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OPERATIONAL EXPERIENCE WITH THE MULTIPASS 16-DISC
LONG PATH LASER SYSTEM

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OPERATIONAL EXPERIENCE WITH THE MULTIPASS 16-DISC LONG PATH LASER SYSTEM

J. W. Shearer and J.E. Swain

A. INTRODUCTION

This is a brief summary of the operational and maintenance requirements for the Livermore "long path" laser system -- the first short pulse neodymium ($\lambda = 1.06 \mu\text{m}$) glass disc laser system. It is being issued at this time because the system is presently scheduled to be shut down at the end of the calendar year 1973. If the hardware is then put on the surplus equipment list, it would be useful for the future owner to have such information.

Overall descriptions of the disc laser technology are included in two published references.^{1,2} There is also a useful detailed internal report on the glass disc design.³

The present laser system, just prior to disassembly, is composed of the following elements:

1. A half-inch diameter, 9-inch long rod oscillator assembly, using KDP Pockels cells for Q-switching and pulse shaping. The glass rod head is an air-cooled LLL design, using a spiral xenon flashlamp driven at $\approx 11 \text{ KV}$ by a 20 KV power supply.
2. A chain of three half-inch rod amplifiers, using the same head design. There is a gap of about 10 meters between the second and third amplifiers, so that "hot spots" in the beam will be dispersed by diffraction effects.
3. A Faraday rotation isolator assembly.

4. Another chain of three half-inch rod amplifiers, similar to (2).
5. Another Faraday rotator assembly, like (3).
6. Four LLL-designed amplifiers using one inch diameter, 19 inch long glass rods, air cooling, and spiral flashlamps just as in the half-inch heads. These are two closely spaced pairs, separated by about a sixty-foot gap for beam cleanup, similar to (2) and (4).
7. Another Faraday rotator assembly, like (3) and (5).
8. A ≈ 50 meter gap (see (2), (4), and (6)), followed by two large amplifiers (two-inch diameter, 19 inch long glass rods, air cooling, spiral flash lamps in an LLL-designed head).
9. A large aperture Faraday rotator purchased from CGE-Hadron.
10. The 16-disc system, mounted in an 80-meter laboratory to permit multiple passes. Either 5 or 9 passes can be used, depending on the location of two prisms at injection from the rod chain. T.I.R. prisms are used to turn the beam after each pass.
11. The 50 micro-radian half-angle beam is then sent to the experimental area. With this unique quality beam, a one-meter focal length lens is sufficient to produce a 100 μm diameter spot.

It should be emphasized that these components, soon to be declared surplus, can be used in many other systems. As an extreme example, the 16-disc system could be used for an oscillator and amplifier chain system all by itself. One simply apertures 1/2-inch and 1-inch beams through different sections of the discs. Another interesting operational mode,

which was never tried with the 16-disc head, would be as a free-running oscillator over the 500 μ sec - 1 millisec flashlamp pumping time.

Also, a smaller focal length lens could be used to make a smaller focal spot, thus obtaining higher intensities.

B. 16-DISC HEAD AND COMPONENTS

The discs are 5 1/2 inch diameter, 1 inch thick, made of Owens-Illinois ED-2 3% neodymium-doped glass. They are tilted at Brewster's angle to prevent reflection losses; therefore, the laser beam is roughly elliptical in shape. The 19 mm I.D. 200 torr xenon flashlamps are 5 inches long between electrodes, and 5 of them are connected in series in each module. There are 20 modules; hence, 100 lamps. The lamp modules are separately energized by 20 capacitor banks, charged to 4.5 KV (rated at 5 KV), which corresponds to $\approx$ 280 kilojoules.

Since May, 1969 the disk head has been fired approximately 7600 times up to September 1, 1973. For the last 1100 shots, approximately 80% have been "laser firings", and the other 20% were systems checks -- debugging, electronic setup, calibrations, timing checks, etc. No damage to the glass discs has been seen. The disc faces must be cleaned every 3-4 weeks to maintain optimum gain. Attempts to analyze the disc face deposit were almost negative -- only a few hydrocarbon traces were found.

The flashlamps are more fragile; one lamp needs to be replaced about every 25-30 shots. The present procedure is to replace each individual lamp when it becomes inoperative. The earlier procedure, batch replacement after every 1,000 shots, was inconvenient because there were always a few bad lamps in each new batch.

Occasionally a flashlamp will explode; this has happened fewer than 10 times. In all cases the flat glass filter (placed between the lamps and the discs) intercepted the glass fragments and saved the discs. Only once did this flat glass even crack.

The capacitor bank has also been reliable. Some of the units have been fired as much as 15,000 times. (There were many 5-disc head experiments before the 16-disc unit was built.) 2 capacitors (out of 120) have short-circuited internally, but they did not explode. The weakest part of the bank is the lamp breakdown circuit, which is required for such a low voltage system. The "ionization transformers" of the ignition firing chassis arc over and short out, requiring replacement. The average replacement rate is approximately one transformer per month.

C. TURNING PRISMS

These large T.I.R. Schott BK-7 prisms have sustained some damage: one case involved an impurity inclusion, and several cases of surface damage were seen, but the prisms remain in use. These prisms have no dielectric coating; about 20% of the beam energy is lost each time it is turned around and sent back.

D. ROD CHAIN AND COMPONENTS

The present rod chain is arranged so that the highest intensities will occur in the 1-inch rods; these rods do indeed show bubble damage, and require replacement every 3 months. The other rods last much longer.

The present Faraday rotators use Owens-Illinois ED 2.3 laser glass (unpumped); the low Verdet constant is compensated by a high magnetic field and a long pathlength. No damage has been seen. The former units contained high Verdet constant Schott SFS6 glass; they had serious damage problems.

E. DIAGNOSTICS

Usually, there is not enough diagnostics. Ideally, one should monitor every laser head, electrically and optically, over several time periods: 100 μ sec - 1 msec for pumping and free-lasing; 1-10 μ sec for optical transit times (in the 200 foot multipath geometry), 1-10 nsec for gross pulse shaping, and 10-100 psec for detailed pulse structure. The present system is a compromise between this ideal and that which is possible in reality. Dials

and lights monitor the firing of the capacitor banks. The pulse amplitude ($1/2 \mu\text{sec}$ time scale) is monitored at 5 places in the rod chain. Free lasing ($200 \mu\text{sec}$ time scale) is monitored separately for the rod chain and the disc passes. The disc head is monitored at one point for all passes (either 5 or 9). The shape and energy of the nanosecond pulse is observed at the end of the rods and the end of the discs.

F. ALINEMENT

These procedures have been steadily improved; originally, it was a major problem. A commercial Nd-YAG laser is used, which has an output of 4-5 watts TEM_{00} ($1/2 \text{ cm}$ diam). This beam is inserted at various points.

1. Into the oscillator, to line up the oscillator and the rod chain.
2. Into the rod chain, to line up the rod chain and the discs (can usually reach 5 passes, 9 passes require the next insertion point).
3. Into the discs, to line up the discs and the plasma experiment.

There are infra-red sensitive T.V. cameras, monitor screens, and remote controls for the prisms to permit one person to align the disc system.

Alignment to compensate for long term drifts takes about 15 minutes. Alignment of the oscillator after some firemen bumped the prisms, took 2 days. If you start from clean tables, setup and alignment takes 1-2 months.

Of course, if the disc head is used in a simpler system, the alignment procedures will also be simpler.

G. CONCLUSION

Most of the components used in this system are documented with drawings, specifications, or both. Furthermore, there are many duplicate parts, such as another 16-disc head, 2 5-disc heads, and a number of turning prisms at other angles (45° - 65° - 70°).

The record energy outputs (usually a factor of 2 higher than routine operational energies) are:

≈ 400 joules at ≈ 200 nsec

≈ 200 joules at ≈ 5 nsec

≈ 100 joules at ≈ 1 nsec

Examples of laser-plasma research already performed with this instrument can be found in the references.^{2,4} Much of this hardware could still be used in future research projects.

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FIGURE CAPTIONS

Figure 1 Disassembly of the 2-inch rod head, showing the reflectors and the three spiral xenon flashlamps.

Figure 2 The 16-disc head mounted in the long path laboratory. Some of the 5-lamp pumping modules have been removed for this photograph. Also, the diagnostics setup is not yet assembled.

Figure 3 The capacitor bank installation for the 16-disc head.

Figure 4 One version of the early 5-disc head, shown partially disassembled. The long flashlamps are 25-inches between electrodes, and are approximately equivalent electrically to the 5-lamp modules on the 16-disc head.

Figure 1

Figure 2

Figure 3

BLE LOAD 750 LB

Figure 4

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