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**INTERMEDIATE PULSEWIDTH  
LASER SYSTEM**

Semiannual Technical Report No. 2

1 April 1966 - 30 September 1966

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

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

February 1971

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## ABSTRACT

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# INTERMEDIATE PULSEWIDTH LASER SYSTEM

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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 beamsread 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.<sup>1</sup> Phase two is to design, construct and deliver a system based on the findings in Phase one.

The design of the system was discussed previously<sup>1</sup>. 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-grain 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 beamsread 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 beams spread 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. USE OF SATURABLE ABSORBER TO DECOUPLE LASER AMPLIFIER RODS

The possible use of a saturable absorber to decouple laser amplifiers was mentioned in Semiannual Technical Report No. 1. A saturable absorber for use at  $1.06 \mu\text{m}$  is available from the Eastman Kodak Company and is called Eastman Kodak 9740 Q-switch dye solution. The property that makes this dye interesting for this use is that when used inside a laser resonator cavity, the dye which normally absorbs  $1.06 \mu\text{m}$  radiation suddenly bleaches and becomes transparent. The effect is very fast and thus can result in a Q-switch pulse being emitted by the laser. The properties of this dye external to a laser cavity or in a non-resonant laser system were not known.

To investigate the usefulness of the dye to decouple the amplifiers in this system, a dye cell was made up with a two millimeter thickness of the dye solution. The concentration of the dye was varied to produce optical densities ranging from a density of 0.4 to 1.7. The dye cell was placed at the output end of a generator rod used in a double pass configuration. This meant that a mirror was placed at end end of the generator rod to obtain double pass amplified spontaneous emission.

A photodetector was positioned to measure the spontaneous emission that passed through the dye cell. The dye cell could readily be removed to measure the total emission. Upon replacing the dye cell one could measure its absorption. The hope was that as amplified spontaneous emission built up, the dye would suddenly become transparent. The results were negative. The dye acted as a normal absorber over the density range tested.

The results indicated the possible need of a capping shutter at the output end of the third generator rod.

### 3. STACKED PLATE POLARIZERS

The laser system requires a Faraday rotator at the output end of the preamplifier in order to reduce the feedback from optics associated with the final amplifiers and also the target. A large aperture polarizer (3.5 cm) of calcite is very expensive and the durability of the material in the required time domains is unknown at this time. Therefore, a program was initiated to investigate the possibility of constructing a large aperture stacked plate polarizer. Initial experiments were done with a parallel plate stack of microscope slides at Brewster's angle and an extinction ratio of 18 dB was obtained at 1.06  $\mu\text{m}$ . This ratio was obtained by analyzing the transmitted beam with a calcite polarizer and measuring the signal in the high loss and low loss planes with a photomultiplier tube. The ratio of these two values is the extinction ratio.

In order to be useful in the large aperture Faraday rotator an extinction ratio of 25 - 30 dB is highly desirable. Due to the work of G. R. Bird and W. A. Schurcliff<sup>3</sup> an improvement on the design was obtained by using high index glass plates which were wedged and fanned. Twelve plates were made of Schott SF-5 glass with an index of refraction of 1.73 at 1.06  $\mu\text{m}$ . Each plate had a one degree wedge angle. The first plate of the stack was positioned at Brewster's angle and succeeding plates were placed at slightly large angles (called fanning) of 0.25 degrees. Furthermore, since the stack consisted of twelve plates and it was desirable to minimize astigmatism, pairs of plates were inserted with the bases of the wedges opposed. Also to minimize beam deviation the plates were grouped in two stacks of six plates each and the second stack was rotated 120° to keep the light beam approximately on axis. With this arrangement an extinction ratio of 24 dB was obtained. The transmission of the assembly of plates was 96.5% for the low loss plane of polarization.

Based upon the above experiments a final version was evolved for the laser device. The final design called for rectangular plates of high index glass (Schott SF-4) 37 mm wide by 92 mm long, with a 1° wedge angle and 10 mm thick at the base.



#### 4. WORK EFFORT

Aside from the work described above, the principal effort was on mechanical design and fabrication of parts. Also, by mutual agreement with ARPA, ONR, AO and AFSWC, further work on this contract was set aside for several months in order to work on a glass laser system with a DX priority.

## REFERENCES

1. Intermediate Pulsewidth Laser System, Semiannual Technical Report No. 1, Contract No. N00014-66-C-0056, June 1966.
2. G. R. Bird and W. A. Schurcliff. "Pile-of-plates Polarizers for the Infrared: Improvement in an Analysis and Design," J. Opt. Soc. Am., Vol. 49, pp. 235 - 237, March 1959.