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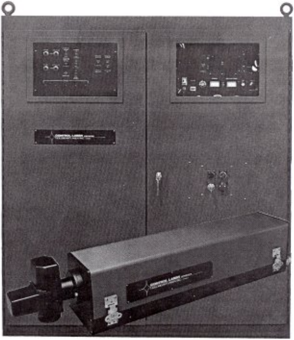
Operation and Maintenance Manual for the InstaMark Laser Engraving System



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1.1 SYSTEM DESCRIPTION

The InstaMark laser engraving system is a special purpose industrial tool designed to engrave alphanumeric characters and special symbols into a variety of materials using a controlled high-energy laser beam. The system is computer controlled, making it easily adaptable to full automatic control. It writes in line, ring, and a combination of line and ring modes.

Table 1.1 shows specifications, and Figure 1.1 shows the block diagram for the system. Figure 1.2 shows various configurations for the basic InstaMark system which consists of a laser/scanner head assembly and a separate cabinet housing the power station components.

1.2 LASING ACTION

The basic components required for lasing are the laser head containing the Nd:YAG rod and krypton arc lamp, a rear high-reflective (HR) mirror, and a front partially transmissive mirror. While not required for lasing, a safety shutter is included on all lasers manufactured by Control Laser Corporation. This shutter is used to block the laser beam when lasing is not required.

Additional optical components are included on the InstaMark system to form and control the laser beam so that it can be used for engraving. They are: an acousto-optical Q-switch, a high-speed shutter and aperture, a power monitor, and a scanner head.

The Nd:YAG rod and krypton arc lamp are mounted inside the laser head in an elliptical, highly reflective, gold-plated pumping cavity. When ignited by the lamp power supply, the krypton arc lamp emits broadband spectral energy (white light), which is focused onto the rod by the ellipse of the pumping cavity. This energy stimulates the neodymium atoms in the rod causing them to release photons in several spectral lines, the strongest at a wavelength of 1.06 microns. The photons travel back and forth between the front and rear mirrors, through the rod, creating on each pass additional photons. These photons form a coherent beam of laser radiation which passes through the partially transmissive front mirror to impact the workpiece.

The InstaMark system will operate in either the continuous-wave (CW), or the Q-switched mode. The Q-switch, which operates on the same principle as a shutter, prevents laser emission until it is "opened", thereby increasing pulse power by shortening pulse duration while keeping the energy per pulse constant. When the Q-switch opens, a short output pulse, normally 150 nanoseconds in duration, is released. This pulse has more output energy per unit time than that produced by CW operation.

Table 1.1 InstaMark System Specifications

Engraving Field	78mm Diameter
Working Clearance	73.03mm (2.875") from bottom of lens protector to workpiece
Writing Speed	
Line Mode	1 to 200mm/second
Ring Mode	1 to 100mm/second
Line Thickness	.1 to 2mm
Positioning Resolution	.02mm/step
Repeatability	±41 micrometers over full lens field
Character size	.4 to 80mm
Characters	Letters, numerals, and symbols (OCR-A alphanumerics optional)
Graphics Capability	Logotypes, schematics, and graphic illustrations can be provided with special programs
Wavelength	1.06 microns
Power Output	50W
Optical Models	Continuous-wave & Q-switched (1-10kHz)
Optical Stability	5%
Dimensions (Standard Unit)	
Laser/Scanner Head	51½"L x 9"W x 10"H
Power Station Cabinet	60"W x 38½"D x 75"H
*Power Requirements	220VAC, 60Hz, 3Ø, 50A, w/ground
Cooling Requirements	
Primary (Deionized)	3-5 gpm @ 35 psi, 70-80°F
Secondary (City)	3-4 gpm @ 45 psi, less than 70°F

*Some systems are wired for single-phase operation - refer to the electrical data tag on the system for verification of input power requirements.

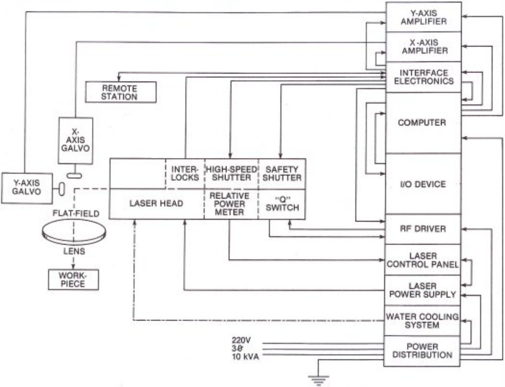

Figure 1.1 Block Diagram of InstaMark Laser Engraving System

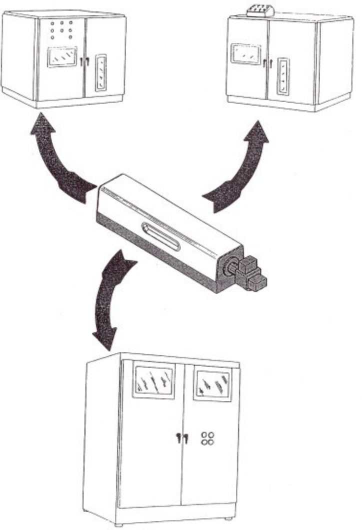

Figure 1.2 InstaMark Laser Engraving Systems

1.3 LASER/SCANNER HEAD ASSEMBLY (Fig 1.3)

The laser head and related optical components are mounted in a NEMA-12 enclosure designed to protect them from contaminants such as oil mist, fumes, dust, etc. The covered enclosure is constructed of heavy aluminum U-channel, aluminum end bulkheads, and an aluminum cover held in place with snap latches. The cover is interlocked so that the safety shutter closes when the cover is removed. The HOOD ON, HOOD OFF, and EXTERNAL SHUTTER indicators on the interface control panel give visual indications of shutter and cover status. Components of the laser/scanner head assembly are described in the following sub-paragraphs.

1.3.1 LASER HEAD

The laser head is mounted on a carriage which allows it to be easily positioned on the optical rail. The carriage is locked to the rail with a locking plate, and either a thumb or Allen screw.

The head block is machined from black methyl methacrylate plastic. It contains water channels for cooling the Nd:YAG rod, krypton arc lamp, and the pumping cavity. It also contains mounting connections for the rod, lamp, and high-voltage lamp cables. O-rings are used to prevent water leaks.

The pumping cavity is precision machined from brass, and electroplated with gold. It contains flow tubes to direct deionized cooling water in series across the rod and lamp (the rod and lamp are mounted through the flow tubes and secured to the head block). The elliptical design of the cavity causes the light from the krypton arc lamp to be focused onto the rod which then releases photons to begin the lasing process.

1.3.2 MIRROR MOUNTS

The front and rear mirrors are mounted in kinematic suspension mounts that provide direct adjustment of the mirror angle, with independent X-Y angular positioning. Adjustments are made by turning the two Allen screws located on the rear of the housing. The mirror is held in place by a threaded cylindrical holder which permits quick and easy change of mirrors.

1.3.3 SAFETY (EXTERNAL) SHUTTER

The safety shutter is attached to the front mirror mount, and is designed to block the laser beam when a system interlock is opened. The shutter is wired in series with the interlock switch on the enclosure cover so that the shutter closes when the cover is removed. On custom systems, additional interlocks are installed on all doors or panels that would allow access to laser radiation (except those that are screwed down).

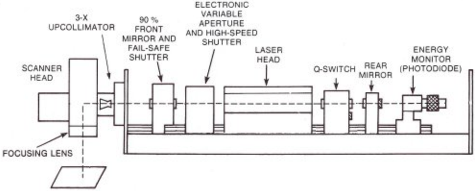

Figure 1.3 Laser/Scanner Head Assembly

1.3.4 HIGH-SPEED (INTERNAL) SHUTTER

The high-speed shutter is used to interrupt the laser beam during periods when writing is not desired, for example, between characters. It is mounted on the optical rail between the laser head and the combination front mirror/safety shutter. The high-speed shutter assembly also contains an .080 aperture that can be electronically inserted into the laser beam path via the APERTURE SELECT switch on the interface control panel.

1.3.5 POWER MONITOR

The power monitor is a silicon-diode module mounted on the optical rail behind the rear mirror. It measures the small amount of laser output transmitted through the rear mirror, and gives a relative reading of average laser power on the RELATIVE POWER meter on the CL-15 control panel.

1.3.6 ACOUSTO-OPTICAL Q-SWITCH

The laser is pulsed by an acousto-optical Q-switch which is inserted in the optical cavity between the laser head and the rear mirror. The Q-switch is driven by the CL-4 RF Driver, and opens and closes at a preselectable repetition frequency, thereby allowing the Nd:YAG rod to store energy between pulses. These pulses, because of their shortened duration, have more output energy per unit time than that produced by continuous-wave (CW) operation.

The Q-switch has an internal water-cooled jacket system to dissipate generated heat. It is cooled with deionized water, and has a thermal interlock which will turn off the lamp power supply if the temperature in the Q-switch rises beyond allowable limits.

A piezoelectric transducer in the Q-switch creates longitudinal (acoustic) vibrations which, in turn, produce planar acoustic wavefronts in a fused quartz transmission block. The laser beam passing through this block is slightly deviated by the action of the acoustic wavefronts, which forms a diffraction grating within the transmission medium. This deflection generally is only slightly more than 1^{o}, but results in a double path loss of more than 32%. This decrease is sufficient to reduce the cavity gain to the point where the system no longer lases. This results in a population inversion that can climb to the density required for the production of "giant" pulses in the Q-switched mode. Attainment of the exact Bragg angle, the angle at which the transmission block is oriented with respect to the laser beam, is achieved with the Bragg angle adjustment (see Section V for adjustment procedure).

1.3.7 SCANNER HEAD (Fig 1.4)

The scanner head is mounted in a separate housing attached to the end of the laser/scanner head enclosure. Fig 1.4 is a diagram of the internal components, and shows the path that the laser beam takes through the scanner head to engrave the workpiece. Components are:

- A 3X upcollimator that makes the diverging laser rays parallel and triples the beam diameter.
- Two dielectric mirrors that reflect the collimated beam in the X-Y axes relative to the workpiece.
- Two galvonometers, operated by computer signals, that move the dielectric mirrors.
- A fixed flat-field lens that focuses the beam from the dielectric mirrors onto the workpiece. Clearance between the lens protector and the workpiece is 73.03 mm (2.875"). The lens has a focal length of 100 mm, and a depth of focus of 1 mm. The InstaMark system has produced good results operating beyond these limits where slightly irregular surfaces were worked.

1.4 POWER STATION (Fig 1.2)

The electrical, electronic, and cooling components of the laser system are mounted in a separate cabinet or framework. Figure 1.2 shows the various styles of cabinets for the InstaMark power station. Power station components are described in the following sub-paragraphs.

1.4.1 HIGH-VOLTAGE LAMP POWER SUPPLY (Fig 1.5)

The regulated DC power supply provides operating power for the krypton arc lamp in the laser head at approximately 100VDC, 10-20A. It also supplies a firing (ignition) pulse in the form of a negative-going spike of 26,000VDC of about 1 microsecond duration followed by a booster discharge period of about 1 millisecond. At any setting, the power supply output current is maintained at a constant value within close tolerances by a feedback regulating circuit that operates the gates of two SCRs which comprise part of the main bridge rectifier. Output currents from 10-20A are held constant within $\pm 1\%$ for any variation of lamp impedance. Total correction time is not more than 250 milliseconds.

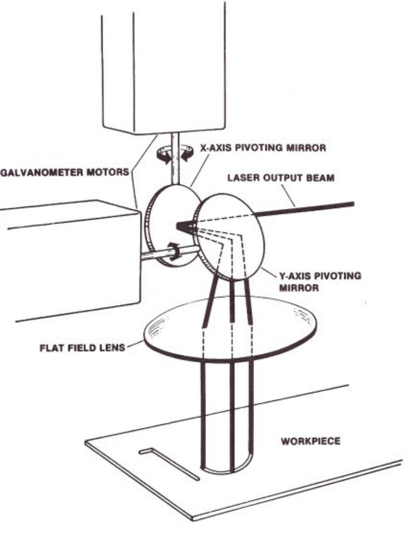

Figure 1.4 Scanner Components & Beam Path