

## Brief Description of Operating Principles of REO Stabilized Helium Neon Laser

Quentin Turchette, R&D Engineer, REO (9/23/13)

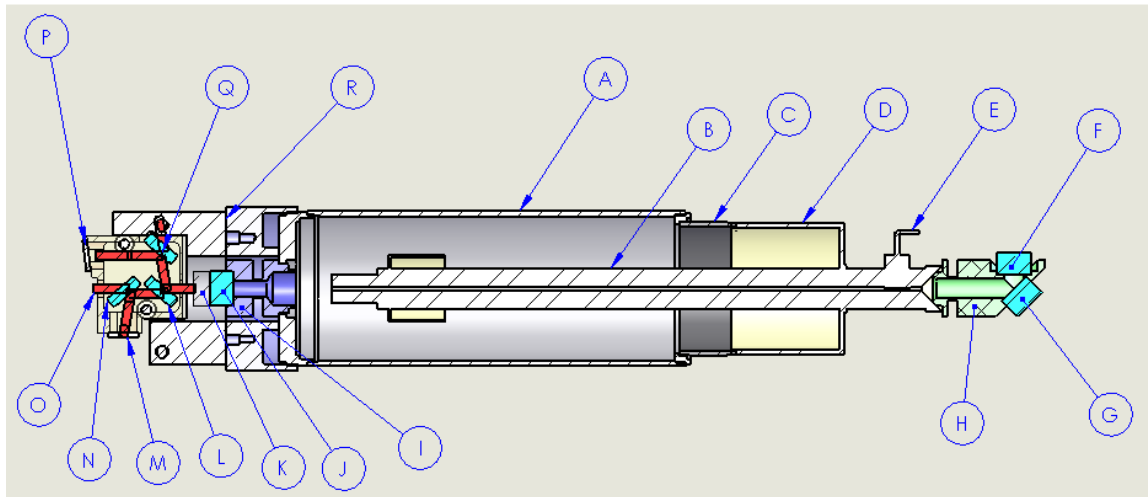
The REO Stabilized HeNe (S-HeNe) employs familiar techniques for stabilization, but also incorporates several new features developed for consistency with REO's preferred laser manufacturing processes. This description provides an overview of the stabilization technique with emphasis on those areas where REO's product differs from other offerings. A schematic figure describing the laser system follows the text.

The REO S-HeNe utilizes the two-longitudinal mode polarization locking method. In this method, the laser's gain, loss and cavity length are designed so that only two longitudinal modes will oscillate. The modes have orthogonal polarization states and are easily separated in the output light of the laser. (The modes are separated and analyzed at the output coupler end of the REO laser.) Each of the two spatially-separated, orthogonal polarization modes are detected at independent photodiodes and a function of the two photo-signals is held constant by controlling the cavity length. The function used depends on the mode of operation (frequency or intensity stabilized). The cavity length is controlled by active heating of the tube (through spread-spectrum pulse-width-modulation of the current to a foil heater blanket wrapped around the tube body) and by passive cooling. An absolute temperature sensor affixed to the tube ensures a consistent operating temperature. REO's laser tube envelopes are metal (most other manufacturers use glass) so the time-constants and gains required for the control loop may be different than those required by glass tubes. The servo system is implemented as an entirely digital PI control loop, which makes the tuning of the servo parameters a matter of parameter selection in software and allows straightforward implementation of the low-frequency filtering necessary for a servo of this type. The control system is robust and versatile.

The two-mode locking method requires that the polarization states of the laser be fixed and well-defined with respect to the mechanical parts that make up the laser tube---the polarization analyzer is fixed with respect to the mechanical parts of the laser tube, so the polarization must be fixed in this frame as well. This has traditionally been a difficult criterion to satisfy for REO lasers. REO lasers use extremely low loss, isotropic Ion-Beam-Sputtered (IBS) cavity optics. Such optics have extremely low birefringence and therefore provide no preferred state of orientation of the polarization of the laser modes. Rather than modify our coating process, REO has recently developed a robust technique that avoids changing polarization orientation by introducing an extra cavity mirror at a non-normal angle of incidence to the cavity laser mode. This mirror is given a coating-designed, fixed, known, and controllable retardance as part of its high-reflectance IBS coating. This means that the polarization orientations are defined with respect to the plane of incidence of the non-normal-incidence mirror, which is rigidly fixed to the mechanical parts of the laser tube. An applied fixed magnetic field assists in allowing a given longitudinal mode to maintain a mode-hop free polarization state throughout the HeNe gain curve as the cavity length is tuned. US Patent 7,787,505 covers this unique method.

REO performs in-house testing of frequency stability by direct comparison with a Winters Electro-Optics Inc. Iodine-stabilized HeNe. Measurements confirm that REO's S-HeNe meets or exceeds typical frequency-stability specifications found in the industry. Intensity stability is confirmed on a Newport 2936 power meter. Both measurements are fully automated.

## Schematic cross-section of REO stabilized HeNe head



- A. Metal laser envelope
- B. Capillary/bore
- C. Glass-to-metal seal
- D. Glass bell
- E. Anode pin
- F. Cavity HR
- G. Cavity HR with polarization reference coating
- H. Dual HR mount
- I. OC mount
- J. OC optic
- K. Compensator lens
- L. Polarizer (transmits p-pol, reflects s-pol)
- M. Photodiode for detection of p-pol
- N. Partial reflector for p-pol
- O. Output beam (p-pol)
- P. Photodiode for detection of s-pol
- Q. PR for s-pol
- R. Mechanical mounting assembly for analyzer