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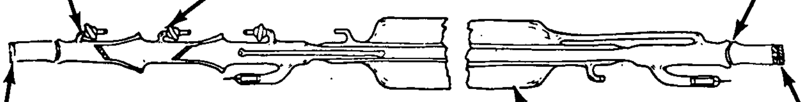
Repetitively Pulsed, Wavelength-Selective CO_2 Laser



A CO_2 laser has been designed to provide a relatively simple portable unit that generates coherent light pulses at selected infrared wavelengths. The improved laser was originally designed for the detection of air pollutants. Other applications of this laser would include optical communication and research in infrared transmissive materials. This laser is designed for sealed-off operation and high-power repetitive pulsing at selected wavelengths. Earlier systems for pulsing a CO_2 laser have employed prisms or gratings within the laser cavity to shift the output from one infrared line to another. However, these systems in addition to being rather cumbersome and difficult to manipulate, significantly reduce the power output of the laser.

The improved CO_2 laser operates with two gas absorption cells built into the cavity. The first of the cells contains a gas which controls the wavelength of emission. The second contains a gas which forces the laser into a high frequency pulsed mode of operation. The pulsing and wavelength shifting are attributed to the spectroscopic and kinetic properties of the gases. With proper choice of absorbing gases, high-powered pulsed operation has been achieved at various wavelengths between 9.08 and 10.6 microns at repetition rates of up to 100 kHz.

The illustration shows a model which has been operated with an output of up to 25 watts. The main body of the laser consists of three concentric glass tubes. The discharge and the laser action take place in the inner tube. Cooling water flows between the inner tube and the middle tube. The annular space between the middle tube and the outer tube is a gas reservoir. The standard taper joints permit extra gas compartments to be included within the laser cavity. The operating gas mixture consists of 85 percent helium, 10 percent nitrogen, and 5 percent carbon dioxide at a total pressure of 8 torr. The laser mirrors are adjusted by moving the end pieces of the laser in the glass ball-and-socket joints. For convenience in aligning the mirrors, the laser is mounted on an optical bench, and the end pieces are adjusted for maximum laser output by means of an optical bench rider which has an X-Y motion in a plane perpendicular to the axis of the laser. When the maximum output is obtained, the ends can be immobilized by covering the ball-and-socket joints with a hard, black wax. The glass laser can then be removed from the optical bench without disturbing its alignment.

Without wavelength control, normal CO_2 emits a 10.6 micron line, and CO_2 containing the oxygen-18 isotope emits a 9.3-micron line. When wavelength control is desired, one or more added gas compartments with Brewster angled windows is used. Gases are admitted to the laser compartments through the stopcocks.

(continued overleaf)

Mirror arrangements vary according to the application. For high-power output, an output mirror which is about 50 percent reflecting and 50 percent transmitting is used. If the laser emission is to be controlled by means of absorbing gases, it is desirable to have an "undercoupled" laser which maintains a high-energy density within the cavity or, to put it another way, which passes the photons through the absorbing gas a number of times before they escape from the cavity. The laser has been operated both ways. For high-power operation the output mirror was a partially reflecting Irtran flat and the other was a 2-meter focal-length, aluminized, spherical mirror. For operation with wavelength and pulsing control, the output mirror was an aluminized, 1.5-meter focal-length spherical unit in which was cut a 1.5-mm-wide slot; the other mirror was an aluminized flat unit.

The CO_2 laser has been pulsed at 10.6 microns with propylene gas, at 9.2 microns with formic acid vapor, and at various wavelengths with CO_2 gas itself. Mixtures of CO_2 gas and propylene have also been used as pulsing agents. When the CO_2 gas acts as a pulsing agent, the absorbing transition is the reverse of the lasing transition. The gas must therefore be heated to populate the absorbing state, which lies at 1300 to 1400 wave numbers above the ground state.

Note:

No documentation is available. Inquiries may be directed to:

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Patent status:

Inqiuries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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