

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

University of California, San Diego

July 1, 1992- June 30, 1993

1. Summary and Plans for the Coming Year

This center, previously known as the UCSD Energy Center, was given its new name in 1986 to underscore the close link on campus between energy and combustion research. Approximately twenty faculty and professional staff members are affiliated informally with CECR.

Since its origins, the center has focused on basic problems in finding new sources of energy and 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 fundamental studies in combustion related to aerospace-plane propulsion, to power production and soot production by hydrocarbon fuels, and to use of solid-propellant fuels and sprays in combustion chambers. Three specific new grants are for "Asymptotic Analysis of Flame Structure with Real Chemistry" for the National Science Foundation, "Chemical Inhibition of Methane-Air Diffusion Flames" for the National Institute of Standards and Technology and the "Advanced Fuel Cell Commercialization Study" for the Department of Energy.

In April, Professor Forman A. Williams was informed of his appointment, effective April 1, 1993, to the newly created and endowed Presidential Chair in Energy and Combustion Research. The purpose of the Chair is to encourage new and interdisciplinary program development in the areas of energy and combustion. The establishment of this Chair is a recognition of the continuing importance of problems of efficient and clean development, use and management of energy resources and an acknowledgment of the scientific and technological challenges that these problems present.

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

Plans for the 1993-94 academic year include further emphasis on the fluid dynamics of reacting flows relevant to propulsion and on chemical aspects of propulsion and energy problems. Proposals have been submitted to the Office of Naval Research for research on "Prediction of NO_x Emissions from Large Diesels," to Lawrence Livermore Laboratory for "Chemical Kinetics of Nitramine Combustion Under Elevated Temperature and Pressure," to NASA for "High-Pressure Combustion of Binary Fuel Sprays," to the Department of Energy for "Fundamental Studies of Spray Combustion," and to the Gas Research Institute for "Nonpremixed Combustion in Porous Radiant Burners with Direct Thermophotovoltaic Energy Conversion", for example. In addition, plans are under way for seeking a large grant from the forthcoming NSF Clean Car Initiative, jointly with Materials research at UCSD.

2. Advisory Committee

The Advisory Committee for this time period is composed of:

Mr. Neal Blue
Chairman and Chief Executive Officer
General Atomics

Mr. Gary D. Cotton
Senior Vice-President
Engineering and Operations
San Diego Gas & Electric

Dr. Edward A. Frieman
Director
Scripps Institution of Oceanography

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

Mr. Mike Merlo
Manager of Research
Southern California Edison Company

These individuals have been serving at the request of the Director of the Center, who consults with them mainly individually. Plans are being formulated to arrange for a more formal manner of appointment to the advisory committee and for a larger representation from within UCSD, especially outside the hard sciences.

3. Faculty and Researchers

Active faculty participants during the period July 1, 1992 - June 30, 1993 included Director Forman A. Williams, Associate Director K. Seshadri, as well as Abraham L. Berlad, Robert J. Cattolica, Alvin S. Gordon, Juan C. Lasheras, Paul A. Libby, Stanford S. Penner, and Massoud T. Simnad.

Professional Researchers during the period 1992 - 93 included G. Balakrishnan, John Card, Jong Soo Kim, Shui-Chi Li, and Kurt O. Lund.

4. Graduate and Postdoctoral Students

The number of graduate and post-doctoral students directly contributing to the unit who were on the unit's payroll or participated through assistantships, fellowships, or traineeships during this period was 14, and the number who were otherwise involved in the unit's work was 5. The latter group is composed mainly of students who work part time in the combustion laboratory.

5. Instructional Programs

Undergraduate and graduate instruction were offered, as in prior years, on energy- and combustion-related topics within the Department of AMES and the Program on Science, Technology and Public Affairs.

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

SEMINAR SPEAKER	DATE	TOPIC
John Card	August 14, 1992	"Asymptotic Analysis for the Burning of n-Heptane Droplets Using Reduced Mechanisms"
Jong Soo Kim	August 17, 1992	"Acoustic Instabilities in Liquid-Propellant Rockets"
Robert J. Cattolica	August 19, 1992	"OH Rotational Temperature and Concentration Measurements in Hypersonic Shock Waves"
Ralph Aldredge	August 21, 1992	"The Propagation of Wrinkled Premixed Flames in Spatially Periodic Shear Flow"
Paul Clavin	August 24, 1992	"Fundamentals of Combustion Instabilities in Rockets"
Amable Liñán	August 26, 1992	"Ignition of Reacting Mixtures by Hot Spots"
Michel Champion	August 28, 1992	"Reynolds Stress Description of Opposed Turbulent Jets"
Bo Yang	August 28, 1992	"Asymptotic Analysis of the Structure of Methanol Air Flames"
Shui-chi Li	September 2, 1992	"Approximate PDPA Measurements in Counterflow"
Kurt O. Lund	September 4, 1992	"Sensible Receivers for Space Solar Power"
Carlos Vazquez-Espi	September 9, 1992	"Effect of Corners on the Ignition of Solids"

SEMINAR SPEAKER	DATE	TOPIC
A. K. Oppenheim	February 10, 1993	"Thermodynamic and Thermochemical Aspects of Combustion in an Enclosure"
Richard Yetter	February 22, 1993	"Transient Modeling of Single Particle Combustion: Emphasis on the Coupling of Heterogeneous/Gas-Phase Kinetics"
Barry Butler	March 1, 1993	"Developments in Solar Energy Technology"
Kozo Saito	March 3, 1993	"Upward Flame Spread along the Vertical Corner Wall" and "Very Small Laminar Diffusion Flames"
Kozo Saito	March 8, 1993	"Lean Production System, It's Impact on Education, Research and Administration"
Alvin S. Gordon	March 8, 1993	"Alternate Fuels for Mobile Transport"
Cesár Treviño	March 17, 1993	"High Temperature Ignition of Hydrogen in Mixing Layers"
Shui-chi Li	March 19, 1993	"Oscillations of a Sphere in Counterflowing Streams"
Jong Soo Kim	April 14, 1993	"Structures of Flow and Mixture-Fraction Fields for Counterflow Diffusion Flames with Small Stoichiometric Mixtures Fractions"
Carlos Fernandez-Pello	April 26, 1993	"The Effect of Gravity on Smoldering Combustion"
Alan Baxter	May 11, 1993	"The Gas Turbine Modular Helium Reactor: A New Type of Electric Power Generation Plant"
Stephen B. Margolis	May 17, 1993	"Resonant Mode Interactions and the Bifurcation of Intrinsic Acoustic Oscillations in a Model Pulse Combustor"

SEMINAR SPEAKER	DATE	TOPIC
Selim Senkan	May 19, 1993	"The Role of Chemical Kinetics and Quantum Mechanics in Combustion and Incineration Research"
Peter Meisen	June 1, 1993	"Is Tapping Renewable Resources a Better Option?"
Ian Kennedy	June 4, 1993	"Particle Dispersion and Chemical Reaction in Turbulent Jets"
Joseph Bentsman	June 7, 1993	"Control-Oriented Modeling of Combustion in Rocket Engines"

6. Participation From Other Organizations

A number of specialists from other organizations working on energy and combustion research have been regular visitors to UCSD and have participated in campus programs through formal lectures and informal discussions. For July 1, 1992 - June 30, 1993, these include:

VISITOR	AFFILIATION
Paul Clavin	Universite Aix Marseilles, France
Antoni K. Oppenheim	University of California, Berkeley, California
Johan Hustad	Norwegian Institute of Technology, Trondheim, Norway
Amable Liñán	Ciudad Universitaria, Madrid, Spain
Kozo Saito	University of Kentucky, Lexington, Kentucky
Mitchell D. Smooke	Yale University, New Haven, Connecticut
Richard Yetter	Princeton University, Princeton, New Jersey
Hideto Ikeda	IHI Research Institute, Tokyo, Japan
Masato Mikami	University of Tokyo, Tokyo, Japan
Nils Røkke	SINTEF Applied Thermodynamics, Trondheim, Norway
Ralph Aldredge	University of California, Davis, California
Carlos Fernandez-Pello	University of California, Berkeley, California
Carlos Vasquez-Espi	Universidad Politecnica, Madrid, Spain
Sun Yi	Energy Conservation Technology Center, Harbin, China
Michel Champion	ENSMA, Poitiers, France
Stephen B. Margolis	Sandia National Laboratories, Livermore, California
Joseph Bentsman	University of Illinois, Urbana-Champaign, Illinois

VISITOR	AFFILIATION
Cesar Treviño	Facultad de Ingenieria, UNAM, Mexico City, Mexico
Taiyue Cao	Changsha Institute of Technology, Changsha, China
Dietmar Trees	RWTH Aachen, Germany
William Ashurst	Sandia National Laboratories, Livermore, California

7. Public Relations Activities

Faculty and staff members associated with the UCSD Center for Energy and Combustion Research continue to be involved in energy policy and analysis activities and studies at local, state, national and international levels. The editorial offices for Energy, The International Journal (published by Pergamon Press in London, England, since 1975) remain housed at the UCSD Center for Energy and Combustion Research. S. S. Penner is the Chairman of the Panel of Experts for the California Council on Science and Technology advising the Integrated Waste Management Board of the State of California. He is also the Chairman of the Advanced Fuel Cell Commercialization Working Group advising the Department of Energy. F. A. Williams serves on the Advisory Committee of the University-wide Energy Research Group and has advised the California Air Resources Board on its Davis Facility for Emissions from Agricultural Burning. A. S. Gordon serves on the Research Screening Committee of the California Air Resources Board.

At the international level, Penner and Williams continue to interact abroad on energy and combustion issues. For example, Penner delivered an invited plenary lecture to the ECO World '92 of the American Society of Mechanical Engineers in Washington, DC. Williams delivered the invited opening plenary lecture at the Twenty-Fourth International Combustion Symposium in Sydney, Australia in July, 1992. Also through his collaborations with the Japanese on Microgravity Science, Williams helped arrange for NASA use of the new Japanese Microgravity Facility in Hokkaido for studying fundamentals of droplet combustion. There is continuing joint research with investigators at Cambridge University, England, RWTH Aachen, Germany, Université de Provence, Marseilles, France, University of Madrid, Spain, and elsewhere.

8. Publications

1. G. Balakrishnan, C. Trevino and F. Mauss, "Asymptotic Structure of Hydrogen-Air Diffusion Flames," *Combustion and Flame* 91, 246-256 (1992).
2. K. N. C. Bray, M. Champion and P. A. Libby, "Premixed Flames in Stagnating Turbulence. Part III - The \bar{k} - $\bar{\epsilon}$ Theory for Reactants Impinging on a Wall," *Combustion and Flame* 91, 165-186 (1992).
3. S. S. Penner, J. Haraden and S. Mates, "Long-Term Global Energy Supplies with Acceptable Environmental Impacts," *Energy-The International Journal* 17, 883-899 (1992).
4. S. S. Penner et al, "Science and Technology Research Priorities to Implement all Tiers of the California Integrated Waste-Management Hierarchy," 65 pp. with Appendix (280 pp), California Council on Science and Technology, The Arnold and Mabel Beckman Center, National Academies of Sciences and Engineering, 100 Academy Drive, Irvine, CA 92715 (1992).
5. K. Seshadri, A. L. Berlad, and V. Tangirala, "The Structure of Premixed Particle Cloud Flames," *Combustion and Flame* 89, 333-362 (1992).
6. M. Bui, K. Seshadri, and F. A. Williams, "The Asymptotic Structure of Premixed Methane-Air Flames with Slow CO Oxidation," *Combustion and Flame* 89, 343-362 (1992).
7. H. Chelliah, M. Bui-Pham, K. Seshadri, and C. K. Law, "Numerical Description of the Structure of Counterflow Heptane-Air Flames Using Detailed and Reduced Chemistry with Comparisons to Experiments," Twenty-Fourth Symposium (International) on Combustion, The Combustion Institute, 851-857, (1992).
8. B. Yang, and K. Seshadri, "Asymptotic Analysis of the Structure of Nonpremixed Methane Air Flames using Reduced Chemistry," *Combustion Science and Technology* 88 115-132 (1992).
9. B. Yang, K. Seshadri and N. Peters, "The Asymptotic Structure of Premixed Methanol-Air Flames," *Combustion and Flame* 91, 382-398 (1992).
10. B. Yang, and K. Seshadri, "The Asymptotic Structure of Methanol-Air Diffusion Flames," *Combustion Science and Technology* 88, 115-132 (1992).
11. M. T. Simnad and D. Czechowicz, "Versatility of HTGR-TRISO Nuclear Fuel Technology," invited paper, Symposium on HTGR Technologies, October 21-23, Oyai, Japan (1992).
12. J.S. Kim, P. A. Libby and F.A. Williams, "Influences of Swirl on the Structure and Extinction of Strained Premixed Flames. Part II: Strong Rates of Rotation," *Physics of Fluids A* 4, 391-408 (1992).

13. J.M. Card and F.A. Williams, "Asymptotic Analysis of the Structure and Extinction of Spherically Symmetrical n-Heptane Diffusion Flames," *Combustion Science and Technology* **84**, 91-119 (1992).
14. J.M. Card and F.A. Williams, "Asymptotic Analysis with Reduced Chemistry for the Burning of n-Heptane Droplets," *Combustion and Flame* **91**, 187-199 (1992).
15. J.S. Kim, P.A. Libby and F.A. Williams, "On the Displacement Effects of Laminar Flames," *Combustion Science and Technology* **87**, 1-25 (1992).
16. G. Balakrishnan, A. Liñán and F.A. Williams, "Rotational Inviscid Flow in Laterally Burning Solid-Propellant Rocket Motors," *Journal of Propulsion and Power* **8**, 1167-1176 (1992).
17. F.A. Williams, "Combustion," *Encyclopedia of Physical Science and Technology*. Vol. 3, Academic Press, New York, 1992, 629-654.
18. F.A. Williams, "The Role of Theory in Combustion Science," *Twenty-Fourth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA, 1-17 (1992).
19. N.A. Røkke, J.E. Hustad, O.K. Sønju and F.A. Williams, "Scaling of Nitric Oxide Emissions from Buoyancy-Dominated Hydrocarbon Turbulent-Jet Diffusion Flames," *Twenty-Fourth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA, 385-393 (1992).
20. G.T. Linteris and F.A. Williams, "Asymptotic and Numerical Predictions of Carbon Monoxide-Nitrous Oxide Flame Structure," *Twenty-Fourth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA, 803-811 (1992).
21. S.C. Li, P.A. Libby and F.A. Williams, "Experimental and Theoretical Studies of Counterflow Spray Diffusion Flames," *Twenty-Fourth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA, 1503-1512 (1992).
22. B.D. Shaw and F.A. Williams, "A Model for the Deflagration of Aqueous Solutions of Hydroxylammonium Nitrate," *Twenty-Fourth Symposium (International) on Combustion*, The Combustion Institute, Pittsburgh, PA, 1923-1930 (1992).
23. J. S. Kim, "A Formulation for Transverse Acoustic Instability in Liquid-Propellant Rocket Motors," CECR Report 92-01 (1992).
24. S. C. Li, A. S. Gordon and F. A. Williams, "The Characteristics of Soot Formation in Laminar Diffusion Flames of Hydrocarbon Fuel With and Without Dilution," CECR Report 92-02 (1992).
25. S. C. Li, P. A. Libby and F. A. Williams, "Measurements in Two-Phase Counterflowing Streams Using a Phase Doppler Particle Analyzer," CECR Report 92-03 (1992).

26. J. S. Kim and F. A. Williams, "Structure of Flow and Mixture Fraction Fields for Counterflow Diffusion Flames with Small Stoichiometric Mixture Fractions," CECR Report 92-04 (1992).
27. R. J. Cattolica, "Electron Beam Fluorescence Imaging for Hypersonic Research, in New Trends in Instrumentation for Hypersonic Research," A. Boutier, ed., NATO ASI Series E: Applied Physics 224, 275-285, Kluwer Academic Publishers, Dordrecht (1993).
28. C. Danker, R. Cattolica, and W. Sellers, "Local Measurements of Temperature and Concentrations: A Review for Hypersonic Flows," in Theoretical and Experimental Methods in Hypersonic Flows, NATO, AGARD-CP-514, Nueilly Sur Siene, France (1993).
29. K. K. Tio, J. C. Lasheras, A. Ganan and A. Linan, "The Dynamics of Bubbles in Periodic Vortex Flows", J. of Applied Scientific Research 51, 285-291 (1993).
30. M. Champion and P. A. Libby, "Reynolds Stress Description of Opposed and Impinging Turbulent Jets. Part I. Opposed Jets," Physics of Fluids 5, 203-216 (1993).
31. L. W. Kostiuk and P. A. Libby, "Comparison Between Theory and Experiment for Turbulence in Opposed Streams," Physics of Fluids 5, 2301-2303 (1993).
32. Kurt O. Lund, Karl W. Baker and Mark M. Weislogel, "The Vapor-Pressure Pumped Loop Concept for Space Systems Heat Transport," First International Conference on Aerospace Heat Exchanger Technology, R. K. Shah and E. N. Ganic, Eds., Palo Alto, CA, Elsevier Science Publishers, Amsterdam, Netherlands, 45-56 (1993).
33. Kurt O. Lund and K. W. Baker, "Minimum-Weight Analysis of Anisotropic Plane-Fin Heat-Pipe Space Radiators," J. Solar Energy Engineering 115, 37-41 (1993).
34. Kurt O. Lund, "Radiation and Phase-Change of Monocrystalline Lithium-Fluoride in an Annular Enclosure with Specified Heat Flux," J. Thermophys. & Heat Transfer 7, 600-607 (1993).
35. S. S. Penner and J. Haraden, "A Low-Cost Technology for Increasing the Earth's Albedo to Mitigate Temperature Rises," Energy – The International Journal 18, 1087-90 (1993).
36. H. Chelliah, K. Seshadri, and C. K. Law, "Reduced Kinetic Mechanisms for Counterflow Methane-Air Diffusion Flames," in Reduced Kinetic Mechanisms for Applications in Combustion Systems (Eds. N. Peters and B. Rogg), Lecture Notes in Physics, Springer Verlag, M15, Springer-Verlag, Heidelberg, 224-240, (1993).

37. C. M. Muller, K. Seshadri and J. Y. Chen, "Reduced Kinetic Mechanisms for Counterflow Methanol Diffusion Flames," in Reduced Kinetic Mechanisms for Applications in Combustion Systems (Eds. N. Peters and B. Rogg), Lecture Notes in Physics, M15, Springer Verlag, Heidelberg, 284-307 (1993).
38. M. T. Simnad and C. P. Zaleski, "Clean Energy for Europe in Transition," invited paper, Energy - The International Journal 18, 1197-1022 (1993).
39. A. J. Strutt, M. T. Simnad, E. Lavernia and K. S. Vecchio, "Analytical Electron Microscopy of a Ag-Y-Ba-Cu Superconductor Precursor Material," Proc. 51st Annual Meeting of the Microscopy Society of America, p. 1992-1993 (1993).
40. M. T. Simnad, "Materials for Passively Safe Reactors," Trans. Amer. Nuclear Soc., 68(B), 11 (1993).
41. F. Mauss, N. Peters, B. Rogg and F.A. Williams, "Reduced Kinetic Mechanisms for Premixed Hydrogen Flames," Chapter 3 of Reduced Kinetic Mechanisms for Applications in Combustion Systems, (N. Peters and B. Rogg, editors), Springer-Verlag, New York, 1993, pp. 29-43.
42. W. Wang, B. Rogg and F.A. Williams, "Reduced Kinetic Mechanisms for Wet CO Flames," Chapter 4 of Reduced Kinetic Mechanisms for Applications in Combustion Systems, (N. Peters and B. Rogg, editors), Springer-Verlag, New York, 1993, pp. 44-57.
43. E. Gutheil, G. Balakrishnan and F.A. Williams, "Structure and Extinction of Hydrogen-Air Diffusion Flames," Chapter 11 of Reduced Kinetic Mechanisms for Applications in Combustion Systems, (N. Peters and B. Rogg, editors), Springer-Verlag, New York, 1993, pp. 177-195.
44. A. Liñán and F.A. Williams, Fundamental Aspects of Combustion, Oxford University Press, New York, 1993 (167 pages).
45. H. Ikeda, P.A. Libby, J. Sato and F.A. Williams, "Catalytic Combustion of Hydrogen-Air Mixtures in Stagnation Flows," Combustion and Flame 93, 138-148 (1993).
46. M. Mikami, M. Kono, J. Sato, D.L. Dietrich and F.A. Williams, "Combustion of Miscible Binary-Fuel Droplets at High Pressure Under Microgravity," Combustion Science and Technology 90, 111-123 (1993).
47. S.C. Li, P.A. Libby and F.A. Williams, "Spray Structure in Counterflowing Streams with and without a Flame," Combustion and Flame 94, 161-177 (1993).
48. L. Sinay and F.A. Williams, "Stability of Nonadiabatic Cellular Flames near Extinction," Dynamics of Gaseous Combustion, (A.L. Kuhl, J.-C. Leyer, A.A. Borisov and W.A. Sirignano, editors), Vol. 151 of Progress in Astronautics and Aeronautics, American Institute of Aeronautics and Astronautics, Washington, DC, 1993, 263-273.

49. S.C. Li and F.A. Williams, "Ignition and Combustion of Boron Particles," Combustion of Boron-Based Solid Propellants and Solid Fuels, (K.K. Kuo, editor), CRC Press, Boca Raton, FL, 1993, 248-271.
50. P. Clavin, J. S. Kim and F. A. Williams, "Turbulence-Induced Noise Effects on High-Frequency Combustion Instabilities," CECR Report 93-01 (1993).
51. J. S. Kim and F. A. Williams, "Contribution of Strained Diffusion Flames to Acoustic Pressure Response," CECR Report 93-02 (1993).

9. Numbers of Full Time Employees

The number of full time administrative employees is 2, one university-supported and the other supported on extramural funds.

10. Space

The Center for Energy and Combustion Research occupied these rooms in Urey Hall: 6202, 6206, 6210, 6214, 6218, 6222, 6226, 6234, 6238, 6242, 6246, 6250, 6254, 6258, 6262, and 7230, and these labs in Urey Hall: 6106-6112, 6114, 6116-6120, 6124-6126, 6130 and 6132. In the Engineering Building, the Center occupied rooms 2208 and 3205 and lab 1103.

11. CENTER FOR ENERGY AND COMBUSTION RESEARCH 1992/1993 ANNUAL REPORT

PRINCIPAL INVESTIGATOR	CONTRACT/GRANT NO.	TITLE	PERIOD	1992/1993 AWARD	TOTAL EXPENSE	IDC EXPENSE
Cattoica, R.	NASA NCC2-718.	Electron-Beam Fluorescence Methods for Hypersonic Flow Diagnostics	11/01/91 - 06/30/93	30,000	131,094	30,716
Lasher, J.	United Technologies	Turbulent Reacting Flows	06/30/90 - Open	20,000	32,473	0
Libby, P.	DOE DEFG03-86ER13527	Premixed Turbulent Combustion	06/01/86 - 11/30/93	60,000	57,316	19,105
Libby, P./Williams, F.	DOE DEFG03-87ER13685	Experimental and Theoretical Study of Fuel Droplets Subject to a Straining Flow	05/01/93 - 04/10/94	126,000	190,987	38,928
Libby, P./Williams, F.	NASA NAG 1-1193	Supersonic Mixing Layers Without and With Combustion	10/22/92 - 01/21/94	30,511	28,332	4,595
Lund, K.	NASA NAG 3-1243	Vapor-Pressure Pumped Heat-Transfer Loop	10/25/91 - 10/24/93	35,000	28,643	9,559
Penner, S.		Energy Research	01/13/84 - Open	0	2,817	0
Seshadri, K.	NSF INT 91-14461	U.S.-Federal Republic of Germany Cooperative Res	05/01/92 - 04/30/95	0	4,326	250
Seshadri, K.	NIST 60NANB2D1285	Experimental Studies on the Extinction of Diffusion Flames Using Halon Substitutes	09/01/92 - 08/31/93	0	33,744	10,272
Seshadri, K.	ARO DAAL03-90-G-0084	The Structure of Laminar Flames of CH ₄ /NO ₂ CH ₂ O/NO ₂ , and HCN/NO ₂	03/01/90 - 03/31/94	40,000	52,566	16,557
Seshadri, K./Berlad, A	NASALewis NAG 3-1297	The Structure of Particle Cloud Premixed Flame Chemistry	09/14/91 - 09/13/92	0	10,662	3,554
Williams, F.	NSF CTS 92-14888	Asymptotic Analysis of Flame Structure with Real Chemistry	11/01/92 - 10/31/95	257,806	59,465	16,650
Williams, F.	AFOSR 91-0130	Fundamentals of Acoustic Instability in Liquid Propellant Rockets of Organic Matter in Southern California Coastal Basins	12/15/92 - 12/14/93	137,538	119,993	31,166
Sub-total				736,855	752,418	181,352

11. CENTER FOR ENERGY AND COMBUSTION RESEARCH 1992/1993 ANNUAL REPORT

PRINCIPAL INVESTIGATOR	CONTRACT/GRANT NO.	TITLE	PERIOD	1992/1993 AWARD	TOTAL EXPENSE	IDC EXPENSE
Williams, F.	AOSR F49629-93-1-0380	AASERT-92 Theories of Turbulent Combustion in High-Speed Flows	06/01/93 - 05/31/94	91,782	0	0
Williams, F.	NASA NAG3-1081	Scientific Support for a Proposed Space Shuttle Droplet Burning Experiment	01/15/93 - 01/14/94	80,000	57,707	17,528
Williams, F.	NASA NAG3-1248	High-Pressure Combustion of Binary Fuel Droplets	12/15/92 - 12/14/93	35,000	40,783	8,840
Williams, F./Libby, P.	AOSR F49620-92-J-0184	Theories of Turbulent Combustion in High Speed Flows	03/01/93 - 02/28/94	135,200	176,341	55,156
Williams, F./Libby, P.	AOSR 89-0310	Theories of Turbulent Combustion in High Speed Flows	03/01/89 - 02/29/92	0	2,094	892
Williams, F.		CECR General Funds	07/01/92 - 06/30/93	38,271	38,460	0
Williams, F.		Presidential Chair in Energy & Combustion Research	05/19/93 - Open	21,882	0	0
Williams, F.		Catalytic Combustion	01/14/91 - Open	0	2,307	0
Williams, F.		G A Energy Fellowships	04/20/90 - Open	0	0	0
Williams, F.		Energy Center Conferences	0	7,845	7,845	0
TOTAL				1,146,835	1,077,955	263,768

12. CENTER FOR ENERGY AND COMBUSTION RESEARCH**ANNUAL REPORT****July 1, 1992 through June 30, 1993****1. Source of Support:**

CECR/General Fund	38,271
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2. Expenditures for administrative support:

Salaries	27,846
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Benefits	9,528
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Supplies and Expense	1,086
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Equipment	0
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Travel	0
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TOTAL	38,460
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3. Matching Funds:	0
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4. Research Expenditures:	1,077,955
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5. Indirect Cost Expenditures:	263,768
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6. Other Specified Uses:	0
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