01^10 level of CO_2 in a TEA laser with a CO_2 pressure of 300 torr and not 10 ns as would follow from an experiment of Rhodes *et al.*[4] Second, that the maximum gain in gas-dynamic and sealed-off CO_2 lasers, found for ratios of the H_2O and CO_2 densities between 0.10 and 0.15,[5–9] is fully explained by the behavior of the relaxation time of the lower laser level as reported here.

For lasers with indirectly excited upper laser levels it will be shown from the rate equations of the various levels that the laser power decay in the afterglow of the laser discharge is described by a sum of two exponential functions. This analysis of the power decay is applicable to the tail of the power response of TEA lasers and will be illustrated for different ratios of N_2 and CO_2 densities.

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Q.10 A High-Power High-Energy TEA CO_2 Laser, M. C. Richardson, A. J. Alcock, K. Leopold, and P. Burtyn, *Division of Physics, National Research Council of Canada, Ottawa, Ont., Canada*

Many of the problems encountered in the construction of high-power high-energy TEA gas lasers[1] have been associated with the elimination of high-current constricted arcs and the production of a uniformly excited medium between the discharge electrodes. Previous designs aimed at producing large-volume discharges between flat[2,3] or Rogowski profile electrodes[4] have incorporated various types of auxiliary electrodes and double-discharge circuitry. These have the purpose of generating an initial region of uniform conductivity within the excited volume, thereby facilitating an even distribution of the main discharge. An alternate approach employs an extended source of high-energy electrons as a separate means of providing the initial ionization.[5,6]

In this system, a uniform discharge is produced between two curved electrodes, one of solid Al, and the other of a fine stainless steel mesh, spaced 50 mm apart in a 1:2:1 mixture of CO_2, He, and N_2. Initial preionization is provided by electron emission from a third electrode, consisting of separately energized arrays of discharge pins situated behind the perforated electrode. A two-stage 100-kV Marx generator is used both to supply this initial ionization and to energize the main discharge. Sufficient delay between these two processes is facilitated with the incorporation of an auxiliary switch.

The laser system is modular in construction, each module having its own discharge circuit and gas supply. With six modules situated in a 6-m long plane optical resonator, the system produces a 50-mm² cross-sectional beam. Initial measurements of a known sample of the beam, using a pyroelectric meter[7] calibrated with the output of a solid-state laser, indicate total energies of $\sim$150 J. Since the energy input is $\sim$1.5 kJ in an active discharge volume of 6.0–7.5 l, this represents a 10-percent conversion efficiency and energy extraction between 20 and 30 J/l. The pulse shape as measured with a cooled Au-doped Ge detector consists of an initial 50-ns spike followed by a $\sim$2-μs tail. The latter can be largely eliminated by almost complete exclusion of N_2 from the discharge, in which case pulse energies decrease to $\sim$90 J. Thus powers in excess of 1 GW are generated and, when focused with a 10-m radius of curvature fully reflecting mirror, air sparks approximately 3 m in length are produced.

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Q.11 An Optically Pumped CO_2 Laser, T. Y. Chang and O. R. Wood, *Bell Telephone Laboratories, Inc., Holmdel, N. J. 07733.*

Optical pumping by means of a laser has been commonplace for some time in the visible region of the spectrum (e.g., dye lasers). Recently Chang and Bridges[1] extended this technique to gases in the far IR region of the spectrum, where they obtained laser action on pure rotational transitions. In this paper we report observation of laser action in dischargeless pure CO_2 gas on several vibrational–rotational transitions near 10.6 μm using a transverse-discharge hydrogen bromide laser as the pump source.

Several P-branch transitions of the $v = 2 \rightarrow 1$ and $v = 3 \rightarrow 2$ vibrational bands of HBr with wavelengths near 4.3 μm are found to be absorbed by CO_2 gas. In particular, we surmise a close coincidence between the $P(6)$ transition of the $v = 2 \rightarrow 1$ vibrational band of HBr^{81} and the $R(20)$ transition of the $(00°0) \rightarrow (00°1)$ vibrational band of CO_2 from the spectroscopic data of Oberly *et al.*[2] The HBr laser should, therefore, be an effective pump source for a CO_2 laser whose upper laser level is the (00°1) state.

The experiment consisted of a linear arrangement of the pulsed HBr laser with internal mirrors, a CO_2 gas cell, and detector. All air paths between the HBr laser and the CO_2 gas cell were eliminated since CO_2 in air was found to strongly absorb the pump radiation. The transverse-discharge HBr laser was similar to that previouly described.[3]

The 66-cm long CO_2 gas cell, having KBr Brewster's angle windows at each end, was situated between two 10-m radius germanium mirrors (spaced by 104 cm) which were coated for 98-percent reflectance at 10.6 μm. The 4.3-μm output of the pulsed HBr laser was introduced into the CO_2 gas cell through one of the germanium reflectors.

With 20 torr of CO_2 present in the gas cell, the output near 10.6 μm is characterized by 1) peak power output $\sim$80 W, 2) pulse duration $\sim$0.5 μs, and 3) pulse delay $\sim$3 μs. The optimum CO_2 pressure (20 torr) appears to coincide with the absorption of approximately 90 percent of the power from the $P(6)$, $v = 2 \rightarrow 1$, transition of HBr, which under these conditions exhibits a peak power of $\sim$300–500 W with a pulse duration $\sim$0.5 μs.

In conclusion, we expect that the optical pumping technique described here may provide an unambiguous means of studying some of the physical mechanisms involved in a CO_2 laser. Finally, we expect this technique to be potentially useful for pumping very-high-pressure CO_2 lasers.

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Q.12 Dependence of the Output Energy of a CO_2 TEA Laser on the Pulsewidth of the Excitation Current, M. G. Drouet, *Institut de Recherche de l'Hydro-Québec, Varennes, P.Q., Canada.*

In order to optimize the design of the power supply we have determined the discharge duration and current intensity in a given gas mixture for maximum laser energy output in a CO_2 TEA laser.

A laser with a 1-m discharge length and a 1.9-cm interelectrode distance was used. The anode was a 1.3-cm brass cylinder. The cathode consisted of 180 1-W 1000-Ω resistors connected in parallel in a single row along the laser axis. The 25-kV 0.005-μF capacitor and its spark gap were mounted in a coaxial housing in order to minimize the circuit inductance. The duration of the discharge in the laser cavity was adjusted by short circuiting the power supply at a preset time after the initiation of this discharge. This was achieved using