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POST FLIGHT OPERATION OF A HIGH PEAK POWER NEODYMIUM YAG LASER ABOARD THE G-449 PAYLOAD FLOWN ON SPACE SHUTTLE COLUMBIA MISSION 61-C

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ABSTRACT

The Nd Yag laser flown on board the G-449 payload completed its postflight testing successfully.

There was no indication that the laser had undergone any electronic or optical component failure. A postflight video was taken immediately following the return of the payload to the laboratory.

Early anticipation of vibration and temperature changes contributed to the successful operation of the laser.

Photographic material resulting from post flight videotape will be presented in the paper.

NASA safety reviews and recommendations supplied the insights which helped contribute to the successful operation of the Nd Yag laser. The safety review data is part of the technical presentation of this paper and gives some insight into why the system survived the severe environment of temperature and vibration during the flight of Space Shuttle 61-C.

INTRODUCTION

Following the flight of Space Shuttle Columbia on Mission 61-C between January 12, 1986 and January 18, 1986, Get Away Special (GAS) payload G-449 was returned to the Laser Laboratory. The payload was removed from the NASA shipping canister and the payload meticulously disassembled.

POST FLIGHT TEST FIRING

The large compartment cover which housed the laser was made of stainless steel. The compartment cover Figure 1 was removed and the laser which was part of the experiment package (Figure 2) was fired from its on-board power packet which consisted of two Eveready metal jacketed alkaline 6-volt batteries #520 wired in series.

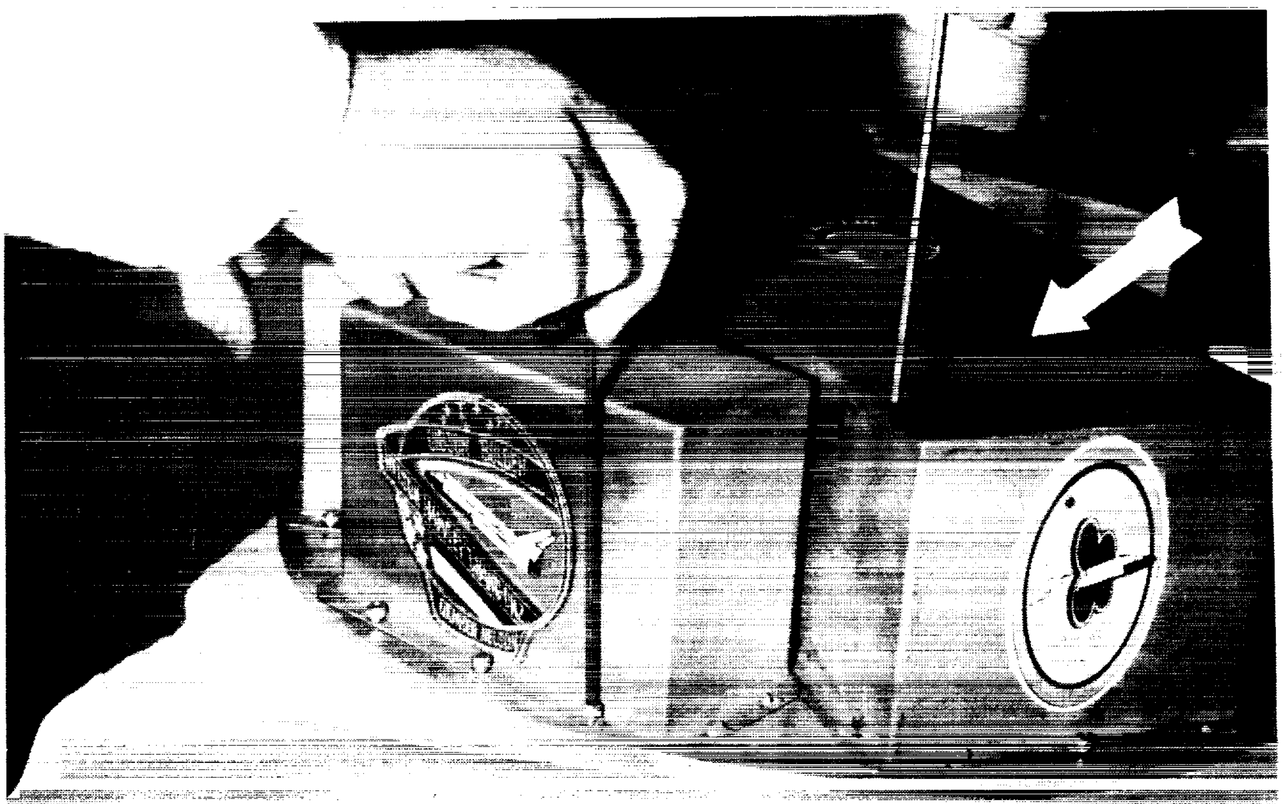

FIGURE 1 - LASER COMPARTMENT COVER (*ARROW*)

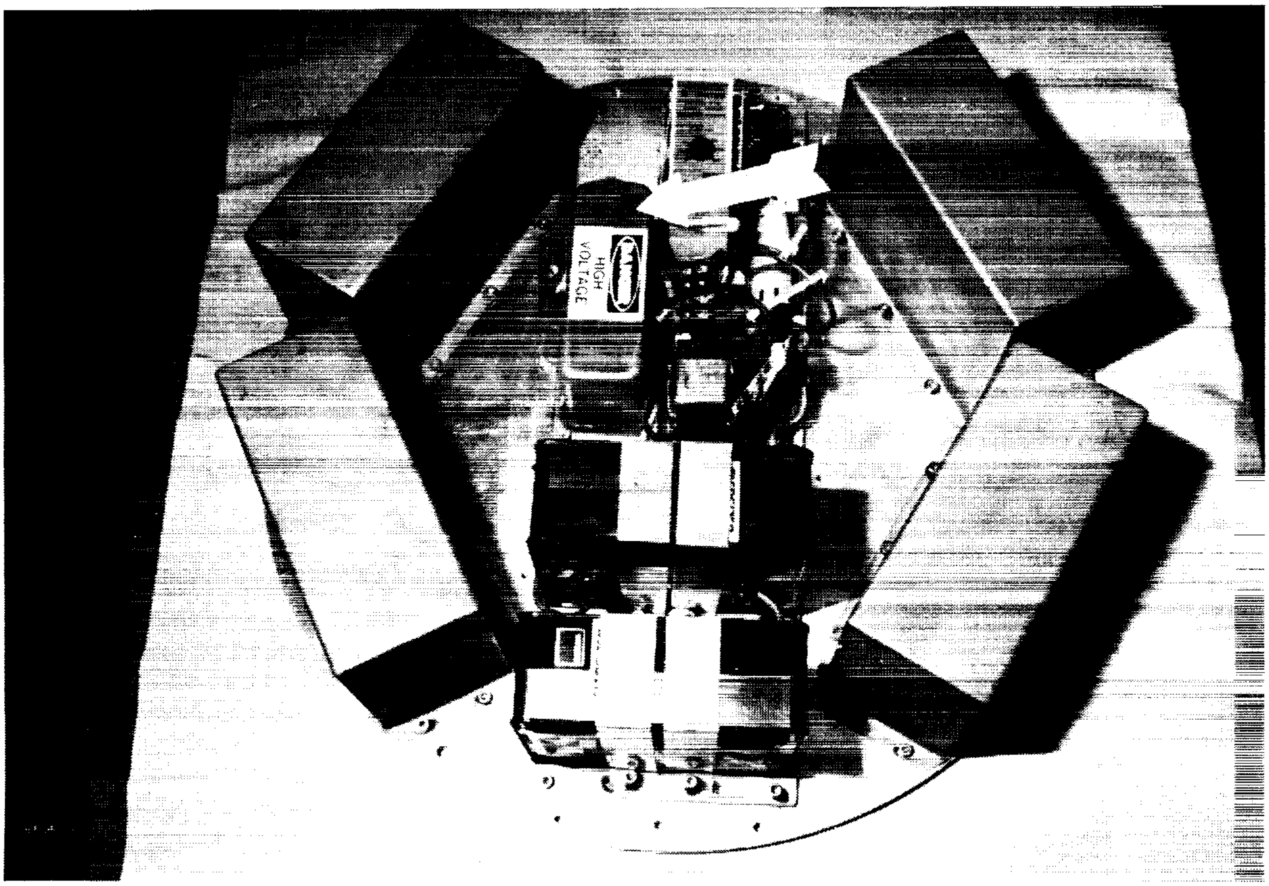

FIGURE 2 - Nd YAG LASER (*ARROW*)

The timer which operated the laser in space was disengaged for the post-flight test and the firing operation was initiated by manually closing the firing circuit.

The deposition of the laser energy upon a target of photographic paper demonstrated the vaporization of the exposed emulsion.

The exposed photographic paper target confirmed excellent beam characteristics as regards beam structure. The test was done upon the exposed photographic paper without using focusing optics. The three initial target tests are shown in Figure 3.

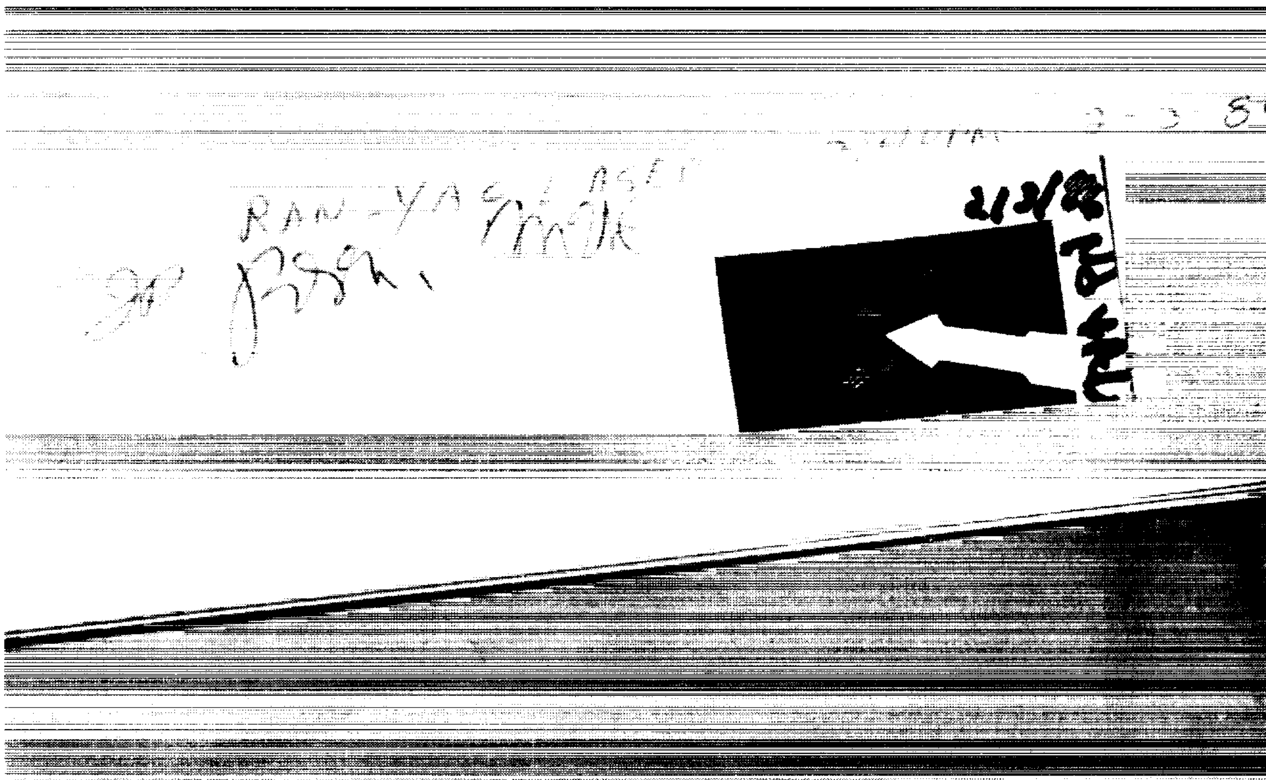

FIGURE 3 - THREE TARGET TESTS (*ARROW*)

Although further additional tests for diagnostics were performed, the visible ablation of the exposed photographic emulsion confirmed the lasers operational status immediately following the removal of the cover from the laser portion of the module.

VIDEO RECORD

Videotaping of the post-flight test supplied us with excellent demonstrable action pictures. Along with the videotaping, synchronized photos for the event supplied the permanently recorded proof of operation.

NASA SAFETY PACKAGE

During the Preparation of the NASA GAS safety package, evaluation of the various parameters related to the laser experiment came under scrutiny. The Laser/Optical Device Use Request/Authorization was the laser document used as part of the safety package. Attention was directed to the hazards of the laser both optically and electrically. It was decided to confine the entire laser experiment to an enclosed compartment.

The telecons with NASA provided the parameters to ensure safe flight operation of the laser.

SURVIVABILITY

Early on, the harsh environment of space drew attention to finding a laser system which had been earth proven as regards to temperature, shock, and vibration parameters. While the search focused upon operational survival, there was also a need for miniaturization. The search ended when the Laser Photonics' Yag laser was found to be available for the experiment.

Laser Module, Laser Transmitter Design, fixed mirror mounting, pump cavity, and laser transmitter/interface is data supplied by Laser Photonics and is published by their permission. The sections attest to reasons for the survivability of the MYL-100 Neodymium Yag Q-switch laser.

LASER MODULE

The laser module consists of an integrally mounted pump chamber, laser resonator, and beam expanding/collimating telescope. The single mechanical structure provides integrity and stability for the critical optical elements.

The laser resonator used on Laser Photonics' MYL-100 system is a ruggedized design developed specifically for systems encountering adverse environments of temperature, shock and vibration. The design employs the state-of-the-art in laser technology in the design of the alignment insensitive folded resonator, the high efficiency pump enclosure, and the miniature integral structure. This design concept has evolved over years of development of rugged military laser products and has proven itself in many fielded systems.

Extensive environmental and military qualification test programs have demonstrated the reliability of the laser resonator design. An extensive effort has been applied to miniaturizing the laser resonator while preserving these proven qualities.

In addition to the outstanding qualities of performance, the miniature laser resonator is designed for produceability and consistent performance.

The following data from Laser Photonics addresses laser transmitter design, fixed mirror mounting, pump cavity and laser transmitter/system interface data.

LASER TRANSMITTER DESIGN

The laser resonator design employed in the MYL-100 Laser is a version of Laser Photonics' high reliability, compact, folded resonator design. The optical resonator consists of two end mirrors (both located on the same optical substrate), the laser rod, folding corner prism, alignment wedges, polarizer, expansion/compensation lens, Q-switch, and phase retardation plate. Optical energy from the laser rod circulates between the two end mirrors with the output portion being transmitted through the partially reflecting mirror. The corner prism has the unique property of folding the optical path 180 degrees without deviation regardless of the orientation of the prism. Thus, minute movements of the corner prism will not result in misalignment of the optical resonator. The inherent stability of the corner prism folded resonator is the primary factor in the reliability and alignment stability of the Laser Photonics' design. Alignment is achieved with weak prisms (Risley prisms) located within the resonator. The prisms are rotated to the optimum position and locked into place. The beam then passes through a multilayer dielectric polarizer. The next element is the intracavity expansion/compensation lens. The lens both expands the beam on the Q-switch and adds the proper optical power to the resonator to maximize the mode volume in the laser rod. A passive dye Q-switch is the next optical component. The final element is a quarter wave retardation phase plate. The phase plate provides the proper phase shift in the beam polarization to inhibit lasing until the Q-switch is activated. The resonator elements function together to form the unique optical resonator for Laser Photonics' miniature Q-switched laser.

FIXED MIRROR MOUNTING

A fixed mirror mounting technique is employed in the folded resonator design to assure alignment stability over severe environments of temperature, shock and vibration. Laser Photonics' lasers are factory aligned modules which need no further adjustment when installed in the field. Alignment stability is assured by having both end mirrors deposited on the same glass substrate. Thus, if the mirror mount were to move slightly, both mirrors would move together in the same direction and would not become misaligned. The coatings are split to provide for the different requirements of output coupler and maximum reflector. Alignment of the resonator is achieved with a pair of rotating prisms. The prisms each deviate the beam over a certain range. When working as a pair, these prisms can vary the amount and direction of beam deviation. Thus, the prisms can compensate for beam deviations caused by other optical elements within the resonator. Once positioned, the prisms are locked down and cannot become misaligned.

PUMP CAVITY

The pump cavity used in the laser resonator consists of a high efficiency close-coupled reflective design. The laser rod and flashlamp are linear cylinders placed near the focii of an elliptical cylinder reflective cavity. The light from the flashlamp is thus imaged onto the laser rod. The lamp is series triggered to eliminate arcing problems associated with parallel triggered systems.

LASER TRANSMITTER/SYSTEM INTERFACE

The laser resonator is built in an optical bed case which is precisely machined. The dimensions of the case are approximately two inches (2") wide by one inch (1") high by four inches (4") long. High voltage feedthroughs are provided for all inter-connecting wiring. The output beam exits the housing through an anti-reflection coated window. Reference location holes can be machined into the outer housing for beam reference. Thus, laser modules are able to be made interchangeable without complete system realignment. Thus, the laser head is completely self-contained in a package which provides a great deal of flexibility in system design.

CONCLUSION

The successful post-flight operation of a High Peak Power Neodymium Yag laser which was flown in canister GAS-449 aboard Space Shuttle Columbia on Mission 61-C demonstrates the survivability of a high peak power laser in the harsh environment of space. The present design limit for the Shuttle is 11 G's in 3 axis simultaneously applied for worst case orientation. The outside temperature ranges are -160° C. to +100° C.

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