TABLE I. Laser operating conditions. Gain Length = 22.4 cm Channel Size = 3 mm × 3 mm.

	T_b (C)	T_g (C)	R (%)
A	−4.5	−71	98
B	−4.5	−71	95
C	−4.5	0	95
D	−4.5	24	95
E	0.5	24	95
F	11.5	24	95
G	−16.0	−71	97

R = Output coupler reflectivity. S = 98% = Secondary mirror reflectivity. Mixture: 43 : 4 : 7 : 0.1 : 4 He : CO : N_2 : O_2 : Xe. Pressure: 58 Torr.

In conclusion, we have demonstrated that steady laser output with significant power levels can be produced by CO waveguide lasers. This is achieved by cooling the gas with the laser operating near room temperature. These results represent a significant improvement in CO waveguide laser performance, as reported in the literature.

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Low-drift optical-densitometer

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A general purpose, optical densitometer has been constructed using inexpensive components. A drift rate of approximately 0.3% per hour, and a measurement accuracy of 0.1%, permit the instrument to detect small changes in the optical transmission of unknown samples.

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In this note we describe a general purpose, low-drift optical-densitometer which was initially developed to quantify the adsorption of submonolayer coverages of protein on indium-coated glass slides.[1–3] The densitometer is characterized by a low drift rate of ≈0.3% per hour after a 30-min warmup, a measurement accuracy of ≈0.1%, and an almost linear response to changes in optical density. By placing suitable filters between the densitometer's photodetector and light source, accurate measurements of the optical density of a sample as a function of visible wavelength can also be obtained.

The densitometer is shown in Fig. 1. A black-anodized, aluminum "bulb-housing" contains a tungsten lamp bulb used to illuminate a sample of interest placed between it and a photocell detector. The mass of the bulb-housing, its color, and vertical heat-fins milled into its surface, serve to stabilize the operating temperature of the tungsten bulb. The bulb housing is fastened to a black-anodized aluminum "sample-stage" which contains a cadmium sulfide photocell of 4-mm diam. active area. A white plastic sheet fastened to the stage contains an aperture positioned above the photocell. By adjusting the diameter of this aperture, a well-defined area of interest on the sample can be examined.

After a 30-min warmup, densitometer drift is stabilized to better than 0.3%/h and a background or "reference"

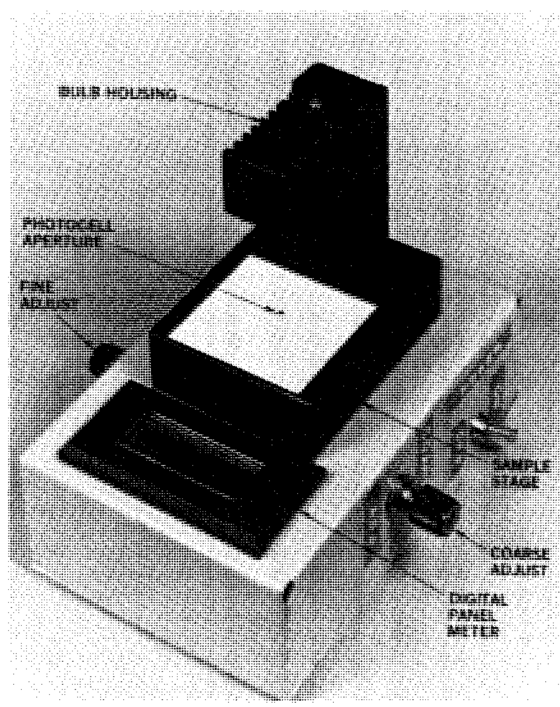

FIG. 1. The optical densitometer described in the text. A sample is positioned over the photocell aperture below the bulb housing which thermally stabilizes an integral tungsten lamp. Relative optical transmission can be read from the digital panel meter to within 0.3% after a 30-min warmup.

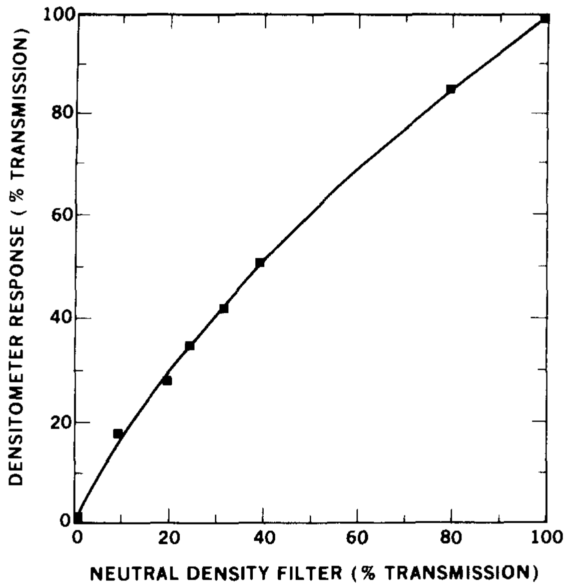

FIG. 2. Densitometer calibration curve. Percent transmission indicated on the digital panel meter of the densitometer for various neutral density filters of known transmission.

optical transmission can be obtained. This is accomplished by adjusting the course and fine potentiometers shown in Fig. 1 until 100.0 appears on the digital panel meter (indicating 100.0% transmission). By placing a sample over the photocell aperture, its optical transmission relative to the background can be directly read on the digital panel meter. If neutral density filters of known transmission are measured in this way, the linearity of

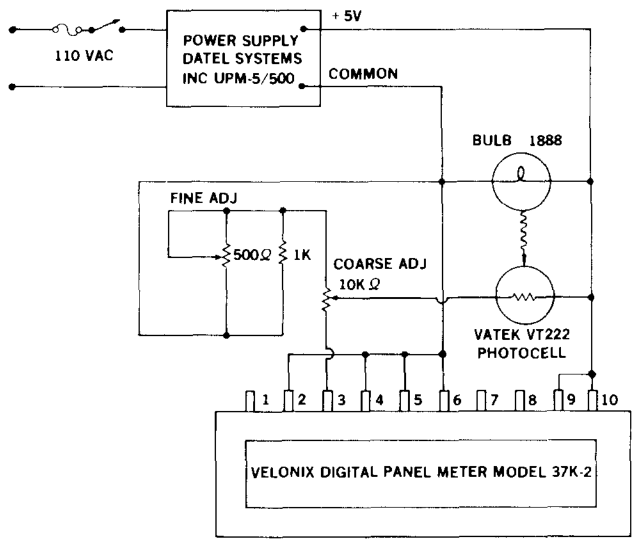

FIG. 3. A schematic drawing of the circuitry of the optical densitometer shown in Fig. 1. The circuitry is housed in the aluminum chassis which serves as the base of the densitometer.

the digital readout as a function of optical density can be obtained (see Fig. 2).

A 15 × 10 × 5 cm aluminum chassis contains the densitometer circuitry and controls. A schematic drawing of the circuitry is shown in Fig. 3. The total cost of components (not including the bulb housing) is less than $150.

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Device for measuring positions in spherical coordinates

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A simple device is described which can determine the positions of objects in spherical coordinate systems by extending a pointer to touch the object. The coordinates are read directly from a digital display.

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It is often necessary in a laboratory to measure the positions of objects in three dimensions relative to some reference frame. Simple approaches using rulers, string, etc., can generally be used, but occasionally one does not have sufficient room to do this, or there are not three well-defined axes against which to make such a measurement. In our case we were required to determine the location of a number of detectors surrounding a small target in a crowded vacuum chamber used for laser plasma studies, and found that physically it was impossible to safely get both arms near enough to the target or detectors to use a conventional measurement technique.

To overcome this problem the device shown in Fig. 1 was constructed. It operates by simply extending the pointer to touch the front of the detector being located

