TYPICAL GAS LASER OPTICAL LAYOUT

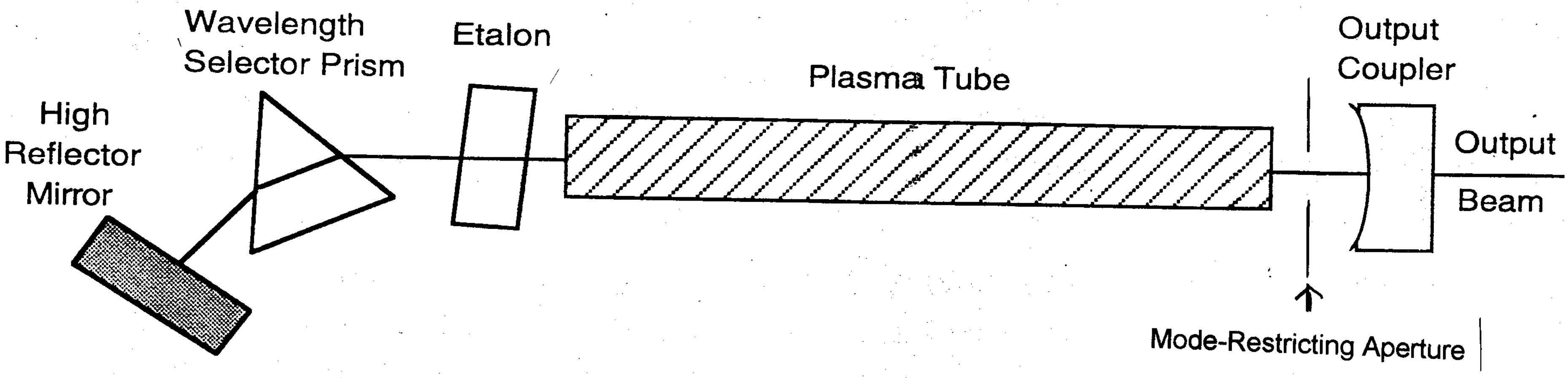


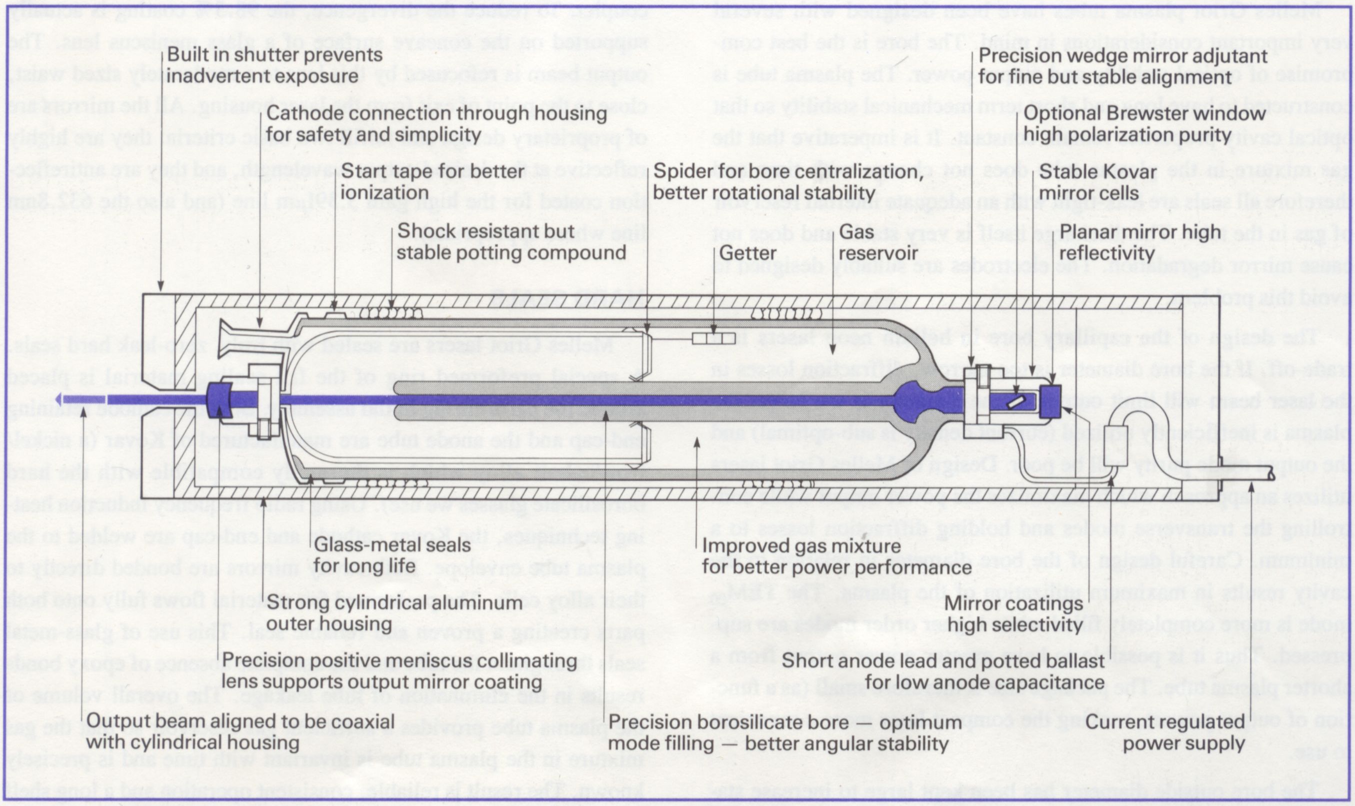
Figure 10-4. Single-Frequency Configuration

HELIUM NEON LABORATORY LASERS

Melles Griot helium neon lasers are reliable, trouble-free laboratory tools which provide the user with stable, directional, monochromatic beams of coherent light. Three different output wavelengths are available; green (543.5nm), red (632.8nm), and infrared (1.523 μm). Both linearly polarized and randomly polarized versions are available at each wavelength. The lasers are available as bare, unhoused plasma tubes as well as in two alternate housings; a cylindrical housing with separate power supply, and a self-contained housing with integral power supply. Although the latter is often preferred for simplicity, the cylindrical housing can be rigidly mounted in a smaller space, often an important consideration.

The red (632.8nm) version of the helium neon laser is the most widely used option, but there are distinct advantages and novel applications of both the GreNe and IReNe lasers. For example, the GreNe should become a popular choice in medicine where its high visibility against a red blood/tissue background is a distinct advantage. The IReNe on the other hand offers a stable, more collimated alternative to laser diodes for fiber optic systems development.

All of these lasers have been designed, developed, and are manufactured by Melles Griot in Carlsbad, California. The majority of lasers produced by Melles Griot are destined for OEM customers. Melles Griot is the largest supplier of helium neon lasers to the OEM market, making lasers to satisfy the most stringent requirements of these customers, particularly stability and reliability. You can therefore be assured that these lasers represent the best available quality, reliability and longevity. Several unique design features are incorporated to ensure a superior product in the belief that consideration of every detail is essential in producing the best possible laser.



CROSS-SECTIONAL VIEW of a Melles Griot helium neon laser head showing the details of the plasma tube.

WARRANTY

Melles Griot helium neon lasers have an expected life in excess of 20,000 hours. The lasers and their power supplies are guaranteed to operate to specification for 12 months after the date of purchase. If for any reason, other than breakage or abuse, they should fail to perform to this level, we will replace them free of charge. This is, we believe, the best warranty in the business. It reflects our confidence in these lasers and our belief that they will have a long and trouble-free life. If you should ever have reason to use this warranty provision, we request that you contact one of our offices for shipping instructions prior to returning the laser.

A complete copy of our warranty is included with every laser that we ship.

PLASMA TUBE DESIGN

Melles Griot plasma tubes have been designed with several very important considerations in mind. The bore is the best compromise of optical stability and output power. The plasma tube is constructed to have long and short term mechanical stability so that optical cavity properties remain constant. It is imperative that the gas mixture in the plasma tube does not change with time and therefore all seals are leak-tight with an adequate internal reservoir of gas in the tube. The discharge itself is very stable and does not cause mirror degradation. The electrodes are suitably designed to avoid this problem.

The design of the capillary bore in helium neon lasers is a trade-off. If the bore diameter is too narrow, diffraction losses in the laser beam will limit output. If the diameter is too large, the plasma is inefficiently utilized (current density is sub-optimal) and the output mode purity will be poor. Design of Melles Griot lasers utilizes an approach which maximizes the power output while controlling the transverse modes and holding diffraction losses to a minimum. Careful design of the bore diameter in relation to the cavity results in maximum utilization of the plasma. The TEM_{00} mode is more completely filled while higher order modes are suppressed. Thus it is possible to have greater power output from a shorter plasma tube. The package size is therefore small (as a function of output power), making the compact laser more convenient to use.

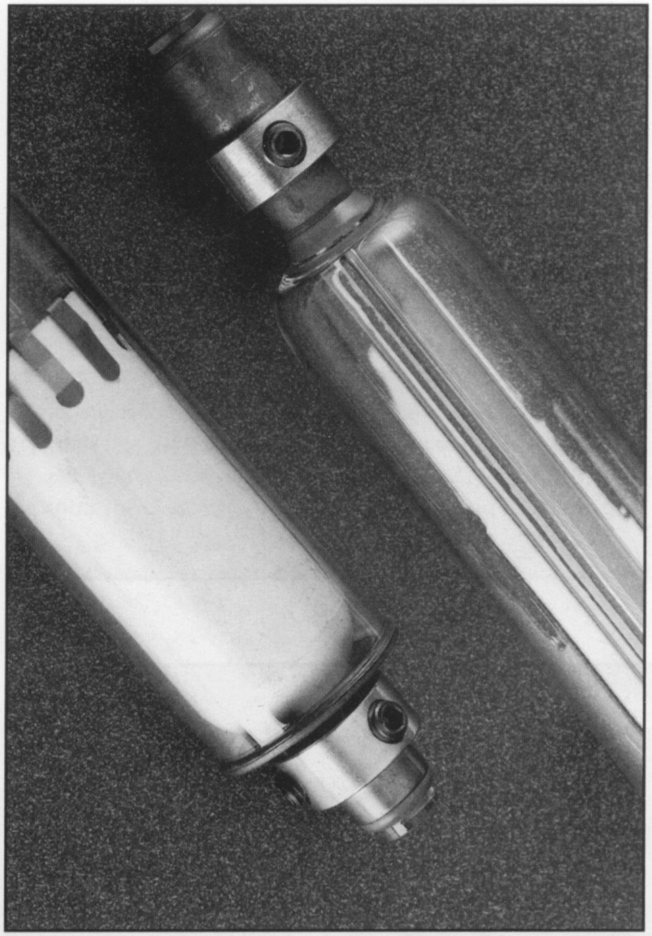
The bore outside diameter has been kept large to increase stability. Hard borosilicate glass is exceptionally rigid and results in a more stable cavity design. The precision capillary bore is firmly attached to the plasma tube at the anode end, and a unique metallic spring spider supports the cantilevered capillary tube at the cathode end. This results in a greatly improved rotational stability of the laser because gravitational sag of the bore is eliminated.

OPTICAL CAVITY DESIGN

Melles Griot uses the most stable cavity configuration, namely the quasi-hemispherical cavity. All Melles Griot packaged helium neon lasers have a planar 100% ($\geq$99.9% in practice) reflectance mirror at the anode end of the plasma tube. Mounted at the cathode end is the output coupler, consisting of a concave mirror of $\approx$98.5% reflectance, which permits a portion of the beam to exit the cavity. The radius of curvature is chosen to maximize both power and stability. This mirror combination produces a beam waist at the 100% reflector and a divergent beam at the output coupler. To reduce the divergence, the 98.5% coating is actually supported on the concave surface of a glass meniscus lens. The output beam is refocused by this lens to a moderately sized waist, close to the point of exit from the laser housing. All the mirrors are of proprietary design and fulfill two basic criteria: they are highly reflective at the desired output wavelength, and they are antireflection coated for the high gain 3.391μm line (and also the 632.8nm line where appropriate).

HARD SEALS

Melles Griot lasers are sealed with truly, zero-leak hard seals. A special preformed ring of the frit sealing material is placed around the parts during initial assembly. Both the cathode retaining end-cap and the anode tube are manufactured of Kovar (a nickel/iron/cobalt alloy which is thermally compatible with the hard borosilicate glasses we use). Using radio frequency induction heating techniques, the Kovar cathode and end-cap are welded to the plasma tube envelope. Both cavity mirrors are bonded directly to their alloy cells. The preformed frit material flows fully onto both parts creating a proven and reliable seal. This use of glass-metal seals throughout the tube and the complete absence of epoxy bonds results in the elimination of tube leakage. The overall volume of the plasma tube provides a sufficient gas reservoir so that the gas mixture in the plasma tube is invariant with time and is precisely known. The result is reliable, consistent operation and a long shelf life.



CATHODE CONSIDERATIONS

Bore design is only one part of the reason why our lasers are rotationally stable and retain great pointing accuracy. The unique patented cathode design contributes significantly to this stability as well. A deep coaxial cathode assures a symmetrical discharge. The hemispherical end-cap protects the nickel-iron end plate from bombardment by the plasma discharge. Without this protection, material from the end plate tends to sputter onto the optical surfaces, thereby shortening tube life. Further, this hemispherical end-cap design assures a more uniform current density distribution between the open end of the bore and the cathode.

UNDERSTANDING HeNe PARAMETERS

Because of the great number of mounted and unmounted helium neon laser available, it is not always immediately clear which laser is appropriate for a specific application. The following comments will be found useful in selecting the correct device for your application.

Power

Output power is one of the main parameters of a laser. In general, the longer the laser bore, the higher the output power. Helium neon lasers are relatively insensitive to operating current, so significant variations in current from optimum levels will make only minor variations in the output power.

It is possible to get increased power from a smaller laser package by several techniques. The bore diameter can be increased, thus increasing the lasing volume. However, the cavity mirror radius must also be increased, compromising the intrinsic alignment stability of a shorter laser cavity. Alternatively, the bore can be lengthened without changing the overall laser length, but this may shorten the laser life if the end of the bore gets too close to the cathode.

Satellite Beams

Beam quality is often overlooked when selecting a helium neon laser, yet many new instruments are increasingly sensitive to satellite beams and diffraction rings. Satellite beams are the secondary beams created by reflections of the main output beam off of the antireflection coating on the output mirror. These beams are present in all gas lasers. Typically the power in the secondary beam is less than 0.2% of the main beam. It is never more than 0.5%, but even at these levels the beam is still visible to the eye, especially in higher power tubes. Novel Melles Griot techniques reduce these effects.

Stray Light

During laser operation, light other than from the main beam is also emitted. The majority of this light is highly divergent and is not easily detectable beyond a few inches from the end of the plasma tube. Some of the light, however, is coherent, and results from grazing angle reflections of the main beam from the smooth walls of the discharge tube itself. This results in a halo around to the beam, visible in a darkened room. Often this halo also contains diffraction rings caused by interference of the reflected light or coming from small particles on the inside or outside of the laser mirror. The total power in the halo is typically less that 1% of the laser's beam.

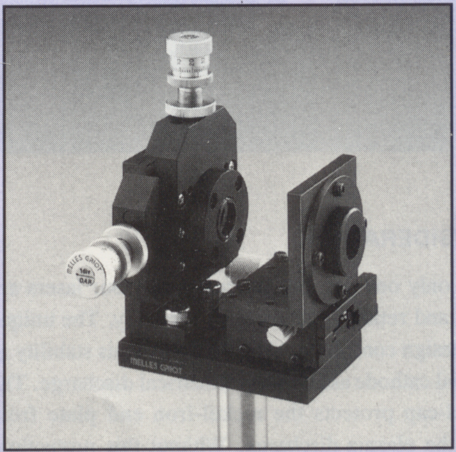
Stability and Mode Sweeping

The term stability refers to a number of parameters when used in the context of helium neon lasers: amplitude stability, noise stability, mechanical stability, to name but a few. Typically of most concern is amplitude stability. There are two main factors that determine amplitude stability: mode sweeping and mirror alignment.

The laser operates at several discrete longitudinal modes, or frequencies, that are separated by c/2L, where c is the speed of light, and L is the separation of the laser mirrors. The number of modes allowed is determined by the gain of the laser. Typically, helium neon lasers operate with three or fewer modes. As the cavity length increases and decreases due to changes in the heat load, the modes move with respect to the laser gain curve. This causes an amplitude fluctuation. The fewer the modes (ie, the shorter the laser) the greater the fluctuations. Typically amplitude fluctuations are 10% with a two longitudinal mode laser, and 5% or less with a higher number of longitudinal modes. The fluctuations are completely dependent on the length changes in the laser cavity, and if temperature equilibrium is reached, the fluctuations will decrease. For this reason, it is important, particularly with a short laser, that it is isolated from drafts or changes of temperature. Normally lasers mounted in cylindrical housings reach equilibrium more quickly than bare power tubes, and operate with higher stability.

Further details regarding helium neon laser design can be found in the article "HeNe Lasers Are Alive and Well" by Anthony L.S. Smith, *Laser Focus World,* July 1989, p75-86. Copies are available from Melles Griot upon request.

SPATIAL FILTERING



Melles Griot has available a number of different spatial filter assemblies — see Chapter 18, Gaussian Beam Theory and Laser Accessories, for full details.