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This research is part of project DEFENDER under the joint sponsorship of the Advanced Research Projects Agency, The Office of Naval Research and the Department of Defense.

INTERMEDIATE PULSEWIDTH LASER SYSTEM

Semiannual Technical Report No. 3

1 April 1967 - 30 September 1967

Contract No. N00014-66-C-0056
ARPA Order No. 306

Prepared by
Central Research Laboratory
American Optical Corporation
Southbridge, Massachusetts 01550

February 1971

J. W. Kantorski, Project Scientist
C. G. Young, General Manager

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) American Optical Corporation Central Research Laboratory Southbridge, Massachusetts 01550	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP N/A

3. REPORT TITLE

INTERMEDIATE PULSEWIDTH LASER SYSTEM
Semiannual Technical Report No. 3

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Semiannual Report 1 April 1967 - 30 September 1967

5. AUTHOR(S) (First name, middle initial, last name)

Joseph W. Kantorski - Project Scientist
C. Gilbert Young - General Manager, Laser Products

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1971	5	None

8a. CONTRACT OR GRANT NO. N00014-66-C-0056 b. PROJECT NO. ARPA ORDER NO. 306 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) TR-582-3 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Distribution of this report is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Part of project DEFENDER.	Physical Sciences Division Office of Naval Research Washington, D.C. 20360

13. ABSTRACT

This report is the third in the series of semiannual technical reports on Contract N00014-66-C-0056. It continues discussion on Phase Two of the contract which consists of the design construction and delivery of an intermediate pulsewidth laser. The generator section is described and preliminary system performance work was begun.

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Lasers						
Glass Lasers						
Laser Systems						
Generators						

Unclassified

Security Classification

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1. INTRODUCTION

The purpose of this program is to design and construct a glass laser system capable of providing high energy spike-free output in square pulses of 1,3, 10, 30 and 100 microsecond lengths. The output beamspread is to be two milliradians or less.

The contract work was split into two phases. Phase one was to study feasibility of such a system and was reported in Semiannual Technical Report No. 1. Phase two is to design, construct and deliver a system based on the findings in phase one.

The design of the system was discussed in Semiannual Technical Report No. 1. The principle of operation is to provide amplified spontaneous emission with a generator rod or rods. This emission is smooth in output, i.e., spike-free, and typically under high-gain conditions, has a duration of 250-300 microseconds full width at half height. At the peak generator output a Kerr cell is switched to provide a square pulse of amplified spontaneous emission. The Kerr cell output is then fed into a preamplifier to further increase signal intensity to drive the final amplifiers. The total output from the combined final amplifiers is to be 1000 joules. If pulse sharpening occurs, the ramp generator can be employed to offset this pulse deformation and provide a square wave output pulse.

The system beamspread is controlled by the overall length of the system and the use of afocal telescopes. The diameter of the final amplifier divided by the overall length of the system is the aspect ratio. This determines the minimum beam divergence that can be obtained without the use of afocal telescopes. Because the rods used in the generator section have a smaller diameter than the preamplifier, an afocal telescope will be used to expand the beam from the generator to match the preamplifier cross section. This reduction of beam divergence will also help to overcome a degradation of beamspread due to thermal distortion in the preamplifier. A second afocal telescope used between the preamplifier and the final amplifiers will help in further reduction of the beam divergence as well as provide an expanded beam diameter. This expanded beam will be large enough in diameter to allow the final amplifier to be clustered within the beam profile and thus make maximum use of the preamplifier output.

2. GENERATOR SECTION

During this time period, most of the effort was directed toward assembly and alignment of the mechanical and electro-optic fixtures. This generator section consists of three one centimeter x one meter laser rods, four Faraday rotators, two Kerr cells and all the associated electronics and optics to enable this section of the system to perform reliably.

Due to the length of the generator section (24 feet), special care was necessary to level all tables and all the laser and Faraday rotator elements to ensure that the axial photons are not vignetted through the system. In order to do this, a preliminary alignment was required in order to properly locate all bolt holes for clamping the elements in place. Once this was done, a final alignment was made.

2.1 GENERATOR RODS

The generator rods are one centimeter x one meter with Brewster ends and had a Nd_2O_3 concentration of four weight percent. Each rod is clad with a 2.5 mm thick non-TIR type cladding. This means the index of refraction of the cladding glass is higher than that of the core material. Furthermore the cladding glass is doped with Samarium oxide to absorb off-axis 1.06 μm photons. The absorbing cladding is necessary in order to achieve gains of 60 dB or more.

The gain versus pump input was measured for one of the generator rods. The laser rod was pumped with two 1 meter long PEK flashlamps with a 25 mm OD. The pump cavity consisted of a close-wrap silver plated brass reflector. The gain measurements were made with a 2 ms flashlamp pump pulse and a maximum gain of 61 dB was measured at 15.3 kilojoule input. Figure 1 shows the gain versus pump input.

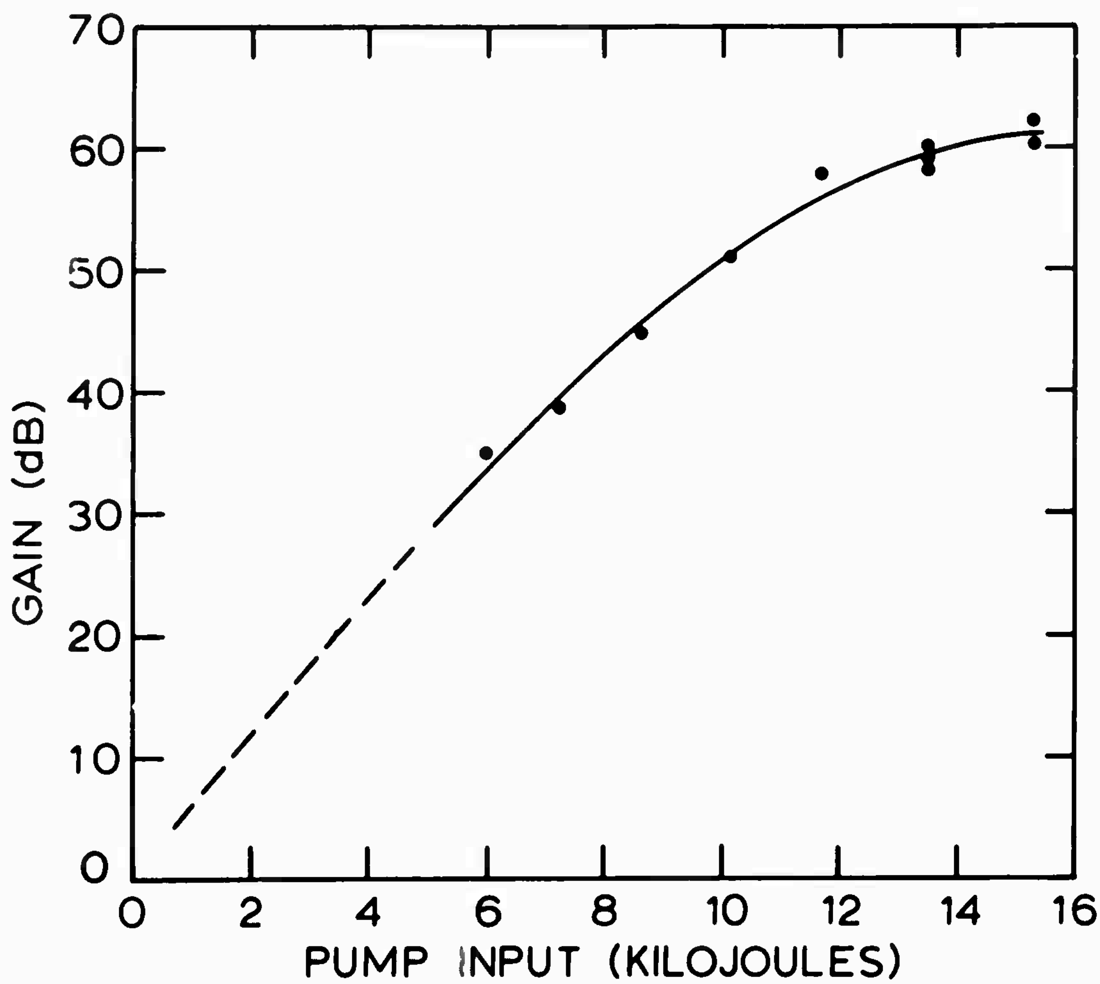

Figure 1. Gain in dB vs. pump input in kilojoules.

2.2 FARADAY ROTATORS

Four Faraday rotators are used in the generator section. The active element is a terbium glass which has a verdet constant of 0.08 minutes per Gauss per centimeter of length. The samples used in the device were 5.5 cm long and 1.5 cm in diameter and had ends parallel but tilted 5° with respect to the long axis. The samples were inserted in the one inch bore of the liquid nitrogen-cooled electromagnets. Also, due to frosting inside the magnet bore, the samples were surrounded by cylindrical heater elements with a thermistor temperature control to maintain a bore temperature of 70°F. Each Faraday rotator required a Glan-Thompson calcite polarizer at input and output end. The polarizers have a 12 mm square aperture and are oriented at 45° to one another.

A 45° rotation of the plane of polarization was obtained with approximately 6 kilogauss of axial magnetic field. The front-to-back extinction ratio was measured to be greater than 28 dB. The exact ratio was not known due to a noise limit in the detection system which limited the measurement to 28 dB. The ratio was obtained by measuring the signal of a chopped source at 1.06 µm in the low loss direction (forward direction) and ratioing to the signal in the high loss direction (backward direction).

3. SYSTEM PERFORMANCE

The completed generator section was fired to determine the beam divergence and also to obtain some information on energy versus total system gain. The beam divergence was measured at an output of 6.2 joules in a 90 microsecond pulse width with a total system gain of 112 dB gross gain. The full angle full energy beamspread was 3 mr.

The most difficult case is for the one microsecond pulse. With a gross gain of 135 dB an output of 7 joules was measured in one microsecond with 3 dB of pulse sharpening. The maximum gross gain available is 180 dB.

4. FUTURE WORK

During the next period the ramp generators will be utilized to eliminate pulse sharpening in the generator section and gain and pump uniformity measurements will be made on a 3 cm preamplifier. The problems of coupling the generator section to the preamplifier will also be investigated.