STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305-4126

DOE/ER/13662--T9

SPONSORED PROJECTS OFFICE
JORDAN QUAD/BIRCH
125 Panama Street

Telephone (415) 723-2883
Fax (415) 723-1654

September 15, 1989

In reply refer to:
SPO #3938

→ Dr. Oscar P. Manley
ER-15
U.S. Department of Energy
Office of Basic Energy Sciences
Germantown Building, MS G226
Washington, DC 20545

Revised Budget Less #

Reference:	DE-FG03-87ER13662
Title:	"Energy Changes in Transforming Solids"
Principal Investigator:	George Herrmann
Co-Investigator(s):	David M. Barnett
Department:	Mechanical Engineering
Period:	January 1, 1990 - December 31, 1990
Amount Requested:	\$170,000

Dear Dr. Manley:

This submission is a revision of our earlier proposal dated August 29, 1989.

Thank you for your consideration of this proposal and should you require additional information, please feel free to contact me at (415) 723-2883.

Sincerely,

[Signature]
#2 Valerie M. G. Mallace
Assistant Director

VMGM/skg
Enclosures

cc: George Herrmann
David M. Barnett
Kay Mahon, Bldg 530 (3032)

Budgets removed etc

*DD
A/90*
[Signature]
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MASTER

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APPLICATION FOR FEDERAL ASSISTANCE

1. TYPE OF SUBMISSION: Application ☐ Construction ☐ Preapplication Construction ☒ Non-Construction ☐ Non-Construction		2. DATE SUBMITTED		Applicant Identifier	
		3. DATE RECEIVED BY STATE		State Application Identifier	
		4. DATE RECEIVED BY FEDERAL AGENCY		Federal Identifier	
5. APPLICANT INFORMATION					
Legal Name: Board of Trustees of the Leland Stanford Jr. University			Organizational Unit: Sponsored Projects Office		
Address (give city, county, state, and zip code): 125 Panama Street, Birch/Jordan Quad Santa Clara County Stanford, CA. 94305			Name and telephone number of the person to be contacted on matters involving this application (give area code): Valerie Mallace (415) 723-2234		
6. EMPLOYER IDENTIFICATION NUMBER (EIN): <div style="border: 1px solid black; padding: 2px; display: inline-block;"> 9 4 - 1 1 5 6 3 6 5 </div>			7. TYPE OF APPLICANT: (enter appropriate letter in box) J <div style="display: flex; flex-wrap: wrap;"> <div style="width: 50%;"> A. State B. County C. Municipal D. Township E. Interstate F. Intermunicipal G. Special District </div> <div style="width: 50%;"> H. Independent School Dist. I. State Controlled Institution of Higher Learning J. Private University K. Indian Tribe L. Individual M. Profit Organization N. Other (Specify) _____ </div> </div>		
8. TYPE OF APPLICATION: ☐ New ☒ Continuation ☐ Revision If Revision, enter appropriate letter(s) in box(es): ☐ ☐ A. Increase Award B. Decrease Award C. Increase Duration D. Decrease Duration Other (specify): _____			9. NAME OF FEDERAL AGENCY: U.S. Department of Energy (Office of Basic Energy Sciences)		
10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER: <div style="border: 1px solid black; width: 100px; height: 20px; margin: 5px 0;"></div> TITLE: _____			11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT: ENERGY CHANGES IN TRANSFORMING SOLIDS		
12. AREAS AFFECTED BY PROJECT (cities, counties, states, etc.): <div style="border: 1px solid black; height: 40px; margin-top: 5px;"></div>					
13. PROPOSED PROJECT:		14. CONGRESSIONAL DISTRICTS OF:			
Start Date 1/1/90	Ending Date 12/31/90	a. Applicant 12th		b. Project 12th	
15. ESTIMATED FUNDING:		16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS? a. YES. THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON: DATE _____ b. NO. ☐ PROGRAM IS NOT COVERED BY E.O. 12372 ☐ OR PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW			
a. Federal	\$ 170,000 .00	17. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT? ☐ Yes If "Yes," attach an explanation. ☒ No			
b. Applicant	\$.00				
c. State	\$.00				
d. Local	\$.00				
e. Other	\$.00				
f. Program Income	\$.00				
g. TOTAL	\$ 170,000 .00				
18. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT, THE DOCUMENT HAS BEEN ONLY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED					
a. Typed Name of Authorized Representative R Robert C Baum		b. Title Assistant Director		c. Telephone number (415) 723-2234	
d. Signature of Authorized Representative				e. Date Signed 9/15/89	

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STANFORD UNIVERSITY
STANFORD, CALIFORNIA 94305-4125

Cont.

SPONSORED PROJECTS OFFICE
JORDAN QUAD/BIRCH
125 Panama Street

Telephone (415) 723-2883
Fax (415) 723-1654

August 29, 1989

In reply refer to:
SPO #3938

Dr. Oscar P. Manley
ER-15
U.S. Department of Energy
Office of Basic Energy Sciences
Germantown Building, MS G226
Washington, DC 20545

Reference:	DE-FGO3-87ER13662
Title:	"Energy Changes in Transforming Solids"
Principal Investigator:	George Herrmann
Co-Investigator(s):	David M. Barnett
Department:	Mechanical Engineering
Period:	January 1, 1990 - December 31, 1990
Amount Requested:	\$175,000

Dear Dr. Manley:

On behalf of Stanford University, it is a pleasure to submit the referenced proposal requesting continued grant support. Additional copies of the proposal and supporting materials are also enclosed.

Thank you for your consideration of this proposal and should you require additional information, please feel free to contact me at (415) 723-2883.

Sincerely,

Valerie M. G. Mallace
Valerie M. G. Mallace
Assistant Director

VMGM/skg
Enclosures

cc: George Herrmann
David M. Barnett
Kay Mahon, Bldg 530 (3032)

Budgets removed at

APPLICATION FOR FEDERAL ASSISTANCE

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Preapplication ☐ Construction ☐ Non-Construction		3. DATE RECEIVED BY STATE	State Application Identifier
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Legal Name: Board of Trustees of the Leland Stanford Jr. University	Organizational Unit: Sponsored Projects Office
Address (give city, county, state, and zip code): 125 Panama Street, Birch/Jordan Quad Santa Clara County Stanford, CA. 94305	Name and telephone number of the person to be contacted on matters involving this application (give area code): Valerie Mallace (415) 723-2234

6. EMPLOYER IDENTIFICATION NUMBER (EIN):

9	4	—	1	1	5	6	3	6	5
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8. TYPE OF APPLICATION:

☐ New ☒ Continuation ☐ Revision

If Revision, enter appropriate letter(s) in box(es):

A. Increase Award B. Decrease Award C. Increase Duration
D. Decrease Duration Other (specify):

7. TYPE OF APPLICANT: (enter appropriate letter in box)

A. State	H. Independent School Dist.
B. County	I. State Controlled Institution of Higher Learning
C. Municipal	J. Private University
D. Township	K. Indian Tribe
E. Interstate	L. Individual
F. Intermunicipal	M. Profit Organization
G. Special District	N. Other (Specify):

9. NAME OF FEDERAL AGENCY:

U.S. Department of Energy
(Office of Basic Energy Sciences)

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER:

TITLE:

11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:

ENERGY CHANGES IN TRANSFORMING SOLIDS

12. AREAS AFFECTED BY PROJECT (cities, counties, states, etc.):

13. PROPOSED PROJECT:

Start Date: 1/1/90
Ending Date: 12/31/90

14. CONGRESSION:

a. Applicant
12th

15. ESTIMATED FUNDING:

a. Federal	\$	175,000	.00
b. Applicant	\$		.00
c. State	\$		.00
d. Local	\$		.00
e. Other	\$		.00
f. Program Income	\$		.00
g. TOTAL	\$	175,000	.00

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12th

ORDER 12372 PROCESS?
MADE AVAILABLE TO THE
SS FOR REVIEW ON:

12372

CTED BY STATE FOR REVIEW

No

16. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT; THE DOCUMENT HAS BEEN DULY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED

a. Typed Name of Authorized Representative Valerie Mallace	b. Title Assistant Director	c. Telephone number (415) 723-2234
d. Signature of Authorized Representative <i>Valerie M. Mallace</i>	e. Date Signed 8/29/89	

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Continuation Proposal Submitted to

U. S. DEPARTMENT OF ENERGY

Office of Basic Energy Sciences

Division of Engineering, Mathematical and Geosciences

for research in the field of

ENERGY CHANGES IN TRANSFORMING SOLIDS

for the period January 1, 1990 to December 31, 1990

Submitted by

David M. Barnett

George Herrmann

Division of Applied Mechanics

Department of Mechanical Engineering

Stanford University

Stanford, CA 94305

August, 1989

Proposal # ME 97-89C

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ENERGY CHANGES IN TRANSFORMING SOLIDS

A Continuation Proposal for Research

Submitted to the

U. S. DEPARTMENT OF ENERGY

for the period

January 1, 1990 to December 31, 1990

Co-Principal Investigators

George Herrmann

David M. Barnett

Proposal # ME-97-89C

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at

ENERGY CHANGES IN TRANSFORMING SOLIDS

1. Work Completed and In Progress During the Current Funding Period

During the reporting period considerable progress has been made in several distinct areas, as is summarized below.

A recently discovered correspondence in plane elastostatics for regions bounded by a circle (with sponsorship of DOE) was used as a building block to treat problems of bonded inclusions as problems of a homogeneous body. The general formulae established are algebraic and universal in the sense of being independent of any particular loading. The more difficult problem of an inclusion with a slipping interface has been shown to be tractable in a similar manner.

Currently the problem of two cavities or inclusions is also being studied. For the case of anti-plane strain it is possible to establish a "two-circle theorem", expressed in terms of converging geometrical series. If the two circles just touch one another, the series has been tabulated and denoted as the "tri-gamma function". Thus, we have an "exact solution" and a generally valid theorem. Also under investigation is the general case of an elastically imbedded inclusion, leading to the bonded and slipping interfaces as limiting cases. An intriguing correspondence between compressible and incompressible plane elastostatics has been uncovered and will be reported in a forthcoming publication.

Progress is also being made in the area of conservation integrals. Non-classical transformations are being examined which are leading, on

the basis of Noether's theorem, to conservation laws both in statics and dynamics which have practical applications in fracture and defect mechanics.

Mathematical and physical modelling of damage in brittle solids is being performed, particularly as regards the underlying thermodynamic formalism. Studies of isothermal deformation are being extended to the non-isothermal case.

In the area of wave propagation in anisotropic solids we have completed a theoretical and numerical study of subsonic interfacial waves in bonded piezoelectric dissimilar half-spaces. We have established definite criteria for the conditions under which such wave modes exist and have implemented these criteria into numerical computations. In the course of this study we have (1) developed a much-improved numerical method which computes the so-called limiting speed to a high degree of accuracy and (2) have developed methods for generating 3-D computer images of wave slowness surfaces. The latter achievement is indispensable for deciding which directions in anisotropic elastic or piezoelectric solids should prove interesting for studying bulk, surface, and interfacial wave phenomena; we expect this method to develop into a commonplace tool for studying and representing wave phenomena in the future.

We have also completed a rather thorough study of which crystal classes are capable of admitting the so-called Type 3 transonic state in anisotropic elasticity. It appears that no real known crystals can satisfy the restrictions on elastic constants producing such a state. This means that only the Type 5 transonic state (of the 6 possible types) needs to be studied in more detail, and we have begun a theoretical study of this state.

2. Work Planned During the Continuation Funding Period

Research during the coming year will closely follow the original four year proposal we submitted. We do intend to extend our wave studies into the supersonic regime, since theoretical work in this area is clearly needed to explain and predict certain experimental observations using the new tool of acoustic microscopy which relies heavily on the generation of leaky surface waves. Furthermore, we intend to complete a study of the general self-force on a three-dimensional dislocation loop element in an elastic medium of arbitrary anisotropy, as this is currently a needed ingredient in modern fracture and damage mechanics and in the study of defects in integrated circuit materials.

PUBLICATIONS IN PRINT AND IN PREPARATION

1. W.W. Liu, T. Honein, and G. Hermann, A Novel Method for Stress Analysis of Elastic Materials with Damage Zones, Proc. of IUTAM Symposium on Yielding, Damage, and Failure of Anisotropic Solids (Grenoble, France), in press.
2. T. Honein and G. Herrmann, The Inclusion Correspondence in Plane Elastostatics for Regions Bounded by a Circle, J. Appl. Mechanics, vol. 55 (1988), pp. 566-573.
3. T. Honein and G. Herrmann, On Bonded Inclusions with Circular or Straight Boundaries in Plane Elastostatics, J. Appl. Mechanics, in press.
4. T. Honein and G. Herrmann, A Circular Inclusion with Slipping Interface in Plane Elastostatics, Proc. Symposium on Micromechanics and Inhomogeneities, Springer, New York (1989), in press.
5. E. Honein and G. Herrmann, On the Correspondence Between Compressible and Incompressible Plane Elastostatics, to be submitted for publication.
6. T. Honein and G. Herrmann, Conservation Laws and Path-Independent Integrals for Non-Homogeneous Elastic Bodies, to be submitted for publication.
7. G. Herrmann and J. Kestin, On Thermodynamic Foundations of a Damage Theory in Elastic Solids, Proc. CNRS-NSF Workshop on Strain Localization and Size Effects Due to Cracking and Damage, Cachan, France, in press.
8. T. Honein and G. Herrmann, Reduction on Non-Homogeneous to Homogeneous Problems in Elastostatics With Applications to Composites, Proc. Symposium on Mechanics of Composite Materials, eds. G. J. Dvorak and N. Laws, AMD, vol. 92, New York (1988), pp. 1-5.
9. D. M. Barnett and J. Lothe, Surface Wave Existence Theory for the Case of Zero Curvature Transonic States, in Elastic Wave Propagation, eds. M.F. McCarthy and M.F. Hays, North-Holland, Amsterdam (1989), pp. 33-38.
10. D. M. Barnett and J. Lothe, Zero Curvature Transonic States and Free Surface Waves in Anisotropic Elastic Media, Wave Motion (1989), in press.
11. D. M. Barnett and J. Lothe, What We Know About First Transonic States in Anisotropic Linear Elastic Solids, Proc. IUTAM Symposium on Elastic Wave Propagation and Non-Destructive Evaluation, Boulder, Colorado (1989), in press.
12. Marun Abbudi, Ph.D. Thesis, Division of Applied Mechanics, Stanford University (June, 1989).

13. Marun Abbudi and D. M. Barnett, On the Existence of Interfacial (Stoneley) Waves in Bonded Piezoelectric Half-Spaces, submitted to Proc. Royal Society, London.
14. Marun Abbudi and D. M. Barnett, Computer-Generated Three-Dimension Slowness Surface, in preparation for submission to Wave Motion.

LECTURES PRESENTED

1. G. Herrmann, The Fundamental Elements of an Exact Thermodynamic Theory of Damage in Elastic Solids, CNRS-NSF Workshop on Strain Localization and Size Effects Due to Cracking and Damage, Cachan, France, September, 1988.
2. G. Herrmann, Fracture Mechanics at the Level of the Theory of Strength of Materials, at University of Illinois at Chicago, November, 1988.
3. G. Herrmann, The Involution Correspondence in Plane Elastostatics for Regions Bounded by a Circle, ASME Winter Annual Meeting, Chicago, November/December, 1988.
4. G. Herrmann, Strength of Materials in a New Light, Stanford University, January, 1988.
5. G. Herrmann, Heterogenization in Continuum Mechanics, Chinese Academy of Sciences, Beijing, May, 1989.
6. G. Herrmann, Circle Theorems in Elasticity, Tsinghua University, Beijing, May, 1989.
7. G. Herrmann, Heterogenization in Elasticity and Fluid Mechanics, Beijing University, Beijing, May, 1989.
8. G. Herrmann, Several Lectures on Conservation Laws, Heterogenization, and Damage Mechanics, University of Paris, June/July 1989.
9. G. Herrmann, invited lecture on Non-classical Conservation Laws, International Meeting for the Interaction of Mathematics and Mechanics, Hollabrunn, Vienna, August, 1989.
10. D. M. Barnett, Wave Propagation in Anisotropic Solids, Univ. of Calif. at San Diego, May, 1989.
11. D. M. Barnett, What We Know About First Transonic States in Linear Elastic Anisotropic Solids, IUTAM Symposium on Elastic Waves, Boulder, Colorado, August, 1989.

PROPOSED BUDGET FOR THE PERIOD 1/1/90 - 12/31/90

1.	Direct Salaries	
	Prof. G. Herrmann	
	10% AY	\$ 9,285
	30% Summer	9,090
	Prof. D. M. Barnett	
	10% AY	7,560
	50% Summer	12,335
	(2) Graduate Student	
	Research Assistants (50% time)	26,400
	Secretarial Support (10% time)	<u>2,550</u>
	TOTAL DIRECT SALARIES	\$ 67,220
2.	Staff Benefits	
	27.6% to 8/31/90	
	28.3% to 8/31/91	<u>18,705</u>
	TOTAL DIRECT SALARIES WITH STAFF BENEFITS	\$ 85,925
3.	Miscellaneous Supplies & Services	2,370
4.	Travel	
	2 Trips to East Coast Plus	2,625
	Misc. Local Travel, Air \$850	
	+ 3 days per diem @ \$121	
5.	Communications	1,000
6.	Computing Costs	
	G. Herrmann (1/2 share Appl. Mech.	2,700
	Convex Computer @ \$450/share/mo.)	
	D. Barnett (1/2 share Appl. Mech.	2,700
	Convex Computer @ \$450/share/mo.)	
7.	Publication Cost	<u>850</u>
	SUB-TOTAL	\$ 98,170
8.	Engineering Support Services	
	2.45%	2,405
	MODIFIED TOTAL DIRECT COSTS	\$100,575
9.	Indirect Costs (74% of MTDC)	<u>\$ 74,425</u>
	TOTAL ANNUAL AMOUNT REQUESTED	\$175,000