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LASER IRRADIATION EXPERIMENTS

Avco-Everett Research Laboratory,
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13. ABSTRACT

The "Humdinger Jr." device was run in order to perform laser irradiation experiments in order to determine the steady-state thermal blooming of a train of focused laser pulses in a uniform crosswind as a function of beam overlap and strength of the index of refraction disturbance caused by a single pulse.

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7. Multipulse propagation						

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LASER IRRADIATION EXPERIMENTS

FINAL TECHNICAL REPORT

AVCO EVERETT RESEARCH LABORATORY, INC.
a Subsidiary of Avco Corporation
Everett, Massachusetts

Contract No. N00014-75-C-0108

January 1975

supported by

ADVANCED RESEARCH PROJECTS AGENCY
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DEPARTMENT OF THE NAVY
Arlington, Virginia 22217

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FOREWORD

ARPA Order No: 2439

Program Code No: 5E20

Name of Contractor: AERL, Inc.

Effective Date of Contract: November 18, 1974

Contract Expiration Date: December 24, 1974

Amount of Contract: \$24,800

Contract No: N00014-75-C-0108

Principal Investigator and Phone No.: R. M. Feinberg
(617) 389-3000, Ext. 572

Scientific Officer: L. R. Hetteche, Code 6310

Short Title of Work: Laser Irradiation Experiments

ABSTRACT

The "Humdinger Jr." device was run in order to perform laser irradiation experiments in order to determine the steady-state thermal blooming of a train of focused laser pulses in a uniform crosswind as a function of beam overlap and strength of the index of refraction disturbance caused by a single pulse.

PULSE BLOOMING EXPERIMENT (SUPPORT)

In support of the NRL Pulse Blooming Experiments, AERL operated the Humdinger, Jr. CO₂ laser device in a repetitively pulsed mode with or exceeding the following specifications:

- 1) Output aperture
 - a) 2 cm x 4 cm, approximately uniform irradiance
 - b) 4 cm x 4 cm, unstable resonator with ≥ 60 percent outcoupling
- 2) Pulse energy: ≥ 10 J in $5 \mu\text{sec} \pm 0.5$ sec
- 3) Pulse repetition rate: 10, 20, 40 pps
- 4) Maximum number of pulses/shot: 20
- 5) Average number of shots/day: 12
- 6) Maximum variation of pulse to pulse energy within a single shot: ± 10 percent
- 7) Variation in far field beam quality: $< \pm 15$ percent
- 8) Stability and reproducibility of laser pointing during a pulse train
 - Translation at laser aperture ± 2 mm (x, y)
 - Angular shift during pulse train $\pm 150 \mu$ rad.

AERL provided to Lincoln Laboratory personnel (the experimenter) the necessary electrical signals to operate experimental equipment and assisted in maintaining alignment between the laser and experimental apparatus provided by the experimenter.

As a result of this effort a paper is being prepared by the experimenter and a draft version of the summary is enclosed.

(DRAFT)

THERMAL BLOOMING OF A FOCUSED MULTIPLY PULSED LASER IN A UNIFORM CROSSWIND*

R. W. O'Neil, D. H. Dickey, A. P. Ferdinand,
L. C. Pettingill and H. R. Zwicker

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Lexington, Massachusetts 02173

SUMMARY

L. C. Bradley and J. Herrmann recently completed a steady state multiple pulse propagation computer code for a train of laser pulses.¹ Individual pulses were assumed not to bloom. A multiple pulse thermal blooming experiment was designed to check the limits and accuracy of this code. The laser source, the Avco Everett Research Laboratory 1.6 liter repetitively pulsed e-beam sustainer CO₂ laser was operated to produce trains of 5 μ sec pulses at repetition rates of 10 to 100 Hz. A special design off-axis unstable resonator was used to generate a nearly uniform irradiance rectangular aperture distribution 3.00 x 1.45 cm and 3.4 x 1.82 cm for outcoupling of 60 and 80 percent respectively.² Energy per pulse was varied from 1 to 10 J/pulse and beam overlaps conditions referenced to the beam width at the entrance to a 458 cm long absorption cell were 90, 80, 50 and 33 percent. An effective wind or beam translation velocity of 5-75 cm/sec was generated by a translating corner cube. Beam diagnostics were made on a unit magnification image of the focal spot using transmission grating sampling techniques.^{3,4} When the imaging mirror and corner cube move at exactly the same velocity, that is at half the laser beam velocity, the unit magnification is stationary on the detector. Beam diagnostics were made with pyroelectric energy arrays made up from 1 x 15 mm aperture pulse calorimeters. All measured quantities - input and output energy of each pulse, power, input and output energy distributions, beam velocity and laser pulse rate - were tape recorded and later digitalized for computer processing.

Detailed comparisons of experimental results with computer calculations are discussed. Excellent agreement is found between theory and experiment with no adjustable parameters.

* This work is supported by the Advanced Research Projects Agency of the Department of Defense.

¹ L. C. Bradley and J. Herrmann, M.I.T. Lincoln Laboratory, private communication.

² J. P. Reilly and A. Phillips, Avco Everett Research Laboratory, Inc. to be published.

³ R. W. O'Neil, H. Kleiman, L. C. Marquet, C. W. Kilcline, and D. Northam, Appl. Opt. 13, 714 (1974).

⁴ R. W. O'Neil, H. Kleiman, and J. Lowder, Appl. Phys. Lett. 24, 118, (1974)