

**ANNUAL REPORT OF THE CENTER
FOR ENERGY AND COMBUSTION RESEARCH**

University of California, San Diego

July 1, 1996 – June 30, 1997

1. SUMMARY OF ACTIVITIES AND PLANS FOR THE COMING YEAR

The Center for Energy and Combustion Research focuses on basic problems in finding new sources of energy and on the social, environmental, economic, and political consequences of energy consumption, including combustion. Studies range from investigations into the fundamental nature of energy and combustion to practical applications in energy conservation and production, as well as pollution control.

Current research includes flame theory, combustion in turbulent flows, asymptotic methods in combustion, fire research, reactions in boundary layers, and other areas of combustion and fluid dynamics. Two specific new grants are for "Stretched Diffusion Flames in Von Karman Swirling Flows," from NASA and "Compressible Turbulent Reactive Flows," from the Air Force Office of Scientific Research.

The Center for Energy and Combustion Research has brought together researchers from England, France, Germany, Japan, Korea, Norway and Spain for brief periods of study and of exchange of ideas during this period.

As projected in the plans made in 1995-96, a proposal to ASCI of the Department of Energy was mounted for a large grant for a new Center for the Simulation of Turbulent Reactive Systems. The activity involved the Departments of AMES, Computer Science and Engineering, Chemistry and Biochemistry, and Mathematics, as well as the San Diego Supercomputer Center. At every stage the proposal received excellent reviews, and it made the first cut, from 50 to 15, and was one of the 7 out of 15 selected for a site visit. Unfortunately, for programmatic reasons, the center was not among the 5 finally chose, but fallout from this near miss led to ASCI-2 proposals, at lower funding levels, from CECR and other UCSD organizations, some of which seem quite likely to be funded. Plans for the 1997-98 academic year include further emphasis on fluid dynamics of reacting flows relevant to energy and on chemical aspects of power production.

2. ACADEMIC AND PUBLIC SERVICE

A. Membership

It is necessary to distinguish between CECR "members" and "affiliates". "Members" are those who are involved in CECR on a day-to-day basis and who actively participate in CECR programs and research. These include: The Director and Associate Directors, Active Adjunct and Emeritus Professors, and Researchers who are employed full-time by CECR research grants. "Affiliates" are regular faculty members who participate in some CECR projects but who also have other activities and projects not part of CECR.

Faculty Members:

Forman A. Williams - Director
PhD, Engineering Science
Professor of Engineering Physics and Combustion

Robert J. Cattolica - Associate Director
PhD, Engineering Physics
Professor of Engineering Physics

K. Seshadri - Associate Director
PhD, Engineering Science
Professor of Chemical Engineering and Fluid Mechanics

Alvin S. Gordon
PhD, Chemistry
Adjunct Professor of Engineering Chemistry

Paul A. Libby
PhD, Aeronautical Engineering
Professor Emeritus of Fluid Mechanics

Stanford S. Penner
PhD, Physical Chemistry
Professor Emeritus of Engineering Physics

Norbert Peters
PhD, Mechanical Engineering
Adjunct Professor of Mechanical Engineering

M. Simnad
PhD, Materials Science
Adjunct Professor of Materials Science and Engineering,
Nuclear Engineering and Energy Technologies

Affiliate Faculty Members:

D.J. Benson
PhD, Mechanical Engineering
Associate Professor

J.C. Lasheras
PhD, Mechanical and Aerospace Engineering
Associate Professor of Fluid Mechanics

D.R. Miller
PhD, Chemical Engineering
Professor of Chemical Engineering

M. Meyers
PhD, Physical Metallurgy
Professor of Materials Science

V.F. Nesterenko
PhD, Physics
Associate Professor of Materials Science

K. Nomura
PhD, Mechanical Engineering
Assistant Professor of Mechanical Engineering

S. Sarkar
PhD, Mechanical Engineering
Associate Professor

B. Researchers

Shui-Chi Li
PhD, Mechanical and Aerospace Engineering
Assistant Research Scientist

Kurt O. Lund
PhD, Engineering Science
Assistant Research Scientist

C. Visiting Researchers and Scholars

CECR participants interact extensively abroad on energy and combustion issues. There is continuing joint research with investigators at Cambridge University in England, RWTH Aachen in Germany, Université de Provence in Marseilles, France, The University of Tokyo and Ishikawajima-Harima Heavy Industries in Tokyo, Japan and elsewhere. Renowned scientists from throughout the United States and abroad, specializing in energy and combustion research, regularly visit UCSD and participate in CECR programs through formal lectures, research activities and informal discussions. Visitors from the last year include:

VISITOR	AFFILIATION
Henning Berg	Norwegian Institute of Technology, Trondheim, Norway
K.N.C. Bray	Cambridge University, Cambridge, England
Michel Champion	ENSMA, Poitiers, France
Paul Clavin	Universite Aix Marseilles, Marseilles, France
Junichi Furukawa	Tokyo Metropolitan Technical College
Balakrishnan Ganeshan	Virginia Polytechnic Institute
Adelbert Grudno	RWTH Aachen, Aachen, Germany
James Hill	Iowa State University
Øyvind Hovde	Norwegian Institute of Technology, Trondheim, Norway
Javier Jiménez	Universidad Politecnica de Madrid
Ed Law	Princeton University
Amable Liñán	Ciudad Universitaria, Madrid, Spain
Gregory Linteris	NIST, Gaithersburg, Virginia
Masato Mikami	Yamaguchi University, Yamaguchi, Japan
Keiichi Okai	The University of Tokyo, Tokyo, Japan
Heinz Pitsch	RWTH Aachen, Aachen, Germany
Geir Roertviet	Norwegian Institute of Technology, Trondheim, Norway
Antonio Sanchez	Universidad Carlos III, Madrid, Spain
Jun'ichi Sato	Ishikawajima-Harima Heavy Industries, Tokyo, Japan
Reinhard Seizer	Technical University, Graz, Austria
S. Fred Singer	Science and Environmental Policy Project, Fairfax, VA
Ingrid Smedvig	Norwegian Institute of Technology, Trondheim, Norway

D. Seminars

CECR sponsors a general series of seminars and public lectures in its areas of activities. A listing of these seminars is given in the following tables.

SEMINAR SPEAKER	DATE	TOPIC
Balakrishnan Ganeshan	August 12, 1996	"Direct Numerical Simulation of Diffusion Flames with Large Heat Release in Compressible Homogeneous Turbulence"
Fred Singer	August 13, 1996	"The Ozone-CFC Debacle: Hasty Action, Shaky Science"
Bai-li Zhang	August 14, 1996	"Theoretical Studies of Methanol Droplet Combustion Based on Results from the Shuttle Spacelab during the USML-2 Mission"
Amable Liñán	August 16, 1996	"Burke-Schumann Formulation for Laminar and Turbulent Diffusion Flames with Finite-Rate Recombination Chemistry"
Michele Champion	August 23, 1996	"Non-Gradient Diffusion in 2-D Premixed Flames"
Nenad Ilincic	August 28, 1996	"Modeling of Ignition of Solid Propellant Dark Zone"
Christophe Clanet	September 4, 1996	"On Some Interfacial Phenomena in Liquid Jets"
Yousef Bahadori	October 9, 1996	"Transitional and Turbulent Jet Diffusion Flames in Microgravity"
James Hill	October 16, 1996	"Numerical Experiments on Turbulent Mixing with Chemical Reaction"
Paul Libby	October 23, 1996	"Recent Research on Premixed Flames in Stagnating Turbulence"
Harry Dwyer	October 30, 1996	"Some Recent Progress in the Calculation of Droplet Dynamics"
Carl Meinhart	November 7, 1996	"Particle Image Velocity (PIV) and its Application to a Turbulent Boundary Layer"
Al Turan	November 19, 1996	"Predictive Modelling of Boiler Fouling"

Corinne Connon	November 21, 1996	“Understanding Droplet Stream Behavior under Various Conditions”
Clifford Surko	December 3, 1996	“Phase-Defect Description of Traveling-Wave Convection”
A.K. Oppenheim	January 30, 1997	“Refinement of Heat Release Analysis”
Carl Gibson	March 31, 1997	“Fluid Mechanics of Self-Gravitational Condensation: Super-Clusters, Primordial Fog, Stars and Dark-Matter”
Forman A. Williams	April 11, 1997	“Microgravity Combustion Studies on STS-83”
Gregory T. Linteris	April 30, 1997	“Combustion Experiments in Space”

CECR Special Lecture/Seminar Series

CECR had a special seminar series in the Spring of 1997 which focused on Turbulent Combustion. The lectures were given by Adjunct Professor Norbert Peters, a world expert in this field.

DATE	TOPIC
Lecture 1 March 7, 1997	“Turbulent Combustion, Introduction and Overview”
Seminar March 10, 1997	“Differences between the ‘Thin Flame Regime’ and ‘The Thin-Reaction-Zone Regime’ and the Modeling of the Flame Surface Density”
Lecture 2 March 12, 1997	“Laminar Flamelet Models for Non-Premixed Turbulent Combustion Part I: Turbulent Jet Diffusion Flames”
Lecture 3 March 14, 1997	“Laminar Flamelet Models for Non-Premixed Turbulent Combustion Part II: Prediction of Pollutant Formation in Diesel Engines”

F. Contribution to Graduate or Undergraduate Teaching Programs

CECR personnel participated in teaching the following courses:

118A. Energy: Non-Nuclear Energy Technologies (4)

Oil recovery from tar sands and oil shale. Coal production, gasification, liquefaction. The hydrogen economy. Energy storage systems. Techniques for direct energy conversion. Solar energy utilization. Energy from windmills. Tidal and wave energy utilization. Hydroelectric power generation. Hydrothermal energy. Geothermal energy from hot rocks. Electrical power production, transmission, and distribution. Prerequisites: consent of instructor.

118B. Energy: Nuclear Energy Technologies (4)

A brief survey of energy demands and resources. Available nuclear energy, physical background-thermal dynamics-atomic and nuclear physics; fission and fusion processes, physics of fission reactions-engineering aspects-safety and environmental effects, fusion, scaling laws, and start-up criteria-laser fusion, magnetic confinement-equilibrium instability. Prerequisite: consent of instructor.

118C. Introduction to Fusion Science and Technologies (4)

Overview of basic fusion processes, high-temperature plasma characteristics, and fusion power plant features. Emphasis on the enabling technologies for practical fusion and related applications outside of fusion, such as plasma-material interactions, plasma heating and wave-particle interactions, high heat flux engineering, superconductivity, advanced materials, and nuclear technology. Prerequisite: consent of instructor.

119. Topics in Energy and Thermodynamic Systems (4)

Advanced topics in energy processes and cycles and/or thermodynamic analysis of energy and power cycles such as non-renewable cycles, cogeneration and combined power cycles, and economic, energy, and optimization analysis of thermodynamic systems. Prerequisite: AMES 110 or 111.

211. Introduction to Combustion (4)

Fundamental aspects of flows of reactive gases, with emphasis on processes of combustion, including the relevant thermodynamics, chemical kinetics, fluid mechanics, and transport processes. Topics may include deflagrations, detonations, diffusion flames, ignition, extinction, and propellant combustion. Prerequisites: AMES 101A-B-C or AMES 103A-B-C, AMES 110, or consent of instructor.

213. Mechanics of Propulsion (4)

Fluid mechanics, thermodynamics, and combustion processes involved in propulsion of aircraft and rockets by air-breathing engines, and solid and liquid propellant rocket engines; characteristics and matching of engine components; diffusers, compressors, combustors, turbines, pumps, nozzles. Prerequisites: AMES 101A-B, AMES 110, or consent of instructor.

220A. Physics of Gases (4)

Thermodynamics of gases for use in gasdynamics. Derivation of thermodynamic functions from statistical mechanics. Applications of classical and quantum statistical mechanics to chemical, thermal, and radiative properties of gases. Equilibrium and nonequilibrium radiation, chemical equilibrium, and elements of chemical kinetics. Laser and reacting-flow applications. Prerequisite: AMES 110 or consent of instructor.

220B. Physical Gasdynamics (4)

Velocity distribution functions, the Boltzmann equation, moment equations and the Navier-Stokes equations. The dynamics of molecular collisions. The Chapman-Enskog expansion and transport

coefficients: shear and bulk viscosity, heat conduction, molecular and thermal diffusion. Linearizations about equilibrium: applications to acoustics and supersonic flows with relaxation. Prerequisites: AMES 101A-B-C or AMES 103A-B-C, AMES 220A or consent of instructor.

Graduate Students

NAME	ADVISOR	DATES
John Hewson	F.A. Williams	1991 - 1996
Øyvind Hovde	F.A. Williams	1995 - 1997
Ingrid Smedvig	F.A. Williams	1996 - 1997
Alexander Telengator	F.A. Williams	1995 - present
Lenny Truett	K. Seshadri	1994 - present
Bai-li Zhang	F.A. Williams	1992 - 1997

Post-Graduate Researchers

PGR	ADVISOR	DATES
John Hewson	F.A. Williams	1996 - 1997
Dietmar Trees	K. Seshadri	1996 - 1997

G. University-Industry Activities

Faculty and staff members of the UCSD Center for Energy and Combustion Research continue to be associated with various university-industry activities. In particular, there have been significant interactions with Solar Turbines and with BKM Inc. Joint seminars with Solar Turbines were held both at their San Diego facility and at UCSD. CECR has strong ties with BKM Inc., a San Diego company specializing in Diesel engine research and development. Currently, we have two joint research projects with BKM: One is related to fuel injection and combustion for advanced military Diesel engines and the other one is related to development of Diesel-natural gas engines for high combustion efficiency and low emissions. These two projects are both experimental and theoretical in character. Among other work, the PDPA has been used to characterize the spray structure of new Diesel fuel injectors for those research engines. Our asymptotic analysis is employed in estimate NO_x formation in the dual fuel engines and KIVA code is developed and used in predicting combustion behaviors in Diesel engines. In a collaboration with PHI Applied Physical Sciences, incineration of sulfur containing agents was examined both experimentally and computationally, and a novel optical spectrometer was developed. These university-industry interactions are increasing.

3. ADMINISTRATION

A. Directors

Director:	Forman A. Williams
Associate Director:	Robert Cattolica
Associate Director:	K. Seshadri

B. Advisory Committee

Dr. Harold Agnew
Former Chief Executive Officer
General Atomics

Dr. Alan C. Kolb
Chairman and Chief Executive Officer
Maxwell Laboratories, Inc.

Dr. R.A. Figueroa
Program Manager
Research, Development and Demonstration
SDG&E

Mr. Dave Esbeck
Vice President, Engineering
Solar Turbines Inc.

Dr. Charles Baker
ITER Program
UCSD

Dr. S.S. Penner
Director Emeritus
CECR

4. FACILITIES AND SPACE

Unlike most ORU's, CECR has not been assigned independent space or facilities. Instead, CECR space comes entirely from AMES, and CECR is dependent on AMES for adequacy of its space. In AMES, space is assigned to individual professors, according to their needs, as justified by the sizes of their programs and the number of associates working with them.

A. Laboratories

The CECR laboratory space thus is, in fact, the laboratory space assigned by AMES to the CECR director and the two CECR associate directors. This space comprises B12, B14, B16 and B17 in Engineering Building Unit II and consists, in total, of 6000 sq. ft. This space currently is adequate for the existing CECR laboratory research activities.

The CECR laboratory facilities include three gas-chromatographic systems for measurements of concentrations of stable chemical species, a laser-Doppler velocimeter for velocity measurements in reacting flows, an argon-ion laser system for measurement of particle sizes and number densities by Mie scattering, and a phase-Doppler particle analyzer for measurements of fuel sprays. Laser spectroscopic capabilities include Rayleigh, Raman, and fluorescence spectroscopy using pulsed lasers with advanced detection systems for both one-dimensional and two-dimensional imaging. In addition, there is a laminar coflow diffusion-flame apparatus and a number of counterflow combustion systems for measurement of diffusion-flame, premixed-flame, fuel-spray, and catalytic-combustion processes. Computer systems for computation of flame structures with full chemistry and for extraction of histories of droplet and flame diameters from video or photographic records are available. Droplet-trajectory and droplet-combustion facilities with photographic recording are in place, and a turbulent-jet flame apparatus is under construction, as is a solid-propellant combustion facility and a high-pressure combustion chamber.

B. Offices and Conference Rooms

Professors who are members of CECR have their own offices (Engineering Building Unit II, rooms 256, 555, 556, 557, 558, 559 and 560) and offices for their graduate students, researchers and visitors (Engineering Building Unit II, rooms 561, 562, 563, 564, 570 and 571), all provided by the AMES department. The AMES space allotment to the CECR director is made on the same basis as the allotment to other faculty, without any special consideration of CECR. In Engineering Building Unit II, the CECR administrative office 554, the CECR secretary office and mail, FAX, copy and utility room, 565, all are taken from the CECR director's allotment. No conference rooms, libraries, meeting rooms or related spaces have been assigned to CECR.

**CENTER FOR ENERGY AND COMBUSTION RESEARCH
FUNDS AWARDED -- TYPE / AGENCY**

FUNDING TYPE / AGENCY	FY 96/97
BUSINESS/INDUSTRY	
GIFTS	45,959
<i>TOTAL FOR BUSINESS/INDUSTRY:</i>	45,959
FEDERAL	
AFOSR	191,195
DOE	46,782
NASA	221,200
NOAA	
NSF	
OTHER	
USA	80,000
USAF	
USN	179,440
<i>TOTAL FOR FEDERAL:</i>	718,617
FEDERAL FLOW-THRU	
DOE, DOD, NIH	
<i>TOTAL FOR FEDERAL FLOW-THRU:</i>	0
OTHER	
INCOME ACTIVITY	
<i>TOTAL FOR OTHER:</i>	0
PRIVATE	
CONTRACTS	96,200
ENDOWMENT	39,181
<i>TOTAL FOR PRIVATE:</i>	135,381
STATE	
APPROPRIATION	50,062
<i>TOTAL FOR STATE:</i>	50,062
<i>TOTAL FOR FUND TYPE / FISCAL</i>	950,019

CENTER FOR ENERGY AND COMBUSTION RESEARCH
 DEPT OF AMES - ALLOCATIONS / EXPENSE
 FUND TYPE AND AGENCY

FUND	PI / AGENCY	FY 96/97	
		ALLOC	EXPENSE
BUSINESS/INDUSTRY			
40555A	Lund ADVANCED SILICON MTLs INC		6,239
53078A	Lund PHI APPLD PHYSCL SCI	45,000	64,176
57422A	Lund SML ASSO		
45139A	Penner ENERGY RES FDN		
43130A	Williams ISHIKAWA JIMA UC/FDN 1195	959	1,363
47292A	Williams GA SCHOL/FND #1365		
	TOTAL FOR BUSINESS/INDUSTRY	45,959	71,777
FEDERAL			
23299A	Cattolica NASA NCC 2-718		
22419A	Libby DOE DEFG03-86ER13527	46,782	60,126
22422A	Libby DOE DEFG03-87ER13665		141,889
23279A	Libby NASA/LAN NAG 1-1193		
23290A	Lund NASA NAG3-1243		
22459A	Penner DOE DEFG03-93ER30213		27,308
21330A	Seshadri NSF INT 91-14461		
22580A	Seshadri NIST 60NANB2D1285		
22581A	Seshadri NIST 60NANB3D1435		
23010A	Seshadri ARO DAAH-95-1-0108	80,000	57,499
23022A	Seshadri ARO DAAL03-90-G-0084		
21374A	Williams NSF CTS 92-14888		
22508A	Williams AFOSR F49620-92-J-0184		
22516A	Williams AFOSR 91-0130		
22523A	Williams AFOSR F49620-93-1-0380		14,530
23244A	Williams NASALERC NAG 3-1081		
23291A	Williams NASA NAG3-1248		
26924A	Williams UCLLNL B264086		
31000A	Williams ONR N00014-94-1-0679	4,800	32,997
31148A	Williams ONR N00014-97-1-0412	174,640	1
31164A	Williams ONR N00014-97-1-0958		
31340A	Williams NSF CTS 95-26410		117,249
31802A	Williams AFOSR F49620-94-1-0166		83,547
31817A	Williams AFOSR F49620-96-1-0106	110,185	84,519
31625A	Williams AFOSR F49620-97-1-0098	81,010	28,968
31917A	Williams NASA/LEW NAG 3-1689	43,000	49,028
31920A	Williams NASA NCC 3-407	162,000	69,721
31957A	Williams NASA NCC3-506	16,200	14,417

CENTER FOR ENERGY AND COMBUSTION RESEARCH
 DEPT OF AMES - ALLOCATIONS / EXPENSE
 FUND TYPE AND AGENCY

FUND	PI / AGENCY	FY 96/97	
		ALLOC	EXPENSE
32836A	Williams NASA LEWIS NAG3-2161		
TOTAL FOR FEDERAL		718,617	781,799
FEDERAL FLOW-THRU			
78604A	Penner EG&G IDA HO INC.		
78605A	Penner EG&G IDAHO		
TOTAL FOR FEDERAL FLOW-THRU		0	
OTHER			
60826A	Williams CECR-MISC INCOME		1,274
66834A	Williams CONFERENCES/EXP		
66850A	Williams CONFERENCES/WMS		2,195
TOTAL FOR OTHER		0	3,469
PRIVATE			
79576A	Li BKM INC. PO #17840		
79695A	Li BKM INC. PO #17214	96,200	8,866
39426A	Williams UC PRESI DENTS OFFICE	39,181	47,619
79527A	Williams SOLAR TURB PO #HD9704839		
TOTAL FOR PRIVATE		135,381	56,485
STATE			
07427A	Cattolica ACAD SEN RW146-G		5,736
19900A	Lund CALSPACE #CS-33-95		
19900A	Seshadri ACAD SEN RX143-GB		
19900A	Williams CECR GENERAL FUNDS	44,326	44,830
TOTAL FOR STATE		50,062	44,830
TOTAL FOR GROUPS / FISCAL YEARS		950,019	958,360

DEPT OF AMES

FUNDS AWARDED / EXPENDITURES BY GROUP

FUNDING TYPE / AGENCY	FY 96/97	
	ALLOC	EXPENSE
ENERGY AND COMBUSTION		
ACADEMIC SALARIES	39,181	47,619
GENERAL ASSISTANCE		225,436
BENEFITS	60,526	86,555
INCOME		1,274
SUPPLIES & EXPENSE	223,399	85,584
EQUIPMENT	295,528	290,594
TRAVEL	286,385	157,122
ASSESSMENT FEE	45,000	64,176
MISCELLANEOUS FEES		
<i>TOTAL FOR ALL GROUPS</i>	950,019	958,360
<i>TOTAL FOR FUND TYPE / FISCAL YEARS</i>	950,019	958,360

ENERGY AND COMBUSTION
Fiscal Year 1996 - 1997

EMPLOYEE	SALARY	TITLE NAME	GROUP
<u>FACULTY</u>			
SARKAR, SUTANU	7,001.40	ASO RES - 9-MOS 1/9 PYMT-B/E	RESEARCH
SESHADRI, KALYANASUNDARAM	23,266.68	RES - -9-MOS 1/9 PAYMT - B/E	RESEARCH
WILLIAMS, FORMAN A.	41,066.70	RES - -9-MOS 1/9 PAYMT - B/E	RESEARCH
	71,334.78		
<u>OTHER FACULTY</u>			
LIBBY, PAUL A.	63,744.75	RESEARCH PROFESSOR-VERIP	RESEARCH
<u>GRADUATE STUDENTS - GSR</u>			
GAO, HONGXUN	10,031.49	GRAD STDNT RES- NO REMISSION	GRADUATE STUDENTS
HEWSON, JOHN C.	3,611.40	GRAD STDNT RES- NO REMISSION	GRADUATE STUDENTS
PANTANO-RUBINO, CARLOS ALE	6,465.55	GRAD STDNT RES-TUIT & FEE REM	GRADUATE STUDENTS
PRESTRIDGE, KATHERINE P.	10,007.01	GRAD STDNT RES-TUIT & FEE REM	GRADUATE STUDENTS
RUSS, BENJAMIN E.	3,647.52	GRAD STDNT RES- NO REMISSION	GRADUATE STUDENTS
TELENGATOR, ALEXANDER M	11,300.73	GRAD STDNT RES-TUIT & FEE REM	GRADUATE STUDENTS
ZHANG, BAILI	16,681.56	GRAD STDNT RES- NO REMISSION	GRADUATE STUDENTS
	61,745.26		
<u>RESEARCHERS - PGRS</u>			
SEISER, REINHARD	2,035.84	STAFF RESEARCH ASSOC I	RESEARCH
TREES, DIETMAR	6,690.62	STAFF RESEARCH ASSOC II	RESEARCH
LI, SHUI CHI	54,249.99	ASST RES ----- 11-MOS	RESEARCH
LUND, KURT O'FERRALL	8,515.38	ASST RES ----- 11-MOS	RESEARCH
ILINCIC, NENAD	7,091.38	POSTGRAD RES ----- 11-MOS	RESEARCH
LI, HUAIDONG	1,273.36	POSTGRAD RES ----- 11-MOS	RESEARCH
TREES, DIETMAR	28,993.00	POSTGRAD RES ----- 11-MOS	RESEARCH
	108,849.57		
<u>ADMINISTRATIVE</u>			
BASTIAN, NANCY B	36,008.08	____ASSISTANT III	ADMINISTRATIVE
REEDY, JOHN THOMAS	1,593.60	CODER	ADMINISTRATIVE
	37,601.68		
<u>TECHNICAL</u>			
WILLEMSE, WERNER W.	13,449.44	ENGINEERING AID	TECHNICAL
ZANG, RUI-XIAN	8,398.87	LABORATORY ASST I	TECHNICAL
	21,848.31		
TOTAL SALARY	365,124.35		
Reimbursement - Vacation Accruals	-5,659.35		
	359,465.00		

ENERGY AND COMBUSTION
Fiscal Year 1996 - 1997

	HEAD COUNT		FTE	RATIO /FAC
	FT	PT		
Administrative	0	0	0.00	////////
Faculty (tenure)	3	0	3.00	////////
Faculty (non-tenure)	0	0	0.00	////////
*Other Faculty	0	4	1.70	////////
Student Teaching Assistants/Readers	0	10	1.00	0.21
Student Research Assistants/Fellows	0	7	3.98	0.85
Technicians/Specialist	0	2	0.75	0.16
Office/Clerical Employees	1	3	1.50	0.32
Others (Research, PGRS)	2	5	3.75	0.80
Managerial Employees	0	0	0.00	0.00
Undergraduate Students	28	0	0.00	5.96
Graduate Students	4	0	0.00	0.85

E. Publications of CECR Researchers

1. Members Publications List

Robert J. Cattolica

David R. Farley and Robert J. Cattolica, "Collisional Quenching and Excitation Cross-Sections of the CO_2^+ $A^2\Pi$ (1 - 3,0,0) and $B^2\Sigma^+$ (0,0,0) Excited States from Electron-Impact Ionization," *Chemical Physics Letters*, vol. 274, pp. 445-450, 1997.

John C. Hewson

J. C. Hewson and F. A. Williams, Modeling and Scaling of NOx Emissions from Methane Diffusion Flamelets, in *Combustion Fundamentals and Applications*, 1997 Technical Meeting of the Central States Section/The Combustion Institute, April, 1997.

J. C. Hewson and M. Bollig, Reduced Mechanisms for NOx Emissions from Hydrocarbon Diffusion Flames, *The Twenty-Sixth Symposium (International) on Combustion*, The Combustion Institute, pp. 2171-2179, 1996.

M. Bollig, H. Pitsch, J. C. Hewson, and K. Seshadri, Reduced n-Heptane Mechanism for Nonpremixed Combustion, *The Twenty-Sixth Symposium (International) on Combustion*, The Combustion Institute, pp. 729-737, 1996.

Shui-Chi Li

Shea, L.E., Sastry, I.S.R., MiKittrick, J. and Li, S.C., "Predicting and Modeling the Adiabatic Flame Temperature during Combustion Synthesis of Luminescent Oxide Powders," *Proceedings of The Fifth World Congress of Chemical Engineering*, San Diego, CA, July 14-18, 1996.

Li, S.C., Dabora, E.K. and Williams, F.A., "Effects of Strain Rates and Diluents on the Extinction Limits of Silane," Presented in the Poster Session of Twenty-Sixth Symposium (International) on Combustion, July 28-August 2, 1996.

Li, S.C. and Williams, F.A., "Experimental and Numerical Studies of Two-Stage Methanol Flames," *Twenty-Sixth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA, 1996, pp. 1017-1024.

Li, S.C., Ilincic, N. and Williams, F.A., "Reduction of NOx Formation by Water Sprays in Strained Two-Stage Flames," *Journal of Engineering for Gas Turbines and Power* Vol. 119, No. 4, pp. 836-843 (1997).

Paul A. Libby

P.A. Libby and M.D. Smooke, "The Computation of Flames in Stagnation Flows", *Combustion Science and Technology* 127, 1970-211. (1997)

Kurt O. Lund

Lund, K. O. and Ball, M. A., "A Two-Element Energy-Storage Receiver for Space Solar Energy Systems," *AIAA Aerospace Sciences Meeting*, Reno, NV, January, 1997.

Norbert Peters

Pitsch, H., Peters, N., and Seshadri, K., "Numerical and Asymptotic Studies of the Structure of Premixed iso-Octane Flames," Twenty-Sixth Symposium (International) on Combustion, The Combustion Institute, 1996, pp. 763-771.

K. Seshadri

Grudno, A., and Seshadri, K., "Characteristic Residence Times of Laminar Nonpremixed Flames at Extinction," Combustion Science and Technology: 112, 1996, pp. 199-201.

Ilincic, N., Bui-Pham, M. N., and Seshadri, K., "Structure of Nonpremixed CH_4NO_2 Flames," Combustion Science and Technology: 119, 1996, pp. 281-300.

Bollig, M., Pitsch, H., Hewson, J. C., and Seshadri, K., "Reduced n-Heptane Mechanism for Nonpremixed Combustion with Emphasis on Pollutant Relevant Intermediate Species," Twenty-Sixth Symposium (International) on Combustion, The Combustion Institute, 1996, pp. 729-737.

Pitsch, H., Peters, N., and Seshadri, K., "Numerical and Asymptotic Studies of the Structure of Premixed iso-Octane Flames," Twenty-Sixth Symposium (International) on Combustion, The Combustion Institute, 1996, pp. 763-771.

Seshadri, K., "Multistep Asymptotic Analyses of Flame Structures," Invited Topical Review, Twenty-Sixth Symposium (International) on Combustion, The Combustion Institute, 1996, pp. 831-846.

Ilincic, N., Anderson, W. R., Seshadri, K., and Meagher, N. E., "Simplified Chemical-Kinetic Mechanisms for Characterizing the Structure of the Dark Zones of Double Base and Nitramine Propellants," Twenty-Sixth Symposium (International) on Combustion, The Combustion Institute, 1996, pp. 1997-2006.

Dietmar Trees

T. Fay, A. Fay, D. Trees, K. Seshadri, and K. Lund: Optical background emission and structure in fuel/air flames seeded with diethyl sulfide, $(\text{C}_2\text{H}_5)_2\text{S}$. Meeting of the Society of Photo-Instrumentation Engineers (SPIE), Denver, CO, August, 1996.

D. Trees, K. Seshadri: Experimental and numerical studies on chemical inhibition of methane-air diffusion flames by CF_3I . The Fall Meeting, Western States Sections of the Combustion Institute, Los Angeles, CA, October, 1996.

Forman A. Williams

H. Kobayashi, T. Tamura, K. Maruta, T. Niioka and F.A. Williams, "Burning Velocity of Turbulent Premixed Flames in a High-Pressure Environment," Twenty-Sixth Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, PA, 1996, 389-396.

S.C. Li and F.A. Williams, "Experimental and Numerical Studies of Two-Stage Methanol Flames", Twenty-Sixth Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, PA, 1996, 1017-1024.

D.L. Dietrich, J.B. Haggard, Jr., F.L. Dryer, V. Nayagam, B.D. Shaw and F.A. Williams, "Droplet Combustion Experiments in Spacelab", Twenty-Sixth Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, PA, 1996, 1201-1207.

S.B. Margolis, F.A. Williams and A.M. Telengator, "Combustion of Porous Energetic Materials in the Merged-Flame Regime", Twenty-Sixth Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, PA, 1996, 1969-1979.

F.A. Williams, "Combustion Theory in the Post-Zel'dovich Period", Advances in Combustion Science: In Honor of Ya.B. Zel'dovich, (W.A. Sirignano, A.G. Merzhanov and L. DeLuca, editors) Vol. 173 of Progress in Astronautics and Aeronautics, American Institute of Aeronautics and Astronautics, Washington, DC, 1997, 19-35.

F.A. Williams, "Reduced Chemical Kinetics for Turbulent Hydrocarbon-Air Diffusion Flames", Advanced Computation and Analysis of Combustion, (G.D. Roy, S.M. Frolov and P. Givi, editors), ENAS Publishers, Moscow, 1997, 1-13.

A.L. Sánchez, A. Liñán and F.A. Williams, "A Generalized Burke-Schumann Formulation for Hydrogen-Oxygen Diffusion Flames Maintaining Partial Equilibrium of the Shuffle Reactions", Combustion Science and Technology **123**, 317-345 (1997).

M.L. Rightley and F.A. Williams, "Burning Velocities of CO Flames," Combustion and Flame **110**, 285-297 (1997).

B.L. Zhang and F.A. Williams, "Alcohol Droplet Combustion", Acta Astronautica **39**, 599-603 (1997).

F.A. Williams, "Some Aspects of Metal Particle Combustion" (Chapter 11), Physical and Chemical Aspects of Combustion, (F.L. Dryer and R.F. Sawyer, editors), Gordon and Breach, Amsterdam, 1997, 267-288.

2. Affiliates Publications List

David J. Benson

Benson, D. J., "The Numerical Simulation of the Dynamic Compaction of Powders," in High Pressure Shock Compression of Solids IV, Response of Highly Porous Solids to Shock Loading, edited by L. Davison, Y. Horie, M. Shahinpoor, Springer-Verlag, 1996, 24 pages.

Nieh, T. G., Luo, P., Nellis, W., Lesuer, D. and Benson, D., "Dynamic Compaction of Aluminum Nanocrystals," Acta Materialia, Vol., 44, No. 9, 1996, pp. 3781-3788.

Benson, D. J., "A Contact Mixture Theory for Eulerian Finite Element Formulations," Recent Advances in Computational Structural Dynamics and High-Performance Computing, edited by R. R. Namburu, 1996, pp. 95-112.

Juan C. Lasheras

J. C. Lasheras, E. Hopfinger and E. Villermaux. "On the Atomization Mechanisms of a Water Jet by a High Momentum Coaxial Gas Jet." EUROMECH Colloquium 355, September 11-13, Ecole Polytechnique. Paris, France (1996).

J. C. Lasheras. "Breakup of a Round Water Jet by a High Speed Air Stream." 1996 ASME Fluids Engineering Division Summer Meeting. San Diego, California, July 7-11, 1996.

J. C. Lasheras. "Mixing in the Context of Combustion." NATO Advanced Studies Institute. Mixing: Chaos and Turbulence. Cragese, Corsica, July 7-20. (1996)

J. C. Lasheras and K.P. Prestridge. "Three-Dimensional Vorticity Dynamics in Coflowing Jets Subjected to Axial and Azimuthal Forcing." 28th AIAA Fluid Dynamics Conference, 4th AIAA Shear Flow Control Conference. June 29 - July 2, Snowmass Village, CO, paper # AIAA 97-1880 (1997).

Marc Meyers

H.C. Chen, V.F. Nesterenko, and M.A. Meyers, "Shear-Induced Chemical Reactions in Controlled High-Strain-Rate Shear Bands," in "Shock Compression of Condensed Matter 1995," ed. S.C. Schmidt and W.C. Tao, AIP Press, (1996) 713-716.

L.E. Murr, M.A. Meyers, C-S. Niou, Y.J. Chen, S. Pappu and C. Kennedy, "Shock-Induced Deformation Twinning in Tantalum," *Acta Met. et. Mat.*, 45 (1997) 157-175.

L.E. Murr, S. Pappu, C. Kennedy, C-S. Niou, and M.A. Meyers, "Tantalum Microstructures for High-Strain-Rate Deformation: Shock Loading, Shaped Charges, and Explosively Formed Penetrators," in "Tantalum," TMS-AIME, Warrendale, PA, (1996), R.145-155.

D.H. Lassila, M.M. LeBlanc, M.A. Meyers, "Effect of Shock Prestrain on the Mechanical Behavior of Tantalum and Tantalum-Tungsten Alloys," in "Tantalum" TMS-AIME, Warrendale, PA, (1996), 185-190.

J.C. LaSalvia, Y.J. Chen, M.A. Meyers, V.F. Nesterenko, M.P. Bondar, and Y.L. Lukyanov, "High-Strain, High-Strain-Rate Response of Annealed and Shocked Tantalum," in "Tantalum," TMS-AIME, Warrendale, PA, (1996) 139-144.

S. Pappu, C. Kennedy, L.E. Murr, and M.A. Meyers, "Deformation Twins in a Shock-Loaded Ta-2.5 %_w Precursor Plate and a Recovered, Ta-2.5 %_w Explosively Formed Penetrator," *Scripta Mat.*, 35, No. 8 (1996) 959-965.

Vitali Nesterenko

O.G., Epanchintsev, A.S., Zubchenko, A.E., Kobelev, A.E., Korneyev, V.F. Nesterenko, V.A. Simonov, and Y.L. Luk'yanov, "Shock-wave diamond synthesis from fullerenes", *Molecular Materials*, 1996, vol. 7, (no. 1-4), pp. 293-296.

V.F. Nesterenko, M.A. Meyers, and T. W. Wright, "Characteristic Spacing in a System of Adiabatic Shear Bands", *Proceedings of Plasticity' 97: The Sixth International Symposium on Plasticity and its Current Applications*, Edited by Akhtar S. Khan, Juneau, Alaska, July 14-18, 1997, pp. 131-132.

S.R. Cooper, D.J. Benson, and V.F. Nesterenko, "The Role of Void Geometry on Hot Spot Formation in Ductile Materials", *Proceedings of Plasticity' 97: The Sixth International Symposium on Plasticity and its Current Applications*, Edited by Akhtar S. Khan, Juneau, Alaska, July 14-18, 1997, pp. 301- 302.

D.J. Benson, V.F. Nesterenko, F. Jonsdottir, and M.A. Meyers, "Quasistatic and Dynamic Regimes of Granular Material Deformation under Impulse Loading", *Journal of the Mechanics and Physics of Solids*, 1997, vol. 45, no. 11/12, pp. 1955-1999.

Keiko Nomura

Nomura, K. K., Post, G. K., Diamessis, P., "Characterization of Small-scale Motion in Incompressible Homogeneous Turbulence". *AIAA Paper 97-1956*, pages 1-29, Fluid Dynamics Conference, Snowmass, Colorado, 1997.

Sutanu Sarkar

S. Stanley, and S. Sarkar, "Direct Simulation of the Spatial Evolution of a Plane Jet," 49th Annual Meeting of the Division of Fluid Dynamics, APS, Syracuse, November 1996.

"Turbulence Evolution in Stably Stratified Flow with Nonvertical Shear," 49th Annual Meeting of the Division of Fluid Dynamics, APS, Syracuse, November 1996.

J. Whitmire, and S. Sarkar, "Computation of Sound Generated by a Compact Region of Turbulence," 49th Annual Meeting of the Division of Fluid Dynamics, APS, Syracuse, November 1996.

S. Sarkar, "On density and pressure fluctuations in uniformly sheared compressible flow," *IUTAM Symposium on Variable Density Low-Speed Flows*, Marseilles, July 1996, *Fluid Mechanics and its Applications*, 41, eds., L. Fulachier, J. L. Lumley, and F. Anselmet, Kluwer Academic Publishers, Dordrecht, 1997.

S. Stanley and S. Sarkar, "Simulations of spatially developing plane shear layers and jets," 15th Intl. Conference on Numerical Methods in Fluid Dynamics, *Lecture Notes in Physics*, 490, 418-423, P. Kutler, J. Flores, J. -J. Chattot (Eds.), Springer-Verlag 1997.

F. Jacobitz and S. Sarkar, "Turbulent Mixing in a Stably Stratified Shear Flow," *NATO Advanced Study Institute on Mixing: Chaos and Turbulence*, Cargese, France, July 1996.

3. Graduate Students PhD Thesis's

J.C. Hewson, "Pollutant Emissions from Nonpremixed Hydrocarbon Flames", 1997.