

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

BB-574

Closeout Notice Date 02/14/95

Project No. E-25-W13 _____ Center No. 10/24-6-R7857-0A0_
Project Director UMEAGUKWU I C _____ School/Lab MECH ENGR _____
Sponsor NATL SCIENCE FOUNDATION/GENERAL _____
Contract/Grant No. DDM-9311796 _____ Contract Entity GTRC
Prime Contract No. _____
Title RES EQUIP PROP: LASER ARRAY INDUCED ULTRASOUND FOR WELD QUALITY CONTROL____
Effective Completion Date 941231 (Performance) _____ (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	N	_____
Final Report of Inventions and/or Subcontracts	N	_____
Government Property Inventory & Related Certificate	N	_____
Classified Material Certificate	N	_____
Release and Assignment	N	_____
Other _____	N	_____

Comments _____
LETTER OF CREDIT APPLIES. 98A SATISFIES PATENT REQUIREMENT. _____

Subproject Under Main Project No. _____

Continues Project No. _____

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Management	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other _____	N
_____	N

OMB Number 345-0058
NATIONAL SCIENCE FOUNDATION
1800 G STREET, NW
WASHINGTON, DC 20550

E-25-w13
/

BULK RATE
POSTAGE & FEES PAID
National Science Foundation
Permit No. G-69

PI/PD Name and Address

Charles I. Ume
Mechanical Engineering
GA Tech Res Corp - GIT
Atlanta, GA 30332-0405

NATIONAL SCIENCE FOUNDATION FINAL PROJECT REPORT

PART I - PROJECT IDENTIFICATION INFORMATION	
1. Program Official/Org.	Warren R. DeVries - DMI
2. Program Name	Manufacturing Processes & Equipment Prog
3. Award Dates (MM/YY)	From: 07/93 To: 12/94
4. Institution and Address	GA Tech Res Corp - GIT Administration Building Atlanta, GA 30332
5. Award Number	9311796
6. Project Title	Engineering Research Equipment Grant: Laser Array Induced Ultrasound for Quality Control

This Packet Contains
NSF Form 98A
and 1 Return Envelope

NSF Grant conditions (Article 17, GC-1, and Article 9, FDP-11) require submission of a Final Project Report (NSF Form 98A) to the NSF program officer no later than 90 days after the expiration of the award. Final Project Reports for expired awards must be received before new awards can be made (NSF Grants Policy Manual Section 677).

Below, or on a separate page, provide a summary of the completed projects and technical information and attach it to this form. Be sure to include your name and award number on each separate page. See below for more instructions.

PART II - SUMMARY OF COMPLETED PROJECT (for public use)

The summary (about 200 words) must be self-contained and intellegible to a scientifically literate reader. Without restating the project title, it should begin with a topic sentence starting the project's major thesis. The summary should include, if pertinent to the project being described, the following items:

- The primary objectives and scope of the project
- The techniques or approaches used only to the degree necessary for comprehension
- The findings and implications stated as concisely and informatively as possible.

This equipment proposal was to purchase a Q-switched YAG laser, vibration isolation optical table, and optical mounting devices to carry on the following research:

The research was to develop a non-contact and a non-destructive laser array techniques for generating ultrasound. An analytical model was also to be developed for each array type. The long range plan is to use these array techniques for on-line depth of penetration and porosity monitoring and control, during gas metal arc welding process. An electro-magnetic acoustic transducer (EMAT) was to be used as the receiver.

The equipment was purchased. Two different array techniques (phased and linear) were developed, and successfully applied to measure the depth of solidified welds. Both the time of flight and amplitude methods were used in these measurements. Array techniques were found to enhance signal generation in the thermoelastic region. Temporal laser modulation technique was developed and used to generate ultrasound. Signals generated by modulated beams were found to have greater amplitude and narrow bandwidth around the modulation frequency. Analytical models for laser generations of ultrasound were developed and validated with experimental results.

PART III - TECHNICAL INFORMATION (for program management use)

List references to publications resulting from this award and briefly describe primary data, samples, physical collections, inventions, software, etc. created or gathered in the course of the research and, if appropriate, how they are being made available to the research community.

See the attached.**

I certify to the best of my knowledge (1) the statements herein (excluding scientific hypotheses and scientific opinion) are true and complete, and (2) the text and graphics in this report as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or of individuals working under their supervision. I understand that willfully making a false statement or concealing a material fact in this report or any other communication submitted to NSF is a criminal offense (U.S. Code, Title 18, Section 1001).

	2-6-95
Principal Investigator/Project Director Signature	Date

**IMPORTANT:
MAILING INSTRUCTIONS**
Return this *entire* packet plus all attachments in the envelop attached to the back of this form. Please copy the information from Part I, Block I to the *Attention Line* on the envelope.

** Publications Resulting From This Research

1. Yang, J., N. DeRidder, C. Ume, and J. Jarzynski, "Noncontact Optical Fiber Phased Array Generation of Ultrasound for Nondestructive Evaluation of Materials and Processes," Ultrasonics, Vol. 31, No. 6, pp.387-394, November 1993.
2. Yang, J. and C. Ume, "Performance Evaluation of Fiber Array for NDE Application," in press, Research in Nondestructive Evaluation, Vol. 5, No. 3, pp. 175-190, May 1994.
3. Graham, G., J. Yang, C. Ume, "Laser Ultrasound Directivity in CS-3 Ceramic," in press Materials Evaluation, Vol. 52/No. 5, pp. 607-610, May 1994.
4. Pierce, S., C. Ume, and J. Jarzynski, "Signal Enhancement in Laser Generated Ultrasound for Nondestructive Testing," in press, Ultrasonics, January 1994.
5. Yang, J., G. Graham, C. Ume, J. Jarzynski, "Laser Phased Array Generated Ultrasound for Nondestructive Evaluation of Ceramic Materials," accepted, Journal of Nondestructive Evaluation, February 1994.
6. Yang, J., T. Sanderson, G. Graham, and C. Ume, "Laser Phased Array Measurement of Simulated Solidified Weld Penetration Depth," in press, ASME Journal of Engineering in Industry, April 1994.
7. Sanderson, T., Ume, C., and Jarzynski, J., "Second Sound Effects in Dynamic Thermoelasticity Reconsidered," submitted, ASME Journal of Applied Mechanics, January 1995.
8. Sanderson, T. and Ume, C., "Second Sound Effects in Laser Ultrasonics," in preparation. To be submitted to the Journal of Applied Physics.
9. Graham, G., and C. Ume, "Data Acquisition System for Laser Generated Ultrasound," 1994 ASME/ISCIE Japan-U.S.A. Symposium on Flexible Automation.
10. Umeagukwu, C., and J. Jarzynski, "Laser Phased Array Generation of Ultrasound with Application to On-Line Nondestructive Weld Quality Control," NSF Design and Manufacturing Systems Grantees Conference, University of Texas, Austin, Texas, January 1991.
11. Umeagukwu, C., N. DeRidder, J. Yang, and J. Jarzynski, "Study of the Directivity Patterns of Laser Optical Fiber Generated Ultrasound," Invited Paper, 121st Meeting of the JASA, Vol. 89, No. 4, Pt. 2, Baltimore, Maryland, April 1991.
12. Yang, J., G. Graham, M. Timmerman, C. Ume, and J. Jarzynski, "Study of the Directivity Patterns of Laser-Optical Fiber Generated Ultrasound in Ceramic Blocks," Invited Paper, SEM Spring Conference, Las Vegas, June 1992.
13. Yang, J., N. DeRidder, C. Ume, and J. Jarzynski, "Noncontact Optical Fiber Phased Array Generation of Ultrasound for Nondestructive Evaluation of Materials and Processes," NSF Design and Manufacturing Systems Grantees Conference, Georgia Tech, Atlanta, Georgia, January 1992.
14. J. Yang and C. Ume, "Optical Fiber Phased Array Generation of Ultrasound for Process Control," Joint US-Taiwan Symposium on Advanced Manufacturing Processes, Ga. Tech., Atlanta, Georgia, February 10-11, 1993.
15. C. Ume, "Laser/Optical Fiber Phased Array Generation of Ultrasound for On-Line Weld Quality Control," NSF Design and Manufacturing Systems Grantees Conference, UNC Charlotte, NC, January 6-8, 1993.
16. C. Ume, "Laser/Optical Fiber Phased Array Generation of Ultrasound for NDE of Materials and Processes," Ford Motors Material Systems Reliability, November 19, 1992.
17. Ume, C., and Graham, G., "Laser Phased Array Generation of Ultrasound for On-Line Weld Quality control: Predicted and Measured Array Gain," NSF Design and Manufacturing Grantees Conference, MIT, Boston, Massachusetts, January 5-7, 1994.
18. Yang, J., Sanderson, T., Graham, G., and Ume, C., "Ultrasonic Weld Penetration Depth Sensing with a Laser Phased Array." ASME International Mechanical Engineering Congress and Exposition. Chicago, IL. November 11-14, 1994.
19. Graham, G.M., "Intelligent Welding with Laser Ultrasonic Sensing," The First World Congress on Intelligent Manufacturing Processes and Systems, Mayaguez, Puerto Rico, February 13-17, 1995.
20. Sanderson, T.M., Graham, G.M, Ume, C.I. and Jarzynski, J., C.I. Ume, "Comparison of Laser Ultrasonic Source Models for Weld Quality Control." Submitted 4th International Conference on Trends in Welding Research. Gatlinburg, TN. June 5-9, 1995.
21. Graham, G.M., Sanderson, T.M., and Ume, C., "Laser Array Generated Ultrasound for Weld Quality Control." Submitted 4th International Conference on Trends in Welding Research. Gatlinburg, TN. June 5-9, 1995.

PART IV -- FINAL PROJECT REPORT -- SUMMARY DATA ON PROJECT PERSONNEL

(To be submitted to cognizant Program Officer upon completion of project)

The data requested below are important for the development of a statistical profile on the personnel supported by Federal grants. The information on this part is solicited in response to Public Law 99-383 and 42 USC 1885C. All information provided will be treated as confidential and will be safeguarded in accordance with the provisions of the Privacy Act of 1974. You should submit a single copy of this part with each final project report. However, submission of the requested information is not mandatory and is not a precondition of future award(s). Check the "Decline to Provide Information" box below if you do not wish to provide the information.

Please enter the numbers of individuals supported under this grant.
Do not enter information for individuals working less than 40 hours in any calendar year.

	Senior Staff		Post-Doctorals		Graduate Students		Under-Graduates		Other Participants ¹	
	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.	Male	Fem.
A. Total, U.S. Citizens	2				6	1	4			
B. Total, Permanent Residents										
U.S. Citizens or Permanent Residents ² :										
American Indian or Alaskan Native					1					
Asian										
Black, Not of Hispanic Origin										
Hispanic					1					
Pacific Islander										
White, Not of Hispanic Origin					4	1	4			
C. Total, Other Non-U.S. Citizens			1		3					
Specify Country										
1. Taiwan					1					
2. Pakistan					1					
3. China			1							
D. Total, All participants (A + B + C)	2		1		9	1	4			
Disabled ³										

Decline to Provide Information: Check box if you do not wish to provide this information (you are still required to return this page along with Parts I-III).

¹ Category includes, for example, college and precollege teachers, conference and workshop participants.
² Use the category that best describes the ethnic/racial status for all U.S. Citizens and Non-citizens with Permanent Residency. (If more than one category applies, use the one category that most closely reflects the person's recognition in the community.)
³ A person having a physical or mental impairment that substantially limits one or more major life activities; who has a record of such impairment; or who is regarded as having such impairment. (Disabled individuals also should be counted under the appropriate ethnic/racial group unless they are classified as "Other Non-U.S. Citizens.")

AMERICAN INDIAN OR ALASKAN NATIVE: A person having origins in any of the original peoples of North America and who maintains cultural identification through tribal affiliation or community recognition.

ASIAN: A person having origins in any of the original peoples of East Asia, Southeast Asia or the Indian subcontinent. This area includes, for example, China, India, Indonesia, Japan, Korea and Vietnam.

BLACK, NOT OF HISPANIC ORIGIN: A person having origins in any of the black racial groups of Africa.

HISPANIC: A person of Mexican, Puerto Rican, Cuban, Central or South American or other Spanish culture or origin, regardless of race.

PACIFIC ISLANDER: A person having origins in any of the original peoples of Hawaii; the U.S. Pacific territories of Guam, American Samoa, and the Northern Marianas; the U.S. Trust Territory of Palau; the islands of Micronesia and Melanesia; or the Philippines.

WHITE, NOT OF HISPANIC ORIGIN: A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.