INCREASING THE POWER OUTPUT FROM INEXPENSIVE CO_2 LASERS

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Inexpensive CO_2 molecular gas lasers have been constructed(1, 2). This report describes a method for increasing power output from these devices by using a simple technique for lengthening the active gas tube and by introducing a cooling system. A novel combination Brewster angle window holder which also serves as an electrode is described.

Twenty watts of output power has been obtained at 6-7% overall efficiency from a three meter tube with a one-centimeter bore diameter, using the above techniques. The laser gas tube was constructed from commercial, water-jacketed Cenco(West improved with S joints), male-female condenser columns 65 cm in length with a clear bore of 1 cm diameter. Occasionally a drip tip had to be sawed off to assure a 1 centimeter bore. Four of these tubes were fitted together using vacuum grease at the ground glass joints. An aluminum center electrode (Fig. 2) was inserted in the middle of the gas tube. The overall laser tube length can be quickly altered by additional condenser columns as space or power requirements dictate.

A closed loop water-cooling system was constructed by interconnecting the condenser column water jackets with Tygon tubing, using a large, plastic rubbish barrel as a water reservoir. A water pumping rate of about 1 gal./min was used. Heat dissipation was sufficient to yield 6-7% overall laser system efficiency at room

temperature. The overall system efficiency was further increased to about 9% using water at an input temperature of 10 °C. Adding ice to the water reservoir in a closed loop system will provide this input water temperature.

Combination aluminum electrodes and Brewster angle window holders were turned down on a lathe and fitted with vacuum grease to the female ends of the condenser column gas tube (Fig. 3). Sodium chloride Brewster angle windows were secured to the aluminum with low vapor pressure epoxy such as Torr-Seal. The useful lifetime of these windows is in excess of a few months when kept in an atmosphere of less than 45% relative humidity. This was accomplished by heating the air near each NaCl window with a 100 watt light bulb. Plastic bags were employed to cover the windows when the laser was not in use. When the NaCl flats required repolishing, they were, without damage, slid off the aluminum by heating with a torch and applying slight hand pressure.

Large radius mirrors were fabricated from glass flats using amateur telescope-makers' equipment. Gold was vacuum deposited onto the surface of these mirrors after a 1-2mm diameter hole had been drilled in the center of the output mirror. A larger beam diameter with higher total power at reduced coherence was obtained using a sodium chloride flat as the output mirror. The 4% first surface

reflection from the sodium chloride flat was sufficient to yield a laser output of 20 watts from this narrow bore gas tube.

Mode patterns can be studied by directing the output beam onto the surface of an asbestos sheet or Marinite insulating board. These insulators begin to glow at a temperature of about 600°C which is reached in about 30 seconds at a beam intensity of about 20 watts/cm^2. Increased power density can be obtained by gold-coating a concave glass lens and reflectively focusing the output beam slightly off axis.

It should be noted that radiation at the CO_2 wavelength is invisible and extremely hazardous. It is strongly reflected by many metal surfaces. In experimental studies on rabbit eyes, even at power densities as low as 0.2 watts/cm^2, gross injury to the cornea was produced(3). At higher power levels ulceration of the cornea occurred which healed by scarring(4). Such a scar can interfere with vision. Restoration of vision requires removal of the scarred tissue and its replacement by corneal transplantation. Although plastic or glass face shields may protect against low level backscattered radiation, they will not offer adequate protection against the direct beam at the above power levels(3). Also, clothing and hair are inflammable. Consequently, extreme caution must be used in the operation of CO_2 lasers.

References

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Figure Captions

1. System schematic. The helium, nitrogen and carbon dioxide gas mixtures are controlled with micro-regulating valves, V_2. The valves labeled, V_1, are shutoff valves.

2. Aluminum center electrode.

3. Combination aluminum end electrode and Brewster angle window holder. Two are required.