we are aware of (on a 65,000 processor Connection Machine 2 running a seismic code). (Peter Gregory's article on parallel systems performance in our November issue would appear to support Rattner's efficiency estimates; actually, Gregory indicated that efficiency levels of 60 to 65 percent should be readily achievable.)

The software design philosophy of the system relies on "lightweight" operating systems with layered support for specific programming models, applications or tools that minimizes overhead for messages and processes. High-level software services are distributed via service nodes or across a local area network. The system provides UNIX compatibility (**see related article on distributed operating systems in this issue**). Standard languages are FORTRAN and C/C++, with minimal augmentation. Interactive tools to assist in parallelization of programs are also planned.

Valued at $15 Million

The Delta field prototype is not the precursor to a product, Intel says, but it will be built to full commercial standards, according to Rattner. Both Intel and the consortium are mum on the matter of pricing, but an Intel

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source said that the system would be priced at around $15 million if it were sold commercially. Intel chairman Andy Grove reportedly told a New York financial analysts group that the contract to provide the Delta field prototype was worth in excess of $10 million.

The next Touchstone step is Sigma, well along in design, with an internal prototype scheduled for the end of this year (see box). Sigma will use the same design philosophy as Delta, but new processors and four times as many. The peak performance objective for Sigma is 150 gigaflops (a conservative estimate -- Rattner admits that the system could possibly deliver as much as 200 gigaflops). With 64 GB of main memory and a half a terabyte of on-line storage, the system would be capable of attacking currently intractable problems.

And the amazing thing is, 1992 is just around the corner.

Skiing the Performance Slope

Target: Conventional Wisdom

To John Gustafson, director of the computing center at Ames Laboratory, Ames, IA, the conventional wisdom is basically a target to shoot at. He demonstrated this in a substantial way when, as head of a team at Sandia National Laboratories, he punched holes in Amdahl's Law with a near linear speedup from one to more than a thousand processors on a real-life problem, a feat that earned the team a Gordon Bell award for achievement in parallel processing.

Gustafson's latest target is benchmarking, where the conventional wisdom has been that the measure of a computer's capacity lies in how many operations per second it can perform while doing a fixed task. Wrong, he argues: the best measure is how much work the computer system can do in unit time. To prove his point, he and colleagues at Ames Laboratory, a Department of Energy facility managed by Iowa State University, have devised SLALOM, an acronym for Scalable, Language-independent, Ames Laboratory, One-minute Measurement.

Straightforward Concept

The acronym is a little tortured, but the concept is straightforward. Given a repetitive problem, see how many repetitions the computer can complete in one minute. Since it is known how many floating point operations must be executed to complete a given number of repetitions, the system power in MFLOPS can be derived.

Scalability is an important factor, Gustafson says, because systems of the future will be so much more powerful than current systems that existing standard benchmarks such as Linpack and the Perfect Club will not be relevant. In fact, he says, even the 1000x1000 Linpack problem is too small to be a good measure of today's most powerful systems. However, with SLALOM, he says, it will be possible to compare accurately a PC and a teraflop supercomputer. Scalability with SLALOM begins with any system that can execute at least 148 floating point

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(NEW YORK) NEWSDAY
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Group Buys Fastest Supercomputer

By Joshua Quittner
STAFF WRITER

A group of national laboratories, universities and federal agencies have bought what is expected to be the fastest supercomputer ever built, and their scientists are teaming up to solve some of the world's most complex scientific problems.

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"We can use it to correct the lens for the Hubble telescope," said Mike Bernhardt, a spokesman for Intel's supercomputer division. "On the fastest supercomputer available today, it would take well over a year to do the computations. With the new system, it could be done in 45 to 50 days."

"I think it's going to be an exciting machine. Exciting science is going to come out of it," said Tom Prince, an astronomer and astrophysicist at Caltech who hopes to use the computer to search for binary pulsars — collapsed, rapidly spinning stars.

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And increasingly, parallel supercomputers are becoming the computers of choice for scientists, who prefer them to the more conventional and expensive serial computers, which rely on single, powerful processors.

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Parallel supercomputers are effective tools in massive computations because of their ability to distribute pieces of calculations between each of the microprocessors that are arrayed.

The Delta System harnesses 528 microprocessors — far smaller than previous, "massively parallel" supercomputers which relied on as many as 64,000 microprocessors. Delta's greater speed comes from more powerful microprocessors and a unique, "mesh routing system," which rapidly relays operating instructions and data between each of the processors. In previous technologies, processors had to interrupt their work to pass messages.

The Delta System is "just the next point on the curve. It means there will be vast new kinds of problems that can be solved," said Stephen Squires, chief scientist of the federal Defense Advanced Research Projects Agency's Information Technology and Science Office.

Squires' agency, which was born in the shadow of Sputnik, acts as kind of a national watering can, nurturing private and academic research and development of high-performance computing with more than $100 million in grants a year. Seventy-five percent of that money is used to develop technology, with the rest earmarked for defense applications, he said.

The agency has given nearly $13 million to Thinking Machines with the hopes of a trillion-calculation-per-second computer, which Squires said he hopes to see by 1996. In the meantime, Intel's Delta System is an "intermediate result which is good enough for people to want to use it," he said.

The consortium includes scientists from Caltech, Purdue University, NASA, the federal Defense Research Advanced Projects Agency and the National Science Foundation, Argonne National Laboratory, Lawrence-Livermore National Laboratory, Pacific Northwest National Laboratory, Oak Ridge National Laboratory, Sandia National Laboratory and Los Alamos National Laboratory, the Jet Propulsion Laboratory at Caltech and Intel itself.

Supercomputer Means Not Just Cray Alone

To the Editor:

"Cray Computer in Livermore Pact" (Business Day, Dec. 11), reporting an order for a Cray 3 supercomputer, calls its theoretical top speed of 16 billion calculations a second "about eight times faster than today's most powerful supercomputers." This comparison is not even close to accurate. The delta system from Intel supercomputer division, announced last month at the Supercomputing '90 meeting in New York City and due for delivery to Caltech early in 1991, has a theoretical peak performance of 32 billion calculations a second, and there are several other announced systems that top the Cray 3's theoretical peak.

The category of supercomputer extends beyond systems manufactured by companies whose names include Cray, and includes systems that incorporate hundreds or even thousands of processors. It is now well recognized that such massively parallel systems, not the development branch represented by the Cray 3, represent the long-term future of supercomputing.

RICHARD H. HILL
Editor in Chief
Spang Robinson Report
on High Performance Computing
Eugene, Ore., Dec. 11, 1990

Dick Hill had called to have us check the letters to the editor in todays New York Times for a New Year's surprise... this is what we found.

highly parallel computing would probably continue to grow at something close to the current rate of speed. In short, not very fast.

If efficient software tools for highly parallel systems become commonplace, however, supercomputing could be transformed rapidly. The killer micros could really buzz, and the market would expand accordingly.
— *Norris Parker Smith*

New Consortium to Run Intel's Delta Superparallel System

Intel Corporation's supercomputer systems division and 13 other institutions have formed the Concurrent Supercomputer Consortium. Paul Messina, director of CalTech's Concurrent Supercomputing Facilities, will be executive director of the consortium.

Its principal objective is to run large-scale codes, described as scientific problems that could not be attempted without the power provided by a new Intel system. In doing so, consortium members will also explore software tools that could help make highly parallel computing more easily accessible.

The members will share use of an Intel Touchstone Delta System, a milestone in Intel's DARPA-supported program to advance toward Teraflop computing. The new machine will be installed next spring at CalTech.

An outgrowth of Intel's iPSC/860 model, the Delta will have 570 microprocessors — 528 Intel i860 numeric processors and 42 chips managing I/O. Memory size will be 8.8 Gbytes. The capacity of the communications system is to be 16 Gbytes per second.

The distinctive feature of the Delta will be the use of new communications chips developed at CalTech under the direction of Charles Seitz. In contrast to the hypercube architecture used by Intel so far, the Delta will use a mesh architecture.

Intel claims a peak performance of 32 GFLOPS. One experienced observer commented that use of the mesh-routing chips will improve actual throughput of the Delta by a factor of 10 in comparison with the iPSC/860.

You can't go to the neighborhood Econobyte store and buy a Delta. It is described as a limited-production model, which means that an additional machine or two may be built for test-bed purposes. The price paid by the consortium was not revealed. Justin Rattner, director of technology for Intel's supercomputer division, said that if it were on the commercial market, the price would be $15 to $20 million.

Rattner added, however, that one of the objectives of the Delta project and the Touchstone program is to lead to better products in the future.

The new consortium should increase the already active interchange among institutions actively investigating highly parallel systems. Its members already operate their own hives of killer micros.

Participating institutions (in addition to Intel) described as partners include Argonne National Laboratory, CalTech, the Jet Propulsion Laboratory at CalTech, the Center for Research in Parallel Computation, DARPA, NASA, National Science Foundation programs in science and engineering, and the Pacific Northwest Laboratory.

Institutions described as additional members are Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Purdue University and Sandia National Laboratories.
— *Norris Parker Smith*

Small Businesses Get Big Boost from Computing Consortium

Industrial research on supercomputers has so far mostly been a big- company game. But now, as part of an innovative state-funded program launched last spring, the University of Illinois National Center for Supercomputing Applications (NCSA) is taking the first steps to put supercomputing power in the hands of more small to mid-sized firms as well.

NCSA is working initially with a nonprofit group called the Effingham Computing Consortium. Organized by citizens and business leaders in rural Effingham, Ill., the consortium currently counts four Effingham companies among its membership. The firms pay an annual fee of $5,000 to $30,000 to belong to the consortium, depending on size. In turn, at no additional cost, they get access to NCSA training, services and supercomputer time applied to their specific business needs. It's a resource that most could have otherwise never afforded; NCSA's lowest level "industrial partnership" costs $250,000 per year.

Seed Grant

The Illinois program got off the ground last April with a $300,000 seed grant to NCSA from the Governor's Science Advisory Committee. Second-year funding at the same level was recently awarded, said James R. Bottum, NCSA deputy director, and the center is hoping for an extension that would provide additional monies to start a similar project with another group of small firms in Edwardsville, Ill. That effort would also tie in resources, faculty and students at Southern Illinois University, in Edwardsville.

In the Effingham project, initial work involves com-

Chemical Design Automation News

Volume 6 Number 1 January 1991

Concurrent Supercomputing Consortium Acquires Touchstone Delta System

This coming spring, the world's fastest supercomputer —a Touchstone Delta System—will be installed at the California Institute of Technology. Fourteen national research institutions, which have joined to form the Concurrent Supercomputing Consortium, will use the computer in work on their most demanding computational and scientific research projects. The Delta System is an advancement of Intel's iPSC/860 supercomputer, a limited production model, which features 528 numeric processors working simultaneously to provide a peak speed of 32 GFLOPS (32 billion floating point operations per second).

The Consortium members include: Argonne National Laboratory; California Institute of Technology; Caltech's Jet Propulsion Laboratory; The Center for Research in Parallel Computation (an NSF Science and Technology Center); Defense Advanced Research Projects Agency (DARPA); Intel Corp.'s Supercomputer Systems Division; NASA; NSF Programs in Computational Science and Engineering; Pacific Northwest Laboratory (PNL); Lawrence Livermore National Laboratory; Los Alamos National Laboratory; Oak Ridge National Laboratory; Purdue University; and Sandia National Laboratories. Researchers at other institutions will have access to the Touchstone Delta System by working through Consortium members. Paul Messina, Director of Caltech's Concurrent Supercomputing Facilities, has been named Executive Director of the Consortium. Operation of the Consortium will be managed by a Policy Board with representatives from each member; the first Chairman of the Policy Board will be Caltech astrophysicist Thomas A. Prince.

Among those who will use the system for CAMD-related efforts will be Thom Dunning, of PNL's Molecular Sciences Research Center (MSRC). One of MSRC's projects will be the modelling of the activity of a common enzyme with the potential to render contaminants harmless if genetically re-engineered. ■

PARALLEL COMPUTING NEWS

NORTHEAST PARALLEL ARCHITECTURES CENTER AT SYRACUSE UNIVERSITY

VOLUME 4 NUMBER 1
January / February 1991



Ken Kennedy and Geoffrey Fox discuss machine-independent programming.

Kennedy discusses Intel Touchstone project; collaboration with Fox

By Diane Purser

"A compiler should hide architectural details from the user," said Ken Kennedy, as he described the compilers he wants to develop for the Intel Touchstone multicomputer. Kennedy, Scientific Director of the Center for Research on Parallel Computation (CRPC), visited Syracuse University in December. Invited by the Computer and Information Science Department and NPAC, he discussed the CRPC's part in the Intel Touchstone multicomputer project.

The Intel Touchstone will be a distributed-memory multicomputer containing over a thousand Intel i860 central processors. Configured with this many powerful processors, it will be one of the fastest computing systems ever created.

"The goal of the Intel Touchstone project," he said, "is to come up with a vehicle that will support a wide variety of important computational problems." Kennedy feels this goal will be obtained by addressing two challenges—developing compilers that improve performance, and

Continued P. 3

making message passing between processors efficient enough to accommodate distributed-memory programming.

Focusing on the first of these two challenges, Kennedy and the CRPC are working on a new compiler for the i860 that combines several high-level and low-level techniques to generate very efficient code. These include techniques in floating-point register allocation and cache management, among others. Kennedy said that in some cases these techniques lead to codes that run over twenty times faster than those generated by other compilers. They are also developing a compiler that translates a sequential FORTRAN program, augmented with data-distribution specifications for multicomputer processors, into a message-passing program. This program is capable of a high degree of efficiency on a multicomputer. In this system, the parallelism is derived from a method of data distribution in which any value assigned to a datum is computed on the owner of that datum. FORTRAN with message passing accommodates distributed-memory programming, and produces a parallel program with the speed to run scientific applications.

Kennedy also discussed the issue of machine-independent programming. "Because of parallelism, we need to develop new methods of accomplishing this type of programming," he said. Parallel programming has lost much of the ease and portability of coding for a serial computer, because often programmers must introduce architecture-specific dependencies when writing parallel codes. Kennedy wants programmers to enjoy the same programming ease when writing parallel codes, without having to worry about the number of processors or communication on each different kind of computer. He feels this should be the compiler's job, which is why he places a strong emphasis on compiler technology.

He and NPAC director Geoffrey Fox are now exploring methods of expressing FORTRAN programs that can be compiled into efficient object codes on a variety of

Continued P. 12

"We are looking at various languages that can support machine-independent programming..."

parallel machines. In what Kennedy refers to as "the triangular plan," they are investigating methods that first convert FORTRAN 77, augmented with multicomputer processor data-distribution specifications, to FORTRAN 90. Second, these FORTRAN 90 programs are converted to FORTRAN 77 with message-passing primitives, which can be run on distributed-memory architectures. If the first translation produces efficient FORTRAN 90 programs, it will establish the extended version of FORTRAN 77, which Kennedy calls FORTRAN D (for distribution), as a good vehicle for machine-independent programming. If the second translation works well, FORTRAN 90 will be established as such a vehicle.

"We are looking at various languages that can support machine-independent programming, as well as various compiler techniques," said Kennedy. "Most people dislike programming with message passing—it's nice to have an interface that can hide these details."

As part of this project, he and Fox hope to complete a system of scientific benchmarks to evaluate compiler techniques and different versions of FORTRAN, and to find the best hypercube FORTRAN. Efficient performance is of primary importance, and their standards are very high. They use an optimal code to compare the code generated by Kennedy's compiler. "Anything off by more than a factor of two," said Kennedy, "is considered a defeat."

Dr. Kennedy completed his PhD in Computer Science from New York University in 1971. In addition to his responsibilities as Scientific Director of the CRPC, Kennedy currently holds a Noah Harding professorship in the Department of Computer Science at Rice University. Elected to the National Academy of Engineering in 1990, he is Director of the Computer and Information Technology Institute.

Announcing the *Fastest* Computer in the World

What if bio-medical researchers could simulate the reaction of the body to a new drug? What if scientists could show exactly what the ozone layer would be like in a hundred years, or could map the human genetic structure to better understand inherited diseases?

Intel has announced a new supercomputer which will enable researchers to create more accurate models for all these problems and much more. Intel's Touchstone Delta System, to be installed next spring at the California Institute of Technology (Caltech), will be the fastest, most powerful computer in the world.

Lilliputians toppling the giant

The new system's power comes from 528 i860™ microprocessors and 42 386™ microprocessors working simultaneously to provide a peak speed of 32 gigaFLOPS — 32 billion floating-point operations per second. "Just as drops of water combine to turn a mill, these desktop-level processors add up to incredible power when they work together," says Mike Bernhardt, Marketing Communications manager for the Supercomputer Systems Division.

Until recently, parallel processing was considered the underdog technology for supercomputers. Now, with improvements both in processor connectivity and in software, consensus is growing that conventional supercomputers may be obsolete by the middle of the decade, according to a recent *New York Times* article. Every leading supercomputer maker in the U.S. is now exploring parallel processing alternatives for future designs. Intel is poised to tap the growth: the Supercomputer Systems Division has already shipped more parallel supercomputers than any other company in the world.

Science goes high-tech

As the most advanced of the parallel supercomputers, the new Delta System will allow researchers to tackle the most demanding computational and scientific problems facing the world today. The Concurrent Supercomputing Consortium, consisting of Caltech and 13 other leading U.S. research institutions, has been formed to take advantage of the Delta System's power. The consortium includes such prominent institutions as Argonne National Laboratory, the Defense Advanced Research Projects Agency (DARPA) and NASA.

"Frankly, we can't wait to get our hands on it," says Paul Messina, director of Caltech's Concurrent Supercomputing facilities and executive director of the new consortium.

In the past, Messina explains, no machine had enough memory to handle all the data required for simulations such as global climate modeling. "We'd have to represent the entire climate of the state of Oregon with one data point," he says. "Such a model would be grossly oversimplified, and so the results couldn't be considered statistically accurate or reliable."

The Delta System, by comparison, has enough power to allow for ten or twenty data points for an area of geography the size of Oregon. "With that level of detail, we're starting to mirror reality; we can get some real answers about the impact of deforestation, the depletion of the ozone layer — all kinds of situations."

The scale of the computation involved is huge: even with the Delta System's awesome processing power, it will take the machine up to two weeks of solid computing time to provide a simulation of Earth's climatic changes over the next 100 years.

Answering the big questions

Global climate modeling is the most popular application for the new system, with seven of the 14 research institutions planning projects in that area. The Delta System should also shed light on some other very practical problems:

* Purdue University plans to use the machine for modeling cold and flu viruses, to better understand how they work and how they might be cured.

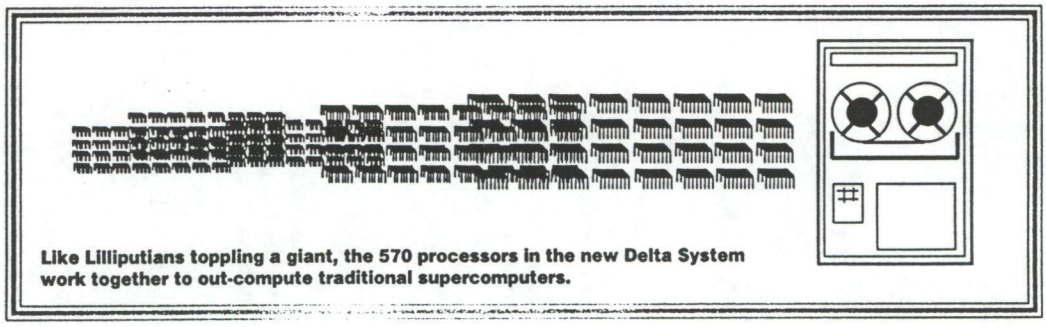
* NASA will test computer designs of a new, super-high-speed, shuttle-replacing spacecraft. "No wind tunnel can operate at 25 times the speed of sound, so the aerodynamics of the new design can only be tested by computer," Messina notes.

* Pacific Northwest Labs will model the molecular processes of natural and contaminated systems to better understand the behavior of nuclear contaminants in the environment.

Parallelism is here to stay

While looking forward to the results of such efforts, Messina does not expect miracles. "As always with science, it's impossible to predict whether we'll get any significant breakthroughs from these experiments. But we will get some insights we couldn't otherwise get.

"And just as important, we'll be demonstrating the viability of parallel computing. I expect that the Delta System will help convince the world that parallel processing as a practical technology is here to stay." ■



Like Lilliputians toppling a giant, the 570 processors in the new Delta System work together to out-compute traditional supercomputers.

JOURNAL OF BUSINESS
12-19-90

Richland lab to use world's fastest computer

Machine could solve 32 billion problems a second

Battelle's Pacific Northwest Laboratory in Richland, expects to be using the world's fastest computer next year to study radioactive waste at Hanford and atmospheric pollutants in the Northern Hemisphere.

The lab is a member of the Concurrent Computing Consortium, which owns the computer, says Kathryn Lang, a public relations specialist at the lab.

The computer will be housed at the California Institute of Technology, in Pasadena, Calif., a consortium member, and is to be operable by fall, Lang says.

Called the Intel Touchstone Delta, the computer is made by Intel Corp.'s supercomputer division in Beaverton, Ore., and will be able to run 528 computations simultaneously. At peak speed, those computations will be performed at a speed of 32 "gigaFLOPS"— 32 billion additions, subtractions, multiplications, or divisions a second, Lang says. This is the world's fastest computer, she claims.

The lab is now using a Cray "supercomputer", which can perform only 473 million such functions a second, Lang says.

The Intel is so speedy because it harnesses the power of 528 processors and puts them to work at once, Lang says. A processor is essentially the brains of a computer.

The lab will share time on the computer with other consortium members, including NASA, the Argonne National Laboratory, and the National Science Foundation.

The Richland lab is operated by Battelle Memorial Institute, of Columbus, Ohio, under contract with the U.S. Department of Energy.

Scientists at the Pacific Northwest Laboratory will be linked to the Intel computer by a special phone line and will be able to operate the computer from Richland, Lang says.

The Richland lab will use its allotted computer time to:

- Analyze the physical behavior of radioactive wastes stored in tanks on the Department of Energy's Hanford site and study the effects of remedial action.
- Improve computer models that study the concentration and movement in the Northern Hemisphere of air pollutants, such as those that contribute to acid rain and global warming.
- Study "in situ vitrification," which involves melting contaminated soil into glass and trapping contaminants in the glassified soil. The contaminants could include low-level radioactive material. ❑

The lab will use the computer to analyze the physical behavior of radioactive wastes stored in tanks at Hanford.

COMPUTERWORLD
12-10-90

Tackling systems tasks in tandem

Processors in hybrid computers use cooperative approach to boost performance

BY GARY H. ANTHES
CW STAFF

High-performance computers of the year 2000 are likely to be built from specialized modules employing different architectures, each module performing a task — such as image or speech processing, sorting or encryption — for which it has been explicitly designed. Manufacturers are now beginning to combine specialized engines for better overall system performance, and experts said the trend will accelerate as companies look for ways to distinguish their products in an increasingly standardized world.

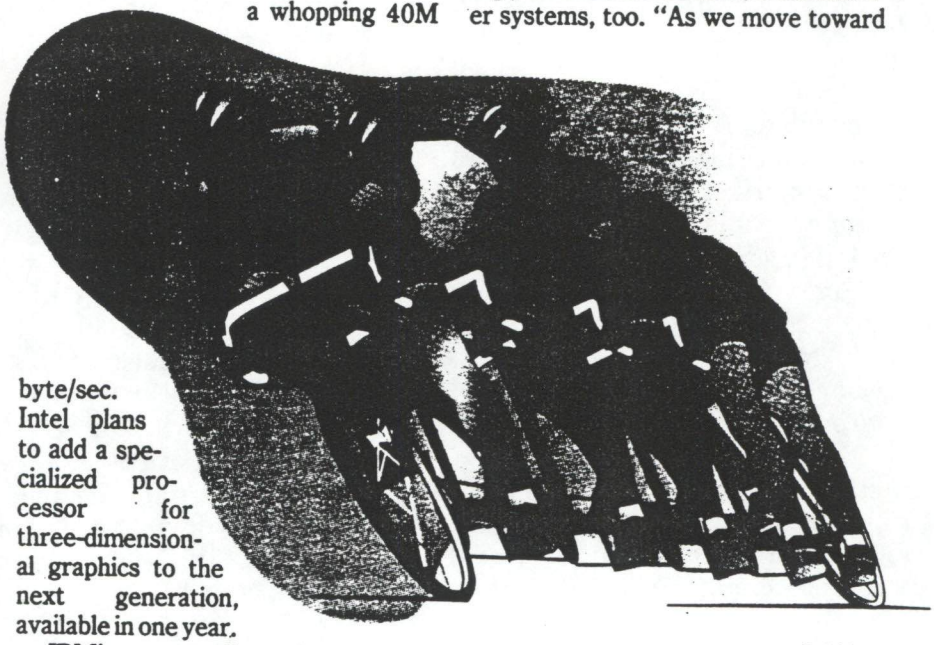
Companies have traditionally made their machines more powerful by building faster processors. But as the laws of physics threatened to flatten soaring performance curves, it became a matter of faith that the fastest computers would need multiple processors.

Mainstream companies such as IBM embraced the concept of parallel processing in a limited way, while a few bold companies — often with help from Uncle Sam — went whole-hog with systems having thousands of processors.

While the limits of neither approach are in sight, computer designers are increasingly trying out a third, complementary tack in which heterogeneous systems — computers or groups of computers — employ multiple specialized components, each doing what it does best.

Super specialized

Last month, the supercomputer unit of Intel Corp. announced the planned delivery of a new generation of its Touchstone computer, an ultra-fast — peak speed is claimed to be 32 billion operations per second — machine with 528 Intel I860 processors. But Touchstone also uses 42 Intel 80386 processors for I/O and special routers that pass messages between processors at a whopping 40M byte/sec.



Paul Mock

Intel plans to add a specialized processor for three-dimensional graphics to the next generation, available in one year.

IBM's recent rollout of the new System/390 included a $125,000 optional processor specially designed to do the number crunching demanded by data encryption algorithms. Michael Monachino, director of IBM's Mid-Hudson Valley Development Laboratory, said a European bank with the add-on has been able to extend total machine performance by 46% while running programs requiring encryption or decryption.

James Key, assistant director at the University of Maryland's Engineering Research Center, said future supercomputers will have basic architectures with hooks for field additions of modules for graphics, animation, speech input and output, image and data compression and encryption. Some of these will work in parallel with the CPU, and some will act as front or back ends.

Key said the approach will increasingly be used in mainframes and smaller systems, too. "As we move toward standardization, how do you add value? You drop in specialized, application-specific modules." Key said manufacturers will be reluctant to incur the enormous expense of developing new architectures if product differentiation can be achieved some other way.

Key said demand will blossom for image processing in areas such as medical, seismic and satellite photography applications. And users will increasingly want their images animated — something that takes enormous processing power. Even relatively mundane applications such as processing digitized credit-card receipts could benefit from specialized modules, he said.

ARGONNE Week

Monday, Dec. 10, 1990

Lab joins supercomputer consortium

ANL helps buy world's fastest computer

Argonne has entered a consortium to purchase the world's fastest supercomputer, capable of performing billions of operations per second.

Argonne researchers will use the Intel Touchstone Delta supercomputer to tackle complex problems in climate modeling, hazardous waste transport and computational science.

The Delta has 528 interconnected, high-speed microprocessors which work together to solve problems through a new "mesh interconnect" scheme. The computer is capable of performing 32 billion floating-point operations per second (Gflops).

"For a few years at least, this will be the fastest computer on the planet," said Ewing Lusk (MCS), scientific director of Argonne's Advanced Computing Research Facility (ACRF).

A smaller Touchstone Gamma computer will be housed at the ACRF. It will serve as a "staging platform" for the Touchstone Delta, giving Argonne users a chance to test codes and familiarize themselves with the special features of the supercomputer's architecture.

"For a few years at least, this will be the fastest computer on the planet."

—Ewing Lusk (MCS)

The Delta will be located at the California Institute of Technology and will be accessed through Argonne's ESnet computer network node, which will be upgraded to handle the additional data flow. Argonne users will be able to work with the Delta supercomputer as though it were in the next room, Lusk said.

Other members of the Concurrent Supercomputing Consortium include Caltech's Jet Propulsion Laboratory, the Defense Advanced Research Projects Agency, the Center for Research in Parallel Computation, the National Aeronautics and Space Administration, the National Science Foundation and Pacific Northwest Laboratory.

The Delta computer will be delivered in April and should be available to users by summer.

New supercomputer acquired by consortium that includes Jet Propulsion Labs

A new highly parallel supercomputer capable of solving problems at extremely high speeds is being acquired by a consortium involving the California Institute of Technology, the Jet Propulsion Laboratorty, NASA and a number of other organizations, it has been announced.

Complex problems in space sciences and global atmospheric modeling related to the greenhouse effect and ozone depletion will be among topics assigned to the supercomputer, according to Dr. Carl Kukkonen of JPL.

The speed and memory of the supercomputer — a Touchstone Delta System made by the Intel Corp. — will make it the world's most powerful computer when it is installed early next year, consortium organizers say.

The Delta uses a network of 528 Intel i860 processor units working concurrently on a problem at a given time. As a result it can achieve a peak speed of 32 gigaflops, or billions of floating-point operations per second. Its memory capacity is 8 gigabytes.

The Delta is 2 to 20 times faster than other existing supercomputers, said Kukkonen.

The Delta System is the result of research collaboration between Caltech and Intel. Work in parallel processing has been pursued at Caltech and JPL throughout the past six years.

JPL researchers will use the supercomputer to explore a wide range of Earth and space science topics under NASA's High Performance Computing Initiative. In addition to atmospheric studies, initial problems to be run on the Delta include solar and astrophysical modeling.

Another major application will be visualization of scientific data from the planets Venus and Jupiter gathered by the NASA/JPL Magellan and Galileo missions, Kukkonen said.

JPL will also use the Delta to design future solar system exploration spacecraft and remote-sensing instruments, and to develop command sequences to control spacecraft.

NASA researchers in other parts of the country are expected to use the Delta in areas such as computer simulation of aerospace vehicles.

Joining Caltech and JPL among the consotrium's partners will be Argonne National Laboratory; the Center for Research in Parallel Computation, operated by several institutions under National Science Foundation sponsorship; various other National Science Foundation-sponsored programs; the federal Defense Advanced Research Projects Agency (DARPA); Intel Corp.'s Supercomputer Systems Division; NASA; and Pacific Northwest Laboratory.

Other consortium members include Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Purdue University and Sandia National Laboratories.

The Delta will be physically located at Caltech's Concurrent Supercomputing Facilities in Pasadena, Calif. ◊

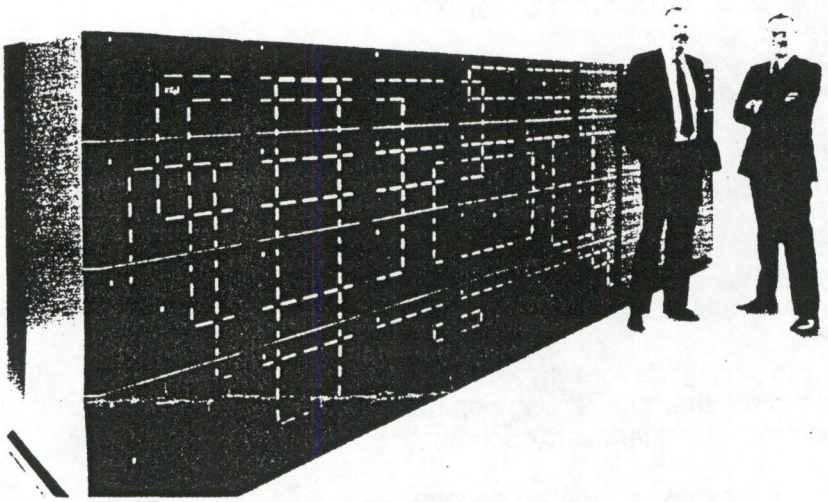
CHEMICAL AND ENGINEERING NEWS
December 10, 1990

Consortium forms to use "fastest" supercomputer

A supercomputer to be installed next spring at California Institute of Technology, which is being called "the world's fastest computer," will form the basis for a new consortium of research institutions, the Concurrent Supercomputing Consortium. Many of the applications anticipated for the supercomputer are chemistry-related.

The consortium, composed of 14 member institutions, is acquiring the Touchstone Delta system, a parallel supercomputer made by Intel Corp. The system has 528 numeric processors that work in parallel to provide a peak computational speed of 32 gigaFLOPS (32 billion floating-point operations per second). In comparison, a Cray Y-MP supercomputer is rated at 2.7 gigaFLOPS, and a four-processor NEC SX-3 currently in development claims a peak rate of 22 gigaFLOPS.

The members of the consortium are Argonne National Laboratory, Battelle Pacific Northwest Laboratories, Caltech, Caltech's Jet Propulsion Laboratory, the Center for Research in Parallel Computation (a National Science Foundation Science & Technology Center), the Defense Advanced Research Projects Agency, Intel, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, the National Aeronautics & Space Administration, the National Science Foundation (programs in computational science and engineering), Oak Ridge National Laboratory, Purdue University, and Sandia National Laboratories. Researchers from nonmember institutions can gain access to the supercomputer by working through consortium members.



Intel officials with company's Touchstone Delta supercomputer

Problems that members of the consortium are planning to study on the Caltech supercomputer include several that are chemistry-related. Among them:

- Calculating the rates of chemical reactions using ab-initio quantum chemistry techniques.
- Pattern recognition of DNA sequences within the human genome.
- "Engineering" enzymes for enhanced biodegradation.
- Modeling of molecular processes in natural and contaminated systems to better understand the behavior of contaminants in the environment.
- Modeling and simulations of global climate change.

For example, Battelle's molecular science research center will use the computer to help modify an enzyme for enhanced biodegradation. According to Battelle associate director Thom Dunning, "It takes our current supercomputer one hour to model one trillionth of one second of the enzyme's activity. While we still won't be able to model the whole process with the massively parallel computer, we can get a more accurate picture of what is happening more quickly."

Stu Borman

THE BUSINESS JOURNAL
December 9, 1990

Intel works on another supercomputer

Lost amid last month's headlines of Intel Scientific Computer's creation of the world's fastest parallel supercomputer for a consortium of colleges and research laboratories was the fact that Intel is working on an even faster and more powerful version of the same computer for commercial release in 1992.

Intel Scientific, based in Beaverton, revealed in November that it is building the Delta version of the company's Touchstone supercomputer for the California Institute of Technology. The machine is a vastly more powerful version of its current commercial machine, the iPSC/860 supercomputer.

The Delta system, scheduled for delivery next spring, will offer the power of 500 processing nodes, as opposed to 128 in the iPSC/860, said Justin Rattner, director of technology for Intel's supercomputer systems division.

Intel claims the Delta is the fastest parallel architecture supercomputer in existence and could sell on the open market for $15 million to $20 million. Yet it has no plans to commercially market the machine. Instead, it is holding out for the Sigma version of the technology, which won't be available for another 12 to 16 months, Rattner said.

The company is willing to wait for two reasons: First, Intel Scientific feels its current commercial machine—the iPSC/860—has considerable shelf life remaining. The machine has been in full commercial production only six months, Rattner said. Second, the Sigma machine will be so powerful, the company is confident it will not be surpassed by a rival computer maker in the interim.

Intel touts the Delta machine as the fastest in the world, capable of 32 gigaflops (millions of floating point operations per second.) By comparison, the Sigma version will operate at an estimated 150 gigaflops, Rattner said.

Both the Delta and Sigma machines are part of the ambitious Touchstone project, which Intel launched in 1989 with partial funding from the U.S. Defense Department.

SPACE NEWS
December 9, 1990

NASA Joins Consortium For Supercomputer Time

NASA researchers will have access to the world's fastest supercomputer in mid-1991, as part of the newly formed Concurrent Supercomputing Consortium based at the California Institute of Technology (Caltech), Pasadena.

The consortium plans to acquire a Touchstone Delta System supercomputer from Intel Corp.'s Supercomputer Systems Division, Beaverton, Ore. The Delta system will be capable of 32 billion calculations per second, making it two to ten times faster than any other supercomputer presently planned.

Researchers from NASA field centers and the Jet Propulsion Laboratory, Pasadena, will use the supercomputer to model complex problems in atmospheric science and to create visual images of scientific data returned from the Magellan Venus radar mapper and the Galileo Jupiter probe. Other potential space agency uses include simulations of remote-sensing instruments and models of spacecraft command and control algorithms.

NEW TECHNOLOGY WEEK
12-3-90

Supercomputer Consortium Attracts DOE Lab

BY DENNIS WAMSTED

Seeking to boost its environmental research and development capability, the U.S. Department of Energy's Pacific Northwest Laboratory has purchased a piece of the world's fastest supercomputer. The lab, which is run by Battelle for DOE, contributed $1 million to join a 14-member consortium that bought the unit, which has a market value of $15 million to $20 million. PNL will also pay $100,000-$150,000 a year to maintain the machine, which will be installed at the California Institute of Technology in Pasadena.

The supercomputer, an Intel Touchstone Delta, will be delivered to the Caltech campus next spring. The system, an advancement of Intel's iPSC/860 model, is a limited production model that is being built by Intel's Supercomputer Division. The new model will be both faster and have more memory than current state-of-the-art systems, according to Paul Messina, the director of concurrent supercomputing facilities at Caltech.

Specifically, the system will have a theoretical peak speed of 32 gigaFLOPS—32 billion floating point operations per second. This is more than 10 times faster than the theoretical peak speed of the Cray YNP, another leading supercomputer, Messina continued. The new system's speed stems from the fact that 528 numeric processors will be working simultaneously. By contrast, the Cray YNP has eight processors. The Intel unit will also have "considerably larger memories," added Messina.

PNL researchers intend to put the system's speed and memory to full use testing a number of promising environmental cleanup techniques and developing more advanced atmospheric models for use in drafting policies to cope with global climate change. "We intend to harness the potential power of parallel processing to solve real problems, not just interesting 'ivory tower' investigations," said Bob Mahan, PNL's manager of advanced technology planning. "With the new computer, we can model complex environmental processes about 15 times faster than with our present supercomputer."

PNL researchers will use part of their time on the new supercomputer to model the activity of a common enzyme that, if genetically re-engineered, has the potential to decontaminate a number of pollutants, said Thom Dunning, associate director of the lab's Molecular Science Research Center. Currently, PNL must devote one hour of time on its supercomputer "to model one-trillionth of one second of the enzyme's activity," Dunning added. "While we still won't be able to model the whole process with the massively parallel computer, we can get a more accurate picture of what is happening more quickly."

Similarly, PNL researchers will use the new supercomputer to boost their understanding of the *in situ* vitrification process, an innovative technology that uses electricity to melt contaminated soil into a glass-like substance. PNL's current models show how the process works, but only on a limited scale. By contrast, the new computer will enable PNL to model the process more accurately, said Don Trent, a chief scientist at PNL and the developer of the current model.

"Modeling gives us a way to predict what happens in the soil during the vitrification process," Trent added. "Knowing that, we can improve vitrification equipment design and safety."

The new supercomputer should also help PNL researchers improve their understanding of the movement and concentration of pollutants in the atmosphere, which will be of particular use in answering some of the many questions surrounding the debate over global climate change. "We want to expand and refine the model that tracks the atmospheric movement of chemicals that play an important role in global warming and acid rain," said Deborah Luecken, an atmospheric scientist at PNL. For example, current models include far too few data points and only analyze a few significant shambles.

"Policymakers want accurate information before they make choices about pollution control measures," added Luecken. "With these new capabilities, we plan to give them more accurate information on many more chemicals."

American Association for the Advancement of Science

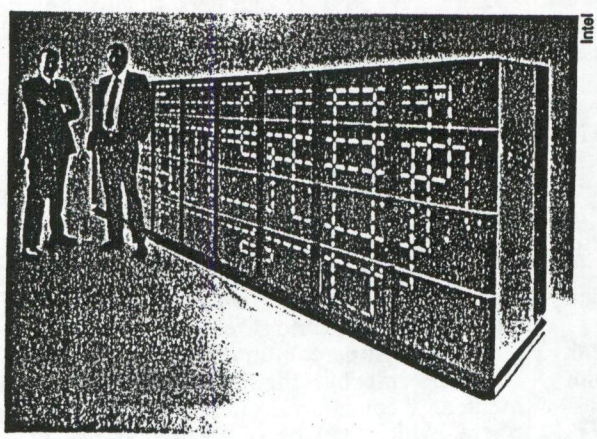
SCIENCE

Date: 11-30-90
Page: 1203

World's Fastest Computer

No longer content to limp along at only one to two billion calculations per second—the typical speed of today's fastest supercomputers—researchers from 14 institutions have formed a consortium to build the fastest and most powerful computational engine on the planet: a machine that should do 5 to 15 billion calculations per second on the average and 32 billion per second on the straightaway.

The new machine is called Touchstone Delta, and is being built by the Intel Corporation based on an existing supercomputer design. It will achieve its power in two ways: by harnessing 528 individual processors to work in parallel, and by incorporating "mesh-routing" chips developed at Caltech to help the processors communicate with one another. If all goes as planned, it should be up and running at Intel by January 1991. It will be installed at Caltech by the following April, ready to tackle such problems as better modeling of global climate change, processing data from the Magellan and Galileo spacecraft, recognizing DNA patterns within the human genome, and searching for radio signals from binary pulsars.



Headquartered at Caltech, the consortium includes Intel, NASA, NSF, DARPA, and most of the Energy Department's national laboratories. "We didn't set out to create a consortium," says Caltech's Paul Messina, who will be the group's executive director. But the technology was ready, and all these institutions had researchers aching to attack computational problems on a massive scale. "So we said, 'Let's go,'" says Messina.

Super supercomputer. *Robert Rockwell (left) and Justin Rattner of Intel stand next to mockup .*

THE ENERGY DAILY
11-30-90

DOE Lab Buys Part Of The World's Fastest Computer For Environmental R&D

Seeking to boost its environmental research and development capability, the U.S. Department of Energy's Pacific Northwest Laboratory has purchased a piece of the world's fastest supercomputer. The lab, which is run by Battelle for DOE, contributed $1 million to join a 14-member consortium that bought the unit, which has a market value of $15 million to $20 million. PNL will also pay $100,000-$150,000 a year to maintain the machine, which will be installed at the California Institute of Technology in Pasadena.

BY DENNIS WAMSTED

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GOVERNMENT COMPUTER NEWS

NOVEMBER 26, 1990
VOLUME 9 NUMBER 25

THE NATIONAL NEWSPAPER OF GOVERNMENT COMPUTING

Supercomputer Users Hail Intel Corp.'s Delta System

BY DARRYL K. TAFT
GCN Staff

NEW YORK — The nation's foremost supercomputer-using organizations are rallying around a supercomputer technology developed by Intel Corp. with federal government support.

Intel announced that 14 prominent research institutions have united to form the Concurrent Supercomputing Consortium. Intel officials also said the consortium is acquiring the Touchstone Delta System, an Intel supercomputer that company officials claim is faster and more powerful than any existing computer.

Intel officials would not disclose how much the consortium is paying for the system. They made the announcement at the Supercomputing '90 conference here this month.

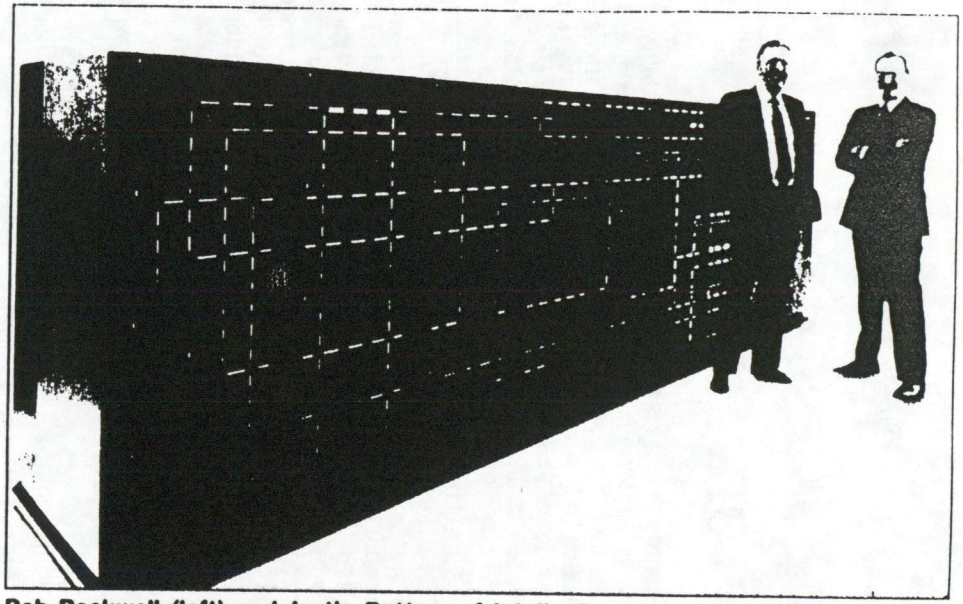
Intel's Supercomputer Systems Division in Beaverton, Ore., developed the Delta System with some government support. The Defense Advanced Research Projects Agency (DARPA) provided initial funding for the project.

The Delta System is an enhanced version of Intel's iPSC/860 supercomputer. The system, which Intel calls a limited production model, will use 528 numeric processors working simultaneously to produce a peak performance level of 32 billion floating point operations per second. The system starts at $15 million.

Gil Weigand, the program manager for DARPA's Touchstone project, which funded the Delta development, said: "DARPA has led the technology development in the area of concurrent computer systems for many years. We are gratified to see DARPA's support produce such monumental results."

Delta will extend computational capabilities in areas important to the Defense Department, Weigand said. "Quite frankly, as a consortium member, we are very eager to get our hands on it," he said.

Besides DARPA, consortium members include NASA, the



Bob Rockwell (left) and Justin Rattner of Intel's Supercomputer Systems Division show off the Touchstone Delta System.

SAN FRANCISCO CHRONICLE
11-26-90

Technology at Hand for New Generation of Supercomputers

By John Markoff
New York Times

New York

The long-running debate about how best to make computers thousands of times more powerful than they are today appears [redacted] ending in a stunning consen-

The nation's leading computer designers have agreed that a technology considered to be the underdog as recently as two years ago has the most potential for the next generation of the world's fastest computers, called supercomputers.

The winning technology is known as massively parallel processing, and it involves hundreds or thousands of independent processors — silicon chips that perform calculations — teaming up as one computer to solve problems far too imposing for even the most powerful computers today.

Until now, the leading supercomputer makers — including Cray Research Inc., Convex Computer Corp. and IBM — have built machines that link only two to eight processors.

Among the problems the new technology could address are simulating the reaction of the body to a new drug without the need for human subjects; mapping the human genetic structure to better understand inherited diseases; generating models of the world's climates to study changes induced by air pollutants, and recognizing spoken languages and images in order to improve the versatility of factory robots.

Clear Signals

A conference in New York earlier this month, sponsored by the Institute for Electrical and Electronic Engineers, provided clear signals of how much things have changed.

"We've moved from an era in which massively parallel computers were thought of as toys to one where they've become something that a scientist is willing to bet his career on," said Larry Smarr, an astrophysicist who directs the National Center for Supercomputer Applications in Champaign, Ill.

For example, leading computer designers at Cray and Convex said last week that their companies are embarking on designs for massively parallel computers.

And Intel Corp. announced at the conference that a consortium of 14 U.S. laboratories is buying a custom-made massively parallel computer the company has based around 512 of its most powerful microprocessors.

Yet another indication of the consensus came when W. Daniel Hillis, an advocate of massively parallel computing, asserted in the keynote address to an audience of almost 1,000 researchers that conventional supercomputers would be obsolete by the middle of the decade.

No one disputed his claim. At past conferences, he had faced loud dissent.

'The world is moving to massively parallel computers more quickly than I would have thought even recently,' said a researcher

Conventional supercomputers line up billions of calculations, then use one or several extremely complex and expensive processors to race through them.

By contrast, massively parallel computers divide a computing problem among many simple, inexpensive processors.

Like Lilliputians, these processors, each with the same amount of power as today's personal computer, can in theory work together as an army with enough power to overwhelm a Gulliver, like the Cray Y/MP supercomputer.

But until recently, it was thought that software to coordinate the work of so many separate processors was either still many years in the future or not possible.

As a result, many computer designers stood by the competing technology as the most realistic alternative.

They argued that the chaos resulting from inadequate attempts to harness many processors would offset any significant gains from the many extra chips.

Programming Advances

But advances in programming techniques have convinced many skeptics that problems that were until now solvable only by single-processor supercomputers, known as vector processors, can be attacked at much faster speeds by massively parallel machines.

"The world is moving to massively parallel computers more quickly than I would have thought even recently," said George Lindamood, a researcher at the Gartner Group who follows the industry producing the highest-performance computers.

The victory for parallel processing has implications not only for the computing industry but for U.S. competitiveness.

In the industry, Cray and Convex are finding themselves behind companies that moved quickly toward parallel designs in recent years and that are now selling such products.

Among those companies are Hillis' company, Thinking Machines Corp., of Cambridge, Mass.; NCube, of Beaverton, Ore.; the scientific-computer division of Intel, also in Beaverton; Maspar Computer Corp., of Sunnyvale, Calif.; Teradata, of Los Angeles; and Supercomputer Systems Inc., a start-up company run by Steve Chen, a former Cray designer, and financed partly by IBM.

Japan's Machines

The largest Japanese computer makers have been slow to adapt to parallel technology and are still building vector machines that imitate those of Cray and Convex.

The shift to massively parallel designs appears to consolidate the U.S. lead in supercomputer technology.

Analysts give U.S. companies a lead of 18 months to two years.

But the Japanese government, recognizing the importance of parallel computing, is organizing a larger research effort to catch up.

THE MODESTO BEE
November 25, 1990

Super status for Cal Tech

Los Angeles Times

PASADENA — The world's fastest and most powerful computer will be installed at the California Institute of Technology in the spring to aid in researching such complex scientific issues as changes in the planet's environment and climate.

The supercomputer, capable of 32 billion operations per second, will be the cornerstone of a cooperative program involving 14 research institutions, called the Concurrent Supercomputing Consortium.

Known as the Delta System, the powerful computer is being built by Intel Corp. as part of a research collaboration between the company and Cal Tech. The system employs many high-speed microprocessors, tied together in a communications network, according to an announcement on the opening day of Supercomputing '90 in New York City.

"I am delighted that the most powerful computer in the world will be housed at Cal Tech," said Thomas E. Everhart, president of Cal Tech.

The supercomputer will be used for a wide range of projects, including the study of the depletion of the ozone layer.

NOV 2 5 1990

HUNTINGTON
HERALD PRESS

Purdue in consortium tackling supercomputing

NEW YORK (UPI) — Purdue University researchers will gain access to the world's fastest, most powerful supercomputer to study and develop new techniques for computing.

Purdue is one of 14 research institutions to join together to form a supercomputing consortium aimed at designing and developing computing techniques for the future. Announcement of the consortium was made recently in New York City in conjunction with the opening of a supercomputing conference.

Members of the Concurrent Supercomputing Consortium will use a new type of supercomputer that employs a technique called parallel computing to handle massive computational problems.

The system is made up of a large number of individual processors that are capable of operating simultaneously — or in parallel — to carry out more than one operation at one time.

"Parallel supercomputing is now moving from the research phase to practical applications," said John Rice, head of Purdue's Department of Computer Sciences. "By the year 2000, all our engineers and scientists will use parallel machines, and membership in this consortium will keep Purdue at the forefront of supercomputing.

Intel Delta System to Caltech

Fourteen of the nation's most prominent research institutions have joined to form the Concurrent Supercomputing Consortium. Through these institutions, researchers will focus their energy, talent, and resources to address some of the most demanding computational and scientific challenges facing the world today.

To support these researchers, the Concurrent Supercomputing Consortium is acquiring the Touchstone Delta System from the Supercomputer Systems Division of Intel Corporation. The Delta System, which is an advancement of Intel's iPSC/860 supercomputer, is a limited production model, capable of handling massive computational problems. This power comes from 528 numeric processors working simultaneously to provide a peak speed of 32 GFLOPS.

The Delta System is the result of research collaboration between Caltech and Intel that dates from the 1984 founding of Intel's Supercomputer Systems Division. In an example of effective technology transfer, Intel quickly incorporated the results of pioneering Caltech research in multicomputer design and programming into prototypes and products. Both the basic research at Caltech and the accelerated development of prototype systems at Intel are funded by DARPA, the Defense Advanced Research Projects Agency.

According to Gil Weigand, the DARPA program manager responsible for Touchstone, "DARPA has led the technology development in the area of concurrent computer systems for many years. We are gratified to see DARPA's support produce such monumental results. Delta is going to significantly extend computational capabilities in a number of areas important to the Department of Defense; quite frankly, as a consortium member, we are very eager to get our hands on it."

Through the Concurrent Supercomputing Consortium, researchers from the geographically scattered member institutions will have access to the Delta system, which will be physically located in Caltech's Concurrent Supercomputing Facilities, in Pasadena.

The consortium's partners will be Argonne National Laboratory, California Institute of Technology, Caltech's Jet Propulsion Laboratory, the Center for Research in Parallel Computation, DARPA, Intel's Supercomputer Systems Division, NASA, NSF programs in computational science and engineering, and Pacific Northwest Laboratory. Additional members of the consortium will include: Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Purdue University, and Sandia National Laboratories. Researchers at other institutions will have access to the Touchstone Delta System by working through consortium members.

Paul Messina, director of Caltech's Concurrent Supercomputing Facilities, has been named executive director of the newly formed consortium. According to Messina, "The types of computational problems being tackled by the consortium members led us to a unanimous decision. We needed more computing power than anyone has ever harnessed. It will be quite challenging and exciting to work with the members of the consortium to make the most efficient use of this special machine. The Touchstone Delta is allowing researchers to conceive of projects so large that they will take many hours of dedicated processing time, even with the machine's enormous speed. It is particularly gratifying that the government agencies that have supported concurrent computing research over the years -- the Defense Advanced Research Projects Agency, the Department of Energy's Applied Mathematical Sciences program, the National Aeronautics and Space

Administration, and the National Science Foundation -- are all involved in supporting the consortium."

Members of the consortium will use the Delta System for various large-scale computations, including: modeling and simulations of global climate change, which will help develop a better understanding of the impact of environmental issues such as acid rain, increasing CO_2 concentrations, deforestation, and ozone-layer depletion; calculating the rates of chemical reactions from the first principles contained within the complex Schrodinger equation; visualization of scientific data returned from the Magellan and Galileo spacecraft; high-fidelity aerospace vehicle simulations; patter recognition of DNA sequences within the human genome; re-engineering of enzymes for enhanced biodegradation; and modeling of molecular processes in natural and contaminated systems to better understand the behavior of contaminants in the environment.

Intel's Touchstone Delta System is an advanced message-passing multicomputer with a unique mesh interconnect scheme. An advancement of Intel's iPSC/860 supercomputer, the Delta System incorporates Intel's i860 and 386 processors along with a custom mesh-routing chip developed by a Caltech research group led by Charles Seitz. Intel plans to work closely with many of the member organizations as they acquire production iPSC/860s for application development at their own sites and to gain experience from the application of the Delta System to computationally demanding problems.

Of particular interest is how well the system will utilize the full processor configuration and what the sustained performance of the system will be on the applications planned for this new system. Good results could be a major boost for massively parallel computing.

CRAY RESEARCH, INC 1990 GIGAFLOP PERFORMANCE AWARD RECIPIENTS

Unless otherwise noted, all the problems were run on a Cray Y-MP8 system. The sustained speeds (Sust. Spd.) were provided by Cray Research.

AEROSPACE

Vijaya Shankar, Ph.D., Rockwell International Science Center, Thousand Oaks, CA; Ken J. Taylor, Evans C. Harrigan, Cray Research, Huntington Beach, CA; Roy W. Erickson, Rockwell North America, El Segundo, CA

For their achievements in optimizing the shape and material properties of low-observable advanced military aircraft. Sust. Spd.: 1.753 GFLOPS.

Charbel Farhat, Luis Crivelli, Ph.D., Eddy Pramono, University of Colorado, Boulder, CO

For their achievements in developing a research method that conducts a nonlinear, finite element analysis of space structures. Sust. Spd.: 1.680 GFLOPS.

T. Alan Egolf, United Technologies Research Center, East Hartford, CT

For his achievements in enabling design engineers to cost-effectively use computer simulation to predict real-world helicopter rotor blade performance. Sust. Spd.: 1.535 GFLOPS.

Laurence A. Feldman, Ph.D., U.S. Air Force Weapons Laboratory, Albuquerque, NM; Nazareno L. Rapagnani, Ph.D., University of Arizona, Tuscon, AZ; Brian Dodd, Cray Research, Albuquerque, NM

For their achievements in evaluation aircraft performance through numerical simulation. Sust. Spd.: 1.528 GFLOPS.
Viet-Nam Nguyen, M. Vish Bhat, Ph.D.,

Fulfillment of Touchstone Goals Awaits Powerful Supercomputer

By Darryl K. Taft
GCN Staff

NEW YORK - Although Touchstone, the program that spawned Intel Corp.'s powerful Delta supercomputer, has achieved results, its goals will not be met until late next year or early 1992.

Under the Touchstone Program, Intel will deliver an even more powerful supercomputer in December 1991, company officials said.

The Touchstone Program is a research and development project co-sponsored by Intel Corp. and the Defense Advanced Research Projects Agency's Information Science and Technology Office to advance the state of the art in scalable multicomputer systems.

The Delta system is the third of four prototype systems Intel will develop. Late next year, Intel will demonstrate the final Touchstone prototype, known as Sigma. Sigma will comprise more than 2,000 processors and produce peak performance of 150 billion floating point operations per second, company officials said.

The Touchstone Program is a three-year effort to accelerate the progress toward teraFLOPS-level computing by achieving order-of-magnitude improvements in key aspects of high-performance, distributed-memory, message-passing computers, also known as multicomputers.

The program is funded by a $7.6 million DARPA contract and $19.9 million from Intel.

The Touchstone Program has a broad scope, with primary research emphasis on improving performance, bandwidth, latency and scalability of multicomputer interconnection schemes, Intel officials said.

Other research will focus on a range of hardware, software and applications issues, including input/output performance, operating systems, programming tools and applications development.

National Science Foundation, the California Institute of Technology (Caltech) in Pasadena, and many government-funded research laboratories.

"The big news is that all of these guys, up to now, have not been the best of friends. They compete for many of the same government grants, the same funding.

Now they're in this partnership," said Michael P. Burwen, president of the Palo Alto Management Group Inc. in Palo Alto, Calif.

The Delta System will be installed next spring at Caltech. Through the Concurrent Supercomputing Consortium, researchers from the geographically scattered institutions will have access to the Delta System.

Consortium members will use the Delta System for large-scale computations, many of which are associated with the federal High-Performance Computing program.

Consortium members will focus on such issues as visualization of scientific data returned from NASA's Magellan and Galileo spacecraft; recognizing patterns in DNA sequences within the human genome; re-engineering enzymes for enhanced biodegradation; and modeling molecular processes in natural and contaminated systems to understand better the behavior of contaminants in the environment, consortium officials said.

The Delta System began as a research collaboration between Caltech and Intel that dates back to 1984, when Intel formed its Supercomputer Systems Division. DARPA funded both the basic research at Caltech and Intel's work, which quickly turned Caltech's research in multicomputer design and programming into prototypes and products.

"When we initiated the Strategic Computing Program in the early 1980s and invested in basic research at Caltech, one of our dreams was to enable U.S. industry to move to a new high-performance technology base," said Stephen Squires, chief scientist in DARPA's Information Science and Technology Office.

"The Caltech and Intel collaboration that introduced the new technology for the consortium is an excellent example of all the principles of the federal high-performance computing program being used in practice," he said.

The Touchstone Delta System is an advanced message-passing multicomputer with a unique mesh interconnect scheme. The Delta System incorporates Intel's i860 and 386 processors, along with a custom mesh-routing chip developed by a Caltech computer scientist named Charles Seitz.

Machine 'Speaks Unix'

The Delta actually has 570 processors, 528 of them i860 numeric processors and 42 of them 386s used as service processors. In addition, the system "speaks Unix to the outside world," said Wendy Vittori, marketing director of Intel's Supercomputer Systems Division.

Thomas A. Prince, a Caltech astrophysicist and the consortium's policy board chairman, called the Delta System "perhaps the most powerful computational tool ever developed."

Intel's Vittori said consortium members judged the Delta the fastest machine available based on performance ratings for competing systems.

ROANOKE TIMES & WORLD-NEWS
11-22-90

Rapid-fire computer to go on line

Los Angeles Times

PASADENA, Calif. — The world's fastest and most powerful computer will be installed at the California Institute of Technology here next spring to aid in researching such complex scientific issues as global changes in the planet's environment and climate.

The supercomputer, capable of making 32 billion operations per second, will be the cornerstone of a cooperative program involving 14 research institutions, called the Concurrent Supercomputing Consortium.

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The supercomputer will be used for a wide range of projects, including the study of the depletion of the ozone layer, simulating the aerodynamic characteristics of high-performance aircraft, the human genome project and various space projects by the Jet Propulsion Laboratory in Pasadena.

LANCASTER INTELLIGENCER JOURNAL 11-21-90

Companies compete to create faster supercomputers

SAN FRANCISCO (AP) — As competition heats up to make the speediest computers to solve the biggest problems in science, Intel Corp. is ready to introduce what the company says is the world's fastest supercomputer.

Supercomputer fever, spurred on by Pentagon funding in many cases, is getting hotter as researchers look for ways to apply the machines that can speed up medical research and help create "smart" bombs, among other uses.

"If we can make microprocessors smaller and faster, they would be very useful for advanced weapons systems," Pentagon spokeswoman Jan Bodanyi said recently. "They will be the ultimate weapons system. ... Once we get supercomputers down to soup-can size we can put them on missiles."

Industry analysts warn, however, that despite the push to create supercomputers that can handle more information at one time and at mind-boggling speeds, the real challenges are to harness that power, to maintain top speeds and to make the systems even smaller and cheaper.

"There aren't many people out there who can afford to pay $25 million to $30 million for a top of the line supercomputer," said Christopher Willard, senior industry analyst at San Jose-based DataQuest. "Another problem is actually getting and using the full power of the highly parallel computers. It's hard to deliver and sustain the full power."

Intel, which invented the microprocessor, is an industry leader in chip design and manufacture.

Its new supercomputer will use 512 of the company's powerful i860 chips. Now, Intel's most powerful machine uses 128 of those chips.

A parallel system links separate microprocessors to create the supercomputer, which in Intel's case would reportedly reach speeds of up to 32 GigaFLOPs, or 32 billion floating-point operations per second — the customary measure of a computer's ability to crunch numbers and information.

Skeptics, including Intel's competitors NCube of Beaverton, Ore., and Cray Research Inc. of Minneapolis, wonder if the new machine can actually reach that computation speed even for simple problems.

One analyst compared supercomputers to using 10,000 rabbits to plow a field instead of four horses; the rabbits may have more total energy, but controlling that power is difficult.

"No supercomputer can maintain that type of speed," said Charles Grasfl, marketing analyst for Cray, which dominates the supercomputer market. "I want to know what it can do. Where's the breakthrough?"

One analyst compared supercomputers to using 10,000 rabbits to plow a field instead of four horses; the rabbits may have more total energy, but controlling that power is difficult. Still, scientists continue to try.

"What's fascinating about supercomputers is what people will be able to achieve one day," said Abbie Kendall, spokeswoman for NCube. "Right now we're on the edge of technology."

In mid-1989, NCube introduced its supercomputer, which at 27 GigaFLOP was the world's fastest. The company is working on a quicker model.

The Intel supercomputer will reportedly be used for research, including study of how to better apply such huge computer brains.

"Supercomputers still have a long way to go in terms of use for the average programmer," said DataQuest's Willard. "The application, I think, will come from not what the system's top configuration can do but with what its smaller chunks can accomplish.

"Now, the marketplace is limited to universities, military, NASA ... What they need to do is some supercomputing for more mundane uses."

NCube hasn't sold its top-of-the-line, $20 million supercomputer yet, but Kendall said the private company expects to sell one by mid-1991.

Now, she said, NCube sells smaller parallel systems that can do more work faster than regular computers. A drug company, for example, gets results in three to four hours about molecule configurations for new manufactured drugs instead of the three months such a computation took previously.

T E C

The authoritative report on command and control, simulation, and computing

Vol. 1, No. 3 Incorporating *Advanced Military Computing* and *Training Systems Report* November 19, 1990

CalTech establishes supercomputer group

Intel has a contract for its Touchstone Delta System, billed as the world's fastest supercomputer and based on an advancement of the iPSC/860 supercomputer, from CalTech.

It will be used by researchers in a new Concurrent Supercomputing Consortium. It consists of 14 research institutions. They are: Defense Advanced Research Projects Agency, Argonne National Laboratory, California Institute of Technology, Jet Propulsion Lab, Center for Research in Parallel Computation, NASA, Intel Supercomputer Systems Division, National Science Foundation, and Pacific Northwest Lab. Other members of the consortium will include: Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Purdue University and Sandia National Laboratories.

Intel would not say how much the contract is worth, but told several media representatives that if the computer were produced commercially, which it isn't, it would cost between $15 million and $20 million.

The computer, to be installed at CalTech, Pasadena, Calif., next spring, has 5289 numeric processors working simultaneously to provide a peak speed of 32 gigaFLOPS. It incorporates results of research at CalTech. Both basic research at CalTech and development of prototype systems at Intel are funded by DARPA. Gil Weigand, DARPA manager for Touchstone, said he is gratified to see DARPA's support produce such monumental results. "Quite frankly, as a consortium member, we are very eager to get our hands on it," Weigand said.

Some of the uses expected from the consortium include:

- ➤High-fidelity aerospace vehicle simulations.
- ➤Modeling and simulation of global climate change.
- ➤Calculating the rates of chemical reactions.
- ➤Visualization of scientific data returned by the Magellan and Galileo spacecraft.
- ➤Pattern Recognition of DNA sequences within the human genome.
- ➤Analysis of radiotelescope data for evidence of binary pulsars.

Intel officials predicted many of the consortium members will want iPSC/860s for use at their own sites.

Stephen Squires, chief scientist of DARPA's Information Sciences and Technology Office, said the CalTech/Intel collaboration is an excellent example of the principles of the Federal High Performance Computing Program being used in practice.

Group Orders Intel Parallel Supercomputer

By CAROLYN DUFFY MARSAN

NEW YORK — A consortium of federal agencies, laboratories and research institutions has ordered a one-of-a-kind parallel supercomputer from Intel Corp. that the company claims will be the world's most powerful computer when it is delivered next spring.

The 14 members of the newly founded Concurrent Supercomputing Consortium announced the acquisition last week at the Supercomputing '90 show in New York City.

The consortium's announcement is a sign that government laboratories are serious about parallel processing — an emerging technology that is viewed as a replacement to the traditional serial-processing supercomputers offered by vendors such as Cray Research Inc.

"This is the most exciting machine since the first Cray," said Rich Stevens, a researcher with consortium-member Argonne National Laboratory. "This is a major opportunity for us to explore massive parallelism on a broad class of problems."

Intel will provide the consortium with the first Touchstone Delta System, which uses a network of 528 i860 processors to achieve a peak speed of 32 billion floating-point operations per second (Gflops). The system memory capacity is 8G, and it has a communications network that passes information at a rate of 16G per second.

Intel Corp.'s Delta System will be two to 10 times faster than existing supercomputers, according to Carl Kukkonen, director of the Microelectronics and Advanced Computing Technology Office at NASA's Jet Propulsion Laboratory, one of the consortium members.

The system is worth between $15 million and $20 million, according to Justin Rattner, director of technology at Intel's Beaverton, Ore.-based Supercomputer Systems Division. But he declined to say how much the consortium actually paid for the system. And consortium members would not reveal how much money each has contributed to the effort, which is to last three years.

The Delta System is the result of a six-year research collaboration between the California Institute of Technology and Intel. Much of the initial research was funded through the Touchstone Project, a three-year, $27 million effort jointly funded by Intel and the Defense Advanced Research Projects Agency, another member of the consortium.

"Delta is going to significantly extend computational capabilities in a number of areas important to the Department of Defense," according to Gil Weigand, DARPA's Touchstone program manager. "Quite frankly, as a consortium member, we are very eager to get our hands on it."

The unique feature of the Delta System is its use of a communications scheme based on a custom chip developed by a Caltech research group. An extension of the company's iPSC/860 supercomputer line, the Delta System incorporates both i860 and 386 processors as well as the custom mesh-routing chip.

Intel officials declined to say if and when the Delta System would be commercially available.

Federal researchers will use the system to run complex problems in areas such as global climate change, space science, nuclear contamination, aerospace simulations, weather modeling and human genome mapping.

The system will be physically located at the California Institute of Technology, which came up with the idea for the consortium in April and had recruited the members by June. Government officials said they joined the consortium because it was the only way they could afford to get access to a machine as powerful as the Delta System.

The consortium's goal was to buy a large-scale supercomputer based on multiple-instruction, multiple-data (MIMD) technology. The largest MIMD system available today is a 128-node Intel PSCi860 system at Oak Ridge National Laboratory. Other vendors of MIMD systems include Beaverton, Ore.-based Ncube.

Several government laboratories and universities own large-scale systems using the competing parallel processing technology: single-instruction, multiple-data (SIMD) systems. SIMD systems are offered by vendors such as Thinking Machines Corp. of Cambridge, Mass.

"We needed access to a large MIMD system, but we couldn't afford to buy one," said Paul Messina, director of Caltech's Concurrent Supercomputing Facilities. "We looked at all the MIMD architectures, but we were most comfortable with the Intel architecture because it has [powerful] nodes and a large memory."

Intel officials said they believe the sale of the Delta System could be a boon for the company as it tries to convince government customers to begin the transition to parallel processing systems. In fact, some of the consortium members such as Caltech already have purchased smaller Intel systems to use for developing software for the Delta System.

Intel has had a 64-processor Delta System prototype up and running since September. Officials said they will ship a fully operational 528-node system to the consortium by April.

Other consortia members include some Energy Department laboratories. In addition to those labs, five NASA sites also will have access to the machine. ◄

ELECTRONIC ENGINEERING TIMES
11-19-90

Group to study Touchstone

BY TERRY COSTLOW

New York — A consortium of 13 universities and government research labs has purchased a parallel processing system from Intel Corp.'s Supercomputer Systems Division, and it plans to use it to advance programming for parallel computers.

The Concurrent Supercomputing Consortium was pulled together by the California Institute of Technology, which helped Intel develop the system, called Touchstone. The group plans to dedicate the system to a few users with very large tasks instead of opening it up to a broad number of users, as is the norm for time-shared systems.

That usage technique is being employed in part to help the scientists learn how to use extremely large parallel systems. The Touchstone system, developed using funding from the Defense Advanced Research Projects Agency (Darpa), combines 528 i860 processors to provide a peak rating of 32 gigaflops. That's a bit faster than the thousand-processor Thinking Machines system that now claims the lead in peak megaflops, at 28.

Intel plans to ship the system next summer. However, it may be the only one shipped, since the company does not plan to produce it commercially. Intel recently began shipping 128-processor systems, having produced a number of 64-processor versions.

Consortium researchers, who will access the system in Pasadena, Calif., using high-speed T3 phone links, plan to buy other systems over time.

Members of the consortium include Cal Tech, Cal Tech's Jet Propulsion Lab, the Center for Research in Parallel Computation, Darpa, NASA, Purdue University and the National Science Foundation. The national labs involved are Argonne, Lawrence Livermore, Los Alamos, Oak Ridge, Sandia and the Pacific Northwest Lab.

Supercomputer targets 32 GFLOPS

Multicomputer, not multiprocessor, scheme is key to speed

By S Louis Martin
EDN News Contributor

NEW YORK, NY—At Supercomputing 90 this week the Scientific Computer Division of Intel Corp and the California Institute of Technology introduced the fastest supercomputer in the world: the DARPA-sponsored Touchstone Delta computer, offering a staggering 32-GFLOPS performance on 64-bit operands. At the same time the two organizations announced the formation of the Concurrent Supercomputing Consortium (CSC), involving a number of universities and national research laboratories.

Delta is aimed at such computationally intensive applications as prediction of weather, climate, and global change; turbulence predictions in fluid flow; quantum chromodynamics; and machine speech and vision.

Intel's part in the Touchstone project is a 3-year contract and funding agreement with the Defense Advanced Research Projects Agency (DARPA) to "advance the state of the art of multicomputers." Development of four prototype machines, the third of which is Delta, is specified in the contract. The overall goal is to push performance from 1 GFLOPS to 200 GFLOPS over the course of the three years.

Although Delta is not a commercial product, it is the precursor to an even more powerful Touchstone machine under development at Intel, called Sigma, that may lead to a commercial product.

A 64-node Delta prototype is up and running at Intel, and the full 570-node, 32-GFLOPS version is due for delivery to Cal Tech by April 1991. In the mean time, Cal Tech is taking delivery of Gamma, Delta's immediate precursor. The computer uses standard, off-the-shelf i860 μPs and a custom mesh routing chip developed by Cal Tech.

Origins at Cal Tech

Delta is in part the result of a long-term research project of Charles Seitz, professor of computer science at Cal Tech (Pasadena, CA). "Back in the early 1980s, my students and I were doing research on what is now called scalable concurrent computers," says Seitz. "We could have as many computing elements as desired." The early work was sponsored by DARPA.

The Delta project uses a multicomputer as opposed to a multiprocessor architecture. Explains Seitz, "A multicomputer includes a fairly large number of computing nodes, and those nodes include both the processor and the memory. The nodes are tied together by a message-passing network."

The advantage of a multicomputer over a multiprocessor approach (which shares memory among the processors) is the capability to scale multicomputers up to very large sizes, because they are less sensitive to delays in global communication. This results from the separate mechanism for passing messages from one processor or node to another in a multicomputer. The multicomputer can thus dispatch and receive messages while executing programs, whereas multiprocessors must wait.

One thing that makes the Delta powerful and fast, according to Seitz, is the i860 processor from Intel. "Up until the Intel i860, the available processors were all a little underpowered," states Seitz. "At 60 MFLOPS on 64-bit operands, the performance of the i860 is fairly remarkable."

Another factor that gives the Delta power is the work by Seitz and his fellow researchers on low-dimension networks, the use of which permitted Delta to take a fairly simple form. All of the message routing is handled on the backplane. The nodes provide computing and storage. Individual channels or nodes are routed on the backplane by a chip—one per node—developed by Cal Tech.

"You can picture it like a freeway interchange; each chip connects an east-west freeway and a north-south freeway," says Seitz. "When you inject packets into the network, they are routed through these freeway exchanges." The message-passing chips operate at just under 100 Mbytes/sec, though the nodes can only source and sink them at about 30 Mbytes/sec.

Although the Gamma machine—an earlier Touchstone prototype—uses the i860, it is the Delta version that incorporates both the i860 in the nodes and the 2D mesh routing scheme developed at Cal Tech, which Seitz calls the "routing fabric." This fabric, or mesh, not only ties the whole system together, but allows for heterogenous nodes as well. The Gamma machine—with a peak of more than 2 GFLOPS—sells for $3.5 million. The largely CMOS Gamma machine is air-cooled.

Delta supercomputer from Intel/Cal Tech uses 64-bit operands to get 32 GFLOPS

Intel's approach to supercomputing contrasts with that taken by Cray Research (Mendota Heights, MN) in its $23 million, liquid-cooled YMP supercomputer. The



Intel's Justin Rattner: *The Delta project could lead to commercial products.*

YMP uses eight very fast processors (330 MFLOPS) in parallel to achieve some 2.67 GFLOPS of peak system performance. While the Cray processor is fast, there is a drawback to the approach, says Seitz. "The i860 runs one-fifth as fast as a YMP processor—a huge, expensive bipolar piece of silicon. Being able to get comparable performance from a 1.5-sq-cm piece of silicon that is a commodity product is the key to the numeric performance. It only takes five i860s to keep up with one of the Cray processors," he says.

Seitz claims a machine with only 40 i860s can have the same performance as a Cray YMP, which is a multiprocessor system as opposed to a multicomputer.

Fastest for a year

The Delta machine scheduled for spring delivery to Cal Tech will have 570 nodes, with 528 numeric nodes offering 16 Mbytes of primary memory each. Aggregate memory is about 9 Gbytes. There are also 32 disk nodes, each of which can handle 1.25 Gbytes of disk storage. The aggregate peak performance will be about 30 GFLOPS. Delta will be housed in nine cabinets that measure $5 \times 2.5 \times 1.75$ ft each.

Says Seitz, "For somewhat more than a year, Delta will be the fastest computer in the world."

The Delta multicomputer will join other supercomputers at Cal Tech in the Cal Tech Concurrent Supercomputing Facility, where it will be available to a number of research projects. Though the Cal Tech Delta machine is the only Delta machine Intel plans to build at this time (other than the prototype at Intel), Cal Tech is putting together a consortium of other institutions and national research facilities to "pool resources, financially and intellectually," according to Paul Messina, director of the Cal Tech Concurrent Supercomputing Facility.

Messina says the consortium's broad goal is "to get enough money together to get a machine big enough to really make a difference—something convincingly more powerful than anything before—and to share intellectual information." Other members of the consortium will only receive Gamma machines. Messina claims that consortium members will be able to share software developed on the Delta or the Gamma (Hypercube versus mesh topology, but still based on the i860).

The final Touchstone prototype is Sigma, and although Intel has made no final decision as to its commercialization, "We are clearly developing these prototypes with the intent that most of what we do will be a precursor to commercial development," says Justin Rattner, director of technology at Intel's Scientific Computer Division (Hillsboro, OR).

The Sigma prototype is due at the end of 1991. It will include 2000 nodes or cards, and probably a faster version of the i860, very likely a 50-MHz, 100-MFLOPS device expected to be introduced by Intel within the next three months.



Cal Tech professor Charles Seitz *says a multicomputer scheme with 40 i860s can have the same performance as a Cray YMP.*

EDN (Continued) Nov. 15, 1990

INTEL SUPERCOMPUTER GOES TO CALTECH-BASED CONSORTIUM OF SCIENTIFIC LABORATORIES

Intel Corp's supercomputer division says it just won a contract to supply what it calls the world's fastest supercomputer to a group of government and university laboratories.

The machine called the Touchstone Delta System is based on an array of 528 Intel i860 microprocessors that Intel says will have a peak performance of 32 gigaflops. No cost figures for the computer have been made public but a commercial version is thought to be worth $15-$20 million. The machine was built with technology gained in part from the Defense Advanced Research Projects Agency or DARPA.

Intel will install the machine in the first quarter of 1991 at the California Institute of Technology in Pasadena. It will be used by 14 institutions that have formed a user group called the Concurrent Supercomputing Consortium. It includes such luminaries as Lawrence Livermore National Laboratory, NASA, the Jet Propulsion Laboratory, Pacific Northwest Laboratory, Sandia National Laboratories, National Science Foundation, Purdue University and Caltech.

Cray Research Inc., which has been the most successful supercomputer maker for years, has greeted the news "with a big yawn," according to Charles Grassl, a company analyst. "Has it been tested?" he asks rhetorically. "We think its just a paper announcement at this point."

A spokesman at Caltech said the machine would be used to solve scientific problems associated with global climate changes and translating into pictures data sent to Earth by the Magellan and Galileo space probes. "We don't see this as an experimental machine at all," says Paul Messina, the director of the project at Caltech. "We have applications that are ready and waiting." ■

INFORMATION WEEK
11-19-90

COMPUTING TOUCHSTONE

Fourteen major U.S. research institutions last week banded together to form the Concurrent Supercomputing Consortium based at the California Institute of Technology. At the heart of the group is a massively parallel custom supercomputer developed by Intel Corp. Company officials claim the Touchstone Delta system is the fastest supercomputer to date. Intel does not, however, plan to develop Touchstone for commercial use.

INVESTOR'S DAILY
11-14-90

Intel Corp. Announces Sale Of Supercomputer

Investor's Daily News Services

NEW YORK — Intel Corp. said the Concurrent Supercomputing Consortium is acquiring an Intel Touchstone Delta System, a limited production model of Intel's iPSC/860 supercomputer, which the company said is the world's fastest computer. The value was not disclosed.

Intel said Touchstone Delta has a peak speed of 32 billion floating-point operations per second and is the result of a research collaboration with the California Institute of Technology, where the system will be installed next spring.

Concurrent Supercomputing is a consortium of 14 U.S. research institutions.

THE WALL STREET JOURNAL-EUROPE
11-14-90

Intel, in Coup, Captures Supercomputer Contract

By a WALL STREET JOURNAL *Staff Reporter*

SAN FRANCISCO – Intel Corp.'s supercomputer division said it won a contract to supply what it termed the world's fastest computer to a group of U.S. government and university laboratories.

The deal is a coup for Santa Clara, California-based Intel, which is trying to make a name for itself in high-performance computers. The market for supercomputers – multimillion-dollar machines built to process huge numbers of calculations at an extremely high speed – has been dominated by companies such as Cray Research Inc.

Called the Touchstone Delta System, the new Intel machine uses so-called parallel-processing technology to lace together 528 of its i860 microprocessor chips so they do calculations simultaneously. The machine produces a peak speed of 32 gigaflops, or billions of floating-point operations a second. Today's fastest machines run at peak speeds in the mid-20s of gigaflops.

Robert Rockwell, general manager for Intel's supercomputer division in Beaverton, Oregon, valued the machine at $15 million to $20 million.

Mr. Rockwell said Intel will install the machine early next year at the California Institute of Technology in Pasadena for use by 14 institutions that are forming a group named Concurrent Supercomputing Consortium. The group includes some of the nation's top research institutions.

The group plans to use the machine for such things as simulating global climate changes and translating into pictures the masses of data sent by the Magellan and Galileo space probes.

DAILY JOURNAL OF COMMERCE
11-14-90

Intel to make fastest computer

Intel Corp.'s Beaverton-based Supercomputer Systems Division is making what it claims to be the fastest computer in the world.

The Touchstone Delta System will be capable of computing 32 billion — 32 gigaflops — operations per second and will be located at Caltech next spring.

The system is a parallel processor containing 528 of Intel's i860 microprocessors. Intel expects to deliver the machine this spring.

Caltech is the head of a 14-member United States research consortium that will use the computer for complex numerical tasks such as modeling of global climate changes, chemical reactions, and visualization of data from spacecraft and military research.

The project received $7.6 million in funding from the Defense Advanced Research Projects Agency. Other institutions involved in the consortium include NASA, the National Science Foundation, Lawrence Livermore National Laboratory and Purdue University.

The machine was formally announced Tuesday at Superconducting '90

Purdue in consortium for supercomputer use

NEW YORK (UPI) — Purdue University researchers will gain access to the world's fastest, most powerful supercomputer to study and develop new techniques for computing.

Purdue is one of 14 research institutions to join together to form a supercomputing consortium aimed at designing and developing computing techniques for the future. Announcement of the consortium was made Tuesday in New York City in conjunction with the opening of a supercomputing conference.

Members of the Concurrent Supercomputing Consortium will use a new type of supercomputer that employs a technique called parallel computing to handle massive computational problems.

The system is made up of a large number of individual processors that are capable of operating simultaneously — or in parallel — to carry out more than one operation at one time.

"Parallel supercomputing is now moving from the research phase to practical applications," said John Rice, head of Purdue's Department of Computer Sciences. "By the year 2000, all our engineers and scientists will use parallel machines, and membership in this consortium will keep Purdue at the forefront of supercomputing.

The computer system, called the Touchstone Delta System, was developed by the Supercomputer Systems Division of Intel Corporation. It will be installed next spring at the California Institute of Technology. Caltech will serve as the leading institution of the consortium.

"The Intel Delta machine will be the world's most powerful computer," Rice said. "By having access to this system, Purdue researchers will have the opportunity to move their computational projects to the next generation of supercomputers."

The system will allow Purdue researchers to develop new techniques for parallel computing, and to find ways to apply parallel computing to solve real-life problems, said John Steele, director of Purdue's Computing Center.

He predicted that it will be late next summer before the supercomputer and access to it by universities will be complete.

Steele noted the link to the new supercomputer will be used only by a handful of researchers at Purdue.

"The consortium was designed to study and develop new ways of computing," he said. "It will not substantially affect or reduce the need for supercomputing facilities for general research at Purdue. It will be years before researchers in most disciplines will be able to use this technology effectively."

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LEBANON
REPORTER

D. 6,463

LA OPINION Miércoles 14 de noviembre de 1990

Estará en Caltech, Pasadena

Instalan la computadora más poderosa del mundo

Por Marcelo M. Zuviría

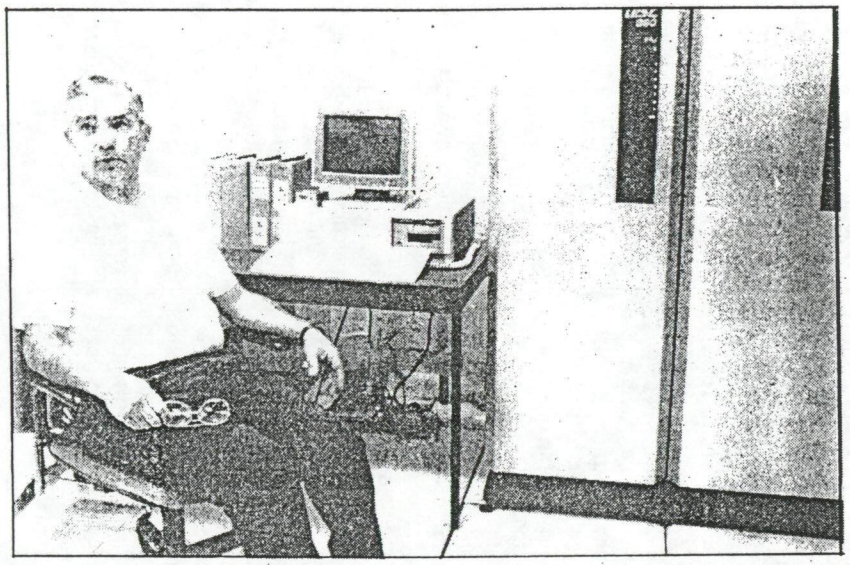
Especial para LA OPINION

Comenzó a instalarse la más poderosa super computadora del mundo en el Instituto Tecnológico de California, en Pasadena, la cual permitirá a los científicos lanzarse a proyectos antes imposibles de realizar por cuestión de falta de velocidad y de tiempo.

"Con esta computadora puedo procesar datos 100 veces más rápido que con cualquier otra computadora... hacer un cálculo que hoy me tomaría un año con las mejores computadoras disponibles, con ésta me tomará tres días," señaló a LA OPINION Aron Kuppermann, profesor de Física y Química, de este instituto y uno de los científicos envueltos en el proyecto.

"En muchos casos con esta computadora se podrán hacer cosas hasta ahora imposibles de intentar, por una cuestión de tiempo," agregó Kuppermann.

Esta super computadora, denominada Touchstone Delta System y construida por la compañía Intel, en colaboración con este instituto, podrá efectuar 32 mil millones de operaciones por segundo, señala un informe de Caltech.



Aron Kuppermann, profesor de física y química de Caltech, junto a dos paneles pertenecientes a la computadora del sistema Delta. (Foto: María Caño-Miller/LA OPINION)

"Se va a usar en diferentes áreas de la ciencia, como en astrofísica, turbulencia y meteorología, en dinámica líquida, en óptica... yo la usaré para trabajar en la química, o más exactamente, en reacciones químicas, que es mi especialidad," aseguró Kuppermann.

"Por ejemplo, la mecánica Quántum fue descubierta en 1926, hace 64 años, pero recién ahora se van a poder aplicar estos conocimientos en reacciones químicas, se ha hecho muy poco sobre esto desde entonces por el largo tiempo que hubiera tomado... ahora se abrirán enormes posibilidades," manifestó Kuppermann, quien nació en Brasil y enseña en este instituto desde hace 27 años.

Kuppermann aseveró que la computadora ayudará a descifrar información recibida del telescopio espacial Hubble, el cual fue fabricado con defectos técnicos que se descubrieron cuando se lo puso en funcionamiento en el espacio, hasta tanto éste sea reparado.

Y señaló que si bien esta computadora podría ser usada para programas militares, no sería utilizada para proyectos secretos. En cuanto al costo, aseguró que era difícil dar una suma exacta, pero, rondaría en los 10 millones de dólares.

El informe de Caltech señala que esta computadora, que fue financiada por la Agencia de Proyectos de Investigación Avanzada para la Defensa (DARPA), podrá ser utilizada también para estudios sobre la

Pasa a la página 4.

Instalan...

Viene de la página 3

capa de ozono de la atmósfera, para investigaciones sobre genética humana y proyectos espaciales del Jet Propulsion Laboratory, de esta misma ciudad, entre muchas otras cosas.

La computadora será utilizada y administrada por un consorcio de 14 de las más prestigiosas instituciones de investigación científica de este país, el cual se denominará Concurrent Supercomputing Consortium y usarán este instrumento para descifrar los más complejos enigmas científicos de nuestro tiempo, señala este mismo informe.

BLADE-CITIZEN
11-12-90

Supercomputer battle heats up

SAN FRANCISCO (AP) — As competition heats up to make the speediest computers to solve the biggest problems in science, Intel Corp. is poised to introduce what the company says is the world's fastest supercomputer.

Supercomputer fever, spurred on by Pentagon funding in many cases, is getting hotter as researchers look for ways to apply the machines that can speed up medical research and help create "smart" bombs, among other uses.

"If we can make microprocessors smaller and faster, they would be very useful for advance weapons systems," Pentagon spokeswoman Jan Bodanyi said last week. "They will be the ultimate weapons system. Once we get supercomputers down to soup-can size, we can put them on missiles."

Industry analysts warn, however, that despite the push to create supercomputers that can handle more information at one time and at mind-boggling speeds, the real challenges are to harness that power, to maintain top speeds and to make the systems even smaller and cheaper.

"There aren't many people out there who can afford to pay $25 million to $30 million for a top-of-the-line supercomputer," said Christopher Willard, senior industry analyst at San Jose-based DataQuest. "Another problem is actually getting and using the full power of the highly parallel computers. It's hard to deliver and sustain the full power."

Officials at Santa Clara-based Intel have refused to release information on the company's new supercomputer before a formal announcement at an industry conference in New York on Tuesday. The California Institute of Technology at Pasadena, where the supercomputer will be installed, also has refused to comment.

Intel's new system would reportedly reach speeds of up to 32 GigaFLOPs, or 32 billion floating-point operations per second — the customary measure of a computer's ability to crunch numbers and information.

Skeptics, including Intel's competitors NCube of Beaverton, Ore., and Cray Research Inc. of Minneapolis, wonder if the new machine can actually reach that computation speed even for simple problems.

"No supercomputer can maintain that type of speed," said Charles Grasfl, marketing analyst for Cray, which dominates the supercomputer market.

Los Angeles Times

Date: 11-13-90
Page: B3
Metro News

Caltech to Be Home for Most Powerful Research Computer

By LEE DYE
TIMES SCIENCE WRITER

The world's fastest and most powerful computer will be installed at Caltech next spring to aid in researching such complex scientific issues as global changes in the environment and climate, according to an announcement that is to be made today in New York City.

The supercomputer, capable of making 32 billion operations per second, will be the cornerstone of a cooperative program involving 14 research institutions called the Concurrent Supercomputing Consortium.

Known as the Delta System, the computer is being built by Intel Corp. as part of a research collaboration between the firm and Caltech. The system employs many high-speed microprocessors, which are linked through a communications network.

The computer's performance can be enhanced by adding more microprocessors through a process called concurrency. The system also reveals how rapidly the computer business is changing because it is several times more powerful than the most powerful computers available just a few years ago.

Such high-speed computers are essential to major research projects because they allow scientists to keep tabs on billions of bits of data that may change every second. That is true for such matters as the study of the atmosphere because information from millions of sensors changes continually, and only a supercomputer can make it possible for scientists to keep track of data and analyze results.

"I am delighted that the most powerful computer in the world will be housed at Caltech," Thomas E. Everhart, president of Caltech, said in a statement.

Development of the Delta System and related Caltech research was funded by the Defense Advanced Research Projects Agency. The supercomputer will be used for a range of projects, including study of the depletion of the ozone layer, simulating aerodynamic characteristics of high-performance aircraft, the human genome project and various space projects by the Jet Propulsion Laboratory.

Members of the consortium include JPL, several national laboratories, DARPA, National Aeronautics and Space Administration, National Science Foundation, Purdue University and Intel.

COLORADO SPRINGS GAZETTE
11-13-90

Consortium expected to buy computer:
A consortium of 14 U.S. research institutions led by the California Institute of Technology is scheduled to announce today that it will purchase a custom-designed supercomputer from Intel Corp. to help solve a series of scientific "grand challenges."

The project, known as the Concurrent Supercomputing Consortium, is one of the most significant endorsements to date of a style of computing known as parallel processing, which chains together many processors and breaks up problems to solve them more quickly.

The machine, whose design is an outgrowth of several research projects backed by the Defense Advanced Research Project Agency, or Darpa, will be used in areas like modeling global climate changes and complex chemical reactions, visualization of scientific data from the Magellan and Galileo spacecraft, and military research.

Supercomputers, described as the fastest systems available at any particular time, are used for scientific research and engineering design. The market for supercomputers has been growing rapidly in recent years and they are now widely used in industries as diverse as petroleum, aerospace, pharmaceuticals, media and entertainment.

EU-CLAIRE LEADER-TELEGRAM
11-13-90

Intel plans parallel supercomputer

By N.Y. Times News Service

A consortium of 14 U.S. research institutions led by the California Institute of Technology is scheduled to announce today that it will buy a custom-designed supercomputer from Intel Corp. to help solve a series of scientific "grand challenges."

The project, known as the Concurrent Supercomputing Consortium, is one of the most significant endorsements to date of a style of computing known as parallel processing, which chains together many processors and breaks up problems to solve them more quickly.

The machine, whose design is an outgrowth of several research projects backed by the Defense Advanced Research Project Agency, or Darpa, will be used in areas like modeling global climate changes and complex chemical reactions, visualization of scientific data from the Magellan and Galileo spacecraft, and military research.

The machine, called the Delta System, is based on an array of 528 Intel i860 microprocessors, which are designed to perform mathematical operations at high speed.

The design of the new computer is based in part on the work of a research group led by a Caltech computer scientist, Charles Seitz.

Intel officials said that once the machine is installed at Caltech in the spring it would be the world's fastest computer, but the claim drew skeptical reaction from a number of the company's competitors.

"We're thinking of it as a yawn," said Charles M. Grassl, a competitive analyst at Cray Research Corp. "Has it been tested? We think it's a paper announcement at this point."

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TRANSCRIPT

DATE November 13, 1990
TIME 5:30 PM
STATION ~~KQED-FM~~ Radio
LOCATION San Francisco
PROGRAM News

Holly Kwan, anchor:

Intel Corporation today announced the development of what it says is the world's most powerful computer. KQED's Peter John Schuller reports.

Peter John Schuller reporting:

The one-of-a-kind supercomputer will be installed at the California Institute of Technology in Pasadena in the spring and will be available to scientists at Intel, Caltech, and a dozen other members of the supercomputing consortium that launched the effort. Intel fellow Justin Rattner says the so-called Delta supercomputer will contain nearly six hundred microprocessors that will allow it to attack scientific problems never before possible.

Justin Rattner (Intel Fellow): One of the first applications for the machine will be to run a model of the earth's climate to study the greenhouse effect, depletion of the ozone layer, and so forth.

Schuller: Rattner says that will take about ten days of computing time on the new machine, compared to more than six months on a conventional supercomputer. But Rattner says this is only an intermediate step. Intel is expected to unveil a prototype a year from now with five times the performance. From the South Bay bureau, I'm Peter John Schuller, KQED Radio News.

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EMBARGOED FOR RELEASE NO EARLIER
THAN A.M.s TUESDAY, NOVEMBER 13, 1990

A new highly parallel supercomputer capable of solving problems at extremely high speeds is being acquired by a consortium involving the California Institute of Technology, the Jet Propulsion Laboratory, NASA and a number of other organizations, it has been announced.

Complex problems in space sciences and global atmospheric modeling related to the greenhouse effect and ozone depletion will be among topics assigned to the supercomputer, according to Dr. Carl Kukkonen of JPL.

The announcement was made this morning (Nov. 13) at a news briefing in New York City at Supercomputing '90, an industry event.

The speed and memory of the supercomputer -- a Touchstone Delta System made by the Intel Corp. -- will make it the world's most powerful computer when it is installed early next year, consortium organizers say.

The Delta uses a network of 528 Intel i860 processor units working concurrently on a problem at a given time. As a result it can achieve a peak speed of 32 gigaflops, or billions of floating-point operations per second. Its memory capacity is

8 gigabytes.

The Delta is 2 to 10 times faster than other existing supercomputers, said Kukkonen.

The Delta System is the result of research collaboration between Caltech and Intel. Work in parallel processing has been pursued at Caltech and JPL throughout the past six years.

JPL researchers will use the supercomputer to explore a wide range of Earth and space science topics under NASA's High Performance Computing Initiative. In addition to atmospheric studies, initial problems to be run on the Delta include solar and astrophysical modeling.

Another major application will be visualization of scientific data from the planets Venus and Jupiter gathered by the NASA/JPL Magellan and Galileo missions, Kukkonen said.

JPL will also use the Delta to design future solar system exploration spacecraft and remote-sensing instruments, and to develop command sequences to control spacecraft.

NASA researchers in other parts of the country are expected to use the Delta in areas such as computer simulation of aerospace vehicles.

Kukkonen heads JPL's Microelectronics and Advanced Computing Technology Office, which will manage JPL's share of the Delta.

Joining Caltech and JPL among the consortium's partners will be Argonne National Laboratory; the Center for Research in Parallel Computation, operated by several institutions under

National Science Foundation sponsorship; various other National Science Foundation-sponsored programs; the federal Defense Advanced Research Projects Agency (DARPA); Intel Corp.'s Supercomputer Systems Division; NASA; and Pacific Northwest Laboratory.

Other consortium members include Lawrence Livermore National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, Purdue University and Sandia National Laboratories.

The Delta will be physically located in Caltech's Concurrent Supercomputing Facilities in Pasadena, Calif.

Development of the Delta at Intel and related basic research at Caltech are funded by DARPA. Additional funding for research in parallel computation at Caltech and JPL was provided by the U.S. Department of Energy's Applied Mathematical Sciences program and the U.S. Air Force's Electronic Systems Division.

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TOTAL P.04

Sarah Keegan
NASA Headquarters, Washington, D.C.
(Phone: 202/453-2754)

November xx, 1990

RELEASE: 90-XXX

NASA TO USE WORLD'S FASTEST SUPERCOMPUTER

NASA researchers will have access to the world's fastest supercomputer as a benefit of the agency's membership in the Concurrent Supercomputing Consortium, a newly-formed group of the nation's premier research organizations.

The Consortium will tackle some of today's most demanding computational and scientific challenges, such as global climate modeling, space science data analysis and pattern recognition of DNA sequences in the human genetic makeup.

Members will be able to access Intel Corporation's Touchstone DELTA supercomputer system, currently slated for installation at the California Institute of Technology (Caltech), Pasadena, Calif., in the spring of 1991. The DELTA system has a peak speed of 32 gigaFLOPS (32 billion floating point operations per second), making it the world's fastest computer.

NASA will use the DELTA system as part of the agency's High-Performance Computing Initiative (HPCI), an ambitious program to accelerate the computing research capabilities required to maintain U.S. aeronautical and space science leadership in the 21st century. For example, DELTA will dramatically improve NASA's capability to simulate the performance of integrated aerospace vehicle systems throughout their flight regimes and mission profiles, and will greatly enhance multidisciplinary research in global climate change and astrophysics.

NASA will begin to use the DELTA system for research problems soon after it becomes available at Caltech. In addition, NASA researchers working on HPCI also will evaluate how much of an increase in

-more-

computational performance DELTA offers over the agency's present systems.

Lee B. Holcomb, Director of the Information Sciences and Human Factors Division in NASA's Office of Aeronautics, Exploration and Technology (OAET), is the agency's representative on the Concurrent Supercomputing Consortium's Policy Board. The Board is headed by Caltech astronomer Thomas A. Prince.

Other members of the consortium are Argonne National Laboratory, Argonne, Illinois; California Institute of Technology; Caltech's Jet Propulsion Laboratory, Pasadena, Calif.; Center for Research in Parallel Computation (lead center, Rice University, Houston); Defense Advanced Research Projects Agency (DARPA), Arlington, Va.; Intel Corporation, Beaverton, Ore.; National Science Foundation, Washington, D.C.; Pacific Northwest Laboratory, Richland, Wash.; Lawrence Livermore National Laboratory, Berkeley, Calif.; Los Alamos National Laboratory, Los Alamos, N. Mex.; Oak Ridge National Laboratory, Oak Ridge, Tenn.; Purdue University, West Lafayette, Ind. and Sandia National Laboratories, Albuquerque, N. Mex.

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11-13-90 For immediate release

West Lafayette, Ind. -- Purdue University researchers will gain access to the world's fastest, most powerful supercomputer to study and develop new techniques for computing.

Purdue is one of 14 research institutions to join together to form a supercomputing consortium aimed at designing and developing computing techniques for the future. Announcement of the consortium was made this morning (11/13) at a news briefing in New York City held in conjunction with the opening of a supercomputing conference.

Members of the Concurrent Supercomputing Consortium will use a new type of supercomputer which employs a technique called parallel computing to handle massive computational problems.

The system is made up of a large of number of individual processors that are capable of operating simultaneously -- or in parallel -- to carry out more than one operation at one time.

"Parallel supercomputing is now moving from the research phase to practical applications," said John Rice, head of Purdue's Department of Computer Sciences. "By the year 2000, all our engineers and scientists will use parallel machines, and membership in this consortium will keep Purdue at the forefront of supercomputing.

The computer system, called the Touchstone Delta System, was developed by the Supercomputer Systems Division of Intel Corporation. It will be installed next spring at the California Institute of Technology.

"The Intel Delta machine will be the world's most powerful computer," Rice said. "By having access to this system, Purdue researchers will have the opportunity to move their computational projects to the next generation of supercomputers."

The system will allow Purdue researchers to develop new techniques for parallel computing, and to find ways to apply parallel computing to solve real-life problems, said John Steele, director of Purdue's Computing Center.

He predicted that it will be late next summer before the supercomputer and access to it by universities will be complete.

Steele noted the link to the new supercomputer will be used only by a handful of researchers at Purdue.

"The consortium was designed to study and develop new ways of computing," he said. "It will not substantially affect or reduce the need for supercomputing facilities for general research at Purdue. It will be years before researchers in other disciplines will have access to the network."

Partners of the consortium include: Argonne National Laboratory; California Institute of Technology; Caltech's Jet Propulsion Laboratory; the Center for Research in Parallel Computation, a National Science Foundation Science and Technology Center; Defense Advanced Research Projects Agency; Intel Corporation's Supercomputer Systems Division; the National Aeronautics and Space Administration; the National Science Foundation programs in computational science and engineering; and Pacific Northwest Laboratory.

In addition to Purdue, members of the consortium include: Lawrence Livermore National Laboratory; Los Alamos National Laboratory; Oak Ridge National Laboratory; and Sandia National Laboratories.

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SACRAMENTO BEE
11-13-90

Caltech buying Intel supercomputer

New York Times

A consortium of 14 U.S. research institutions led by the California Institute of Technology is scheduled to announce today that it will purchase a custom-designed supercomputer from Intel Corp. to help solve a series of scientific "grand challenges."

The project, known as the Concurrent Supercomputing Consortium, is one of the most significant endorsements to date of a style of computing known as parallel processing, which chains together many processors and breaks up problems to solve them more quickly.

Supercomputers, described as the fastest systems available at any particular time, are used for scientific research and engineering design. The market for supercomputers has been growing rapidly in recent years and they are now widely used in industries as diverse as petroleum, aerospace, pharmaceuticals, media and entertainment.

The machine, called the Delta System, is based on an array of 528 Intel i860 microprocessors, which are designed to perform mathematical operations at high speed.

Intel officials said that once the machine is installed at Caltech in the spring it would be the world's fastest computer, but the claim drew skeptical reaction from a number of the company's competitors.

"We're thinking of it as a yawn," said Charles M. Grassl, a competitive analyst at Cray Research Corp. "Has it been tested? We think it's a paper announcement at this point."

Exact cost figures for the new computer were not made public.

SAN JOSE MERCURY NEWS
11-13-90

Intel supercomputer to tackle 'grand challenges'

New York Times

A consortium of 14 U.S. research institutions led by the California Institute of Technology is scheduled to announce today that it will purchase a custom-designed supercomputer from Intel Corp. to help solve a series of scientific "grand challenges."

The project, known as the Concurrent Supercomputing Consortium, is one of the most significant endorsements yet of a style of computing known as parallel processing, which chains together many processors and breaks up problems to solve them more quickly.

The machine, whose design is an outgrowth of several research projects backed by the Defense Advanced Research Projects Agency, or DARPA, will be used in areas like modeling global climate changes and complex chemical reactions; visualization of scientific data from the Magellan and Galileo spacecraft; and military research.

Supercomputers — the fastest systems available at any particular time — are used for scientific research and engineering design.

Analysts said the research leading to the development of the new massively parallel machine is a vindication for the defense agency and for the value of its research for U.S. high-technology companies.

The agency has been criticized by some in the Bush administration for supporting research designed to back specific technologies and companies threatened by international competition.

"This represents an absolute triumph for DARPA and its work in supercomputers," said James Magid, a computer industry analyst at Needham & Co.

The machine, called the Delta System, is based on an array of 528 Intel i860 microprocessors, which are designed to perform mathematical operations at high speed.

The design of the new computer is based in part on the work of a research group led by Caltech computer scientist Charles Seitz. The group has developed a specialized chip that is used to route information efficiently among different processors.

Intel officials said that once the machine is installed at Caltech in the spring it would be the world's fastest computer, but the claim drew skeptical reaction from a number of the company's competitors.

"We're thinking of it as a yawn," said Charles M. Grassl, a competitive analyst at Cray Research Corp. "Has it been tested? We think it's a paper announcement at this point."

Cray, which makes the machines that are generally credited with being the world's fastest, has been increasingly beset by contenders claiming to outperform its systems.

Cray has acknowledged the importance of parallel computing and has recently raised the priority of its effort in that area.

Intel officials said that the peak performance of the Delta would be 32 gigaflops, or billions of mathematical operations a second.

Exact cost figures for the new computer were not made public, but Intel executives said a commercial version of such a system would cost $15 million to $20 million.

The Delta computer will be focused on the largest problems that are beyond the scope of conventional computing, said Paul Messina, a computer scientist who is director of the project at Caltech.

"We don't see this as an experimental machine; we have applications that are ready and waiting to use," he said.

'This represents an absolute triumph for DARPA and its work in supercomputers.'

— James Magid, a computer industry analyst at Needham & Co.

THE OREGONIAN 11-13-90

Intel says computer to be fastest

☐ The machine will do enormous California Institute of Technology jobs

By RICHARD COLBY
of The Oregonian staff

An Oregon unit of Intel Corp. is making what it says will be the world's fastest computer, called the Touchstone Delta, for a scientific consortium based at the California Institute of Technology.

Consortium members' scientists will use the $15 million-plus Touchstone Delta for immense numerical tasks, including modeling the global climate and simulating climate changes, creating topographical maps of Mars and Venus from spacecraft data and recognizing chemical sequences in human genes.

Justin Rattner, technology director for Intel's Supercomputer Systems Division in Beaverton, said the Touchstone Delta will be rated at 32 gigaflops — equal to adding or multiplying two 16-digit numbers 32 billion times a second.

The computer will contain 528 of Intel's i860 microprocessing chips that share — and thus greatly speed up — immense computing tasks, Rattner said.

Another Washington County company, Ncube Inc., in mid-1989 announced itself capable of building a machine that would perform mathematical calculations at 27 gigaflops.

Ncube has not announced any sales of such a machine. Ncube officials couldn't be reached for comment Monday.

Japan's NEC also has said it has a 22-gigaflop device on the drawing board.

The Touchstone Delta will be formally announced in New York on Tuesday, during Superconducting '90, an annual trade show for the super-fast computing industry.

The Intel machine is expected to be assembled by Dec. 31 and to undergo tests by January, Rattner said. It is scheduled for installation at California Institute of Technology by April, he said.

Touchstone Delta will be used by the newly formed consortium of U.S. scientific institutions including the California institute and its affiliated Jet Propulsion Laboratory in Pasadena, Calif.

Other consortium partners include the Argonne National Laboratory, the National Aeronautics and Space Administration and the National Science Foundation.

"We were just extremely flattered that they chose to work with us," Robert Rockwell, the Intel division's general manager, said Monday of the consortium.

Rockwell said the Touchstone Delta could analyze data gathered by the Voyager space probes, for example, to produce clearer pictures of the character of the planets than would otherwise have been possible.

The Intel supercomputer division's Touchstone Project was given $7.6 million research money last year by the Defense Advanced Research Projects Agency to develop superfast computers.

Rattner said the Touchstone Delta's reputation as the world's fastest computer should be eclipsed by December 1991, when Touchstone Sigma, with 2,000 microprocessors, is scheduled for test operation. That machine should reach a peak speed of 150 gigaflops, he said.

Caltech computer a boost for science

STAR NEWS November 13, 1990

By Annette Kondo
Staff Writer

PASADENA — A supercomputer said to be the most powerful in the world — capable at top speed of crunching 32 billion arithmetic operations per second — will be installed at Caltech this spring.

The purchase of the computer by a 14-member research consortium was announced this morning at a New York supercomputer show. The model, a Touchstone Delta System from Intel Corp., was acquired by the Concurrent Superconducting Consortium, which includes Caltech and Jet Propulsion Laboratory. Future users say the computer will tackle complex projects at enormous speed.

"Knowledge not currently available because of the limits of current computer speeds will suddenly become available," said Aron Kuppermann, a Caltech professor of chemical physics. "In a couple of years we will be able to understand some scientific phenomena that have not been previously understood."

As an example, Kuppermann said, the Delta will allow researchers to predict the rates of all chemical reactions between atoms and a diatomic molecules (a molecule with two atoms).

To calculate such reactions on a Cray supercomputer, one of the most popular models on the market, could take up to 10 years, Kuppermann said. The Delta should be able to crunch out the data in about a month.

All fields of science will benefit significantly from this increased computing power, Kup-

See COMPUTER/ Page A-2

Computer

Continued from Page A-1

permann added. Caltech officials said the new supercomputer could be used to aid in atmospheric modeling, to recognize DNA sequences and to visualize data returned from space probes.

The Delta has been in development at Intel for about four years, Intel spokesman Mike Bernhardt said. While other supercomputer makers have claimedto produce the world's most powerful computer, Bernhardt said the Delta is the first computer to provide a peak speed of 32 "giga-FLOPs." A giga-FLOP is equal to 1 billion floating-point, or arithmetic, operations per second.

Caltech and Intel collaborated on the research and development of the Delta with funding from Defense Advanced Research Projects Agency (DARPA).

Bernhardt said the Delta's power comes from its 528 numeric processors, which work simultaneously. He called the acquisition of the Delta by the consortium "the most significant event in supercomputing in two decades."

"All the real leaders in high-performance computing will be working on the same resource," he said.

In addition to Caltech and JPL, the consortium includes DARPA, NASA, Lawrence Livermore National Laboratory, Los Alamos National Laboratory and Oak Ridge National Laboratory.

Researchers are excited about being able to make the leap from hypothesis to conclusion with the new supercomputer.

In the field of combustion, Kuppermann explained, most chemical reaction rates are not known, and present experiments have not been able to measure them. The Delta, however, allows scientists to predict rates and possibly increase combustion.

"We will have the ability to predict even without having the ability to measure," he said. "It allows us to understand the phenomena."

WASHINGTON POST
11-13-90

Intel Corp. plans to announce today that it will deliver the world's fastest supercomputer to the California Institute of Technology. A group of 14 universities and federal labs and agencies will join forces to tackle complex scientific problems on the machine.

Joubil Inc. plans to close its Danville, Va., blue jeans factory in January because of a lack of orders. The plant has 105 employees.

Intel to raise the curtain on fast parallel supercomputer

BY J. A. SAVAGE
CW STAFF

BEAVERTON, Ore. — Intel Scientific Computers will unveil a parallel supercomputer tomorrow that may be the fastest machine available, according to developers and analysts.

The computer will have more than 500 Intel I860 reduced instruction set computing processors in a hypercube architecture and will run at a theoretical 20G floating-point operations per second (FLOPS), according to Jeff Canin, an independent consultant in San Francisco. Intel's earlier machines were capable of a theoretical peak of 7.6G FLOPS with 128 processors. The older machines were also rated at 4,224 million instructions per second (MIPS). No MIPS rating was available for the new computer.

"No applications will be able to harness all that power, but they are constructing the computer," Canin said.

The difficulty with harnessing the potential power is that at this point, nearly all applications for parallel computers must be custom-made to break up a problem so that a part of it runs on each of the processors. Efforts to write such code are being undertaken at Intel as well as in academic settings.

The computer will be owned by a consortium of academic, private and government users and will reside at the California Institute of Technology in Pasadena, Calif., analysts said.

Intel has said it is working on technology to allow speeds of one trillion FLOPS. It is growing out of the $27 million Touchstone project, which derives approximately one-third of its funding from the Defense Advanced Research Projects Agency and the remainder from Intel, according to Benjamin Peek, associate director at the Oregon Advanced Computing Institute.

ELECTRONIC ENGINEERING TIMES
11-12-90

Intel to deliver 30-Gflops machine

Beaverton, Ore. — Intel's Supercomputer Systems Division is expected to announce this week delivery of its highest-performance iPSC/860 supercomputer to the California Institute of Technology in Pasadena.

The 512-node hypercube architecture will operate at 30 Gflops by using four times as many i860 chips as do current-generation products. The company recently introduced compilers and software packages for the iPSC/860 supercomputers that will triple the machine's performance. Other announcements at the Supercomputing '90 show in New York are expected to include a move to mesh topology for Intel's next-generation products.

On a parallel course, Intel is delivering to Carnegie-Mellon University (Pittsburgh) two iWARP systolic-array machines, VLSI versions of the WARP architecture that originally was developed at CMU. The first delivery consists of an 8 × 8 torus of iWARP processors operating at 1.28 Gflops. That will be extended to à machine consisting of a 32 × 32 torus, running at 20.48 Gflops.

FORT LAUDERDALE SUN SENTINEL
11-12-90

Intel prepares to introduce world's fastest supercomputer

The Associated Press

As competition heats up to make the speediest computers to solve the biggest problems in science, Intel Corp. is poised to introduce what the company says is the world's fastest supercomputer.

Supercomputer fever, spurred on by Pentagon financing in many cases, is getting hotter as researchers look for ways to apply the machines that can speed up medical research and help create "smart" bombs, among other uses.

"If we can make microprocessors smaller and faster, they would be very useful for advanced weapons systems," Pentagon spokeswoman Jan Bodanyi said. "They will be the ultimate weapons system. Once we get supercomputers down to soup-can size, we can put them on missiles."

Industry analysts warn, however, that despite the push to create supercomputers that can handle more information at one time and at mind-boggling speeds, the real challenges are to harness that power, to maintain top speeds and to make the systems even smaller and cheaper.

"There aren't many people out there who can afford to pay $25 million to $30 million for a top-of-the-line supercomputer," said Christopher Willard, senior industry analyst at San Jose-based DataQuest. "Another problem is actually getting and using the full power of the highly parallel computers. It's hard to deliver and sustain the full power."

Officials at Santa Clara-based Intel have refused to release information on the company's new supercomputer before a formal announcement at an industry conference in New York scheduled for Tuesday. The California Institute of Technology at Pasadena, where the supercomputer will be installed, also has refused to comment.

Intel, which invented the microprocessor, is an industry leader in chip design and manufacture. Its new supercomputer will use 512 of the company's powerful i860 chips.

A parallel system links separate microprocessors to create the supercomputer, which in Intel's case would reportedly reach speeds of up to 32 GigaFLOPs, or 32 billion floating-point operations per second — the customary measure of a computer's ability to crunch numbers and information.

The Intel supercomputer will reportedly be used for research, including study of how to better apply such huge computer brains.

LIMA NEWS
11-12-90

Super supercomputer on the horizon

SAN FRANCISCO (AP) – As competition heats up to make the speediest computers to solve the biggest problems in science, Intel Corp. is poised to introduce what the company says is the world's fastest supercomputer.

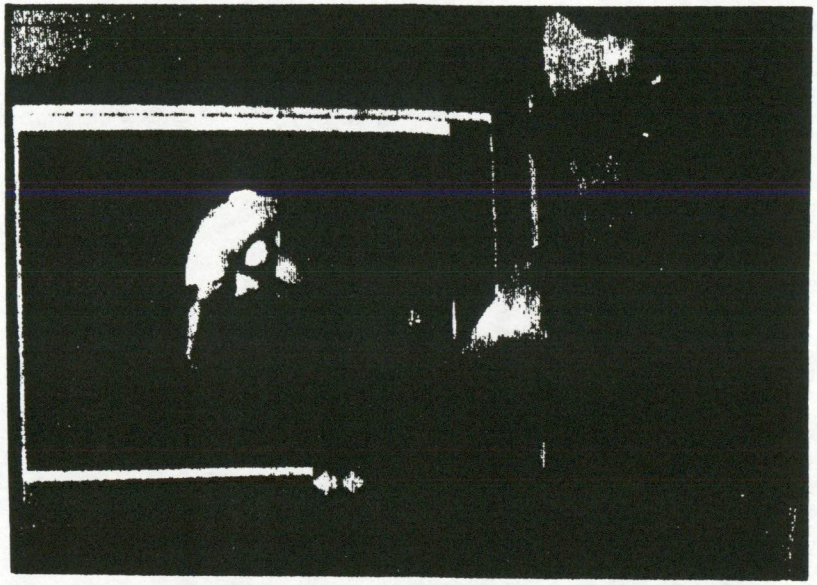
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Charlie Bender with OSU supercomputer

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Skeptics, including Intel's competitors NCube of Beaverton, Ore., and Cray Research Inc. of Minneapolis, wonder if the new machine can actually reach that computation speed even for simple problems.

"No supercomputer can maintain that type of speed," said Charles Grasfl, marketing analyst for Cray, which dominates the supercomputer market. "I want to know what it can do. Where's the breakthrough?"

One analyst compared supercomputers to using 10,000 rabbits to plow a field instead of four horses; the rabbits may have more total energy, but controlling that power is difficult. Still, scientists continue to try.

> Think of a supercomputers to using 10,000 rabbits to plow a field instead of four horses; the rabbits have energy, but control is difficult.

"What's fascinating about supercomputers is what people will be able to achieve one day," said Abbie Kendall, spokeswoman for NCube. "Right now we're on the edge of technology."

In mid-1989, NCube introduced its supercomputer, which at 27 GigaFLOP was the world's fastest. The company is working on a quicker model.

The Intel supercomputer will reportedly be used for research, including study of how to better apply such huge computer brains.

"Supercomputers still have a long way to go in terms of use for the average programmer," said DataQuest's Willard. "The application, I think, will come from not what the system's top configuration can do but with what its smaller chunks can accomplish.

"Now, the marketplace is limited to universities, military, NASA ... What they need to do is some supercomputing for more mundane uses."

COLORADO SPRINGS
GAZETTE TELEGRAPH

11-11-90

Competition stiffening for supercomputers

Intel Corp. says it plans 'world's fastest' machine

By **Laura Myers**
Associated Press

SAN FRANCISCO — As competition heats up to make the speediest computers to solve the biggest problems in science, Intel Corp. is poised to introduce what the company says is the world's fastest supercomputer.

Supercomputer fever, spurred on by Pentagon funding in many cases, is getting hotter as researchers look for ways to apply the machines that can speed up medical research and help create "smart" bombs, among other uses.

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(BLOOMINGTON) THE PANTAGRAPH
11-11-90

High-tech companies competing for speediest supercomputer

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"There aren't many people out there who can afford to pay $25 million to $30 million for a top of the line supercomputer," said Christopher Willard, senior industry analyst at San Jose-based DataQuest. "Another problem is actually getting and using the full power of the highly parallel computers. It's hard to deliver and sustain the full power."

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One analyst compared supercomputers to using 10,000 rabbits to plow a field instead of four horses; the rabbits may have more total energy, but controlling that power is difficult. Still, scientists continue to try.

"What's fascinating about supercomputers is what people will be able to achieve one day," said Abbie Kendall, spokeswoman for NCube. "Right now we're on the edge of technology."

In mid-1989, NCube introduced its supercomputer, which at 27 GigaFLOP was the world's fastest. The company is working on a quicker model.

The Intel supercomputer will reportedly be used for research, including study of how to better apply such huge computer brains.

"Supercomputers still have a long way to go in terms of use for the average programmer," said DataQuest's Willard. "The application, I think, will come from not what the system's top configuration can do but with what its smaller chunks can accomplish.

"Now, the marketplace is limited to universities, military, NASA ... What they need to do is some supercomputing for more mundane uses."

(BINGHAMTON) PRESS & GUN BULLETIN
11-11-90

Supercomputer fever: Catch it

SAN FRANCISCO (AP) — As competition heats up to make the speediest computers to solve the biggest problems in science, Intel Corp. is poised to introduce what the company says is the world's fastest supercomputer.

Supercomputer fever, spurred on by Pentagon funding in many cases, is getting hotter as researchers look for ways to apply the machines that can speed up medical research and help create "smart" bombs, among other uses.

"If we can make microprocessors smaller and faster, they would be very useful for advanced weapons systems," Pentagon spokeswoman Jan Bodanyi said. "They will be the ultimate weapons system. . . . Once we get supercomputers down to soup-can size we can put them on missiles."

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NCube hasn't sold its top-of-the-line, $20 million supercomputer yet, but Kendall said the private company expects to sell one by mid-1991.

Now, she said, NCube sells smaller parallel systems that can do more work faster than regular computers. A drug company, for example, gets results in three to four hours about molecule configurations for new manufactured drugs instead of the three months such a computation took previously.

(ONTARIO) INLAND VALLEY DAILY BULLETIN
11-10-90

High-tech companies compete to make faster supercomputers

Associated Press

SAN FRANCISCO — Supercomputer dreamers look forward to when the machines that now fill entire rooms will fit into a soup can and still solve the most complex problems of science within seconds.

But for now, those visionaries are content to build better and faster supercomputers that, like fancy sports cars, can take scientific roads at peak speeds and ride problem curves in smooth style.

"Right now, we're still working on the technology, but the parallel supercomputers are getting so fast and so much smaller that just about anything seems possible," said Jan Bodanyi, a spokeswoman for the Pentagon, which has given private companies $32 million to develop supercomputers.

Santa Clara-based Intel Corp., which worked with the Pentagon on project Touchstone, is the latest supercomputer developer and plans next week to unveil what the company says will be the world's fastest model.

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(MARYSVILLE) APPEAL-DEMOCRAT
11-9-90

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FRESNO BEE
11-9-90

Intel leads race to create the fastest supercomputer

By LAURA MYERS
Associated Press

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OAKLAND TRIBUNE
11-9-90

High-tech companies poised to build faster computers

By Laura Myers
The Associated Press

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(PALO ALTO) TIMES TRIBUNE
11-9-90

Intel to announce 'fastest'

High-tech companies compete to create best supercomputers

ASSOCIATED PRESS
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SALINAS CALIFORNIAN
11-9-90

High-tech firms vie to make fastest supercomputer

The Associated Press

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SAN JOSE MERCURY NEWS
11-9-90

Intel readies 'fastest' supercomputer

Machine to use 512 powerful chips

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SANTA CRUZ SENTINEL
11-9-90

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The Associated Press

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■ *Chips give desktop video boost — Page D2*

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ATLANTA CONSTITUTION
11-8-90

INTEL TO UNVEIL SUPERCOMPUTER: Intel Corp. is expected to unveil the fastest supercomputer ever sold next week, industry analysts said Wednesday.

Andrew Grove, Intel's chief executive officer, said last month that Intel had received its largest supercomputer order ever. Analysts said that the buyer is the California Institute of Technology in Pasadena and that the order is worth $10 million.



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BALTIMORE SUN
11-8-90

Intel supercomputer

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Analysts said the customer is the California Institute of Technology in Pasadena, Calif., and that the order is worth $10 million.

FINANCE AND COMMERCE
11-8-90

World's Fastest Supercomputer To Be Unveiled

SANTA CLARA, Calif. UPI

Intel Corp. plans to announce next week the development of a powerful supercomputer that could be the fastest in the world, the San Francisco Chronicle reported Wednesday.

The experimental computer will be built by Intel's supercomputer operation in Beaverton, Ore., and will be installed at the California Institute of Technology in Pasadena, Calif., where it was expected to be made available to researchers around the globe, the San Francisco Chronicle reported.

The machine is based on an emerging technology known as "parallel processing," which uses hundreds of microprocessors working together to solve complex scientific problems.

The machine will have a theoretical top speed of 30 billion so-called floating-point operations a second, a standard measure of a computer's speed at complex number-crunching. That compares with 27 billion operations a second claimed by NCube, an Oregon supercomputer company that has yet to sell a machine that powerful.

"It's arguably the highest-performance supercomputer anybody has ever shipped in the industry," Andy Grove, Intel's chief executive officer, told analysts Oct. 26.

The Defense Department has invested in parallel processing technology as a key component of future defense systems. Parallel processing would be used for such tasks as breaking codes and simulating the effects of nuclear explosions. The Defense Advanced Research Projects Agency has spent at least $32 million to foster developments in the technology by private companies.

Intel's machine reportedly links together up to 512 of Intel's powerful i860 microprocessors. Intel's most powerful machine to date uses 128 of the speedy chips.

Intel was expected to introduce the machine next Tuesday at a supercomputer conference in New York, the Chronicle reported.

HOUSTON POST
11-8-90

Supercomputer from Intel on tap

REUTER NEWS SERVICE

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Intel has scheduled a news conference next Tuesday in New York at which it is expected to unveil the machine. A spokeswoman declined to comment on the topic of the news conference.

Intel's new machine is expected to use multiple microprocessors, making them extremely fast for complex scientific applications. Typically, supercomputers use a single microprocessor.

The Intel supercomputer is based on the company's i860 microprocessors and can operate at 30 billion floating-point operations per second, a measurement that refers to the speed at which the scientific and mathematic data is processed.

"That thing is a barn burner," said Andrew Kessler, an analyst at Morgan Stanley & Co.

(SANTA ANA) ORANGE COUNTY REGISTER
11-8-90

Intel expected to unveil fastest supercomputer

Reuters

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Intel employs about 1,500 workers at its Folsom plant, which develops and markets memory components and microprocessors.

SAN ANTONIO LIGHT
11-8-90

World's fastest supercomputer to be unveiled by Intel Corp.

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WASHINGTON TIMES
11-8-90

Intel's speediest out soon

SAN FRANCISCO — Intel Corp. is expected to unveil next week the fastest supercomputer ever marketed, industry analysts said yesterday. "That thing is a barn burner," said Andrew Kessler, an analyst at Morgan Stanley & Co., referring to the company's expected new supercomputer. "They can really crank up the speed."

SAN FRANCISCO CHRONICLE 11-7-

Intel to Unveil World's Fastest Supercomputer

By Don Clark
Chronicle Staff Writer

Intel Corp. next week will announce the development and installation of what appears to be the world's fastest supercomputer, The Chronicle has learned.

The $10 million machine will be built by the Santa Clara-based chipmaker's supercomputer operation in Beaverton, Ore., and installed at the California Institute of Technology in Pasadena. It is expected to be made available for use by researchers around the country who need massive computing power to solve scientific problems.

Industry experts familiar with the machine say that it represents a significant advance for so-called massively parallel computers. Unlike conventional supercomputers, the parallel systems yoke together many separate microprocessors to produce blinding speed.

Intel and Caltech are not strangers. Intel, which produced its first parallel supercomputer in 1985, has long built its machines around a Caltech design called the Hypercube.

Such machines are widely seen as vital to national defense, particularly for simulating the effects of nuclear explosions and breaking codes. The Defense Advanced Research Projects Agency has spent at least $32 million to spur development of parallel supercomputers at private companies.

The new Intel system is an early result of a DARPA-supported project called Touchstone, as well as Caltech research on new ways to efficiently hook microprocessors together. Where Intel's biggest machine in the past used 128 of the company's i860 microprocessors, the new system will feature up to 512 of the powerful chips.

The new supercomputer will have a theoretical top speed of 30 billion so-called floating-point operations per second — the customary measure of a computer's ability at complex number-crunching. That would be faster than the 27-billion mark claimed for the biggest machines offered by NCube, another Beaverton-based company — which, however, has never sold one that powerful.

"It's arguably the highest-performance supercomputer anybody has ever shipped in the industry," said Andy Grove, Intel's chief executive, during a meeting with analysts on October 25.

Grove wouldn't discuss details. He did say that the order was the company's largest ever for supercomputers. An Intel spokesman declined comment pending a formal announcement scheduled for Tuesday at a supercomputer-industry conference in New York.

Claims about the speed of parallel supercomputers have to be taken with a grain of salt. Programming problems often make parallel machines run slower than conventional machines from companies such as Cray Research Inc.

For example, NASA Ames Research Center says that its 128-processor Intel system runs only about as fast as a single processor of Cray's Y-MP system, which is rated as a slower system.

"A lot of the bottlenecks we are seeing on our machine will not be there on the new machine," said Horst Simon, a manager with Computer Sciences Corp., who works at NASA Ames. "This is the first real leap in terms of the technology in the last two years."

"It certainly is an impressive step forward for Intel, which has been kind of in the shadows in the supercomputer business until recently," said J. Richard Sherman, president of Research Consortium Inc., a Minneapolis-based company that studies supercomputer use. "It's a sign we can expect a more aggressive posture from them."

Sources described the new machine as a research tool. It would both demonstrate the feasibility of the new design and help scientists learn how to make the best use of such machines. A commercial version of the system is not expected until Intel produces a successor to the i860 chip.

"The most interesting feature is who will use it and how many researchers will have access to it," said Gary Smaby, a supercomputer-market analyst in Minneapolis.

ELECIRONIC NEWS
10-29-90

■ A contract worth what sources say is "$15-$20 million" has been picked up by Intel Scientific Computers to develop an 860-based system that will have more than "four times" the MPUs than its current iPSC/860 machine, a 128-processor, 7.6Gflops system. The firm expects to disclose details on Nov. 13 at the Supercomputing '90 conference in New York. The contract reportedly was awarded by the California Institute of Technology in concert with Rice University and others.

REFERENCE LISTING OF ARTICLES RELATED TO
THE CONCURRENT SUPERCOMPUTING CONSORTIUM AND
THE INTEL TOUCHSTONE DELTA SYSTEM

CSC-aaa-90
AAAS
World's fastest computer
Science
November 30, 1990
Page 1203
one figure

CSC-ant-90
Gary H. Anthes
Tackling systems tasks in tandem
ComputerWorld
December 10, 1990

CSC-app-90
staff writer
High-tech firms compete to build faster computers
Appeal-Democrat (Marysville)
November 9, 1990
one page

CSC-arg-90
staff writer
ANL helps buy world's fastest computer
Argonne Week
December 10, 1990
half page

CSC-atl-90
staff writer
Intel to unveil supercomputer
Atlanta Constitution
November 9, 1990
3 paragraphs

CSC-bal-90
staff writer
Intel supercomputer
Baltimore Sun
November 8, 1990
3 paragraphs

CSC-bla-90
staff writer
Supercomputer battle heats up
Blade-Citizen
November 12, 1990
half page

CSC-bor-90
Stu Borman
Consortium forms to use "fastest" supercomputer
Chemical and Engineering News
December 10, 1990
one page

CSC-bus-90
staff writer
Intel works on another supercomputer

The Business Journal
December 9, 1990
half page

CSC-che-91
staff writer
Concurrent Supercomputing Consortium acquires Touchstone Delta System
Chemical Design Automation News
Volume 6, No. 1
January 1991
one page

CSC-cla-90
Don Clark
Intel to unveil world's fastest supercomputer
San Francisco Chronicle
November 7, 1990
one page

CSC-col-90
Richard Colby
Intel says computer to be fastest
The Oregonian
November 13, 1990
half page

CSC-cos-90
Terry Costlow
Group to study Touchstone
Electronic Engineering Times
November 19, 1990
half page

CSC-cosp-90
staff writer
Consortium expected to buy computer
Colorado Springs Gazette
November 13, 1990
one column

CSC-dai-90
staff writer
Intel to make fastest computer
Daily Journal of Commerce
November 14, 1990
6 paragraphs

CSC-dye-90
Lee Dye
Caltech to be home for most powerful research computer
Los Angeles Times
November 13, 1990
page B3

CSC-edp-90
staff writer
Intel supercomputer goes to caltech-based consortium of scientific laboratories
EDP Weekly
November 19, 1990

CSC-ele-90
staff writer
Intel to deliver 30-Gflops machine
Electronic Engineering Times
November 12, 1990

3 paragraphs

CSC-eln-90
staff writer
A contract worth what sources say is $15-$20 million...
Electronic News
October 29, 1990
one paragraph

CSC-euc-90
staff writer
Intel plans parallel supercomputer
Eu-Claire Leader-Telegram
November 13, 1990
7 paragraphs

CSC-for-90
staff writer
Intel prepares to introduce world's fastest supercomputer
Fort Lauderdale Sun Sentinel
November 12, 1990
half page

CSC-fin-90
staff writer
World's fastest supercomputer to be unveiled
Finance and Commerce
November 8, 1990
one column

CSC-gul-90a
Karen Gullo
Concurrent Supercomputing Consortium formed
The Spang Robinson Report on High Performance Computing
Volume 4, No. 12
December 1990
page 2-5

CSC-gul-90b
Karen Gullo
The Touchstone Delta
The Spang Robinson Report on High Performance Computing
Volume 4, No. 12
December 1990
page 5-8

CSC-hil-91
Richard H. Hill
Supercomputer means not just Cray alone
The New York Times
January 2, 1991
one column

CSC-hou-90
staff writer
Supercomputer from Intel on tap
Houston Post
November 8, 1990
one column

CSC-hun-90
staff writer
Purdue in consortium tackling supercomputing
Huntington Herald Press
November 25, 1990
half page

CSC-inf-90
staff writer
Computing Touchstone
November 19, 1990
one paragraph

CSC-int-90
Intel
Transcription of remarks by members of the Concurrent Supercomputing Consortium. Supercomputing '90 Press Conference.
November 13, 1990
18 pages

CSC-int-91
Intel
Announcing the fastest computer in the world
Inteleads
January 1991
page 12

CSC-inv-90
staff writer
Intel Corp. announces sale of supercomputer
Investor's Daily
November 14, 1990
3 paragraphs

CSC-jou-90
staff writer
Richland lab to use world's fastest computer
Journal of Business
December 19, 1990
half page

CSC-jpl-90
JPL
Press Release
November 13, 1990
3 pages

CSC-kon-90
Annette Kondo
Caltech computer a boost for science
Star News
November 13, 1990
6 paragraphs

CSC-kwa-90
Holly Kwan, anchor; Peter John Schuller, reporting
Intel Corporation today announced...
KQED-FM Radio NEWS (San Francisco)
November 13, 1990 (5:30 p.m.)

CSC-lan-90
staff writer
Companies compete to create faster supercomputers
Lancaster Intelligencer Journal
November 21, 1990
one page

CSC-leb-90
staff writer
Purdue in consortium for supercomputer use
Lebanon Reporter
November 14, 1990

half page

CSC-lim-90
staff writer
Super supercomputer on the horizon
Lima News
November 12, 1990
one page

CSC-mar-90a
John Markoff
Consortium to buy Intel supercomputer
The New York Times
November 13, 1990
page D1 & D5

CSC-mar-90b
John Markoff
Technology at hand for new generation of supercomputers
San Francisco Chronicle
November 26, 1990
one page

CSC-mars-90
Carolyn Duffy Marsan
Group orders Intel parallel supercomputer
Federal Computer Week
November 19, 1990
one page

CSC-mart-90
S. Louis Martin
Supercomputer targets 32 Gflops
EDN
November 15, 1990
2 pages
2 photos

CSC-mod-90
staff writer
Super status for Caltech
The Modesto Bee
November 25, 1990
one column

CSC-mye-90a
Laura Myers
Intel leads race to create the fastest supercomputer
Fresno Bee
November 9, 1990
half page

CSC-mye-90b
Laura Myers
High-tech companies posed to build faster computers
Oakland Tribune
November 9, 1990
half page

CSC-mye-90c
Laura Myers
Competition stiffening for supercomputers
Colorado Springs Gazette Telegraph
November 11, 1990
half page

CSC-nas-90
NASA
NASA to use world's fastest supercomputer
NASA Press release
November 13, 1990
2 pages

CSC-ont-90
staff writer
High-tech companies compete to make faster supercomputers
Inland Valley Daily Bulletin (Ontario)
November 11, 1990
half page

CSC-ora-90
Intel expected to unveil fastest supercomputer
Orange County Register (Santa Ana)
November 8, 1990
5 paragraphs

CSC-pan-90
staff writer
High-tech companies competing for speediest supercomputer
The Pantagraph (Bloomington)
November 11, 1990
one page

CSC-pdn-90
staff writer
New supercomputer acquired by consortium that includes Jet Propulsion Lab
PD News
December 10, 1990
one page

CSC-pre-90
staff writer
Supercomputer fever: Catch it
Press & Gun Bulletin (Binghamton)
November 11, 1990
one page

CSC-pur-90
staff writer
Purdue University
Press release
November 13, 1990
two pages

CSC-qui-90a
Joshua Quittner
Call this a super-duper computer
Newsday (Long Island)
November 13, 1990
page 15
one figure

CSC-qui-90b
Joshua Quittner
Group buys fastest supercomputer
Newsday (New York)
November 13, 1990
one page

CSC-roa-90
staff writer
Rapid-fire computer to go on line

Roanoke Times & World-News
November 22, 1990
4 paragraphs

CSC-sac-90a
staff writer
Supercomputer from Intel
Sacramento Bee
November 8, 1990
three paragraphs

CSC-sac-90a
staff writer
Caltech buying Intel supercomputer
Sacramento Bee
November 13, 1990
7 paragraphs

CSC-sal-90
staff writer
High-tech firms vie to make fastest supercomputer
Salinas Californian
November 9, 1990
half page

CSC-san-90
staff writer
World's fastest supercomputer to be unveiled by Intel Corp.
San Antonio Light
November 8, 1990
2 columns

CSC-sanj-90a
staff writer
Intel readies "fastest" supercomputer
San Jose Mercury News
November 9, 1990
one page

CSC-sanj-90b
staff writer
Intel supercomputer to tackle "grand challenges"
San Jose Mercury News
November 13, 1990
one page

CSC-sant-90
staff writer
High-tech firms think supercomputers
Santa Cruz Sentinel
November 9, 1990
half page

CSC-sav-90
J. A. Savage
Intel to raise the curtain on fast parallel supercomputer
COMPUTERWORLD
November 12, 1990
page 143

CSC-sch-90
Kathe Schuckel
Purdue's strides recognized
Journal and Courier
November 3, 1990
page A1 & A6

CSC-smi-91
Norris Parker Smith
New consortium to run Intel Delta superparallel System
Supercomputing Review
January 1991
page 14

CSC-spa-90
staff writer
NASA joins consortium for supercomputer time
Space News
December 9, 1990
3 paragraphs

CSC-sup-90
staff writer
Intel Delta System to Caltech
Super Computer Network: The Newsletter for Supercomputer Users
November 1990
page 2-3

CSC-taf-90a
Darryl K. Taft
Supercomputer users hail Intel Corp.'s Delta System
Government Computer News
Volume 9, No. 25
November 26, 1990
2 pages
one figure

CSC-taf-90b
Darryl K. Taft
Fulfillment of Touchstone Goals Awaits Powerful Supercomputer
Government Computer News
??????? 1990
1 pages

CSC-tec-90
staff writer
Caltech establishes supercomputer group
TEC
Volume 1, No. 3
November 19, 1990
half page

CSC-tim-90
staff writer
Intel to announce "fastest"
Times Tribune (Palo Alto)
November 9, 1990
one column

CSC-wal-90b
staff writer
Intel, in coup, captures supercomputer contract
The Wall Street Journal--Europe
November 14, 1990
one column

CSC-wam-90
Dennis Wamsted
Supercomputer Consortium attracts DOE Lab
New Technology Week
December 3, 1990
one page

CSC-was-90
staff writer
Intel Corp plans to announce...
Washington Post
November 13, 1990
one paragraph

CSC-wast-90a
staff writer
Intel's speediest out soon
Washington Times
November 8, 1990
one paragraph

CSC-yod-90
Stephen Kreider Yoder
Intel to supply a supercomputer to group of labs
The Wall Street Journal (Southwest Edition)
November 13, 1990
page B5

CS-zuv-90
Marcelo M. Zuviria
Instalan la computadora mas poderosa del mundo
(The world's most powerful computer to be installed)
La Opinion (Los Angeles)
November 14, 1990

(2)

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Charles Seitz
Professor of Computer Science

(2)

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Tom Prince
Associate Professor of Physics

(1)



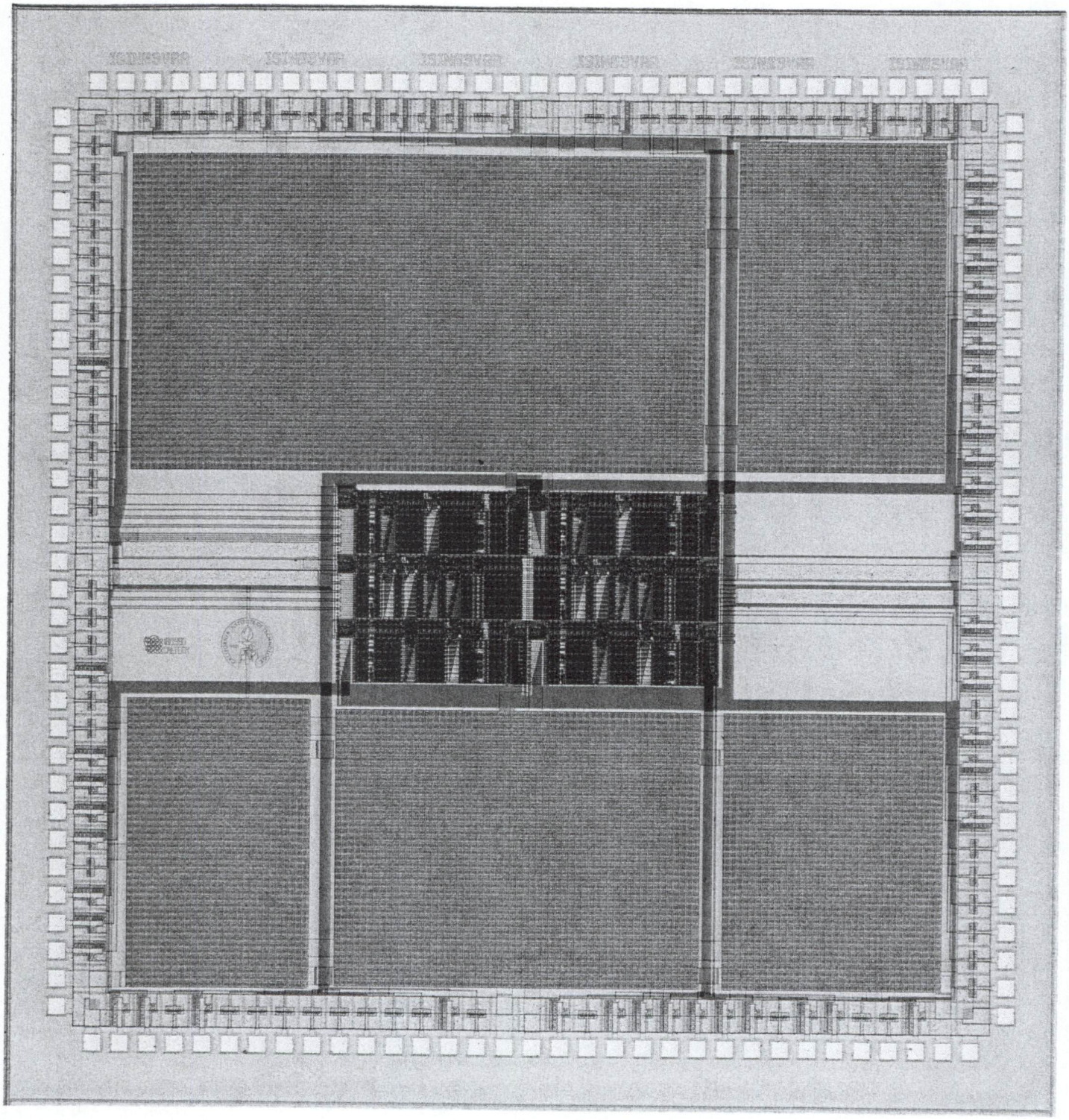
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Paul Messina
Executive Director of the CSC

(3)

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(4)

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Caption: This is a photomicrograph of the Touchstone Delta's custom mesh-routing chip, which was developed by a research group led by Caltech's Charles Seitz, professor of computer science. In actual dimension the chip is 4.5 millimeters square. The chip handles message packets much as a freeway exchange handles automobile traffic.

Photo Credit: Caltech

(4)

Bush Library Photocopy
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Seismology

at the

California
Institute of
Technology

ROBERT FINN
Staff Science Writer
Office of Public Relations

CALIFORNIA INSTITUTE OF TECHNOLOGY
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September 1990

A Profile of the California Institute of Technology

The California Institute of Technology is a small, independent university that carries on instruction and research in science and engineering, with a student body of 776 undergraduates and 1,012 graduate students. With an outstanding faculty, including several Nobel laureates, and such renowned off-campus facilities as the Jet Propulsion Laboratory and Palomar Observatory, Caltech has become one of the world's major research centers, focusing on those areas in which it has the faculty and facilities to excel.

Caltech sits on 124 acres in a residential section of Pasadena, California, a city of 135,000, 25 miles inland from the Pacific Ocean and 10 miles from downtown Los Angeles.

History

Caltech traces its origins to a local school of arts and crafts founded in 1891 by the Honorable Amos G. Throop and named, after him, Throop University. For almost two decades, this school served the Pasadena community, offering programs leading to a bachelor's degree, as well as providing an elementary school and an academy where the emphasis was on vocational training.

Astronomer George Ellery Hale, the first director of the Mount Wilson Observatory, who became a member of Throop's board of trustees in 1907, envisioned a wholly different future for the Institute. He saw it becoming an institution of engineering and scientific research of the highest rank, and under his leadership its transformation began.

By 1921 Hale had been joined by chemist Arthur A. Noyes and physicist Robert A. Millikan. These three men set the school--renamed the California Institute of Technology--firmly on its new course. They were dedicated to the development of exceptional research and instruction in engineering and the fundamental sciences of mathematics, physics, and chemistry, and to the enrichment of that curriculum with course work in the humanities.

For the next 66 years, Millikan, academic head of the Institute, and his successors, Lee DuBridge, Harold Brown, and Marvin Goldberger, led Caltech as it achieved the very best in scientific education and research. During this time new programs were added in geology, biology, aeronautics, astronomy, astrophysics, the social sciences, computer science, and computation and neural systems.

Under our current president, electrical engineer Thomas E. Everhart, Caltech remains the country's finest scientific university, recognized by *U.S. News & World Report* in their October 16, 1989 issue of "America's Best Colleges."

Officers

Ruben F. Mettler, Chairman
Thomas E. Everhart, President
James W. Glanville, Vice Chairman
William F. Kieschnick, Vice Chairman
Benjamin M. Rosen, Vice Chairman
Paul C. Jennings, Vice President and Provost
Lew Allen Jr., Vice President and Director, Jet Propulsion Laboratory
Theodore P. Hurwitz, Vice President for Institute Relations
Gary A. Lorden, Vice President for Student Affairs
David W. Morrisroe, Vice President for Business and Finance and Treasurer
Edward C. Stone, Vice President for Astronomical Facilities

Faculty

Professorial faculty number 314, with an additional 680 research fellows, visiting associates, and other faculty. The Caltech faculty has 63 members of the National Academy of Sciences and 25 members of the National Academy of Engineering. Four resident faculty are Nobel laureates, and 21 prizes in all have been won by Caltech faculty and alumni. One resident faculty member is a Crafoord laureate, and fifteen faculty members have been awarded the National Medal of Science. In fact, the first Medal of Science was presented to Caltech's Theodore von Kármán in 1962.

Off-Campus Facilities

Kresge Building, Seismological Laboratory, Pasadena (1928).

Kerckhoff Marine Biological Laboratory, Corona del Mar (1930).

Jet Propulsion Laboratory, Pasadena (1944). Administered by Caltech; owned and supported by the National Aeronautics and Space Administration.

Palomar Observatory, San Diego County (1948). Site of the 200-inch Hale Telescope.

Owens Valley Radio Observatory, Big Pine (1958).

Big Bear Solar Observatory, Big Bear Lake (1969).

Submillimeter Observatory, Mauna Kea, Hawaii (1986).

W. M. Keck Observatory, Mauna Kea, Hawaii (under construction). The 10-meter telescope to be housed there will be the world's largest optical telescope.

THE DIVISIONS

Biology

John N. Abelson, Chairman

33 professorial faculty
215 other faculty
110 graduate students (84 in biology; 26 in computation and neural systems)
40 undergraduates*

Chemistry and Chemical Engineering

Fred C. Anson, Chairman

36 professorial faculty
142 other faculty
212 graduate students (163 in chemistry, 49 in chemical engineering)
38 undergraduates* (18 in chemistry, 20 in chemical engineering)

Engineering and Applied Science

John H. Seinfeld, Chairman

102 professorial faculty
93 other faculty
401 graduate students (56 in aeronautics, 24 in applied mechanics, 16 in applied mathematics, 62 in applied physics, 12 in civil engineering, 32 in computer science, 117 in electrical engineering, 5 in engineering science, 42 in mechanical engineering, 14 in materials science, and 21 in environmental engineering science)
330 undergraduates* (12 in applied mathematics, 41 in applied physics, 115 in electrical engineering, and 162 in engineering and applied science)

Geological and Planetary Sciences

David J. Stevenson, Chairman

30 professorial faculty
60 other faculty
84 graduate students
15 undergraduates*

Financial information

1990/91 tuition: $13,300
1990/91 estimated operating budget: $200,900,000
(not including $1.1 billion Jet Propulsion Laboratory budget)

Endowment as of July 31, 1990: $522,000,000

Humanities and Social Sciences

David M. Grether, Chairman

38 professorial faculty
45 other faculty
18 graduate students
4 undergraduates*

Physics, Mathematics and Astronomy

Gerry Neugebauer, Chairman

75 professorial faculty
125 other faculty
187 graduate students (135 in physics, 27 in mathematics, 25 in astronomy)
140 undergraduates* (97 in physics, 36 in mathematics, 7 in astronomy)

*Numbers of undergraduates do not include the freshman class, which has 209 members.

Student statistics (as of April 1990)

776 undergraduate students
627 men
149 women (19%)

1,012 graduate students
827 men
185 women (18%)

Mean SAT scores of entering 1990 freshmen
Verbal 660
Math 750

Regional distribution of undergraduates:
53 percent Far West (35 percent from California)
15 percent Midwest
13 percent Northeast
13 percent South
6 percent Overseas

Number of alumni (as of September 1990)
17,218

CALTECH: ONE HUNDRED YEARS IN REVIEW
Pioneering Contributions from the California Institute of Technology

1. The Discovery of Anti-Matter.

In 1934, Caltech physicist Carl Anderson discovered the anti-electron, or positron, the first empirical proof for the existence of anti-matter. In addition to providing inspiration for decades of science fiction writers, Anderson's discovery permanently reshaped our view of the universe and opened major new avenues of investigation in modern physics. He was awarded the Nobel Prize in 1936.

2. The Nature of the Chemical Bond

What has been called the single most important discovery in the history of chemistry was made at Caltech in the 1930s by Linus Pauling. Pauling determined the nature of the chemical bond--how atoms link up to form molecules in both living and non-living systems. Up to that time, chemistry had essentially been a hit-or-miss proposition; Pauling's insight handed chemists a powerful new tool for both predicting and manipulating the outcome of chemical reactions. Major advances in chemistry and molecular biology, and the creation of hundreds of synthetic products, had their roots in this single discovery. Pauling won the Nobel Prize twice: for chemistry, and for peace.

3. The Foundations of Molecular Biology.

Between 1930 and 1960, a remarkable group of biologists at Caltech played a central role in creating the science of molecular biology. They included Thomas Hunt Morgan (1933 Nobel Laureate), whose studies of the relationship of chromosomes to heredity laid the foundations for much of modern biology, and George Beadle (1958 Nobel Laureate), who discovered much of what we now know about the chemical activity of genes. Beginning in the 1940s, Caltech's Max Delbruck, a physicist-turned-biologist, introduced the rigorous techniques of physics to the study of biology and made fundamental discoveries concerning the nature of viruses and viral disease. He received the 1969 Nobel Prize for his work.

4. The Birth of Modern Earthquake Science

Three Caltech scientists, working in the 1920s and early 1930s, played a pivotal role in developing seismology into an international science of earthquake study, detection, and measurement. Caltech geologist Harry Wood invented the first seismograph capable of recording vibrations from distant quakes; physicist Charles Richter and mathematician Beno Gutenberg invented the Richter Scale. This remarkable collaboration almost missed getting off the ground: Wood, who turned seismology from a provincial specialty into a global science, really only wanted to study quakes in southern California; Richter, a Stanford-trained scientist, was working in a warehouse when he wandered into a Caltech theoretical physics lecture and decided to switch professions; Gutenberg, a renowned European mathematician, almost didn't come to Caltech because his wife was worried about finding household help in southern California.

5. The Recommended Daily Adult Requirement.

The RDA of vitamins A, B, C, and D grew out of work carried out at Caltech in the 1930s and 40s by biologist Henry Borsook. His research led the government to establish the Recommended Daily Requirements for Human Nutrition.

6. The Smallest Building Blocks of Matter

In the early 1960s, Caltech physicist Murray Gell-Mann discovered that protons and neutrons--long considered the smallest building blocks of matter--are made up of even smaller particles, which Gell-Mann named quarks. Quarks were not discovered in the laboratory but at Gell-Mann's blackboard; their existence has since been verified experimentally. Their discovery opened up new avenues of research in subatomic physics, clarified the nature of the "strong force" that holds protons and neutrons together in the atomic nucleus, and pointed the way to a better understanding of what occurred in the first instants of the Big Bang, the explosion that gave birth to the universe. Gell-Mann received the Nobel Prize in 1969.

7. Left Brain/Right Brain.

It was at Caltech that psychobiologist Roger Sperry discovered that the left and right hemispheres of the brain are specialized for different capacities: the left brain for verbal thinking and language; and the right brain for spatial-visual thought. His work has had an incalculable impact in fields ranging from education to behavioral psychology to neurophysiology. Sperry was awarded the Nobel Prize in 1981.

8. The Dawn of the Aerospace Age.

The principles of modern aviation and jet flight grew out of work carried on at Caltech by Theodore von Karman, the head of Caltech's Graduate Aeronautical Laboratory (GALCIT) during the 1930s. At GALCIT, von Karman and his students developed the principles of airplane design and flight that helped get the aircraft industry off the ground and turned southern California into the aircraft capitol of the world. In the mid-1930s, off-campus experiments by several of von Karman's students led to the establishment in 1944 of the world-famous Jet Propulsion Laboratory--today the nerve center of America's unmanned space program, including the Pioneer, Mariner, Viking, and Voyager missions to explore the solar system.

9. The Age of the Earth and the Perils of Lead

That the earth has existed for 4.6 billion years was first determined around 1960 by Caltech geochemist Clair Patterson, through studies of the decay rate of lead isotopes in earth's oldest rocks. Patterson subsequently turned his attention from lead in rocks to lead pollution in the oceans and atmosphere. His demonstration that lead pollution from automobile exhaust had reached dangerously high levels was one of the factors in the U.S. government's decision to establish pollution controls within the auto industry. Patterson, and his determined and often lonely crusade against lead pollution, was made the basis of a fictional character in the Saul Bellow novel *The Dean's December*.

10. "We are Starstuff"

This phrase--a familiar one to viewers of the Carl Sagan series *Cosmos*--has much of its genesis in pioneering astrophysics research carried out for over three decades in Caltech's Kellogg Laboratory. There, a team of scientists, headed by the late Charles Lauritsen, demonstrated that nearly all the elements in the universe and in our bodies were originally cooked up inside stars. Kellogg physicist Willy Fowler was awarded the Nobel Prize in 1983 for his "studies of the nuclear reactions of importance in the formation of the chemical elements of the universe."

11. Probing the Secrets of the Universe

A leading British astronomer, Martin Rees, recently summed up Caltech's record in astronomy in this way: "The universe of astronomy has no center but the universe of astronomers does. For years that center has been in Pasadena, California." Among Caltech's major contributions: the first survey of the entire sky visible from the northern hemisphere (in 1948)--a survey that discovered thousands of new stars, galaxies, and comets and created an atlas of the heavens that astronomers the world over used for the next three decades. (A second Palomar sky survey is currently under way.) Palomar is also the home of the 200-inch Hale Telescope, since 1948 the largest and most powerful optical telescope in the Western hemisphere. Some of the most significant astronomical discoveries of the past 40 years have been made with this instrument. It was also at Caltech, in 1964, that astronomer Maarten Schmidt determined that quasars--a puzzling class of cosmic objects--were the most powerful and distant objects in the universe. Since quasar light has been traveling for billions of years to reach Earth, Schmidt's discovery gave astronomers an unprecedented look at how the universe looked at a much younger period in its history, billions of years before the birth of the sun and its planets.

12. Animal Magnetism.

In the 1960s, Caltech paleoecologist Heinz Lowenstam startled biologists and geologists alike with the discovery that many animals do what conventional science had considered impossible: they manufacture substances such as the iron-containing mineral magnetite within their bodies. Out of Lowenstam's work came the more recent finding that many migratory animals, including birds, bees, and whales, generate magnetite within their bodies and may owe their uncanny homing instincts to the presence of this "internal compass" that allows them to navigate by means of Earth's magnetic field.

13. Richard Feynman--a Caltech institution

Richard Feynman, one of the most brilliant theoretical physicists and original thinkers of the 20th century, epitomized Caltech for many. Although Feynman's Nobel-prize winning research (Nobel Laureate 1965) was largely completed before he came to Caltech in 1949, at Caltech he continued to make discoveries that many felt should have won him a second Nobel Prize. Beloved by students as a friend and teacher, Feynman also found time to perform year after year in Caltech student dramatic productions. A drummer and artist as well as a physicist and actor, in 1985 he also turned popular author and published an irreverent memoir--*Surely You're Joking, Mr. Feynman*--that spent 14 weeks on the *New York Times* best-seller list. In 1986, he became known to an even larger audience through his participation--and his famous ice-water experiment--on the Presidential Commission investigating the explosion of the Space Shuttle *Challenger*. Commenting on Feynman's appointment to the commission, one Caltech colleague came as close as any to summing up the essential quality of his genius: "Do they realize," he wondered, "that Feynman asks questions--and keeps asking them until he gets answers?"

Books:

Bolt, Bruce A. (1988). *Earthquakes*. W. H. Freeman and Co., New York.

Coffman, Jerry L., Carl A. von Hake, and Carl W. Stover (1982). *Earthquake History of the United States*. Publication 41-1, U.S. Department of Commerce and Department of the Interior. (Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402).

Gere, James M., and Haresh C. Shah (1984). *Terra Non Firma: Understanding and Preparing for Earthquakes*. W. H. Freeman and Co., New York.

Heppenheimer, T.A. (1988). *The Coming Quake*. Times Books, New York.

Iacopi, Robert (1971). *Earthquake Country*. Lane Books, Menlo Park, California (A Sunset Book).

Kimball, Virginia (1988). *Earthquake Ready*. Roundtable Publishing Co., Santa Monica, California.

Mogi, Kiyoo (1985). *Earthquake Prediction*. Academic Press, Inc., Orlando, Florida.

Nance, John J. (1988). *On Shaky Ground*. William Morrow and Co., New York.

Press, Frank, and Raymond Siever (1986). *Earth*. W. H. Freeman and Co., New York.

Richter, Charles F. (1958). *Elementary Seismology*. W. H. Freeman and Co., New York.

Sharp, Robert P. (1975). *Field Guide: Southern California*. Kendall/Hunt Publishing Co., Dubuque, Iowa.

Yanev, Peter (1974). *Peace of Mind in Earthquake Country*. Chronicle Books, San Francisco.

Maps:

Maps, including the California State Fault Map and the State Geologic Sheets, are sold over the counter at the Division of Mines and Geology, State Office Building, Room 1065, 107 S. Broadway, Los Angeles, telephone (213) 620-3560.

Earthquake Preparedness Information:

Your local chapter of the American Red Cross or the Southern California Earthquake Preparedness Project, (818) 795-9055, are good sources of earthquake preparedness information, as well as the books *Peace of Mind in Earthquake Country* and *Earthquake Ready*, mentioned above. A quick guide to emergencies of all sorts can be found in the front of your telephone book.

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range, broadbased st...
Quaternary faults of southern California are also shown.

California Institute of Technology
Seismological Laboratory
Pasadena, California 91125



Seismology

at the

California Institute of Technology

...repare for

The Seismological Laboratory of the California Institute of Technology is one of the world's most renowned centers for seismological research. It was established by Harry Wood in 1921 under the auspices of the Carnegie Institution of Washington. In the early 1920s, Wood and John Anderson developed the Wood-Anderson torsion seismometer that became the standard for local earthquake recording. Hundreds of these instruments are still in regular use today. In 1926, the Laboratory began cooperative operations with the new geology department at Caltech and embarked on a project of installing a network of Wood-Anderson seismographs around southern California. By 1932, six instruments were in place, and routine publication of a station bulletin (a listing of recorded earthquakes and readings from the seismographs) had begun.

Charles Richter, whose background was in theoretical physics, joined the staff of the Seismological Laboratory in 1927 and began studying the local earthquakes. Beno Gutenberg, a renowned German geophysicist who had extensively studied teleseismic records (recordings of distant earthquakes), joined the geology department of Caltech in 1930. Their collaboration led to several important studies, of which the most well known is the magnitude scale, initially used by Richter and later expanded by Gutenberg and by Hiroo Kanamori, a professor of geophysics at Caltech. Responsibility for the Seismological Laboratory, its programs, and most of its personnel was transferred to Caltech in 1937. Gutenberg and his coworkers – Hugo Benioff, John Buwalda, Richter, and others – led the Seismological Laboratory to worldwide prominence in the study of local earthquakes and, equally important, in the use of teleseismic recordings to study the interior of the earth.

By the early 1970s, the Seismological Laboratory's seismic network included 30 stations distributed around southern California. At the same time, the U.S. Geological Survey (USGS) was directed by Congress to improve seismological recording and study of local earthquakes in California. Thus began the cooperative program between the Seismological Laboratory and the USGS that has developed into the present Caltech-USGS Southern California Seismic Network, which operates more than 200 seismic stations. Seismograms from all of these stations are recorded and processed by computers in the South Mudd building on the Caltech campus. The Seismological Laboratory now has more than 10 Ph.D. researchers involved in many aspects of seismological research including the structure, chemistry, and convective flow of the earth's interior; the physics of earthquakes; and tectonics and deformation of the crust, especially in California. Caltech is continuing its leadership role in seismology with the development of a new generation of seismic instrumentation. The TERRAscope is an expanding system of broad-band, high dynamic-range, digital seismometers around southern California that will provide seismic data of very high quality during major earthquakes anywhere in the world.

What is an earthquake?

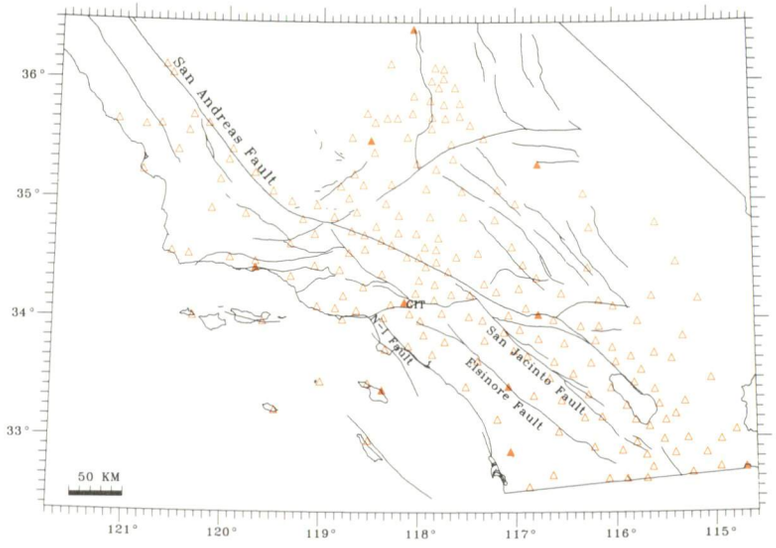
An earthquake is a natural shaking of the ground, usually caused by sudden slippage on a fault. Waves propagate outward from the area of fault rupture in much the same way as ripples do in a quiet pond when a stone is thrown into it.

What is a fault?

A fault is a fracture in the earth's crust, along which movement has taken place. The earth's crust is divided into many plates, which move relative to each other. California's largest fault is the San Andreas, which extends from Cape Mendocino to the Salton Sea; it forms the boundary between the North American and Pacific crustal plates. The plate boundary is badly splintered, however, so that California has many other faults as well. Some faults are very "active," and cause frequent earthquakes; others are relatively "inactive," and seldom cause earthquakes. Some of California's more active faults are shown below. Generally speaking, large earthquakes occur on longer faults; most of our small earthquakes are attributed to unnamed faults that are too small to appear on maps.

Why do earthquakes occur?

Due to heat slowly escaping from the earth's interior, convection (similar to motions in a pot of hot liquid) occurs in the deep, semi-fluid "mantle" of the earth. This convection causes the rigid pieces of the crust, called "tectonic plates," to move with respect to one another, generally a few inches per year. Slip does not usually occur smoothly at the plate boundaries. Instead, the crustal rocks near the plate boundary are slowly deformed by the motion. When the forces involved exceed the frictional forces holding the fault together, slip occurs suddenly, causing an earthquake.



Signals from more than 200 seismic stations are telemetered to the Seismological Laboratory and recorded and analyzed as part of the Southern California Seismic Network. The stations are distributed across all of southern California, as indicated by the triangles. These data are used to locate and determine magnitudes for more than 10,000 earthquakes per year. The stations shown above with solid triangles are being upgraded to wide dynamic range, broadbased stations as part of the TERRAscope project. Some of the major Quaternary faults of southern California are also shown.

What is the difference between earthquake magnitude and intensity?

Seismologists seldom use the term "Richter scale" among themselves. They prefer the general term "magnitude." The magnitude of an earthquake is a number that is related to the total amount of energy released in an earthquake. It is based on the amount of ground motion as recorded by seismometers. For each whole number of magnitude, the ground motion increases by a factor of 10. In other words, a 4.0 produces 10 times the ground motion as a 3.0 at the same distance. Several methods of measuring an earthquake's magnitude can be used, using seismometers with differing characteristics at differing distances. Thus, estimates of the magnitude of the same earthquake often differ; however, they are all estimates of the earthquake's actual size. Intensity, on the other hand, is a subjective rating of the strength of an earthquake at a given place, based on a survey of building damage and interviews with witnesses. It is usually measured on the Modified Mercalli Intensity scale, which goes from I (not felt) to XII (total damage). An earthquake has, theoretically, one magnitude and a map of intensities, with different locations experiencing different intensities.



For both magnitude and intensity, the scale is arbitrary and the numbers on the two scales are unrelated.

How many earthquakes occur each year in southern California?

The Southern California Seismic Network records more than 10,000 earthquakes in an average year. Not including aftershocks, about 100 earthquakes larger than 3.0 and 12 earthquakes larger than 4.0 occur each year. An average of 1.5 earthquakes big enough to cause minor damage (greater than 5.0) occur every year in southern California.

How does California's earthquake activity compare with other parts of the world?

California is second only to Alaska in number of earthquakes recorded for the United States. However, there are many places in the world with more and larger earthquakes than California. Most of these are along the Pacific "Ring of Fire" that includes Japan, many islands in the southwest Pacific, and South America. Whereas the largest earthquake expected on

California's San Andreas fault is about 8, the great Chilean earthquake of 1960 registered a magnitude of 9.5. In addition, in many parts of the world where construction is not as sturdy as in California, relatively small earthquakes routinely cause large disasters.

What are foreshocks and aftershocks?

Earthquakes seldom occur alone. Most earthquakes have a few or no foreshocks and many aftershocks. Foreshocks are smaller shocks that occur in the same place as the mainshock a few hours or days beforehand; aftershocks are smaller earthquakes that occur after the mainshock on the same fault or intersecting faults. Aftershocks of the larger earthquakes can go on for months or even years, gradually decreasing in frequency. In some areas, earthquake "swarms" occur with several large shocks and many small ones, but with no single shock standing out as the mainshock.

Can scientists predict earthquakes?

Not yet. Long-term predictions (for example, that there is a 60 percent chance of an earthquake above 7.5 on the San Andreas fault in the next 30 years) are sometimes made based on knowledge of the fault's usual behavior and the date of the last earthquake. Short-term predictions (for example, that an earthquake might happen in the next few days) are much more difficult and, at present, cannot be made with high probability. Short-term predictions with low probability are fairly routine, however. These are usually based on the chance (commonly about 5 percent) that an earthquake that has just happened is actually a foreshock. This means that if you feel an earthquake, there is at least a 1 in 20 chance that you will feel a larger earthquake from the same location within 3 days. Many scientists doubt that earthquakes will ever be completely predictable.

What does Caltech do after an earthquake?

Caltech's first responsibility after an earthquake is to make sure that its instruments are in working order and are properly recording the data for future study. After that, the Seismological Laboratory provides state and local officials with its latest information on the location and magnitude of the earthquake and its aftershocks. Staff members also respond to questions from the media and make part of their facility available to reporters. In addition, the Seismological Laboratory investigates ground breakage and other geologic phenomena that may be "cleaned up" quickly by emergency services personnel. Caltech's Earthquake Engineering Laboratory studies the performance of local structures during an earthquake.

What should I do in an earthquake?

Don't panic. Because California has had strict building codes for more than 50 years, most buildings are not expected to collapse in an earthquake. The greatest hazard is from broken glass, toppling furniture, falling fixtures, and falling masonry (such as chimneys, brick or stone facades, and unsupported balconies). If you are inside a building, do not run outside. Instead, get under a table or desk (and hold on!) to protect yourself from falling objects. If no table is available, move away from windows and toward interior walls. A doorway can be a refuge, but beware of swinging doors.

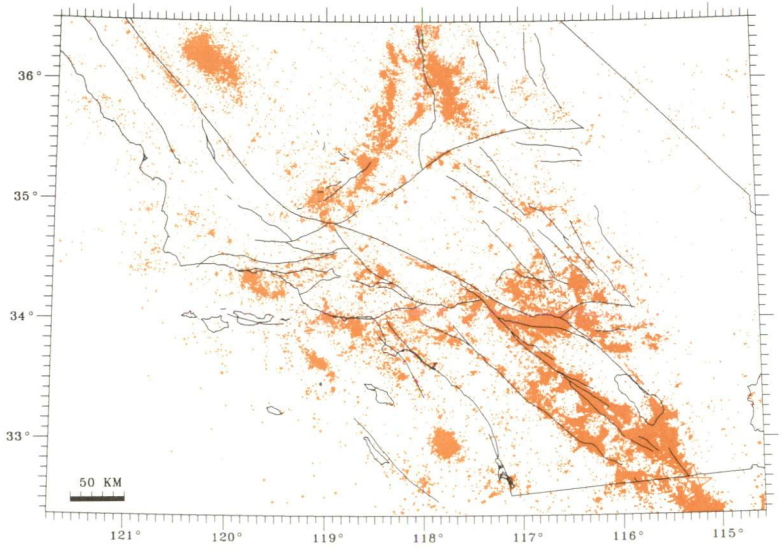
If you are outside, move away from buildings and electrical lines. If you are in your car, stop – but not under a bridge or power lines. Stay in your car; it provides you some protection from falling objects.

Who should I call after an earthquake?

Please don't call anyone, unless there is a medical emergency. The main reason that telephone service is unreliable after an earthquake is the overload of calls. Local officials and Caltech already know that there has been an earthquake. Listen to your radio to learn the details; the Seismological Laboratory works hard to provide the media with accurate information as fast as possible.

How should I prepare for the next earthquake?

Although government studies project that in the worst possible case, tens of thousands of casualties could result from California's largest earthquakes, there are ten *million* people in the area; you are very *unlikely* to be killed or injured. The largest impact on you will probably be the disruption of services. Plan to be without fire and paramedic services, electricity, gas, water, grocery stores, banks, pharmacies, gasoline stations, etc., for several days following a large shock. Be prepared to deal with the physical and psychological needs of yourself, your family, and your neighbors. Your local chapter of the American Red Cross can provide you with much helpful information about how to prepare. A quick emergency guide may also be found in the front of your telephone book.



The +'s indicate all of the earthquakes recorded by the Southern California Seismic Network between 1978 and 1988. Earthquakes above magnitude 5.0 are indicated by stars.

September 1990

A Profile of the California Institute of Technology

The California Institute of Technology is a small, independent university that carries on instruction and research in science and engineering, with a student body of 776 undergraduates and 1,012 graduate students. With an outstanding faculty, including several Nobel laureates, and such renowned off-campus facilities as the Jet Propulsion Laboratory and Palomar Observatory, Caltech has become one of the world's major research centers, focusing on those areas in which it has the faculty and facilities to excel.

Caltech sits on 124 acres in a residential section of Pasadena, California, a city of 135,000, 25 miles inland from the Pacific Ocean and 10 miles from downtown Los Angeles.

History

Caltech traces its origins to a local school of arts and crafts founded in 1891 by the Honorable Amos G. Throop and named, after him, Throop University. For almost two decades, this school served the Pasadena community, offering programs leading to a bachelor's degree, as well as providing an elementary school and an academy where the emphasis was on vocational training.

Astronomer George Ellery Hale, the first director of the Mount Wilson Observatory, who became a member of Throop's board of trustees in 1907, envisioned a wholly different future for the Institute. He saw it becoming an institution of engineering and scientific research of the highest rank, and under his leadership its transformation began.

By 1921 Hale had been joined by chemist Arthur A. Noyes and physicist Robert A. Millikan. These three men set the school--renamed the California Institute of Technology--firmly on its new course. They were dedicated to the development of exceptional research and instruction in engineering and the fundamental sciences of mathematics, physics, and chemistry, and to the enrichment of that curriculum with course work in the humanities.

For the next 66 years, Millikan, academic head of the Institute, and his successors, Lee DuBridge, Harold Brown, and Marvin Goldberger, led Caltech as it achieved the very best in scientific education and research. During this time new programs were added in geology, biology, aeronautics, astronomy, astrophysics, the social sciences, computer science, and computation and neural systems.

Under our current president, electrical engineer Thomas E. Everhart, Caltech remains the country's finest scientific university, recognized by *U.S. News & World Report* in their October 16, 1989 issue of "America's Best Colleges."

Officers

Ruben F. Mettler, Chairman
Thomas E. Everhart, President
James W. Glanville, Vice Chairman
William F. Kieschnick, Vice Chairman
Benjamin M. Rosen, Vice Chairman
Paul C. Jennings, Vice President and Provost
Lew Allen Jr., Vice President and Director, Jet Propulsion Laboratory
Theodore P. Hurwitz, Vice President for Institute Relations
Gary A. Lorden, Vice President for Student Affairs
David W. Morrisroe, Vice President for Business and Finance and Treasurer
Edward C. Stone, Vice President for Astronomical Facilities

Faculty

Professorial faculty number 314, with an additional 680 research fellows, visiting associates, and other faculty. The Caltech faculty has 63 members of the National Academy of Sciences and 25 members of the National Academy of Engineering. Four resident faculty are Nobel laureates, and 21 prizes in all have been won by Caltech faculty and alumni. One resident faculty member is a Crafoord laureate, and fifteen faculty members have been awarded the National Medal of Science. In fact, the first Medal of Science was presented to Caltech's Theodore von Kármán in 1962.

Off-Campus Facilities

Kresge Building, Seismological Laboratory, Pasadena (1928).

Kerckhoff Marine Biological Laboratory, Corona del Mar (1930).

Jet Propulsion Laboratory, Pasadena (1944). Administered by Caltech; owned and supported by the National Aeronautics and Space Administration.

Palomar Observatory, San Diego County (1948). Site of the 200-inch Hale Telescope.

Owens Valley Radio Observatory, Big Pine (1958).

Big Bear Solar Observatory, Big Bear Lake (1969).

Submillimeter Observatory, Mauna Kea, Hawaii (1986).

W. M. Keck Observatory, Mauna Kea, Hawaii (under construction). The 10-meter telescope to be housed there will be the world's largest optical telescope.

THE DIVISIONS

Biology

John N. Abelson, Chairman

33 professorial faculty
215 other faculty
110 graduate students (84 in biology; 26 in computation and neural systems)
40 undergraduates*

Chemistry and Chemical Engineering

Fred C. Anson, Chairman

36 professorial faculty
142 other faculty
212 graduate students (163 in chemistry, 49 in chemical engineering)
38 undergraduates* (18 in chemistry, 20 in chemical engineering)

Engineering and Applied Science

John H. Seinfeld, Chairman

102 professorial faculty
93 other faculty
401 graduate students (56 in aeronautics, 24 in applied mechanics, 16 in applied mathematics, 62 in applied physics, 12 in civil engineering, 32 in computer science, 117 in electrical engineering, 5 in engineering science, 42 in mechanical engineering, 14 in materials science, and 21 in environmental engineering science)
330 undergraduates* (12 in applied mathematics, 41 in applied physics, 115 in electrical engineering, and 162 in engineering and applied science)

Geological and Planetary Sciences

David J. Stevenson, Chairman

30 professorial faculty
60 other faculty
84 graduate students
15 undergraduates*

Financial information

1990/91 tuition: $13,300
1990/91 estimated operating budget: $200,900,000
(not including $1.1 billion Jet Propulsion Laboratory budget)

Endowment as of July 31, 1990: $522,000,000

Humanities and Social Sciences

David M. Grether, Chairman

38 professorial faculty
45 other faculty
18 graduate students
4 undergraduates*

Physics, Mathematics and Astronomy

Gerry Neugebauer, Chairman

75 professorial faculty
125 other faculty
187 graduate students (135 in physics, 27 in mathematics, 25 in astronomy)
140 undergraduates* (97 in physics, 36 in mathematics, 7 in astronomy)

*Numbers of undergraduates do not include the freshman class, which has 209 members.

Student statistics (as of April 1990)

776 undergraduate students
627 men
149 women (19%)

1,012 graduate students
827 men
185 women (18%)

Mean SAT scores of entering 1990 freshmen
Verbal 660
Math 750

Regional distribution of undergraduates:
53 percent Far West (35 percent from California)
15 percent Midwest
13 percent Northeast
13 percent South
6 percent Overseas

Number of alumni (as of September 1990)
17,218

CALTECH: ONE HUNDRED YEARS IN REVIEW
Pioneering Contributions from the California Institute of Technology

1. The Discovery of Anti-Matter.

In 1934, Caltech physicist Carl Anderson discovered the anti-electron, or positron, the first empirical proof for the existence of anti-matter. In addition to providing inspiration for decades of science fiction writers, Anderson's discovery permanently reshaped our view of the universe and opened major new avenues of investigation in modern physics. He was awarded the Nobel Prize in 1936.

2. The Nature of the Chemical Bond

What has been called the single most important discovery in the history of chemistry was made at Caltech in the 1930s by Linus Pauling. Pauling determined the nature of the chemical bond--how atoms link up to form molecules in both living and non-living systems. Up to that time, chemistry had essentially been a hit-or-miss proposition; Pauling's insight handed chemists a powerful new tool for both predicting and manipulating the outcome of chemical reactions. Major advances in chemistry and molecular biology, and the creation of hundreds of synthetic products, had their roots in this single discovery. Pauling won the Nobel Prize twice: for chemistry, and for peace.

3. The Foundations of Molecular Biology.

Between 1930 and 1960, a remarkable group of biologists at Caltech played a central role in creating the science of molecular biology. They included Thomas Hunt Morgan (1933 Nobel Laureate), whose studies of the relationship of chromosomes to heredity laid the foundations for much of modern biology, and George Beadle (1958 Nobel Laureate), who discovered much of what we now know about the chemical activity of genes. Beginning in the 1940s, Caltech's Max Delbruck, a physicist-turned-biologist, introduced the rigorous techniques of physics to the study of biology and made fundamental discoveries concerning the nature of viruses and viral disease. He received the 1969 Nobel Prize for his work.

4. The Birth of Modern Earthquake Science

Three Caltech scientists, working in the 1920s and early 1930s, played a pivotal role in developing seismology into an international science of earthquake study, detection, and measurement. Caltech geologist Harry Wood invented the first seismograph capable of recording vibrations from distant quakes; physicist Charles Richter and mathematician Beno Gutenberg invented the Richter Scale. This remarkable collaboration almost missed getting off the ground: Wood, who turned seismology from a provincial specialty into a global science, really only wanted to study quakes in southern California; Richter, a Stanford-trained scientist, was working in a warehouse when he wandered into a Caltech theoretical physics lecture and decided to switch professions; Gutenberg, a renowned European mathematician, almost didn't come to Caltech because his wife was worried about finding household help in southern California.

5. The Recommended Daily Adult Requirement.

The RDA of vitamins A, B, C, and D grew out of work carried out at Caltech in the 1930s and 40s by biologist Henry Borsook. His research led the government to establish the Recommended Daily Requirements for Human Nutrition.

6. The Smallest Building Blocks of Matter

In the early 1960s, Caltech physicist Murray Gell-Mann discovered that protons and neutrons--long considered the smallest building blocks of matter--are made up of even smaller particles, which Gell-Mann named quarks. Quarks were not discovered in the laboratory but at Gell-Mann's blackboard; their existence has since been verified experimentally. Their discovery opened up new avenues of research in subatomic physics, clarified the nature of the "strong force" that holds protons and neutrons together in the atomic nucleus, and pointed the way to a better understanding of what occurred in the first instants of the Big Bang, the explosion that gave birth to the universe. Gell-Mann received the Nobel Prize in 1969.

7. Left Brain/Right Brain.

It was at Caltech that psychobiologist Roger Sperry discovered that the left and right hemispheres of the brain are specialized for different capacities: the left brain for verbal thinking and language; and the right brain for spatial-visual thought. His work has had an incalculable impact in fields ranging from education to behavioral psychology to neurophysiology. Sperry was awarded the Nobel Prize in 1981.

8. The Dawn of the Aerospace Age.

The principles of modern aviation and jet flight grew out of work carried on at Caltech by Theodore von Karman, the head of Caltech's Graduate Aeronautical Laboratory (GALCIT) during the 1930s. At GALCIT, von Karman and his students developed the principles of airplane design and flight that helped get the aircraft industry off the ground and turned southern California into the aircraft capitol of the world. In the mid-1930s, off-campus experiments by several of von Karman's students led to the establishment in 1944 of the world-famous Jet Propulsion Laboratory--today the nerve center of America's unmanned space program, including the Pioneer, Mariner, Viking, and Voyager missions to explore the solar system.

9. The Age of the Earth and the Perils of Lead

That the earth has existed for 4.6 billion years was first determined around 1960 by Caltech geochemist Clair Patterson, through studies of the decay rate of lead isotopes in earth's oldest rocks. Patterson subsequently turned his attention from lead in rocks to lead pollution in the oceans and atmosphere. His demonstration that lead pollution from automobile exhaust had reached dangerously high levels was one of the factors in the U.S. government's decision to establish pollution controls within the auto industry. Patterson, and his determined and often lonely crusade against lead pollution, was made the basis of a fictional character in the Saul Bellow novel *The Dean's December*.

10. "We are Starstuff"

This phrase--a familiar one to viewers of the Carl Sagan series *Cosmos*--has much of its genesis in pioneering astrophysics research carried out for over three decades in Caltech's Kellogg Laboratory. There, a team of scientists, headed by the late Charles Lauritsen, demonstrated that nearly all the elements in the universe and in our bodies were originally cooked up inside stars. Kellogg physicist Willy Fowler was awarded the Nobel Prize in 1983 for his "studies of the nuclear reactions of importance in the formation of the chemical elements of the universe."

11. Probing the Secrets of the Universe

A leading British astronomer, Martin Rees, recently summed up Caltech's record in astronomy in this way: "The universe of astronomy has no center but the universe of astronomers does. For years that center has been in Pasadena, California." Among Caltech's major contributions: the first survey of the entire sky visible from the northern hemisphere (in 1948)--a survey that discovered thousands of new stars, galaxies, and comets and created an atlas of the heavens that astronomers the world over used for the next three decades. (A second Palomar sky survey is currently under way.) Palomar is also the home of the 200-inch Hale Telescope, since 1948 the largest and most powerful optical telescope in the Western hemisphere. Some of the most significant astronomical discoveries of the past 40 years have been made with this instrument. It was also at Caltech, in 1964, that astronomer Maarten Schmidt determined that quasars--a puzzling class of cosmic objects--were the most powerful and distant objects in the universe. Since quasar light has been traveling for billions of years to reach Earth, Schmidt's discovery gave astronomers an unprecedented look at how the universe looked at a much younger period in its history, billions of years before the birth of the sun and its planets.

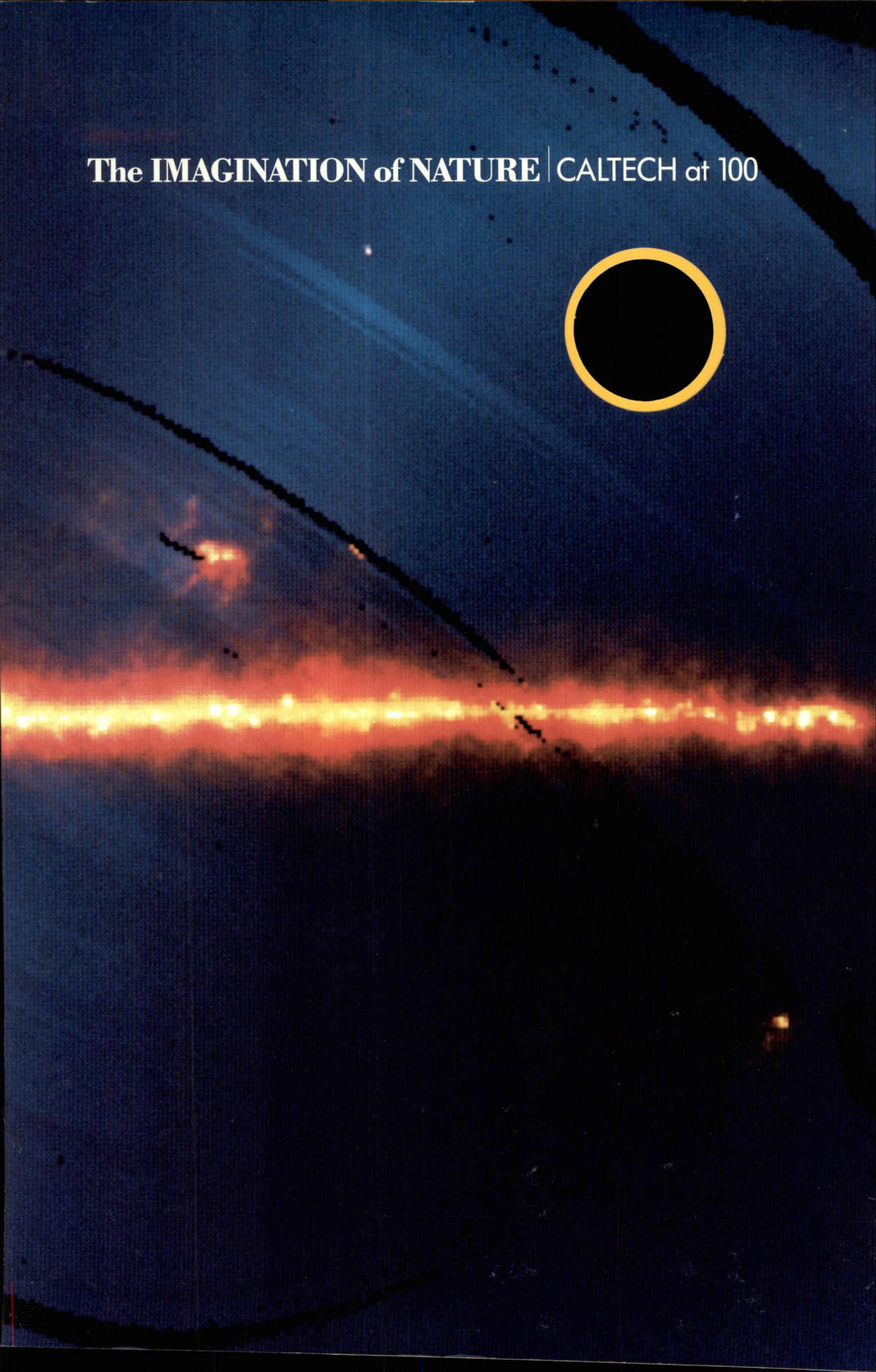
12. Animal Magnetism.

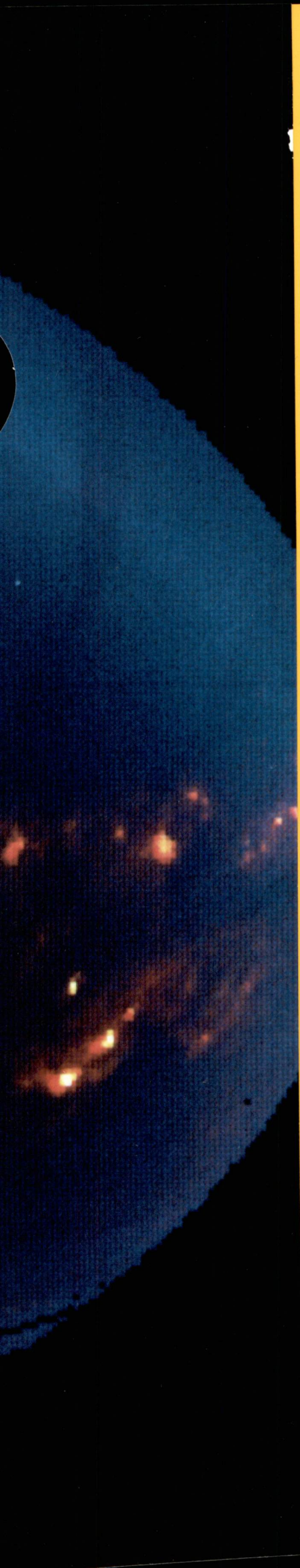
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13. Richard Feynman--a Caltech institution

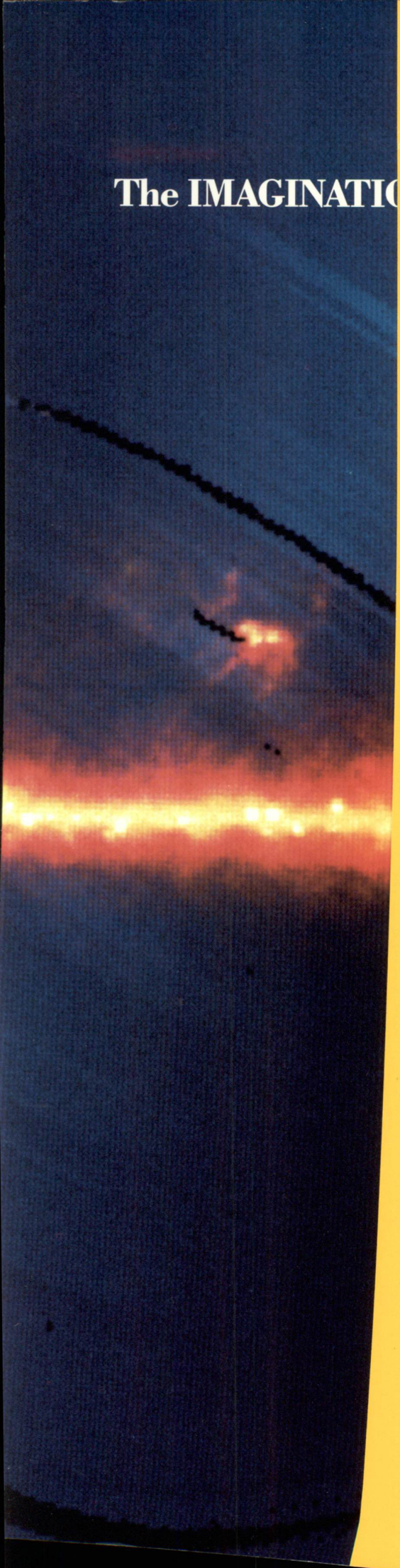
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The IMAGINATION of NATURE | CALTECH at 100





The IMAGINATI

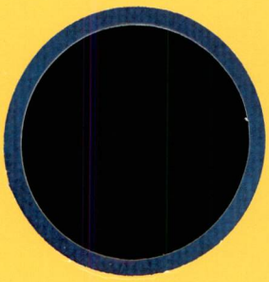


On the cover:

Nearly the entire sky, as seen in infrared wavelengths and projected at one-half degree resolution, is shown in this image, assembled from six months of data from the Infrared Astronomical Satellite (IRAS). The bright horizontal band is the plane of the Milky Way, with the center of the galaxy located at the center of the picture.

On the facing page:

A mechanosensory projection interneuron stained in an adult grasshopper by intracellular iontophoresis of cobalt hexamine. The diameter of the soma (lower right) is about 20 μm.
Photo: G. Laurent

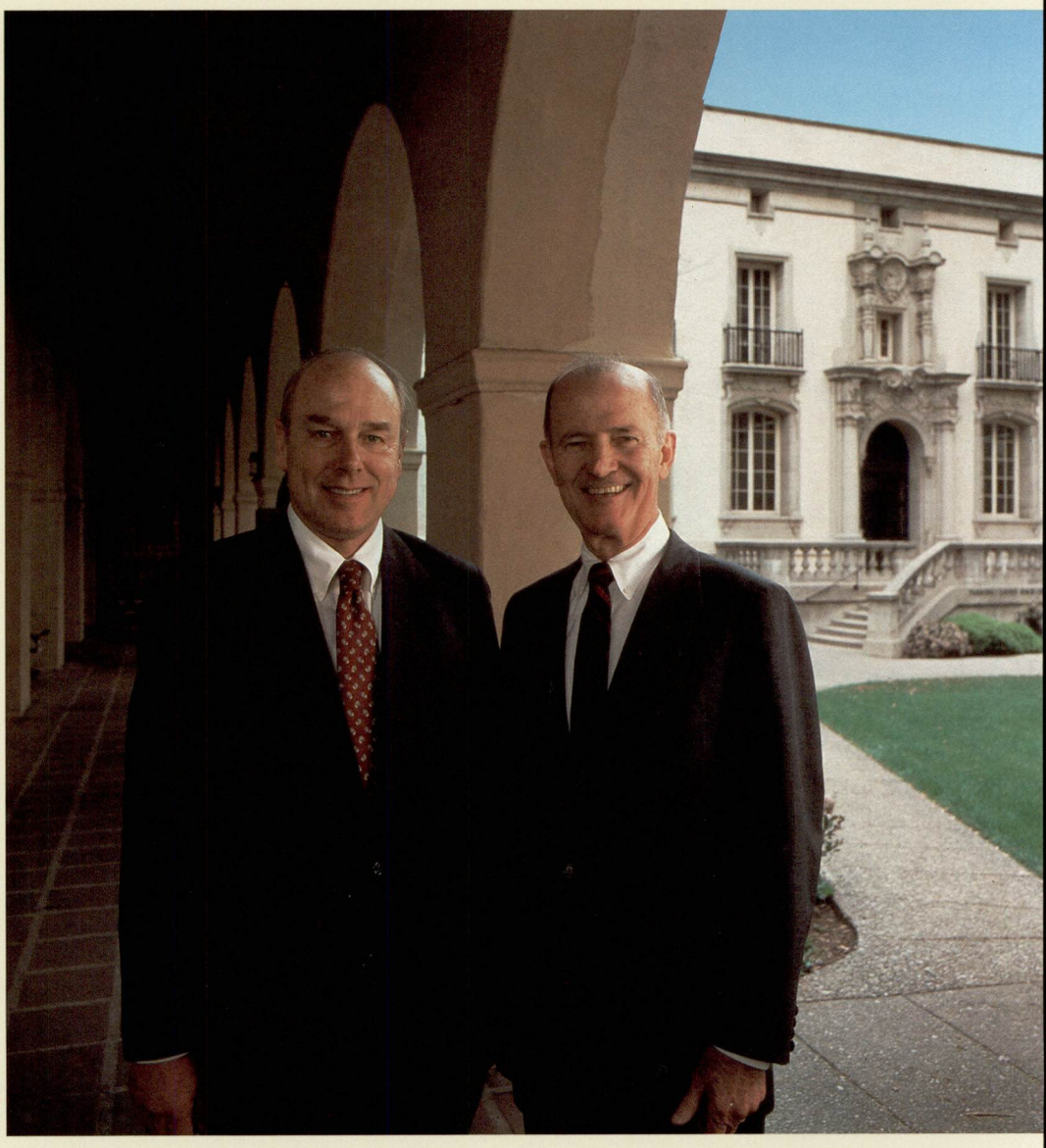




The imagination of nature is far, far greater than the imagination of man. . . . The same thrill, the same awe and mystery, come again and again when we look at any problem deeply enough. With more knowledge comes deeper, more wonderful mystery, luring one on to penetrate deeper still. Never concerned that the answer may prove disappointing, but with pleasure and confidence we turn over each new stone to find unimagined strangeness leading on to more wonderful questions and mysteries — certainly a grand adventure!

Richard P. Feynman

Nobel Laureate
Caltech Faculty Member, 1950–88
Richard Chace Tolman Professor
of Theoretical Physics, 1959–88



Caltech is a century old—an instant of time in the history of humankind. Yet in that instant, Caltech has made substantial scientific, engineering, and technological contributions. These achievements have been acknowledged with the 21 Nobel Prizes, 29 National Medals of Science, and 2 National Medals of Technology awarded to Caltech faculty and alumni. At present, Caltech has on its faculty one of the highest percentages of members of the National Academies of Sciences and Engineering of any university in the nation. ⊖ The explanation for this amazing record lies in the very nature of the Caltech community. Caltech has brought together a small group of outstanding people and placed no barriers between them. Students and faculty work side by side, often beyond the bounds of traditional academic disciplines. Professional divisions have been minimized so that people and ideas may move more freely. In this environment of trust and integrity, people confront exciting and difficult problems; they explore new areas, instead of colonizing the old. In so doing, they have established an impressive tradition of intellectual daring. ⊖ Intellectual pursuits have gone hand-in-hand with practical applications. Early work in Caltech's high-voltage laboratory, for example, contributed to the development of the power industry in southern California. Its wind tunnels helped give birth to the aviation industry, its wartime rocket program to modern spaceflight. Its geologists and engineers have helped bring water to Los Angeles and keep buildings standing during earthquakes. And Caltech's electrical engineering and materials science research has produced innovations in the design of computers and integrated circuits. ⊖ Achievements and contributions—these are not relics of the Institute's past. Rather, they are milestones along a remarkable path of discovery, one that reaches into the future just as surely as it grows out of the past. Highlighted in the following pages are examples of research produced during the first century of Caltech's history. They by no means encompass *all* that Caltech does, but taken together they suggest Caltech's significance to our collective past, present, and future. The next section provides a brief outline of what it will cost to preserve this path of discovery into the Institute's second century. ⊖ The examples presented in this book provide only a sampling of the many contributions made to science, technology, and engineering by generations of Caltech students, alumni, and faculty. The people of Caltech—they are the reason our institution exists and why it deserves the highest levels of support.

Thomas E. Everhart

Thomas E. Everhart
President

Ruben F. Mettler

Ruben F. Mettler
Chairman of the Board

FOUNDATIONS of LIFE and MIND

Caltech's researchers look for answers to the riddles of life, growth, and disease at the most fundamental level—that of genes and the proteins they determine.

Thomas Hunt Morgan, the first chairman of the Division of Biology, identified the gene as a specific entity with a fixed location on a chromosome—an insight central to all subsequent work in genetics. He also recognized that life is fundamentally chemical. Thus, Morgan was instrumental in bringing to Caltech chemists, biochemists, and physicists to seek definitive answers to such questions as how a complex organism can develop from a single fertilized egg, how the body recognizes minute invaders it has never encountered before, and how the brain functions to make us thinking, feeling creatures.

Two of Morgan's recruits, physicist-turned-biologist Max Delbrück and biologist George Beadle, revolutionized our understanding of the nature and function of the gene. A contemporary of theirs, chemist Linus Pauling, helped confirm that genes direct the synthesis of enzymes, which then control the manufacture of the cell's proteins.

By working across disciplines, these faculty members and their colleagues helped lay the foundation for Caltech's current work at the frontiers of neuroscience, biochemistry, and molecular biology. The following examples provide a glimpse at some of the significant projects currently in progress on campus.

Seymour Benzer (a former postdoctoral fellow under Delbrück) is probing how genes control the devel-



Thomas Hunt Morgan, Pamela Bjorkman, Leroy Hood, Peter Dervan, and Seymour Benzer

opment and function of the nervous system. His work has yielded valuable insights, including the identification of the brain cells that selectively degenerate in patients suffering from Alzheimer's disease.

Peter Dervan is designing molecules that bind to specific sites on DNA. These molecules may one day help make it possible to map the spot where any given gene is encoded among the three billion chemical units that make up the blueprint of human heredity.

Using x-ray crystallography, Pamela Bjorkman is deciphering the three-dimensional structure of proteins crucial to the immune response. These so-called histocompatibility molecules bind to infected cells and signal the body's defenses to attack them. Knowing the proteins' structures may one day allow scientists to intervene at the molecular level to enhance the immune response, or prevent it from making mistakes, as in some forms of arthritis and diabetes.



Motivated by his research on families of genes related to the immune response, Leroy Hood has developed instruments to sequence and synthesize DNA and proteins. These instruments already have dramatically increased the productivity of biochemical research. In a single day biologists and chemists can now determine the chemical structure of complex molecules previously requiring teams of researchers many months.



Biologist Seymour Benzer's studies of the fruit fly Drosophila probe the foundations of life and mind – how does a single cell develop into a complex organism whose cells are exquisitely specialized? This micrograph of a larval Drosophila brain shows the axons of developing retinal nerve cells (stained with a fluorescent marker) fanning out toward the brain's visual center as the brain wires itself up.

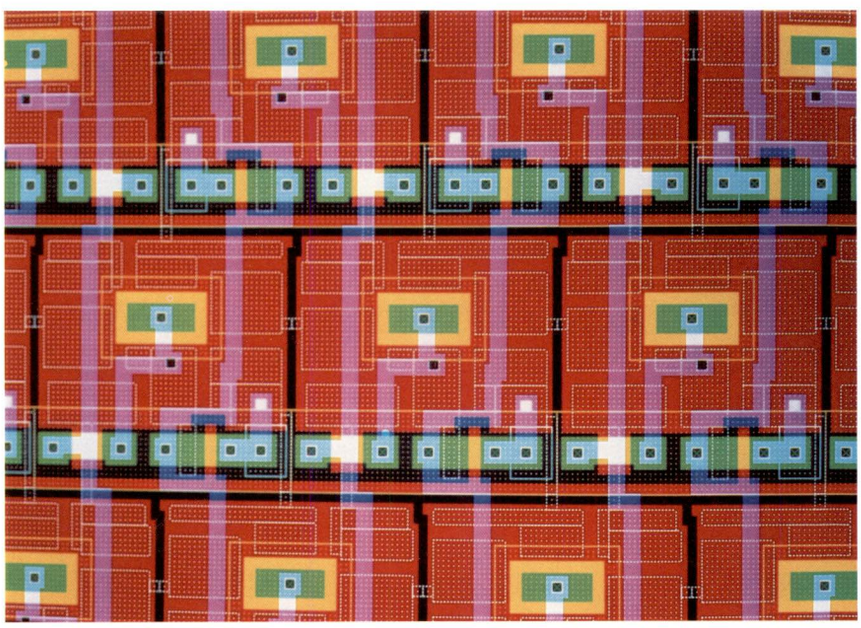
INFORMATICS and COMPLEX SYSTEMS



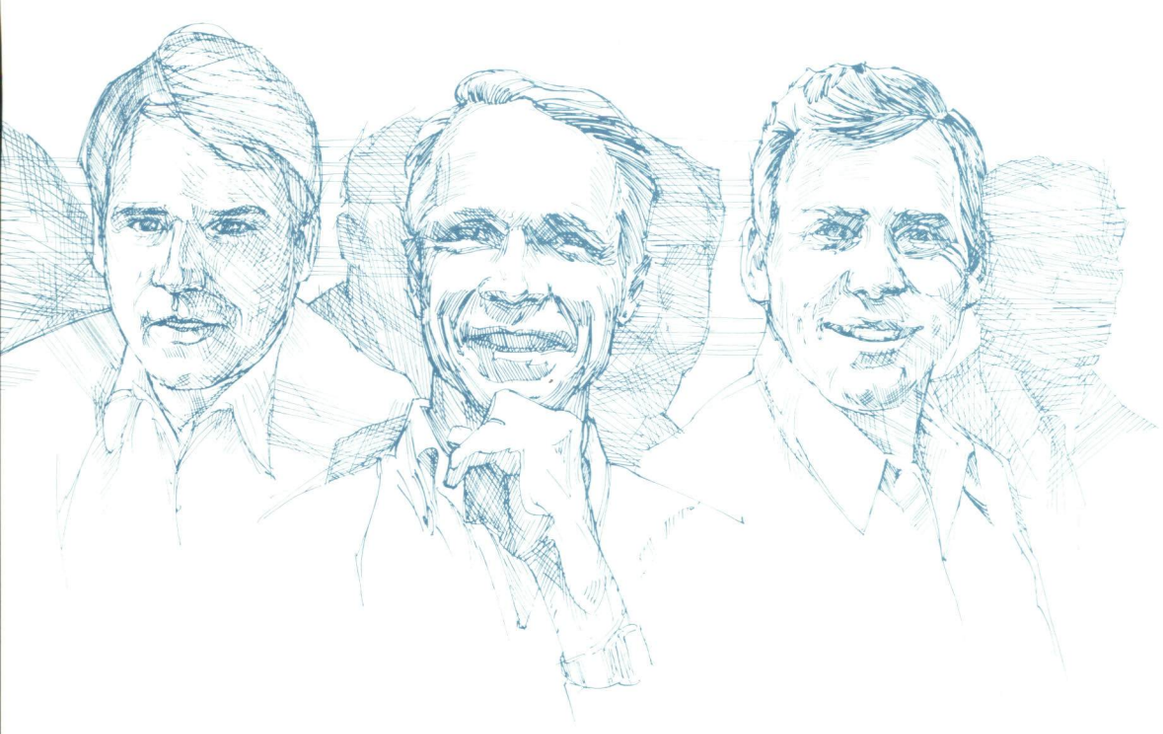
Information technology already drives a $750 billion industry worldwide; yet, surprisingly, this technology is still in its infancy. Through advances at every level of computing, from the design of integrated circuit chips to software that mimics human cognition, to large integrated systems, Caltech faculty are hastening a new relationship between this technology and its users. The computer will no longer be a mere implement but rather an assistant—and perhaps even an advisor—in our work.

At the center of these revolutionary developments is the silicon chip. Carver Mead predicted that chips could hold millions of computing elements; he then devised a way to design such chips. His approach became the industry standard. He also built the first gallium arsenide MESFET transistor, opening the way for a faster nonsilicon-based technology. Finally, Mead and a group of Caltech graduate students created a program for designing specialized chips from symbolic descriptions—the silicon compiler. *Forbes* magazine has predicted that this development may revitalize the American chip industry by speeding innovation. Important leaders of today's most advanced entrepreneurial ventures in chip design, and of large corporations developing information-based systems, have come from Caltech.

This retina chip, developed by Carver Mead and Misha Mahowald, is a first attempt to mimic in silicon-based hardware that which nature does so well in carbon-based "wetware." A housefly avoiding a swatter is solving a complex visual and kinematic problem with a speed and economy of effort that computer designers can only dream of. Biologically successful design principles, honed over millions of years of evolution, have much to offer the next generation of computers.



The Institute's path-breaking work in large-scale chips is complemented by the development of innovative computing systems and software—areas offering enormous potential gains in computing speed and productivity. In 1985, Charles Seitz and his



Carver Mead, Christof Koch, John Hopfield, and Charles Seitz

students developed the highly concurrent Cosmic Cube message-passing multicomputer, a novel approach to high-speed computing that has helped create a new segment of the computer industry. The latest products of his research are ultrafast message-routing chips and software for distributing parts of computing problems to ensembles of small, fast computers. These are being incorporated into the next generation of concurrent supercomputers.

Future computers may be modeled on biological systems. Mead and John Hopfield are part of a group that designs specialized chips and systems of chips, called neural nets, that process information (such as sight and sound) in a way more like the brain does than do traditional computers. Such neural nets promise to advance computing as dramatically as did the integrated circuit, and their ability to learn is being advanced by Caltech faculty. Mead has also developed a rudimentary retinal chip, while Christof Koch is searching for the computational principles that govern visual pattern recognition. As Caltech faculty begin to translate this knowledge into silicon, they take a step toward producing a truly intelligent machine.

As computers evolve, they change the way scientists work. Computer simulations of complex phenomena generate data that would be difficult to obtain in the laboratory. For example, Anthony Leonard is developing techniques to simulate unsteady-flow separation—e.g., the turbulent air caused by a spinning helicopter rotor—in three dimensions.

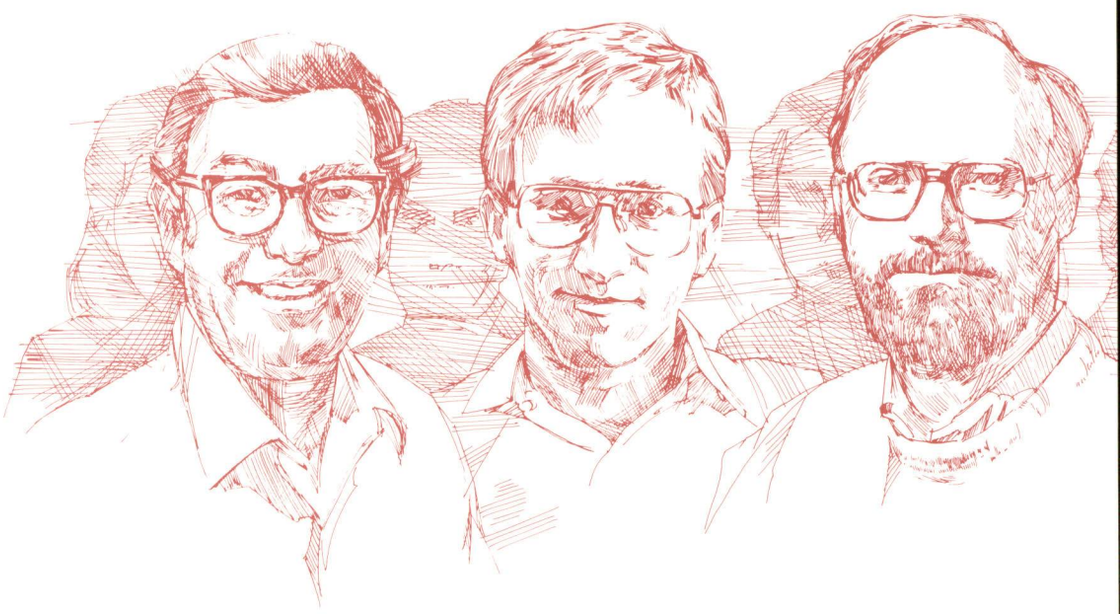
MOLECULES, MATERIALS, and MICRODEVICES

Plastic wires capable of conducting current, electronic devices no more than a few atoms wide, solar cells that might someday mimic photosynthesis: these technological marvels are taking shape at Caltech and elsewhere because scientists now design not only machines but the materials of which they are composed.

Caltech's early materials scientists were driven by practical problems. Just before World War II, Pol Duwez investigated what happens to metals subjected to sudden and intense shocks (explosions, for example). From Duwez's lab notes, aerodynamics expert Theodore von Kármán derived the complete theory of plastic-wave propagation, a major step in our understanding of how materials respond to stress.

Duwez went on to discover a new class of materials, metallic glasses, endowed with unusual electronic and magnetic properties, including resistance to radiation and corrosion. A group of Caltech researchers, including Thad Vreeland, William Johnson, and Brent Fultz, along with both undergraduate and graduate students, has devised a method for fabricating these materials in bulk, a precondition to studying many of their exotic properties.

The microchip revolution has motivated a quest for more efficient conducting materials to make possible supersmall, superfast electronic devices. William Goddard III, through his pioneering computer models of how bonds form between atoms and molecules in chemical reactions, is hastening the chemist's ability to design more complex molecules.

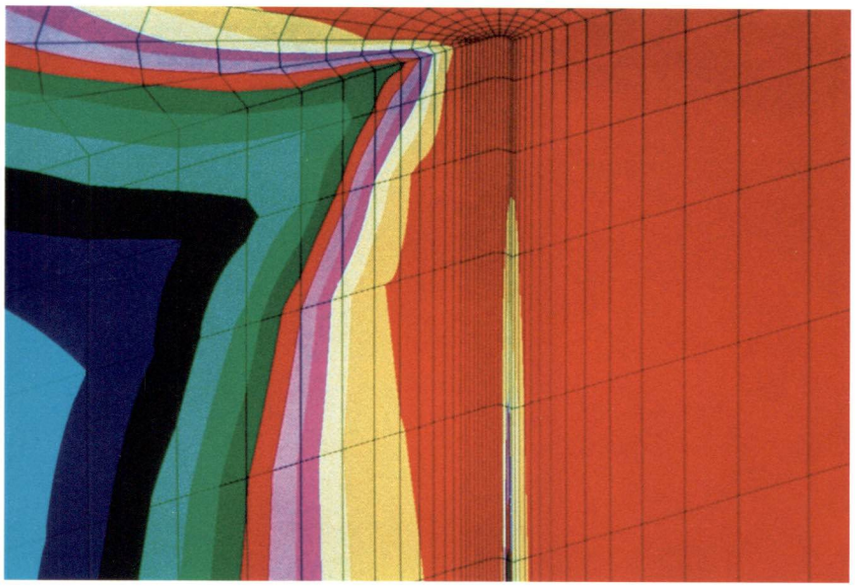


Harry Gray, Kerry Vahala, Robert Grubbs, and Pol Duwez

Robert Grubbs has perfected a new process for making polymers with properties that can be varied by molecular design. His group may eventually be able to create superlattices and composite materials containing different layers that are only a few atoms thick.

Will electronics, a field that was revolutionized by the invention of the transistor, eventually produce devices as small as a few atoms and capable of operating at the speed of light? Amnon Yariv has made a laser only 20 atoms thick that operates on virtually no current. A group led by Kerry Vahala has produced bumps of gallium arsenide a few hundred atoms thick with the capacity to emit light when stimulated by electrons.





Such electronic devices will still need energy to run them. Harry Gray's research into the processes whereby electrons move in metal-containing proteins such as chlorophyll could lead to a chemical system that harvests energy from sunlight the way that green plants do.

While most researchers seek new ways to put molecules and materials together, Ares Rosakis studies what happens when they come apart. This supercomputer simulation of a steel plate breaking shows stresses ranging from low (blue) to high (red). The crack is traveling from left to right. The yellow spike is the crack tip, where breaking bonds relieve local stress. Rosakis's group has developed high-speed methods to measure the stresses and temperatures surrounding a moving crack, which travels faster than a mile a second.

The UNIVERSE

From the farthest reaches of the cosmos to the innermost workings of the atomic nucleus, Caltech scientists probe the origin, evolution, and destiny of the universe.

During Robert Millikan's tenure as administrative head of the Institute (1921–45), Caltech became a world-class center for the study of physics and astronomy. Millikan illuminated a basic constituent of matter, the electron. A former student of his, Carl Anderson, deepened our understanding of the universe and matter by discovering the first antimatter particle, the positron.

Since those early years, Institute faculty members have continued to ask the most searching questions about the nature of physical reality. Richard Feynman completely restructured a major branch of modern physics called quantum electrodynamics. Murray Gell-Mann developed a theory describing the building blocks of matter, which he dubbed quarks; their existence was later demonstrated by experiment. His discovery opened up new avenues of research in subatomic physics, clarified the nature of the "strong force" that holds protons and neutrons together in the atomic nucleus, and pointed the way to a better understanding of what occurred in the first instants of the big bang, the explosion that gave birth to the universe.

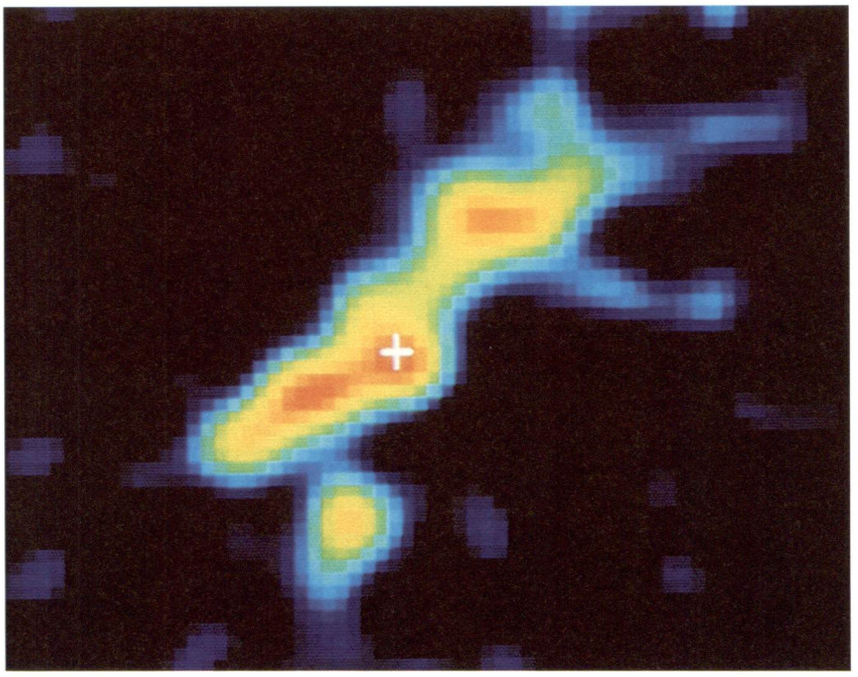
Following in the tradition of the great astronomer George Ellery Hale, Caltech physicists, astronomers, and astrophysicists have built sophisticated instruments to explore our dynamic universe. With them, Institute scientists have discovered the



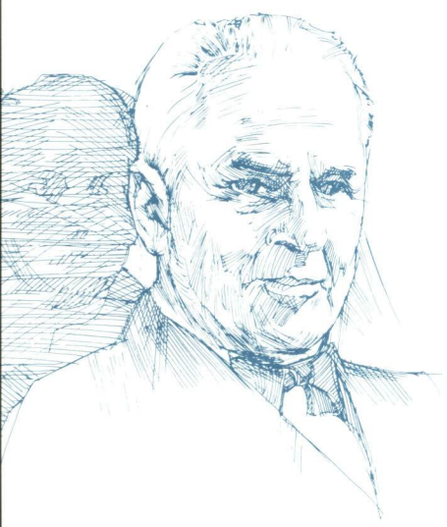
Gerald Wasserburg, Kenneth Libbrecht, Murray Gell-Mann, and Robert Millikan

universe's oldest and most distant objects, identified nearby stars that may be forming their own solar systems, and explored the planets. Closer to home, Kenneth Libbrecht has compiled research data that provide a surprisingly complex picture of the internal dynamics of the sun.

Caltech geologists, too, are looking outward to answer basic questions. Clues to the origin of our solar system are scattered across billions of miles. Gerald Wasserburg has been comparing isotopes in moon rocks and interplanetary debris in an attempt to describe the early chemical and physical evolution of the solar system.



HL Tauri is a nearby sunlike star that is younger than our own. This image, made by Steven Beckwith and Anneila Sargent with the millimeter-wave interferometer at Caltech's Owens Valley Radio Observatory, shows the gas cloud orbiting HL Tauri that may eventually condense into planets. Although no planets have yet been detected outside our own solar system, astronomers believe that planetary formation is a common process throughout the universe.



EARTH and ENVIRONMENT

Throughout Caltech's history, its scientists and engineers have studied the environment in the broadest possible context, expanding our awareness of the forces that shape it, and of our impact upon it.

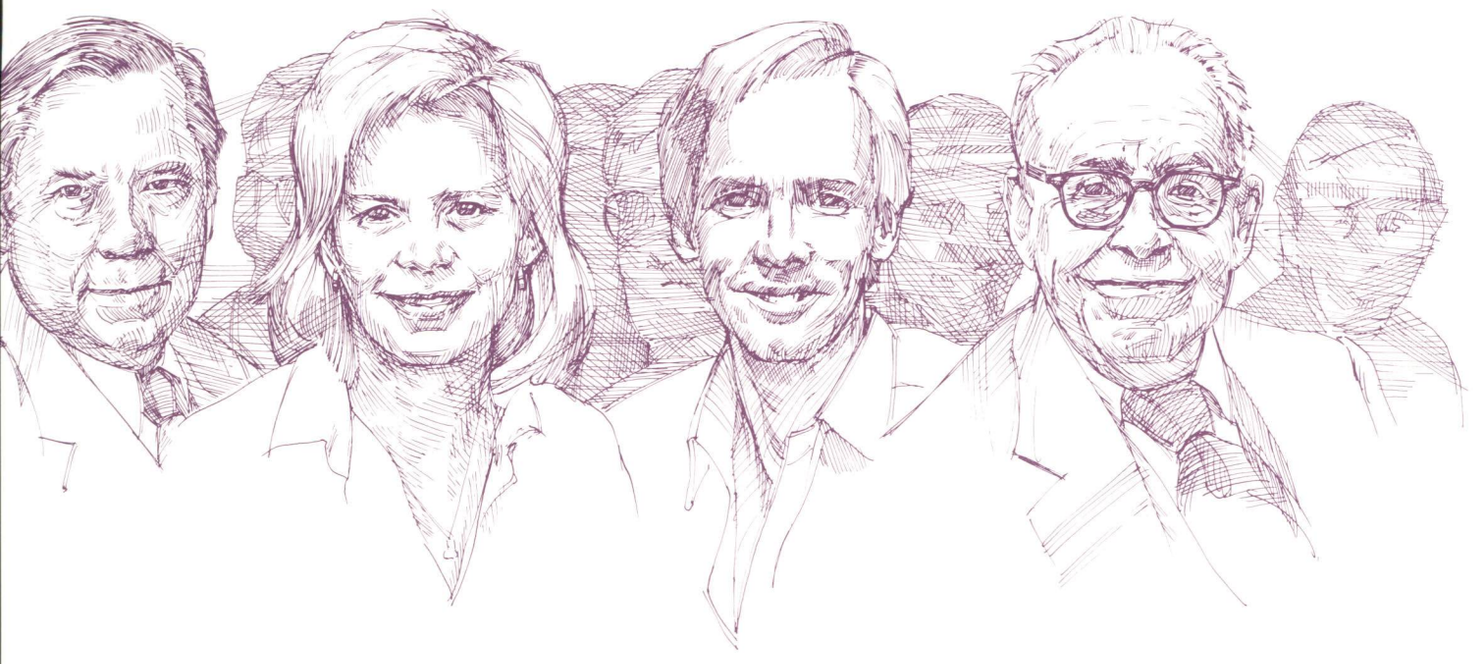
Caltech has pioneered far-reaching investigations and innovations in earthquake science. In the 1930s, Charles F. Richter joined with Beno Gutenberg to devise the first instrumental method for measuring the energy of earthquakes—the Richter scale. In so doing, they helped develop modern seismology. Today, geologist Kerry Sieh is adding to our understanding of earthquakes through the precise dating of recent great earthquakes along the San Andreas Fault. The new dates he has established present an intriguing pattern—a cluster of two or three major shocks within a century or so, separated by two to three centuries of quiet.



Preparing for earthquakes and finding ways to minimize their potential danger to life and property interests earthquake engineers at Caltech. George Housner, known as the "father of earthquake engineering," has developed with other Caltech faculty the design recommendations that have resulted in some of the first earthquake building codes based on modern engineering principles. Housner headed the California commission investigating the collapse of the Nimitz Freeway during the 1989 Loma Prieta Earthquake, which struck the San Francisco Bay area.

Antarctic ice moves toward the sea with glacial slowness – perhaps a dozen feet per year. "Ice streams" tens of miles wide, however, move several feet per day – as much as 100 times faster than the ice sheet around it. A stream is marked from the air by the jumbled, churned-up belt of ice along either margin (a cloud shadow crosses the stream in the middle distance). Geologist Barclay Kamb's studies may show if the Antarctic ice sheet is breaking up, a possible consequence of climatic change.





John Seinfeld, George Housner, Mary Lidstrom, Kerry Sieh, and Charles Richter

In the late 1940s, Arie Haagen-Smit conducted basic research that first identified the components of smog. His discoveries provided the groundwork for Caltech's current work in the chemistry and physics of air pollution. John Seinfeld has developed detailed mathematical models of pollutant behavior in the atmosphere. Now part of the Federal Clean Air Act and in use by the state of California and the Environmental Protection Agency, these models make it possible to examine the hypothetical consequences of reducing levels of emissions.

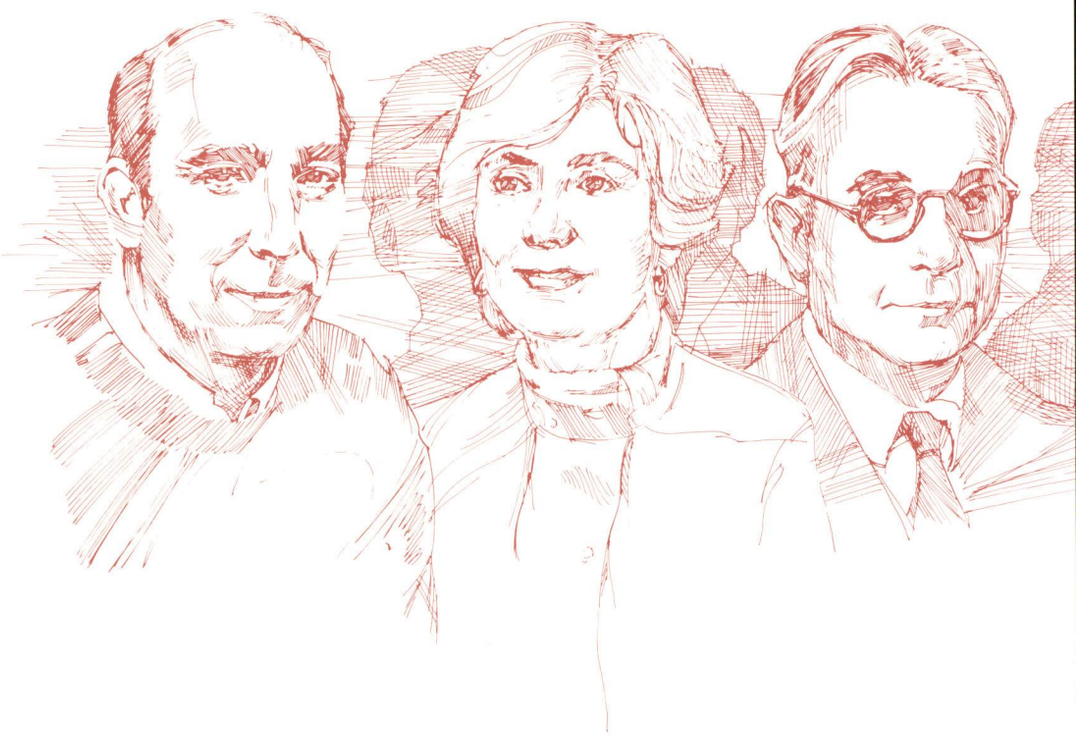
Real solutions to environmental problems must undo damage without creating further disturbances. A potential path to this necessary condition is being explored by Mary Lidstrom. Her approach makes use of naturally occurring bacteria that are capable of consuming chlorinated hydrocarbons, a major class of groundwater pollutants. She and her students are using advanced microbiological techniques to identify the genetic roots of this capability. Her goal is to make it possible to apply these and similar organisms to some of our most serious pollution problems, thereby tapping nature's own potential for self-renewal.

HUMAN VALUES and INSTITUTIONS

From its early days, Caltech has placed scientific and technical education in the context of other human activities. In 1921, the trustees established the requirement—unique in any engineering college at that time—of four consecutive years of study in the humanities for all undergraduates. Historian and political scientist William Munro, who joined the faculty in 1927, played an especially important role in the development of this program, securing endowment for the humanities and reshaping the undergraduate humanities curriculum. Today, Caltech undergraduates spend 20 percent of their course time studying the humanities and social sciences.

Munro's vision has been carefully guarded over the years and has, in fact, been strengthened by the appointment of outstanding faculty members who contribute their scholarly expertise to their Caltech students and their professional peers. Historian Eleanor Searle has brought a new understanding to the Norman period with the research she published in her book *Predatory Kinship and the Creation of Norman Power, 850–1066*. Literature professor John Sutherland studies publishing and printing in Britain and America from the inception of printing to the present day.

Classroom studies are further enriched by Caltech's program in Science, Ethics, and Public Policy. The program introduces students, faculty, and staff to informed thinking on issues related to the development of science and its engineering applications, in a socioeconomic and political context; the ways science and technology shape, and are shaped by, public policy and bureaucratic practice; and the moral and ethical issues related to the uses of science and technology.



Daniel Kevles, Eleanor Searle, William Munro, Thomas Palfrey, and Charles Plott

The program was developed by Daniel Kevles, who is now collaborating with Caltech biologists to examine the moral implications of modern biotechnology and its potential applications.

Investigators led by Charles Plott, working in Caltech's Laboratory for Experimental Economics and Political Science, have pioneered innovative techniques that have made it possible to examine the validity of various political and economic theories under controlled laboratory conditions. Studies that Plott and his colleagues have carried out over the last 15 years have had a direct impact on policy making in the public and private sectors in such areas as interstate commerce and transportation.

Thomas Palfrey has been using similar experimental techniques together with theoretical models to study a wide range of problems, from the effects of futures markets and insider trading on asset price volatility, to a comparative study of different procedures for eliciting voluntary contributions. He has also been studying the theoretical foundations for the design of incentive schemes, with applications to cartel behavior, voting rules, auctions, and multilateral contracting.



"The Duke's vessel lands at Pevensey" is part of the famed Bayeux tapestry, embroidered in the Middle Ages as a record of the Norman conquest of England. Recent studies by historian Eleanor Searle indicate that the medieval Norman state was built on a complicated network of kinship alliances. Kin loyalty was added to the more fragile bonds of chosen leadership, resulting in a group of cousins-by-marriage that could not only defend itself against French threats, but could (and did) see to it that no other, unallied group flourished in Normandy.





The achievements presented here were made in an intimate, unfettered community of discovery. Over the decades, this Caltech community has required significant resources to maintain such a high level of productivity. With the increasing competition for public funds, the urgent question arises: who will step forward to assure that the most daring work in engineering and science can continue, the kind of work upon which our competitive future as a nation depends? ⊖ Government support for fundamental scientific research has increased significantly in the past half-century. That commitment, as well as support for engineering and education, has fluctuated with policy objectives. The excellence of Caltech's work has earned it a generous share of such support, but such success may prove to be a mixed blessing. Grants from public sources are becoming smaller, their duration shorter, their stipulations and constraints more cumbersome. Less and less do they allow for the fluid, farseeing exploration that is Caltech's hallmark, or for the costly process of training tomorrow's innovators to think in the Caltech way. ⊖ The key issue remains the price of innovation—and the cost of its neglect. If narrow notions of cost-benefit limit our best minds to doing only what they have successfully done before, then true innovation may cease and the greatest advances might well elude us. Caltech's leadership in innovation represents a practical and an intellectual resource that the nation cannot afford to lose. ⊖ Such a loss is unthinkable to those who value Caltech. They understand that money invested in Caltech is venture capital for the highest-quality work in science and engineering. Thus private donors have helped underwrite the construction of Caltech's buildings, supported Caltech students with scholarships and fellowships, and sponsored a range of research projects. Many of Caltech's most ambitious current enterprises, including the construction of the world's largest optical telescope and of an institute dedicated to developing new technologies to spur discovery in biology and chemistry, were made possible by significant commitments from private sources. ⊖ Tomorrow's bold scientific achievements will depend on equally bold philanthropic commitments. At Caltech, the two go together, for trust and conviction motivate the philanthropic investment—trust in the power of human intelligence and conviction that ideas can transform our lives for the better. A century of achievement at Caltech is powerful evidence that donors with this trust and conviction are the most farseeing and astute of investors.

UNDERGRADUATE EDUCATION



My four-year experience at Caltech revolutionized the way I thought about science, society, scientific endeavors, and myself. Although one might argue that any rational person would react that way to the "college experience" in whatever setting, I would argue that my conclusions were different from those I would have drawn from attending any other university. After I left Caltech, I found that my approach to problems, my standards and expectations, certainly set me apart from a good many of my fellow graduate students. In short, whenever anyone asks me, "Where did you go to college?" I am always tempted to say, "I didn't, I went to Caltech."

Madeline A. Shea (B.S. '77)
Presidential Young Investigator
Assistant Professor, Biochemistry
University of Iowa

Caltech's 800 undergraduate students are among the most gifted and talented in the country. As Caltech students, they benefit from a student/professor ratio of 3:1, perhaps the nation's lowest. They learn science and engineering by working in labs with outstanding faculty. In the process they also experience the excitement of being at the intellectual cutting edge of their chosen fields. Their accomplishments in this environment are impressive, from the discovery of a distant supernova to the development of techniques for fabricating new industrial materials. As graduates, they become leaders in science, engineering, business, and medicine. Indeed, they make it a matter of national interest that the academic community of Caltech be maintained.

The task requires considerable financial commitment. First, to preserve the low student/professor ratio, Caltech has resisted income-generating increases in enrollments, just as it has resisted dependence on graduate students for much of its instruction. Second, Caltech provides extensive opportunities for conducting independent research under the supervision of faculty. To take but one example, Caltech has expanded its highly successful program of Summer Undergraduate Research Fellowships (SURFs) from an original 18 to more than 100 students annually at a cost exceeding $600,000. One of the Institute's primary goals is to make similar opportunities available to more Caltech students. Finally, Caltech admits students without regard to their financial means, then works with them and their families to meet their demonstrated need.

Given the cost of such commitments, can Caltech remain affordable and accessible? Several factors threaten those qualities.

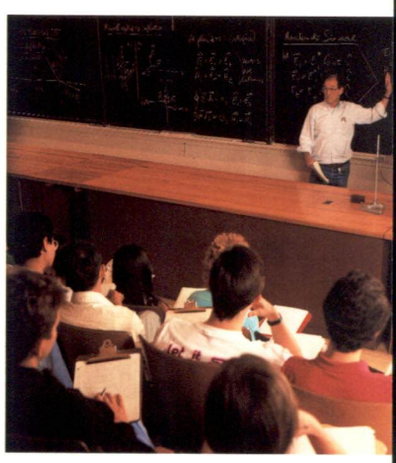
At Caltech, as elsewhere, the cost of education has been rising steadily. That rise has been fueled by a number of factors, including changes in teaching and research technologies and the need to modernize old facilities, from student houses to labs. Increased costs have been partially reflected in increased tuition. Yet in the last decade, federal support for student financial assistance has steadily decreased. Two-thirds of Caltech's undergraduates currently receive need-based financial aid, and the Institute funds an increasing percentage of the cost. If Caltech cannot maintain this level of support, it may not be able to accept many excellent students.

In a sense, any private gift that reduces the educational cost to the student—no matter how indirectly—will help preserve the character and educational effectiveness of Caltech. In four areas, however, private support can have a direct impact: financial assistance to students, undergraduate research opportunities, the upgrading of student housing, and the expansion



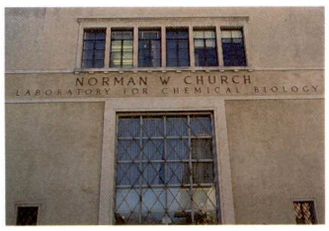
Two-thirds of Caltech's undergraduates receive need-based financial aid. Caltech admits students on the basis of talent and their interest in science and engineering, without regard to their ability to meet the full costs of attendance.

of athletic facilities. Without private support, Caltech will eventually be forced to choose between those areas. Students discouraged from coming to Caltech because their financial needs cannot be met or because facilities are outmoded represent potential that may go unfulfilled at a time when the nation needs high achievement in science and engineering. America's best and brightest deserve the opportunity to excel; private support can guarantee them that chance.



The small student-to-professor ratio (3:1) provides many opportunities to interact with faculty, in the classroom and lab.

GRADUATE EDUCATION



When I began my courses at Caltech, I thought I had made a terrible mistake. I had thought my study of science was behind me and what I needed was to become expert at applying science to the design of real-life electrical equipment. My eyes were opened to a whole new concept of how to prepare for a career in the application of science. . . . Innovative engineering consists in part in inventing new ways to put well-established principles to work. But a large part of what engineering is about, I came to see, is the exploiting of new knowledge as soon as possible after it is uncovered. It's like the difference between learning how to pump oil ever more efficiently from an existing well and finding new oil deposits. Caltech taught me how to make discoveries.

Simon Ramo (Ph.D. '36)
Caltech Life Trustee
Co-Founder and Director
Emeritus, TRW Inc.

If the United States is to maintain its international leadership in science and its competitiveness in advanced technology, if it is to meet the challenge of human health and assure clean air and water, it must encourage potential graduate students to enter degree programs in the sciences and engineering. Moreover, it must challenge them to ask new and penetrating questions and assume intellectual as well as professional leadership. Caltech has created an environment for graduate study in which such challenges are central.

At Caltech, graduate students can concentrate on the primary goal of their education—establishing themselves as independent investigators. The total Caltech faculty—which includes postdoctoral fellows as well as professorial, research, and visiting faculty—nearly equals the number of graduate students. Thus, these students are certain to be working closely with outstanding scientists and engineers.

The most important dimension of graduate education at Caltech, however, is intellectual responsibility. Graduate students are essential to the research conducted by Caltech faculty. They are treated as colleagues and members of a team. When they graduate, they are prepared to make a difference rapidly, and their record of achievement speaks for itself. Caltech doctoral graduates occupy leadership positions in academia, industry, and government.

Because of Caltech's importance in training the next generation of scientific and engineering leaders, it is essential that the Institute recruit and support the most outstanding graduate students. As with its undergraduates, Caltech must meet keen competition to maintain the caliber of its graduate student body. Because a graduate student's choice of schools is strongly influenced by economic factors, first-year fellowships are critical to Caltech's ability to attract the very best science and engineering students. Graduate students are frequently supported by federal research grants, a funding pattern that leaves many good students—particularly those with special needs or in areas underfunded by the federal government—in need of private support.

The Institute's continued ability to attract and support outstanding graduate students therefore depends on adding to the current endowment for graduate fellowship support.

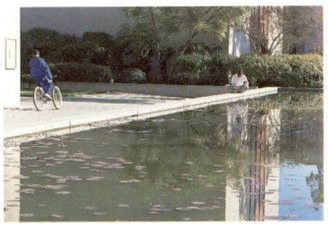


Working as independent investigators, Caltech graduate students prepare themselves for future leadership positions in academia, industry, and government.

Graduate students have the opportunity to do their research at such off-campus facilities as Palomar Observatory.



POSTDOCTORAL STUDY



When you put a lot of powerful intellects together in one place, the chances are almost nil that they will consistently agree with each other. Caltech is small enough, and the people here know and respect each other well enough, that they feel free to disagree. That generates a tremendous amount of intellectual energy. When I first arrived on the Caltech campus, I saw Albert Einstein and Robert Millikan heatedly debating on the steps of Throop Hall. I said to myself, "This is where I belong."

William A. Fowler (Ph.D. '36)
Nobel Laureate
Caltech Faculty Member, 1936–
Institute Professor of Physics, Emeritus, 1982–

Caltech's contributions to science and engineering depend on protecting and nurturing its community of scholars, one in which faculty, undergraduate and graduate students, and postdoctoral fellows all play a vital role.

With the increasing pace and complexity of research, postdoctoral fellows have become especially important members of the research community in many fields of inquiry. They perform a vital function as mentors to both graduate and undergraduate student researchers. They are, at the same time, a key means by which the range of research and intellectual activity on campus is extended.

In return for these critical contributions, Caltech faculty guide postdocs through the crucial final stage of their scientific training, the final preparation for their careers as research scientists and engineers. Many postdocs do their most creative, "breakthrough" work during this period, before they take on the additional responsibilities of teaching and administration that come with professorial appointments.

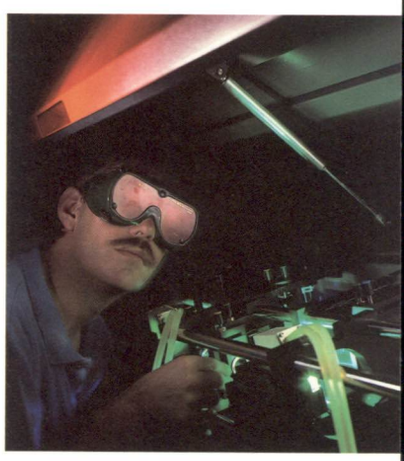
The cost of maintaining this element of the Caltech community is anywhere from $28,000 to $40,000 per fellow per year, as well as a large amount to maintain the facilities in which postdocs work. Some of that money comes from private contributions, but at present the bulk of it derives from public sources, usually federal grants.

Federal funding for postdoctoral fellows varies greatly from field to field and, as with faculty and students, the best individuals are in great demand. Endowed funds to support postdoctoral fellowships will ensure that the Institute can continue to attract and support outstanding fellows in many important fields.



Postdoctoral fellows and their faculty advisors establish a research environment in which new ideas are developed and explored. Together, they are the leaders of research projects that also include graduate and undergraduate students.

Endowed postdoctoral fellowships permit outstanding young scientists and engineers to conduct advanced research projects at Caltech.



RESEARCH



Caltech has been and remains the most exciting center in the world for science and its closely associated technologies. One reason is that the Institute itself is small, even while it operates the giant engineering activities at the Jet Propulsion Laboratory. The preeminent quality of its students, its faculty, and of the research program at Caltech assures a continuation of the Institute's long record of Nobel Prize winners, of widening the frontiers of science, of creating new technologies and even entire new industries. It is indeed at the same time a national resource and a world treasure.

Harold Brown
Caltech Trustee
Caltech President, 1969–77
Secretary of Defense, 1977–81

Over the history of the Institute, Caltech scientists and engineers have extended humankind's field of vision and capacity to alter the world for the better. They promise to extend both even further in the decades ahead as they design computers that are orders of magnitude faster, probe the heavens with the world's largest optical telescope, and design robots that can "see."

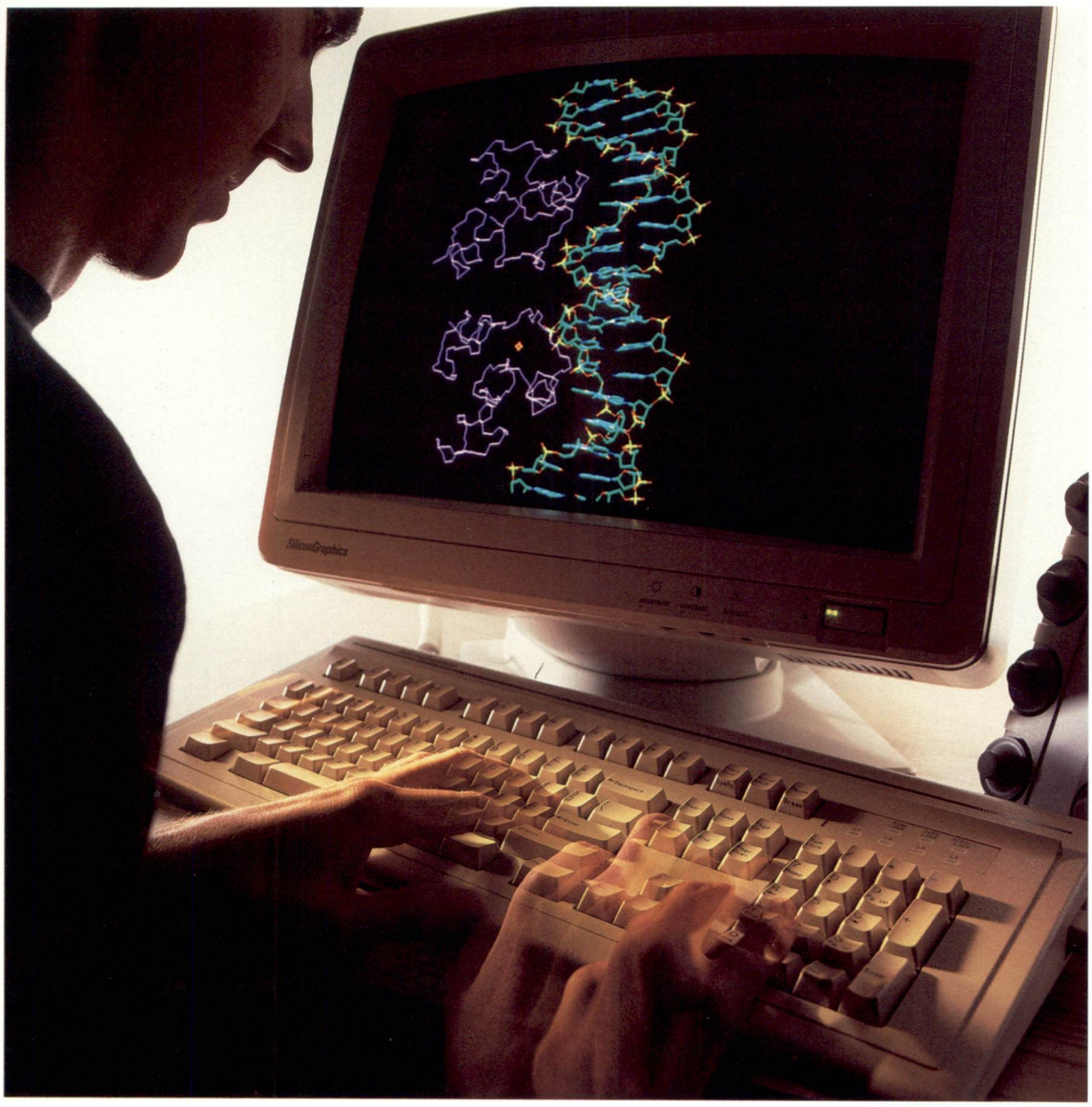
A major impediment to these breakthroughs would be the loss of scientific independence. As a private institution, Caltech exists to foster that independence. The freedom to pursue ideas wherever they lead has made Caltech one of the world's premier academic institutions. But guaranteeing that intellectual independence is costly. It cannot be done without significant private support.

The federal government does not fund the creation of research infrastructure on university campuses. At Caltech that infrastructure—primarily buildings—has been created almost entirely from private contributions. Major gifts have demonstrated that no intellectual challenge is too daunting when met with the resources of private philanthropy. Yet, apart from those initiatives, Caltech still faces significant capital needs to support research. These range from completely new facilities to renovated laboratories.

In addition to funds for capital projects, Caltech also needs direct private investment in research programs. Several factors make that need urgent. Currently, almost 60 percent of Caltech's operating budget is supported by the federal government. Grants from such agencies as the National Science Foundation help defray the costs of salaries, equipment, support staff, and maintenance. Because of the quality of Caltech's work, the level of federal support is unusually high. Thus, Caltech's very success has made it vulnerable to cutbacks and changes in federal funding policies.

The more research Caltech is able to support from its own and private sources, the greater will be its freedom from the effects of federal budgetary fluctuations. More important, increased direct private support will also guarantee Caltech's ability to set its own research agenda: to expand its research facilities, purchase and develop new equipment, assist new faculty with start-up funds for their laboratories, and launch promising projects.

Most important, private support will enable Caltech faculty to follow the path of imagination rather than that of conformity. That path is often complicated, and its payoffs are never guaranteed, but as we look back on Caltech's contributions from a world greatly altered by them, we recognize that path as ultimately the most efficient and productive possible.



Sophisticated computer technology enables researchers to design experiments that may unlock the secrets of human heredity.

Summer Undergraduate Research Fellowships (SURFs) are granted to more than 100 undergraduates, who devise their own research projects.





In 1891, Amos G. Throop, a Pasadena businessman, founded the modest school of arts and crafts—Throop University—that later would become Caltech. An important step in this transformation was made shortly after the turn of the century by Throop trustee and noted astronomer George Ellery Hale, who changed the focus of the school to the training of outstanding scientists and engineers.



"Father" Amos G. Throop, founder of Throop University.

Throop was renamed the California Institute of Technology in 1920. The next year, the distinguished physicist Robert A. Millikan (who had been persuaded by Hale and chemist Arthur Amos Noyes to come to Pasadena in 1917) became the Institute's first administrative head. This event initiated one of the most rapid rises to prominence of any institution in the country. Two years after his appointment, Millikan was awarded the Nobel Prize for his work determining the charge on the electron.

In the 1920s, the Seismological Laboratory was established. This was part of the development of seismology into the international science of detecting, measuring, and studying earthquakes. In the 1930s, Charles F. Richter and Beno Gutenberg invented the Richter Scale for measuring quake energy. Today, the Seismological Laboratory continues to be one of the premier centers for earthquake study. In the 1960s, modern earthquake engineering also emerged as a field at Caltech. George Housner and his coworkers developed methods that have helped in creating codes for earthquake-resistant tall buildings, in Los Angeles and other seismically active areas.



Charles Richter by the Seismological Lab's recording drums in 1970.

In 1926, Caltech established the Guggenheim Graduate School of Aeronautics (now known as the Graduate Aeronautical Laboratories, or GALCIT), and in 1929, built the lab associated with it. In 1930, Theodore von Kármán joined the Caltech faculty. Under his direction, researchers at GALCIT developed



The California Institute of Technology educates approximately 800 undergraduate and 1,000 graduate students each year. Nearly 1,000 faculty members are in residence, including 280 professorial faculty, 380 research faculty (including 290 postdoctoral fellows), and 300 visiting and other faculty. Many of the Institute's 17,000 living alumni have achieved positions of leadership in science, engineering, business, government, and industry. The campus is situated on 124 acres and includes among its 100 structures some 40 laboratory and research buildings equipped with the latest scientific instrumentation. The newest and largest research facility is the Beckman Institute, whose unique mission is to accelerate discoveries in biology, chemistry, and related sciences by developing and applying inventions of methods, materials, and instrumentation.

principles of flight that helped launch the aircraft industry in California. In 1962, von Kármán was awarded the first National Medal of Science for his outstanding contributions to the development of science and engineering. Since then, 28 more Caltech faculty and alumni have received this highest national award for scientific achievement.



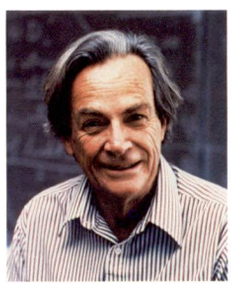
Theodore von Kármán receiving his award from President Kennedy.

The work of Caltech engineers impacted the growth of California in other ways. In the 1930s, 1940s, and 1950s, they played a crucial role in the design and construction of high-voltage transmission systems and of major irrigation projects in California. They established the High Voltage Laboratory and the Pump Laboratory and helped develop the pumping systems, aqueducts, and electrical components to bring water and power to Los Angeles.



Carl Anderson

In the 1930s, Caltech became a world center for the study of physics, a position it continues to hold. During those early years, Albert Einstein was a visitor on the Caltech campus, and Robert Oppenheimer served as a faculty member. In 1934, Carl Anderson discovered the anti-electron, or positron, the first empirical proof for the existence of antimatter. He was awarded the Nobel Prize in 1936. Richard Feynman joined the Caltech faculty in 1950, after completing his revolutionary work in quantum electrodynamics, work that earned him the Nobel Prize in 1965. At Caltech he expanded on these discoveries over a career of nearly 40 years, during which time he completely revised the teaching of undergraduate physics. Feynman was a key member of the Presidential Commission that investigated the 1986 explosion of the space shuttle *Challenger*.



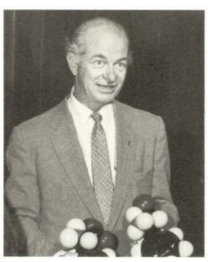
Richard Feynman

In the early 1960s, as problems developed with the accepted explanations of nuclear phenomena, Caltech physicists Murray Gell-Mann and George Zweig determined that protons and neutrons, long considered the fundamental building blocks of matter, were made up of even smaller particles, which Gell-Mann called quarks. Their theory was confirmed five years later, opening a new chapter on our knowledge of the atom. In 1969, Gell-Mann was awarded the Nobel Prize for this and other seminal discoveries. In 1984, John Schwarz and Michael Green proposed the "superstring" theory, which may prove to be the single unifying theory of elementary particles and forces that has long been sought by physicists.

Caltech displayed its determination to focus on "frontier" disciplines by bringing together a group of scientists who helped usher in molecular biology in the 1930s and 1940s. Thomas Hunt Morgan, who established the links between heredity and genes, won the Nobel Prize in 1933. George Beadle, who arrived at Caltech in 1935, made a group of discoveries that greatly expanded our understanding of the function of the gene; his discoveries included the pivotal notion that genes direct the formation of enzymes. He was awarded the Nobel Prize in 1958. Max Delbrück revolutionized the study of biology by bringing to it the techniques and perspectives of physics; his work earned him the Nobel Prize in 1969. Among the postdoctoral fellows during the 1930s was Jacques Monod, who had come to Caltech to study molecular biology. He was awarded a Nobel Prize in 1965.



George Beadle



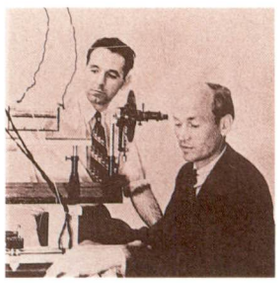
Linus Pauling

One of the most important discoveries in the history of chemistry was made at Caltech in the 1930s by Linus Pauling, who determined the nature of the chemical bond—how atoms link up to form molecules in both living and nonliving systems. Major advances in chemistry and molecular biology, and the creation of hundreds of synthetic products, had their roots in this single discovery. Pauling won the Nobel Prize twice: for chemistry, in 1954, and for peace, in 1962.



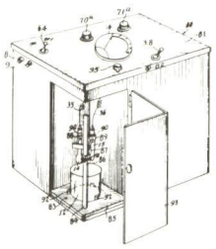
Caltech also operates the Jet Propulsion Laboratory for the National Aeronautics and Space Administration. The world's leader in unmanned planetary exploration, JPL grew out of work initially done by Caltech faculty and graduate students; the collaboration between the campus and JPL continues to be very active and highly productive. Other off-campus facilities include the Palomar Observatory, with its 200-inch Hale Telescope; the Owens Valley Radio Observatory; the Big Bear Solar Observatory; and the William G. Kerckhoff Marine Biological Laboratory, all in California; and the W.M. Keck Observatory, which will house the world's largest optical telescope, and the Submillimeter Observatory, both on Mauna Kea, Hawaii.

Pictured above: Owens Valley Radio Observatory



Arnold Beckman and James McCullough in a Caltech laboratory, ca. 1933.

In 1934, chemist Arnold Beckman invented the pH meter, effectively launching a new era in the development of sophisticated scientific instrumentation. In the 1950s, John Roberts demonstrated the power of new instrumental techniques by using the first commercial nuclear magnetic resonance (NMR) spectrometer on a



Design for the acidimeter, later called the pH meter.

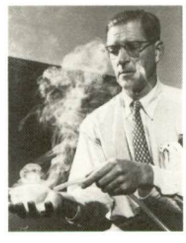
college campus to perform a series of experiments that altered our understanding of reactivity in organic molecules. The tradition of bringing new instruments to bear on scientific questions was continued in the 1970s by Leroy Hood and his group, who developed a prototype DNA synthesis machine that has become an essential tool in genetic engineering and biotechnology.

In 1989, Caltech dedicated the Beckman Institute, the largest building on campus. Work undertaken there will focus on the invention of instrumentation, methods, and materials that hold the promise of opening new avenues for fundamental research in chemistry, biology, and related sciences.

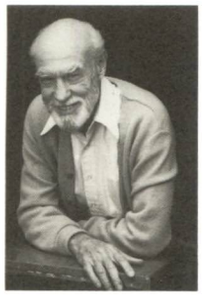
The Beckman Institute



At the end of the 1940s, Arie Haagen-Smit first identified the constituents of smog. His research opened the way for other Caltech researchers to elucidate the role of various emissions in the degradation of air quality. Later, geochemist Clair Patterson's demonstration that lead pollution from automobile exhaust had reached dangerously high levels was one of the factors in the federal government's decision to establish pollution controls within the auto industry. In the 1950s and early 1960s, Patterson's studies of the decay rate of lead isotopes were instrumental in determining that the earth has existed for 4.6 billion years.



Arie Haagen-Smit



Roger Sperry

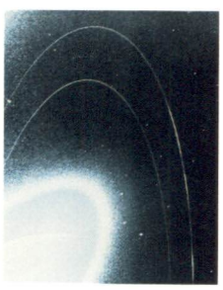
In the late 1960s and early 1970s, working at the forefront of the emerging discipline of neuroscience, Roger Sperry discovered that the left and right hemispheres of the brain are specialized for different capacities: the left for verbal thinking and language, the right for spatial-visual thought. Sperry was awarded the Nobel Prize in 1981. In 1986, under the leadership of chemist/biologist John Hopfield and computer scientist Carver Mead, Caltech established the first interdisciplinary doctoral program to study problems arising at the interface between neurobiology, electrical engineering, computer science, and physics.

Carver Mead also pioneered design techniques for VLSI (Very Large Scale Integration), techniques which proved to be powerful tools for the creation of complex electronic circuits on single semiconductor chips. Mead's work was a basis for revolutionary developments in electronic systems in the 1980s. In 1985, Charles Seitz and his students developed the Cosmic Cube, a revolutionary, message-passing multicomputer that signaled a new approach to high-speed computing and helped create a new segment of the computer industry.



Early days at the Jet Propulsion Laboratory.

In 1944, off-campus work by Caltech faculty and graduate students led to the establishment of the Jet Propulsion Laboratory, which later became the premier research and design center for the American unmanned space program, including flight missions to the moon and all the planets except Pluto. In 1989, Voyager 2 completed its grand tour of the outer planets, after being launched some 12 years before. Having flown by Jupiter, Saturn, and Uranus, the spacecraft sent back picture-postcard photos of Neptune—nearly 4 billion miles distant along



A view of Neptune's two rings, as recorded by Voyager 2.

NOBEL LAUREATES

1923 Robert A. Millikan*
Physics

1933 Thomas Hunt Morgan*
Physiology or Medicine

1936 Carl D. Anderson*
BS '27, PhD '30
Physics

1951 Edwin M. McMillan
BS '28, MS '29
Chemistry

1954 Linus C. Pauling*
PhD '25
Chemistry

1956 William B. Shockley
BS '32
Physics

1958 George W. Beadle*
Physiology or Medicine

1960 Donald A. Glaser
PhD '50
Physics

1961 Rudolf Mössbauer*
Physics

1962 Linus C. Pauling*
PhD '25
Peace

1964 Charles H. Townes
PhD '39
Physics

1965 Richard P. Feynman*
Physics

1969 Murray Gell-Mann*
Physics

1969 Max Delbrück
Physiology or Medicine

1975 Leo James Rainwater
BS '39
Physics

1975 Howard M. Temin
PhD '60
Physiology or Medicine

1976 William N. Lipscomb
PhD '46
Chemistry

1978 Robert W. Wilson
PhD '62
Physics

1981 Roger W. Sperry*
Physiology or Medicine

1982 Kenneth G. Wilson
PhD '61
Physics

1983 William A. Fowler*
PhD '36
Physics

CRAFOORD LAUREATES

1986 Gerald J. Wasserburg*
Geochemistry

**indicates those individuals who were members of the Caltech faculty when they received the award.*

NATIONAL MEDAL OF SCIENCE

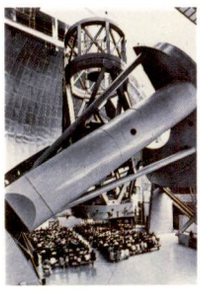
1962 Theodore von Kármán*
1963 John R. Pierce*
BS '33, MS '34, PhD '36
1967 Alfred H. Sturtevant*
1969 Wolfgang K.H. Panofsky
PhD '42
1970 Allan Sandage
PhD '53
1970 Saul Winstein
PhD '38
1973 Arie J. Haagen-Smit*
1974 William A. Fowler*
PhD '36
1974 Linus C. Pauling*
PhD '25
1974 Kenneth S. Pitzer
BS '35
1975 Sterling B. Hendricks
PhD '26
1975 William H. Pickering*
BS '32, MS '33, PhD '36
1975 E. Bright Wilson, Jr.
PhD '33
1979 Richard P. Feynman*
1979 Simon Ramo
PhD '36
1979 Donald E. Knuth
PhD '63
1983 Seymour Benzer*
1983 Charles H. Townes
PhD '39
1986 Harry B. Gray*
1986 Hans W. Liepmann*
1986 H. Richard Crane
BS '30, PhD '34
1986 Bernard M. Oliver
MS '36, PhD '40
1988 George W. Housner*
MS '34, PhD '41
1989 Arnold O. Beckman
PhD '28
1989 Rudolph A. Marcus*
1989 Harden M. McConnell
PhD '51
1989 Eugene N. Parker
PhD '51
1989 Robert P. Sharp*
BS '34, MS '35
1989 Roger W. Sperry*

NATIONAL MEDAL OF TECHNOLOGY

1988 Arnold O. Beckman
PhD '28
1989 Alvin V. Tollestrup
PhD '50

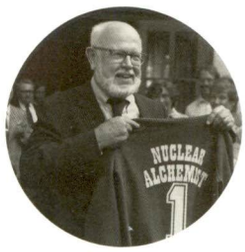
**indicates those individuals who were members of the Caltech faculty when they received the award.*

Voyager's route—revealing an extraordinary variety of terrains, some unlike any that had been seen elsewhere in the solar system.



The 200-inch Hale Telescope at its dedication in 1948.

When Caltech astronomers put the 200-inch Hale Telescope on Palomar Mountain into operation in 1948, it was the largest and most powerful device in the world for viewing the heavens. Caltech faculty subsequently undertook such ambitious projects as the search for distant objects at the edge of the universe. In 1964, Maarten Schmidt determined that quasars—energy-emitting sources in deep space—are the brightest and most distant objects in the universe. His discovery provided a new vision of the universe at an early period of its history. In 1983, William Fowler was awarded the Nobel Prize for his studies of the nuclear reactions, deep within stars, that formed the chemical elements of the universe.



William Fowler, after winning the Nobel Prize.

In the coming decades, Caltech scientists will continue their work with the help of a new instrument, the W. M. Keck Telescope at Mauna Kea, Hawaii, the world's largest optical telescope. The partially completed telescope will see "first light" in 1990. When completed in 1991, it will have the capacity to look deeper into space—and hence further back in time—than has ever been possible before.



The W.M. Keck Observatory atop the extinct Mauna Kea volcano in Hawaii.

In times like these, there need to be a few places that look ahead and still dare to do the most ambitious things that human beings can accomplish. Caltech still has that ambition and that daring.

President Thomas E. Everhart
Inaugural Address
April 12, 1988



"INVITATION FOR DR. BROMLEY"

TYPE: INVITATION-SPEECH DOCUMENT NUMBER: 9120854

****

SPEECH: YES NO

FROM: PUSH, Stephen: POWELL ADMAS & RINEHART

DATE OF EVENT: 05/22/91

LOCATION OF EVENT: WASHINGTON, D.C.

TIME OF EVENT:

SUBJECT: INVITATION TO BE A DINNER SPEAKER AT A WORKSHOP ON NUTRITION OF THE ELDERLY, SPECIFICALLY AN ISSUE IN PUBLIC POLICY THAT HAS AN IMPACT ON HUMAN NUTRITION.

****

RSVP:

CONTACT PERSON:

CONTACT NUMBER:

****

INVITATION ACCEPTED? YES NO

****

COPIES TO: Life Sciences

REMARKS: 4/2/91 Regretted to Tom Bell!
MM

Sponsor: Nestle, Inc.
Subject: Nutrition of the elderly
Audience: 50 researchers and other professionals
Date: May 22 or 23, Tuesday or Wednesday, evening
3/28/91 Location: Washington, D.C.
Contact: Stephen Push
Conflicts: You will be going on personal leave May 23.

for Bell

YES NO

Out of town. No. DAH? So need to decline

Powell Adams & Rinehart
An Ogilvy Company

1901 L Street, N.W.
Suite 300
Washington, D.C. 20036
Tel: 202-466-7590
Fax: 202-466-7598

RECEIVED
91 MAR 22 P5:10
OFFICE OF THE DIRECTOR

March 22, 1991

D. Allan Bromley
Assistant to the President and Director
Office of Science and Technology Policy
Old Executive Office Building, Room 358
Washington, D.C.

Dear Dr. Bromley:

On behalf of my client, Nestlé USA, I would like to invite you to be a dinner speaker at a workshop on nutrition of the elderly scheduled for May 22-24, 1991, in Washington, D.C. Although most of the workshop will be devoted to research topics, the participants would be pleased if you would speak about any issue in public policy that may have an impact on human nutrition.

The workshop is an annual event sponsored by Nestlé's research and development team to foster scientific communication on nutrition research. Participating in the workshop will be 25 senior researchers from leading universities and research institutes in the United States and several foreign countries. In addition, Nestlé will open the workshop to approximately 25 observers from government agencies, professional societies, public interest groups, and other organizations concerned about nutrition and health. The news media will be invited to attend.

Nestlé USA's units include Carnation Company, Nestlé Foods Corporation, and Stouffer Foods Corporation.

The workshop agenda is enclosed. We would be pleased if you would deliver a 20- to 30-minute address. Tom Beall of Powell Adams & Rinehart will call your office to discuss which evening, May 22 or 23, might be convenient for you.

Thank you in advance for your time and consideration.

Sincerely yours,

Stephen Push
Senior Associate

Enclosure

cc: Tom Beall

NESTLE NUTRITION SERVICES



29th NESTLE NUTRITION WORKSHOP

Washington D.C., USA

22 - 24 May, 1991

NUTRITION OF THE ELDERLY

To be held at : The Mayflower Hotel, 1127 Connecticut Avenue NW,
Washington D.C. 20036, USA

Tel. (202) 347 3000; Fax. (202) 466 9082; Tlx. 892324

Co-Chairmen : Hamish Munro, Boston, USA
Erich Lang, Erlangen, Germany

Tuesday 21 May

	Arrival of participants and registration	
20.00	Welcome cocktail party	

Wednesday 22 May

09.00 - 09.20	**Welcome and opening**	
09.20 - 09.40	Introduction	Hamish Munro Boston, USA
SESSION 1:	SOCIOLOGY	CHAIRMAN: ERICH LANG Erlangen, Germany
09.40 - 10.00	Health and population statistics: discussion and interpretation	T.F.Williams Bethesda, USA
10.00 - 10.30	Discussion	
10.30 - 11.00	Coffee break and group photograph	
11.00 - 11.20	Sociology of aging in different cultures	J. Hautvast, Wageningen, Holland
11.20 - 11.50	Discussion	
	Lunch	

SESSION 2:	**PHYSIOLOGICAL CHANGES DUE TO AGEING**	**CHAIRMAN: HAMISH MUNRO BOSTON, USA**
14.00 - 14.20	Water, electrolytes, kidney function	H.Sato Tokyo, Japan
14.20 - 14.50	Discussion	
14.50 - 15.10	Endocrine function	Malcolm Hodkinson London, UK
15.10 - 15.40	Discussion	
15.40 - 16.00	Coffee break	
16.00 - 16.20	Digestive function	I.Rosenberg Boston, USA
16.20 - 16.50	Discussion	
16.50 - 17.10	Energy metabolism	J.Durnin Glasgow, UK
17.10 - 17.40	Discussion	
	Dinner	

Thusday 23 May

SESSION 2 (continued)		**CHAIRMAN: SUSAN SCHIFFMAN DURHAM, USA**
08.30 - 08.50	Brain function and behaviour	D.Blazer Durham, USA
08.50 - 09.20	Discussion	
09.20 - 09.40	Taste changes and appetite	C.Murphy San Diego, USA
09.40 - 10.10	Discussion	
10.10 - 10.30	Coffee break	
10.30 - 10.50	Immunodeficiency	A. de Weck Bern, Switzerland
10.50 - 11.20	Discussion	
SESSION 3:	**SPECIFIC NEEDS OF THE ELDERLY**	**CHAIRMAN: J.HAUTVAST WAGENINGEN, HOLLAND**
11.20 - 11.40	Energy	Zvi Glick Los Angeles, USA
11.40 - 12.10	Discussion	
	Lunch	
14.00 - 14.20	Protein	David Kritchevski Philadelphia, USA
14.20 - 14.50	Discussion	
14.50 - 15.10	Fatty acids	P.Nestel Adelaide, Australia
15.10 - 15.40	Discussion	
15.40 - 16.00	Coffee break	
16.00 - 16.20	Vitamins	Werner Kübler Giessen, Germany
16.20 - 16.50	Discussion	

,.50 - 17.10	Trace minerals	William Mertz
,7.10 - 17.40	Discussion	Beltsville, USA
	Dinner	

Friday 24 May

SESSION 4:	**SPECIAL DISEASES OF AGEING AND THEIR PREVENTION**	**CHAIRMAN: PIERRE GUESRY VEVEY, SWITZERLAND**
08.30 - 10.30	Round table on Prevention of Osteoporosis	
08.30 - 08.45	Calcium, phosphorus, magnesium, vitamin D	Jean-Pierre Bonjour Geneva, Switzerland
08.45 - 09.00	Hormones	P.D. Delmas Lyon, France
09.00 - 09.15	Physical activity	C.Meredith Davis, Ca, USA
09.15 - 09.30	Fluoride	P.J.Meunier Lyon, France
09.30 - 10.30	Round table discussion	
10.30 - 10.50	Coffee break	
10.50 - 11.10	Senile dementia	J.A.Edwardson Newcastle, UK
11.10 - 11.40	Discussion	
SESSION 5	**PRACTICAL ASPECTS OF NUTRITION OF THE ELDERLY**	**CHAIRMAN : JOHN MORLEY LOS ANGELES, USA**
11.40 - 12.00	At home	L.Davies London, UK
12.00 - 12.20	Discussion	
12.20 - 12.40	Institutions	B.Steen Göteborg, Sweden
12.40 - 13.00	Discussion	
13.00	Conclusion	Erich Lang Erlangen, Germany
	Lunch	

"INVITATION FOR DR. BROMLEY"

TYPE: INVITATION-SPEECH DOCUMENT NUMBER: 9121145

****

SPEECH: YES NO

FROM: DAVIES, Terry: EPA

DATE OF EVENT: 06/11/91

LOCATION OF EVENT: SHERATON CRYSTAL CITY HOTEL, ARLINGTON, VA.

TIME OF EVENT:

SUBJECT: REQUEST TO BE THE KEYNOTE SPEAKER AT THE SECOND NORTH AMERICAN CONFERENCE ON FORESTS AND GLOBAL CHANGE

****

RSVP: 04/03/91

CONTACT PERSON: DENNIS TIRPAK

CONTACT NUMBER: 202/475-8825

****

INVITATION ACCEPTED? YES NO

****

COPIES TO:

REMARKS:

DATE OF LETTER: 03/04/91 DATE RECEIVED: 04/03/91

FILE: P- INVITATION-SPEECH

9121145

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAR 4 1991

OFFICE OF
POLICY, PLANNING AND EVALUATION

Dr. D. Allan Bromley
Science Advisor
The White House
360 Old Executive Office Building
Washington, DC 20506

Dear Dr. Bromley:

The U.S. Environmental Protection Agency, the U.S. Forest Service, and the American Forestry Association are hosting the Second North American Conference on Forests and Global Change. We would like to invite you to be the keynote speaker at lunch on the first day of the conference. The conference will be held June 11-12, 1991 at the Sheraton Crystal City Hotel in Arlington, Virginia.

The first conference, held last May in Washington, focused on the issue of forestry responses to climate change. This year's conference will be more technical. It will focus on innovative strategies to sequester and store carbon in forest and vegetative systems, and the policy tools required to implement them. We would like you to give your personal vision of how the U.S. government and the world could address pressing forestry issues, such as a global forest agreement, climate change, and biodiversity, and what the U.S. contribution could be. This is an opportunity for you to address 200 or more of the primary experts, analysts, and decision makers in this area.

We would welcome your participation in as much of the conference as you can attend. Enclosed, please find a copy of the conference agenda. If the lunch presentation is not convenient for you, we would welcome you as a featured speaker at a plenary session or at the second lunch.

If you have any questions you can call Dennis Tirpak, Director of the Climate Change Division at (202) 475-8825, or Neil Sampson of the American Forestry Association at (202) 667-3300. Thank you very much for your consideration.

Sincerely,

Terry Davies,
Assistant Administrator

Enclosure

of the carbon sources and sinks present in current-day forests, along with some insight into the opportunities for effecting change. While this analysis will still fall short of a full cost-benefit presentation, it should give a clear idea of the opportunies currently seen to exist, their relative magnitude in terms of impact upon atmospheric carbon buildup, and some idea of the policy, program, investment, and research needs that have been suggested. Author: **Neil Sampson**, AFA.

Noon -- Luncheon with speaker -- preferably world-class environmental overview thinker.

Suggestions:

Assigned to Contact Potential Speaker: Ken Andrasko

1:30 - 4:30

Second Session: Forestry opportunities to mitigate global climate change: what kind of specific application opportunities exist, and how are leading forestry thinkers proposing that they can and should be exploited. (Session Coordinators: Steve Winnett and Stan Krugman)

Session Moderator: **Steven Winnett**, EPA

Paper #1 -- What Role do Woody Plants Have in Mitigating CO_2 Emissions? Serves as an introduction to the three technical papers to follow. Will capture the relevant points of the first North American conference and bring conference up to date with current efforts and policies. Will emphasize the biological/ecological focus of the session. Author: **Steven Winnett**, EPA.

Paper #2 -- Management Strategies for Sequestering and Storing Carbon in Natural, Managed, and Highly Disturbed Hardwood Ecosystems. Will emphasize biological opportunities, considering the list of elements from mitigation memo #1 and adding any that the author may be interested in. Author: **Robert Kellison,** North Carolina State University.

Paper #3 -- Management Strategies for Sequestering and Storing Carbon in Natural, Managed, and Highly Disturbed Coniferous Ecosystems. Parallel to paper #2. Author: **John Helms**, University of California, Berkeley.

Paper #4 -- Management Strategies for the Application of Woody Plants for Sequestering and Storing Carbon in Traditional and Non-Traditional Growing Conditions. An assessment of opportunities in such efforts as ecosystem restoration, expansion of trees and forests for conservation uses, urban and community forests, and other forest expansions that are not aimed at timber production. Authors: **Jim Barnett** and **Clyde Hunt**, USFS.

Session Wrapup -- **Stanley Krugman**, USFS

Evening -- A poster session where participants can gather in a reception-type atmosphere and people can discuss work-in-progress with poster papers. The number of papers will be established by the available space, the decisions of the planning committee, and the willingness of good authors. Possible target: 10. Coordinator: **Al Sample**

Carbon Reserves -- Opportunities and Economics -- Peter Parks, Duke University

MINK -- A Case Study of Forest Opportunities -- Roger Sedjo, RFF

HARVCARB -- Where does Carbon Go? -- Clark Row, Consultant and Bob , FS.

Creating a National Forest-Carbon Model -- Werner Kurz, Forestry Canada

Energy Plantations -- Promise and Potential -- Jack Ranney or Lynn Wright, Oak Ridge

Living Snow Fences -- Saving Lives, Energy, and Dollars -- Jim Hubbard, Colorado

Second Day -- Wednesday, June 12, 1991

8:30 a.m. -- Opening exercises

8:45 - Noon Third Session: Forest management strategies to adapt to global climate change: what kinds of challenges do we face, and what are leading forestry thinkers proposing that forest managers can and should be planning to do about them. (Session Coordinators: Bill Sommers and Mike Fosberg)

Session Moderator:

Paper #1 -- Discussion of management strategies for existing stands, either planted or natural. Possible Speaker: **Peter Duinker**, Canada.

Paper #2 -- Discussion of adaptive management strategies of innovative stand establishment. Possible Speakers: **Norm Johnson**, Weyerhaeuser; **Dennis LeMasters**, Purdue.

Paper #3 -- Impacts of climate change on the genetic base of forest ecosystems, and the potentials and challlenges of using genetic diversity to maintain or improve the productivity and sustainability of forest stands subjected to environmental stress. Possible Author: **Tom Ledig**, USFS, CA.

Paper #4 -- What are the potential impacts of climate change and the most likely adaptive strategies suitable for reserved areas such as parks

and wilderness areas? Possible Speaker: **Bill Gregg**, NPS

Session Wrapup -- **Tom Crowe**, USFS, WI

Assigned to Contact Potential Authors – Mike Fosberg, FS

Noon -- Luncheon with speaker -- preferably world-class policy type

Suggested Speakers:

Assigned to Contact Potential Speaker: Ken Andrasko

1:30 - 4:30 Fourth Session: Implications of Forest and Land Use Policy Decisions for Climate Change. (Session Coordinators: Ken Andrasko and Dave Darr)

Paper #1 -- Can We Link Forestry to Energy and Agriculture, and Reduce Greenhouse Gas Emissions? Explore the intersection forestry and the energy sector, including the potential impact as high intensity, short rotation forestry moves into agricultural lands and operations. Possible Speaker: **Greg Marland**, Oak Ridge

Paper #2 -- Forestry Mitigation Decisions Undertaken Thus Far A look at relevant forest policy decisions, both within the U.S. and other countries, with emphasis on their potential impact (intended or unintended) upon greenhouse gas emissions. Possible Authors: **Bruce Lippke, CINTRAFOR, and Ken Andrasko, EPA**

Paper #3 -- Managing Moving Targets: Unifying Climate Change Impacts and Mitigation Analyses. An effort to identify efforts and methods for evaluating forest management options that take both potential impacts and mitigation into account. Possible Author: **Mike Apps, Forestry Canada**

Paper #4 -- Adding Climate Change and Ecological Criteria to Multiple Use Management of North American Forests. Possible Authors: **Scott Wallinger, Westvaco, Dick Porterfield, Champion**

Assigned to Contact Potentiall Authors: Ken Andrasko, EPA

4:30 p.m. Closing Exercises and Summaries

5:00 p.m. Adjourn

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
POLICY, PLANNING AND EVALUATION

MAR 4 1991

Dr. D. Allan Bromley
Science Advisor
The White House
360 Old Executive Office Building
Washington, DC 20506

Dear Dr. Bromley:

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The first conference, held last May in Washington, focused on the issue of forestry responses to climate change. This year's conference will be more technical. It will focus on innovative strategies to sequester and store carbon in forest and vegetative systems, and the policy tools required to implement them. We would like you to give your personal vision of how the U.S. government and the world could address pressing forestry issues, such as a global forest agreement, climate change, and biodiversity, and what the U.S. contribution could be. This is an opportunity for you to address 200 or more of the primary experts, analysts, and decision makers in this area.

We would welcome your participation in as much of the conference as you can attend. Enclosed, please find a copy of the conference agenda. If the lunch presentation is not convenient for you, we would welcome you as a featured speaker at a plenary session or at the second lunch.

If you have any questions you can call Dennis Tirpak, Director of the Climate Change Division at (202) 475-8825, or Neil Sampson of the American Forestry Association at (202) 667-3300. Thank you very much for your consideration.

Sincerely,

Terry Davies,
Assistant Administrator

Enclosure

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
POLICY, PLANNING AND EVALUATION

MAR 4 1991

Dr. D. Allan Bromley
Science Advisor
The White House
360 Old Executive Office Building
Washington, DC 20506

Dear Dr. Bromley:

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If you have any questions you can call Dennis Tirpak, Director of the Climate Change Division at (202) 475-8825, or Neil Sampson of the American Forestry Association at (202) 667-3300. Thank you very much for your consideration.

Sincerely,

Terry Davies,
Assistant Administrator

Enclosure

PROPOSED AGENDA
CONFERENCE ON FORESTS AND GLOBAL CHANGE
A Symposium on Forestry Opportunities to Mitigate
and Adapt to Global Climate Change

First Day -- Tuesday, June 11, 1991

8:30 a.m. --- Opening exercises

9:00 - Noon -- Opening Session: The State of Knowledge in Climate-Forest Interaction Issues. (Session Coordinators: Neil Sampson and Tom Hamilton)

Session Moderator: -- **John Gordon,** Yale University

Overview -- Our Changing State of Knowledge -- This brief (10-15 minute) paper will set the stage by outlining how the scientific and policy thinking on the climate change issue has changed over the past decade or so, and some of the over-arching issues we may need to understand still better if we are to keep up with the pace of change that is likely to face us. Proposed Speaker -- **John Gordon**

Assigned to Invite Speaker: Neil Sampson

Paper #1 -- The Importance of Climate and Environmental Concerns in Today's Forest Management This is a very tentative title, to be used as a base to attract a leader in the forest products industry to participate in the meeting. If something can be arranged, the title will be adjusted to suit. Proposed author: To be Sought (Ideas Invited).

Assigned to Find Speaker: Scott Berg

Paper #2 -- Forest Policy, Program, and Practice -- History and Prospects A review of the recent trends in policies, programs and practices in forestry, both public and private. How are public pressures affecting professional practice, and where does this seem to be leading. Are "New Forestry," "New Perspectives in Forestry," etc., really new, and what kinds of issues do these new lines of thinking raise for the challenge of adapting forest management to the challenges of climate change? Author: **John Beuter**, USDA.

Paper #3 -- The Global Forestry Agreement and its Promise -- A look at the international efforts to affect forest policy and their potential for impacting global climate concerns. Possible Speaker: **Buff Bohlen**, U.S. Department of State

Assigned to Invite Speaker: Ken Andrasko

Paper #4 -- Forestry Potentials for Mitigating Global Warming in the United States An overview, heavily illustrated with charts and graphs, of the work completed under the EPA-USDA-AFA-AFC project by the same name. The overview should present some idea of the magnitude

THE WHITE HOUSE

WASHINGTON

April 3, 1991

Dear Mr. Davies:

Thank you for your letter of March 4, 1991, inviting me to be the keynote speaker at your conference scheduled for June 11, 1991, at the Sheraton Hotel in Arlington, Virginia.

Given the importance of natural fluxes of carbon in the global carbon cycle, I would very much have liked to be a part of your conference. However, I am scheduled to be away from Washington during that time, so I must regretfully decline your invitation.

Thank you for thinking of me and let me offer my best wishes for the meeting.

Sincerely yours,

D. Allan Bromley
Assistant to the President
for
Science and Technology

Mr. Terry Davies
Assistant Administrator
U.S. Environmental Protection Agency
401 M Street, Southwest
Washington, D.C. 20460

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION DOCUMENT NUMBER: 9120974

****

FROM: GENEL, Myron: YALE UNIVERSITY

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 03/28/91

SUBJECT: THE COUNCIL OF ACADEMIC SOCIETIES' CONFERENCE, "RECRUITING & NURTURING YOUNG FACULTY AND INVESTIGATORS".

****

ASSIGNED TO:

ACTION REQUIRED:

****

SENDER'S DUE DATE: OSTP DUE DATE:

DATE COMPLETED:

****

COPIES TO: D. Allan Bromley
Life Sciences
Steve Olson

****

WHITE HOUSE TRACKING #: CONTACT PERSON:

REMARKS:

DATE RECEIVED: 04/02/91 FILE: P. initiative SPEECH ~~FOLLOW-UP~~

9120974

Yale University

Office of Government and Community Affairs

School of Medicine
Sterling Hall of Medicine
333 Cedar Street
P.O. Box 3333
New Haven, Connecticut 06510-8056

Campus address:
1202 SHM
333 Cedar Street
Telephone:
203 785-6019
FAX:
203 785-7208

Myron Genel, M.D.
Associate Dean

RECEIVED
91 APR 2 P12: 26
OFFICE OF THE DIRECTOR

March 28, 1991

D. Allan Bromley, Ph.D.
Assistant to the President for Science & Technology
Director, Office of Science & Technology Policy
Old Executive Office Building
17th Street & Pennsylvania Avenue, N.W.
Washington, DC 20506

Dear Allan:

Our Savannah meeting, which concluded on Wednesday, was by all accounts the most successful since the Council of Academic Societies adopted the expanded spring conference format five years ago. In large measure this reflected the importance of the conference theme "Recruiting and Nurturing Young Faculty and Investigators" and the interest generated by your appearance. Your keynote address at the conference dinner Monday night was vintage Allan Bromley and clearly a highlight of our meeting.

I am cognizant of your busy schedule, especially at this time of year, and very much appreciate your setting aside the time to be with us and to share your thoughts on the status of biomedical research. I am sure that I speak not only for myself, as chair of the Council of Academic Societies, the AAMC's faculty component, but also on behalf of the Association's officers, including our President, Bob Petersdorf, and our immediate past chairman, David Cohen.

I look forward to our continuing personal and professional interaction.

Sincerely,

Myron Genel, M.D.
Professor of Pediatrics
Associate Dean
Chair, Council of Academic Societies

MG:pac

cc: Robert G. Petersdorf, M.D., President, AAMC
Thomas E. Malone, Ph.D., Vice President for Biomedical Research, AAMC
David H. Cohen, Ph.D., Immediate Past Chairman, AAMC

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION DOCUMENT NUMBER: 9120964

****

FROM: O'HARA, Joseph A.: FORDHAM UNIVERSITY

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 03/26/91

SUBJECT: RE: DR. BROMLEY'S VISIT TO FORDHAM TO DELIVER THE SIEVERS LECTURE AND THE POTENTIAL OF RECEIVING AN HONORARY DOCTORATE OF SCIENCE.

****

ASSIGNED TO:

ACTION REQUIRED:

****

SENDER'S DUE DATE: OSTP DUE DATE:

DATE COMPLETED:

****

COPIES TO: D. Allan Bromley

****

WHITE HOUSE TRACKING #: CONTACT PERSON:

REMARKS:

DATE RECEIVED: 04/01/91 FILE: P. initiative SPEECH ~~FOLLOW-UP~~

FORDHAM
1841 1991
150 YEARS
KEEPING FAITH WITH THE FUTURE

Fordham University
Bronx, New York 10458
(212) 579-2003

Office of
The President

RECEIVED
91 APR 1 P2:47
OFFICE OF THE
DIRECTOR

March 26, 1991

Dr. D. Allan Bromley
Assistant to the President for
Science and Technology
Old Executive Office Building
Room 358
Washington, DC 20506

Dear Dr. Bromley,

I was pleased to learn from Dr. Mary Powers, Dean of our Graduate School of Arts and Sciences that you will be visiting Fordham on April 25, to deliver the annual Sievers Lecture. As you know, this annual lecture is sponsored by Fordham University in collaboration with the Center for the Study of the Presidency.

As a sign of our gratitude for your accepting this invitation, I intend to seek the approval of our Board of Trustees to offer you an honorary doctorate of science. Ordinarily, our honorary degrees are awarded at the time of Fordham's annual Commencement, which will be held this year on May 18, 1991. Our 1992 Commencement will be on Saturday, May 16.

Fordham would be honored if you could be with us on either of these occasions. In any case, I look forward to welcoming you to Fordham on April 25.

Sincerely,

Joseph A. O'Hare, S.J.

JO'H/lg

Joseph A. O'Hare, S.J.

"INVITATION FOR DR. BROMLEY"

TYPE: INVITATION-SPEECH DOCUMENT NUMBER: 9120958

****

SPEECH: YES NO

FROM: FISHER, Fen: LIFT

DATE OF EVENT: 06/27/91

LOCATION OF EVENT: RADISSON PLAZA HOTEL, LONG ISLAND, NEW YORK

TIME OF EVENT: 01:15PM

SUBJECT: INVITATION TO BE THE KEYNOTE SPEAKER AT LIFT'S ANNUAL CONFERENCE TITLED, "INFORMATION IN THE 21st CENTURY: POTENTIALS AND OPPORTUNITIES."

****

RSVP:

CONTACT PERSON:

CONTACT NUMBER:

****

INVITATION ACCEPTED? YES NO

****

COPIES TO: Dr. Wong

REMARKS:

DATE OF LETTER: 03/26/91 DATE RECEIVED: 04/01/91

FILE: P- INVITATION-SPEECH

THE WHITE HOUSE

WASHINGTON

April 18, 1991

Dear Mr. Fisher:

Thank you for your letter of March 26 inviting me to be the keynote speaker at your Annual Conference scheduled for June 27 in Long Island, New York.

Although I would very much like to join you, particularly given the importance and potential of the communications industry, my schedule for the month of June is completely booked, so I must regretfully decline.

I appreciate your thinking of me and would like to offer my best wishes for a successful conference.

Sincerely yours,



D. Allan Bromley
The Assistant to the President
for
Science and Technology

Mr. Fen Fisher, Chairman
Long Island Forum for Technology, Inc.
P.O. Box 170
Farmingdale, Long Island, New York 11735

LONG ISLAND FORUM FOR TECHNOLOGY, INC., P.O. Box 170, Farmingdale, Long Island, New York 11735 (516) 755-3321 FAX (516) 755-9264

9120958

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91 APR 1 P2 48
OFFICE OF THE DIRECTOR

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LEONARD ZUCKERMAN, Electronic Dev. Assoc., Inc.
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*ROBERT J. SANATOR, Geotel, Inc.
*ELSTON SWANSON, Instruments for Industry, Inc.
DAVID WESTERMANN, Westermann & Tryon
*Board Member

March 26, 1991

Dr. Allan Bromley
Director
Office of Science Technology Policy
Executive Office of the President
Washington, D.C. 20500

Dear Dr. Bromley:

The Long Island Forum for Technology, Inc. (LIFT) invites you to be the luncheon keynote speaker at our Annual Conference, on Thursday, June 27, 1991. Titled, "INFORMATION IN THE 21ST CENTURY: POTENTIALS AND OPPORTUNITIES", this full day conference will be held at Radisson Plaza Hotel, 1350 Old Walt Whitman Road, Melville, Long Island, NY 11747.

As Long Island seeks to diversify its high technology industry base, we believe our region is well positioned to capitalize on the extraordinary foreseeable growth of the information industry. For example, our region is home to the world's leading independent software provider - Computer Associates International; the world's leading information systems company - Reuters Information Services; and, the world's leading developer of bar code scanning - Symbol Technologies. In addition, a significant portion of our core defense industry is devoted to information products, including command and control systems, avionics and telecommunications.

Lunch is at 12:30 p.m. You will be introduced at 1:15 p.m. Currently, the time allotted for your remarks is 45 minutes with or without Q/A as you prefer. The Conference will reconvene at 2:30 p.m. The Conference will include top business executives and senior government officials. I have enclosed an initial draft conference program which illustrates the flavor of the event. We expect 250 people to be in attendance.

LIFT is a nonprofit organization prepared to reimburse your round trip travel expenses from Washington, D.C., to Long Island, New York. Details of your travel schedule, including pickup at the airport and return transport to your next appointment, will be worked out with your staff.

Since we are attempting to confirm the conference program as soon as practicable, your reply before April 15 would be appreciated. We await your favorable response to our invitation and look forward to greeting you on June 27.

Sincerely,

Fen Fisher

Fen Fisher, Chairman

LONG ISLAND FORUM for TECHNOLOGY, INC

To Strengthen LI's Economy by Continuing Improvement and Expansion of Technological Industry

PO Box 170, Farmingdale, Long Island, NY 11735 * * (516) 755-3321 * * FAX (516) 755-9264

LIFT 1991 June 27 CONFERENCE

Working Title -
"THE INFORMATION INDUSTRY IN THE 21ST CENTURY: OPPORTUNITIES FOR GROWTH"

Program (Draft - all speakers are subject to confirmation unless *)
7:30 REGISTRATION & CONTINENTAL BREAKFAST

8:00 WELCOME
Introducer: *Richard Bravman, Vice President - Marketing, Symbol Technologies
Conference Committee Chairman
o Nassau County Executive - Hon. Thomas S. Gulotta
o Suffolk County Executive - Hon. Patrick G. Halpin
o LIFT Chairman - *Allan E. Greenberg, President, Cardion Electronics Inc.

8:15 "CHALLENGES FOR L.I.'s INFORMATION INDUSTRY: NOW, TOMORROW AND BEYOND" (Lofty goal/vision)
Introducer: LIFT Chairman - *Allan E. Greenberg, President, Cardion Electronics Inc.
o Keynote Speaker: *Dr. Jerome Swartz, Chairman and CEO, Symbol Technologies

8:45 "MATCHING UNIVERSITY RESOURCES AND INDUSTRY NEEDS" (Success stories)
Introducer:
Moderator:
Speakers:
o Polytechnic University/Industry(to be identified)
o NYNEX/University(to be identified)

9:45 BREAK

10:00 "REGIONAL INFRASTRUCTURE - WHAT, WHERE AND HOW TO USE IT"
Introducer:
Speakers:
NYS Centers for Advanced Technology - H. Graham Jones, Executive Director, NYS Science and Technology Foundation
NSF Centers at Universities (Columbia University Telecommunications)

10:30 "INFORMATION INDUSTRY - WORLD OVERVIEW" (New technologies, research, products)
o Introducer:
Speakers:(for only two of the listed topics)
o Multi Media -
o Use of Wireless Technology -
o Ergonomics -
o Value Added Networks -

11:45 "UNIVERSITY/INDUSTRY RESEARCH PARKS"
Introducer:
Speakers:
o SUNY Stony Brook Research Industrial Park
o New York Institute of Technology Research Park - Stephen M. Jones
o Polytechnic University - MetroTech - Dr. Seymour Scher, Director

12:30 LUNCHEON
o Introducer: Richard Bravman, Conference Committee Chairman
Keynote Speaker:
o Dr. D. Allan Bromley, Director, U.S. Office of Science Technology Policy

2:30 "APPLICATIONS OF HIGH TECH INFORMATION SYSTEMS" (More success stories?)
o Introducer:
o Moderator: * Dr. Phil Lewis, SUNY at Stony Brook
Speakers:
o SUNY Stony Brook/Symmbol Technologies
o Hofstra University/Industry

3:30 "LOCAL ASSISTANCE FOR INDUSTRY"
Introducer:
Speakers:
o TECHNICENTER at Suffolk Community College - Elana Stern
o Long Island High Technology Incubator - Pat Hession, President
o The Bicounty Technology Development Organization (TDO) - George C. Soos, President, LIFT*

4:30 KEYNOTE TO END CONFERENCE
Introducer:
Keynote Speaker:
o Charles Wang, CEO, Computer Associates International

5:00 RECEPTION Sponsored by Symbol Technologies

Conference Location:
Radisson Plaza Hotel, 1350 Old Walt Whitman Road, Melville - 423-1600

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