Gas Lasers

- Atomic (atoms not ionized)
- Nobel Gas Ion Lasers
- Molecular Lasers
- Excimer Lasers

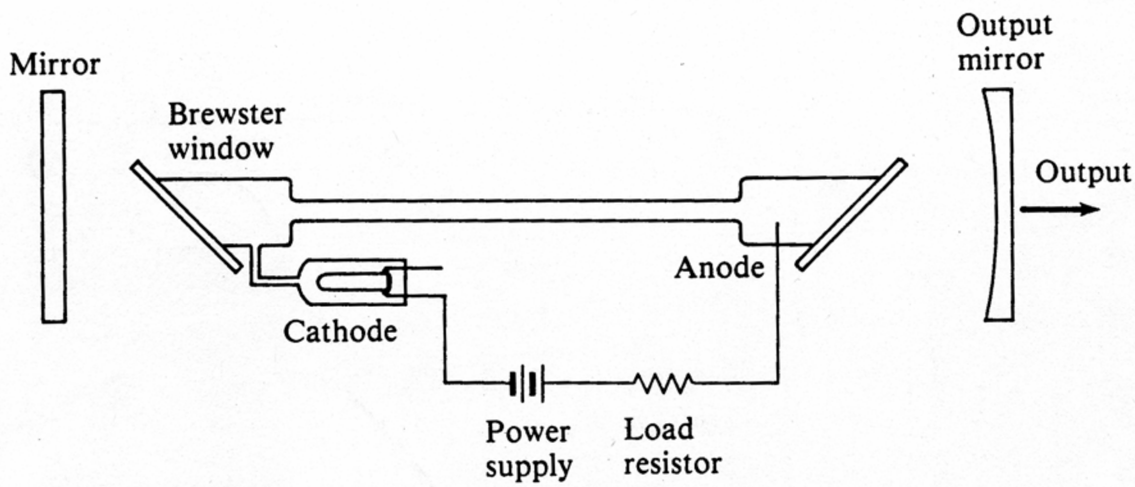


Fig. 2.25 Schematic construction of a low-power gas laser such as the helium–neon laser. The load resistor serves to limit the current once the discharge has been initiated.

He-Ne Atomic laser

- Transitions between levels non ionized atoms
- He-Ne first: 1960 by Javan at Bell Labs
- He:Ne 10:1 ratio, at 10 torr
- Wall collision needed for ground: narrow tubes
- Very narrow line width, cheap
- Power 0.5 - 10 mW typically

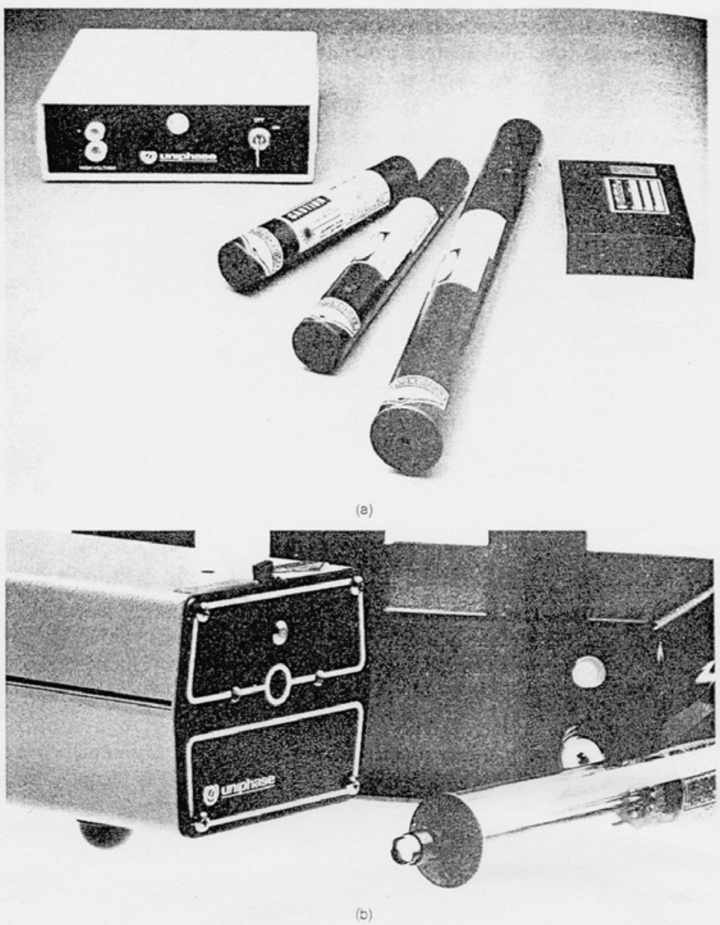


Figure 7.5 Packaged helium-neon lasers: (*a*) cylindrical laser heads with separate power supplies; (*b*) complete laser package (left) and unmounted He–Ne tube (right). (*Courtesy of Uniphase.*)

He-Ne Atomic laser

- He-Ne most common: uses DC arc current to pump
- Current excites He
- He 2^1S at Ne 3S level & metastable
- Transfer by atomic collision
- Transitions at 3.39 μm, 1.15 μm, 632.8 nm & 543.5 nm
- Choose wavelength by dielectric mirror reflectivity
- Fast decay to Ne ^3S

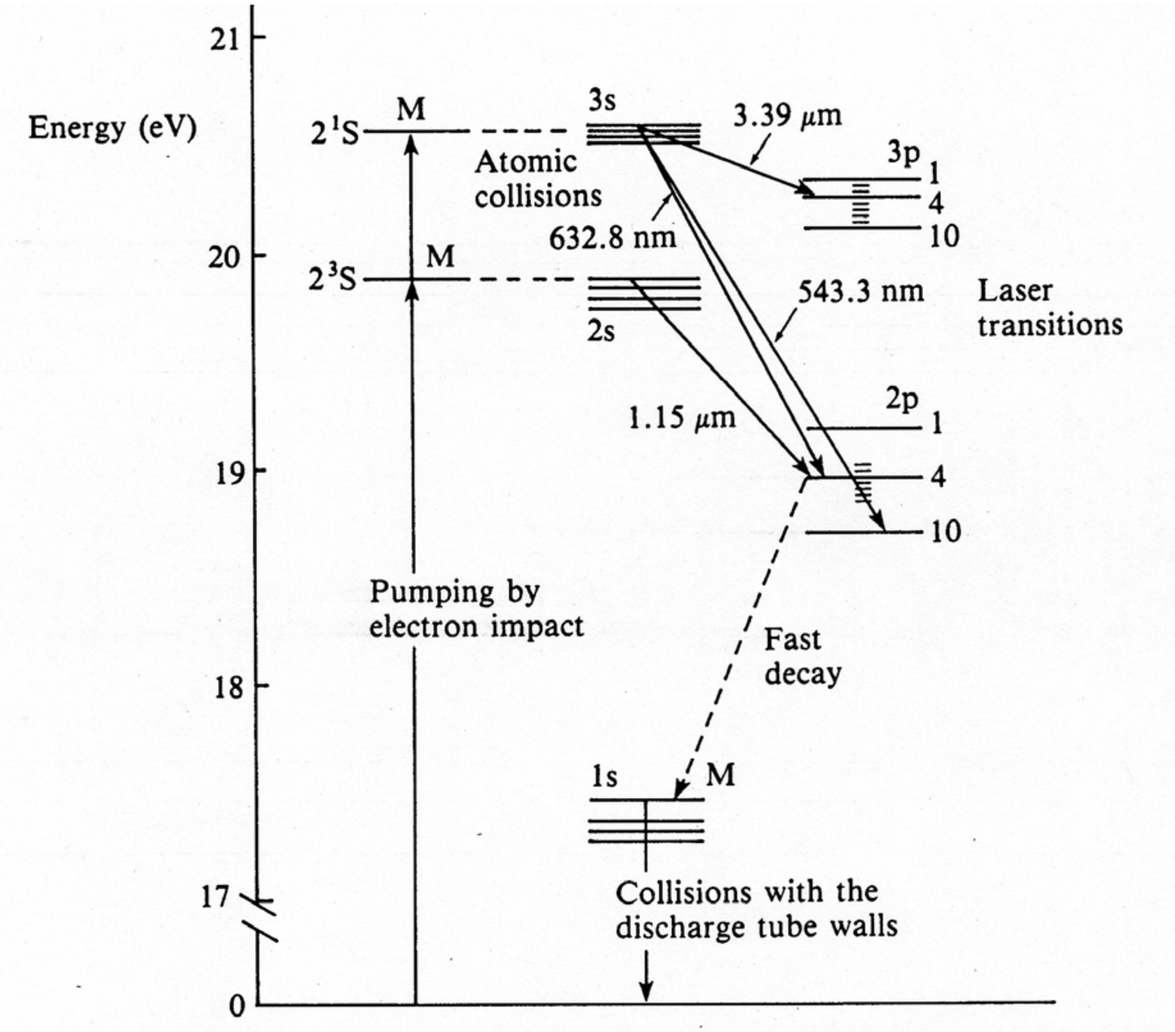


Fig. 2.26 Energy levels relevant to the operation of the HeNe laser. M indicates a metastable state (see p. 19).

Typical He-Ne

- Small ballest like ignitor (like fluorescent lamps/)
- Tube just like Neon tubes
- Can be extremely stable.
- Note: possibly no Brewster windows

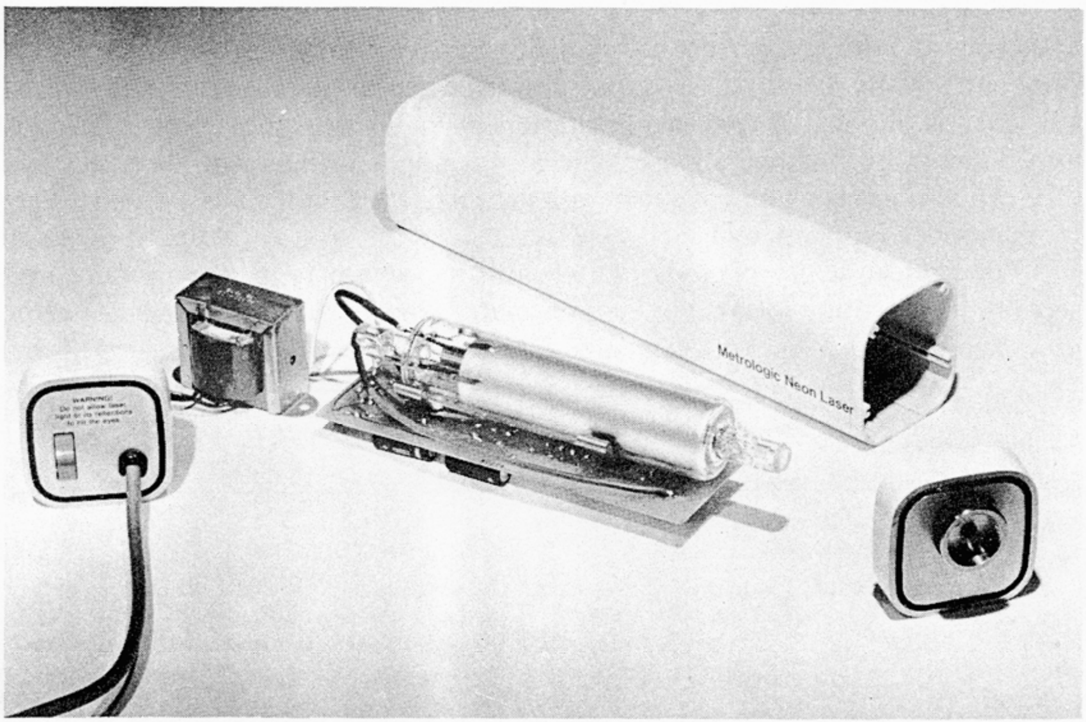
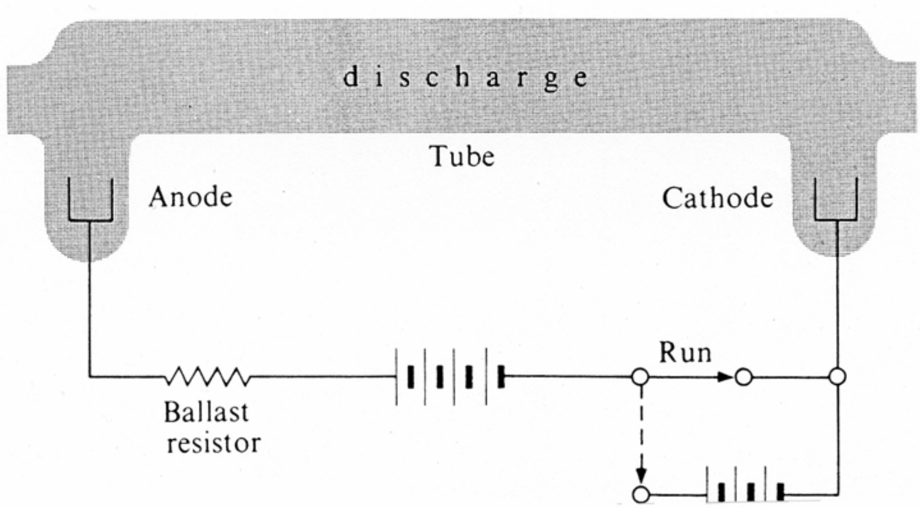


Fig. 6.2 Mass-produced helium-neon laser, consisting of an extruded aluminum case, a voltage transformer, a voltage multiplier and rectifying circuit on a printed circuit board, and a laser tube. (Courtesy of Metrologic Instruments, Inc.)



Sealed End He-Ne

- Seal mirror onto tube
- Very narrow line width, cheap
- Power 0.5 - 10 mW typically
- Note: no Brewster windows here so not polarized

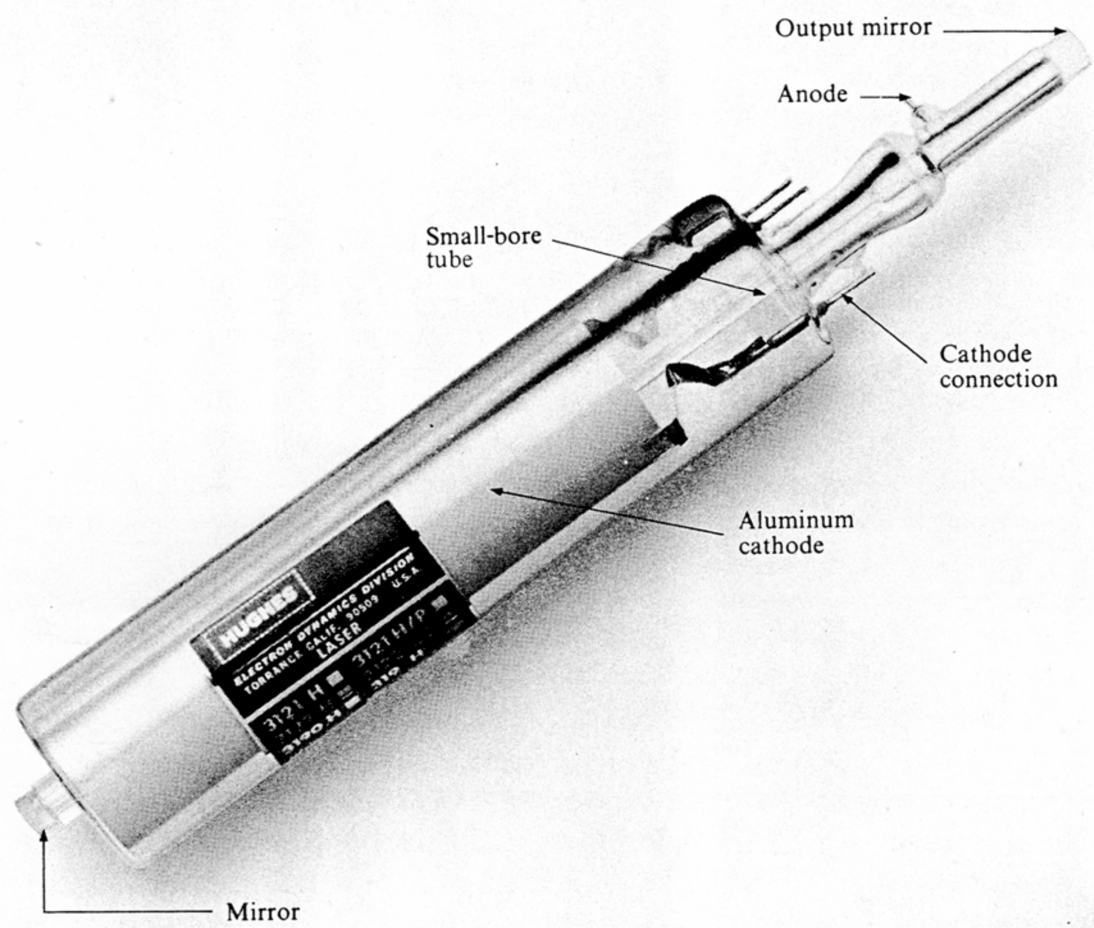


Fig. 6.4 Laser tube with internal mirrors. The large tube is fitted internally with a small-bore tube (about 3 mm inside diameter). The bore confines the discharge to the region between the mirrors and provides the surface for wall collisions needed to maintain the population inversion in the HeNe system. (Courtesy of Hughes Aircraft Company, Electron Dynamics Division.)

Nobel Gas Ion Lasers

- Most powerfully visible light lasers - up to 10's of Watts
- Must ionize the gas
- Heater heats the gas initially
- Starting current: 10-50 Amp
- Running current few Amp - 100 amp
- longer laser, more power (0.5 - several m)
- Magnetic field keeps ions away from walls
- Most water cooled
- Efficiency about 5%
- Select wavelength using prism: only one λ path to mirror

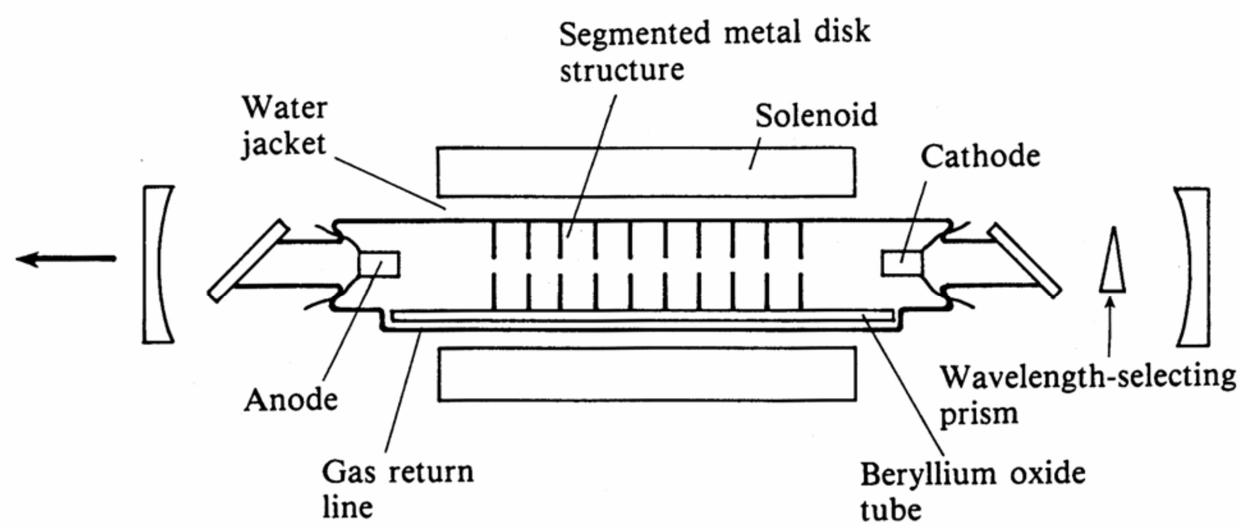
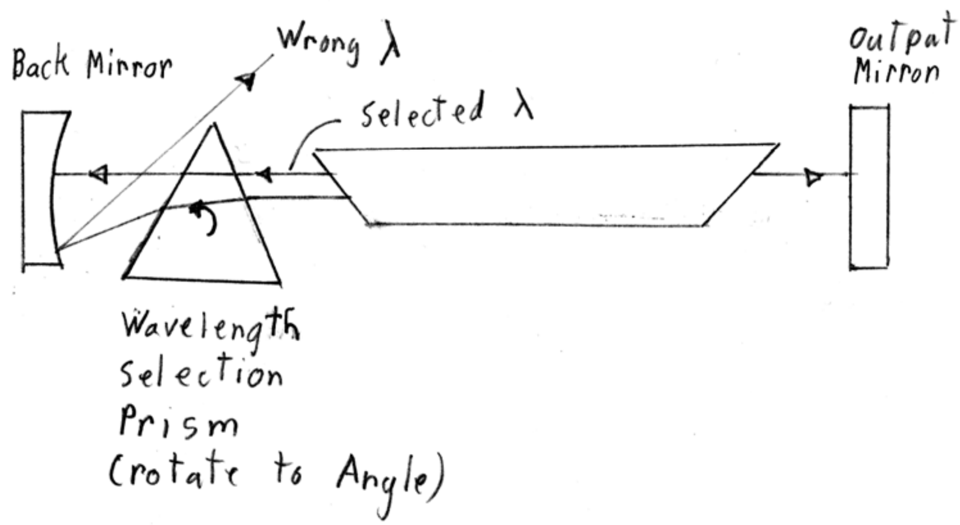


Fig. 2.29 Construction of a typical argon ion laser.



Argon & Krypton Laser

- Most common
- Argon: current pumping to 4p levels
- 4s transition for 514.5 nm & 488 nm

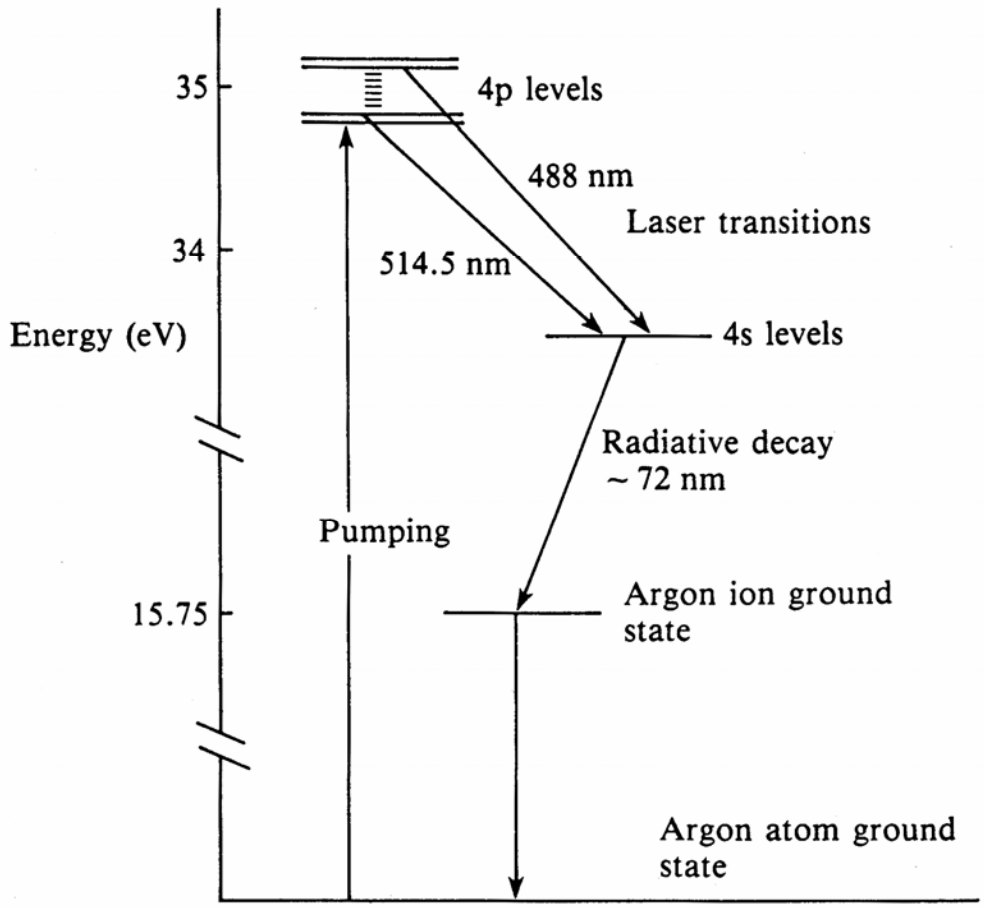


Fig. 2.28 Simplified energy level diagram for the argon laser. Ten or more laser lines are produced but the two shown are by far the most intense.

Argon & Krypton Laser

- Actually many transitions
- Most power runs all lines
- Select wavelength with prism
- Widely used in laser light shows
- Argons for Greens - Blues also UV
- Krypton for Red - Yellow

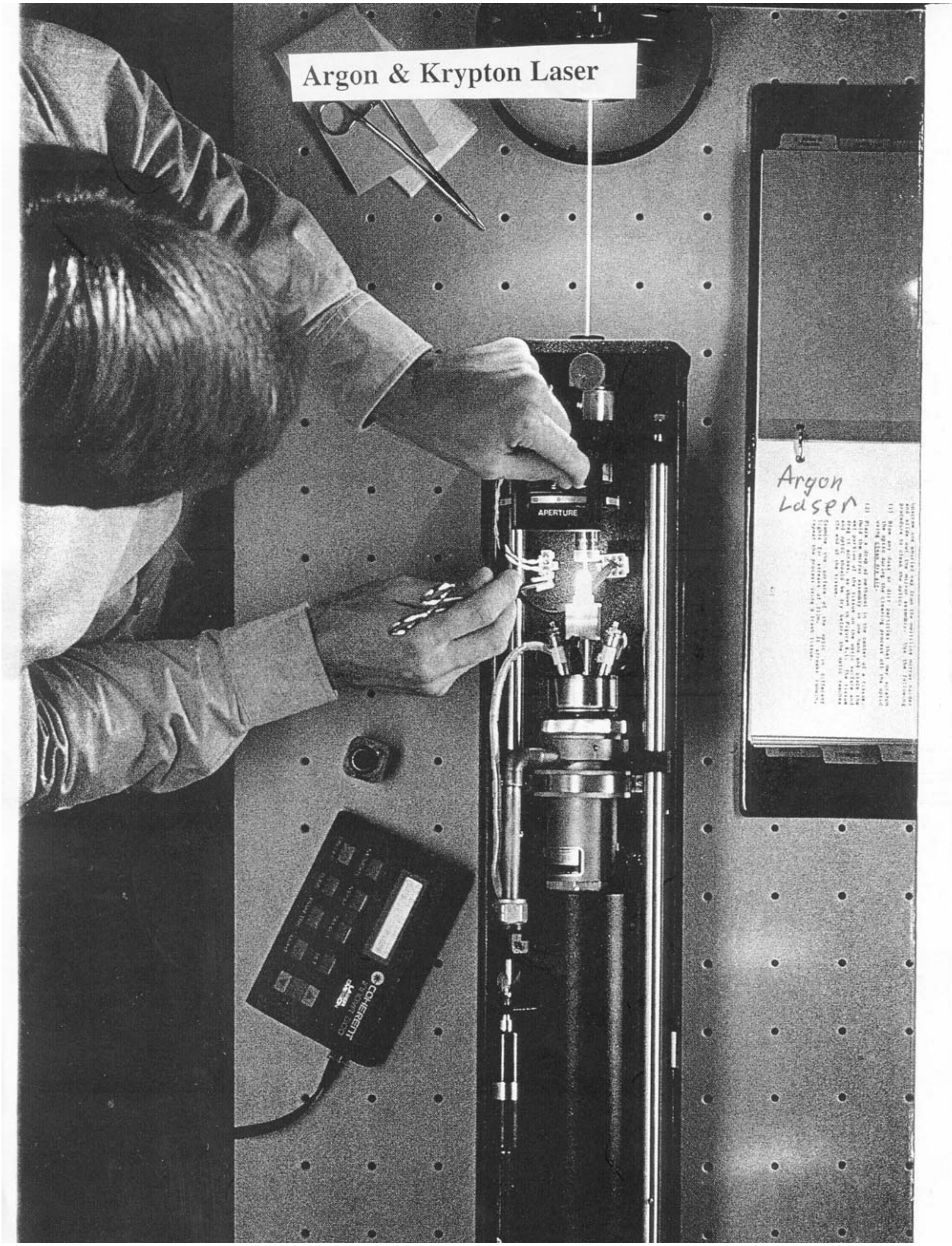
POWER SPECIFICATIONS[1]

	ARGON			KRYPTON
Wavelength (nm)	INNOVA 304	INNOVA 305	INNOVA 306	INNOVA 301
Multiline Visible	**4.0**	**5.0**	**6.0**	SEE NOTE 2
Multimode Visible	5.0	6.0	7.2	—
1090	0.04	0.05	0.07	—
793.1–799.3	—	—	—	0.03
752.5	—	—	—	0.10
676.4	—	—	—	**0.12**
647.1	—	—	—	**0.60**
568.2	—	—	—	0.15
530.9	—	—	—	0.20
528.7	0.20	0.35	0.42	—
520.8	—	—	—	0.07
514.5	**1.70**	**2.00**	**2.40**	—
501.7	0.30	0.40	0.48	—
496.5	0.50	0.60	0.72	—
488.0	**1.30**	**1.50**	**1.80**	—
482.5	—	—	—	0.03
476.5	0.50	0.60	0.72	—
476.2	—	—	—	0.05
472.7	0.12	0.20	0.24	—
465.8	0.10	0.15	0.18	—
457.9	0.25	0.35	0.42	—
454.5	0.05	0.12	0.14	—
350.1–356.4	—	—	—	0.15
333.6–363.8	0.20	0.40	0.50	—

Beam Specifications[2]

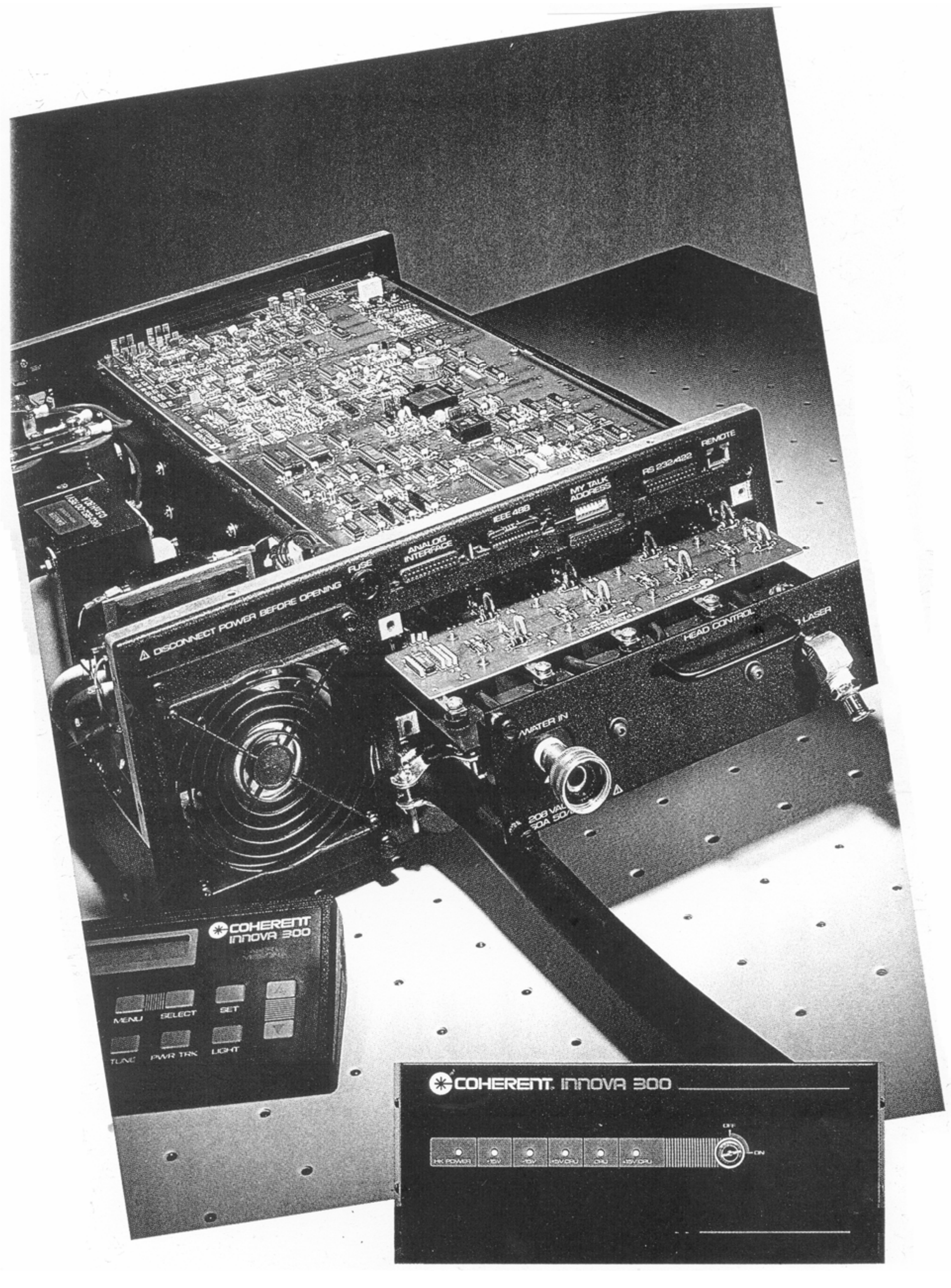
	Argon	Krypton
Beam Diameter (@ $1/e^2$ points)[3]	1.5 mm	1.5 mm
Beam Divergence (full angle)	0.5 mrad	0.8 mrad
Beam Waist Diameter[4]	1.4 mm	1.1 mm
Beam Waist Location[4]	1.50 m	1.27 m
Cavity Length		
Single-line	1.16 m	1.16 m
Multiline	1.14 m	1.14 m
Long-Term Power Stability[5]		
Light Regulation	±0.5%	±0.5%
Current Regulation	±3.0%	±3.0%
Optical Noise (rms)[6]		
Light Regulation	±0.2%	±0.2%
Current Regulation	±0.2%	±0.2%

Argon & Krypton Laser



Argon & Krypton Laser Power Supply

- Water cooled, 3 phase, 240 V supply



Molecular Lasers

- Operate by molecular vibration transitions
- Generally Infrared
- Most important CO_2
- Power from 10's - 1000's Watts
- High efficiency: up to 30%

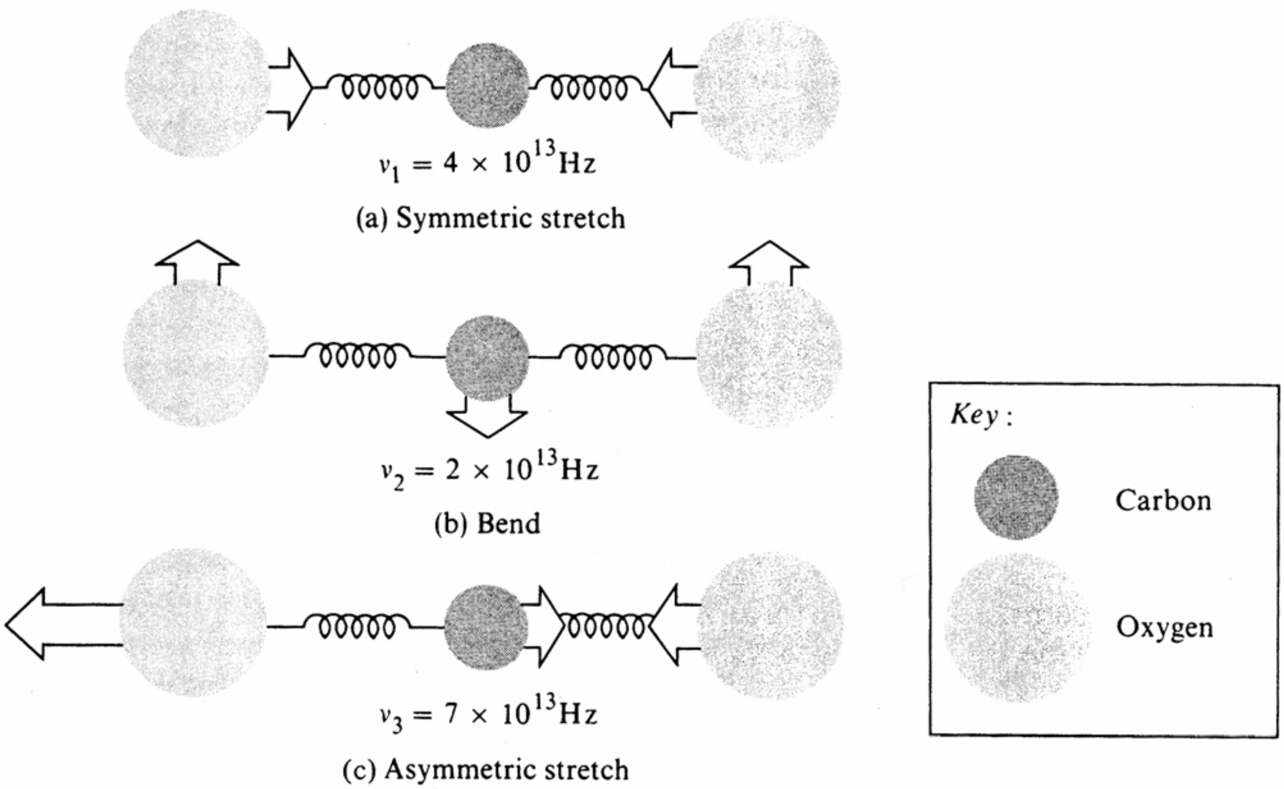


Fig. 6.8 Vibrational modes of the CO_2 molecule.

Carbon Dioxide Lasers

- N-CO_2:He mixture 1:1:1
- N_2 (001) vibration level close to CO_2 (001)
- N_2 excited collisions with CO_2
- Emissions at 10.6 μm (most important) and 9.6 μm
- 10 torr for CW, high pressure for pulsed

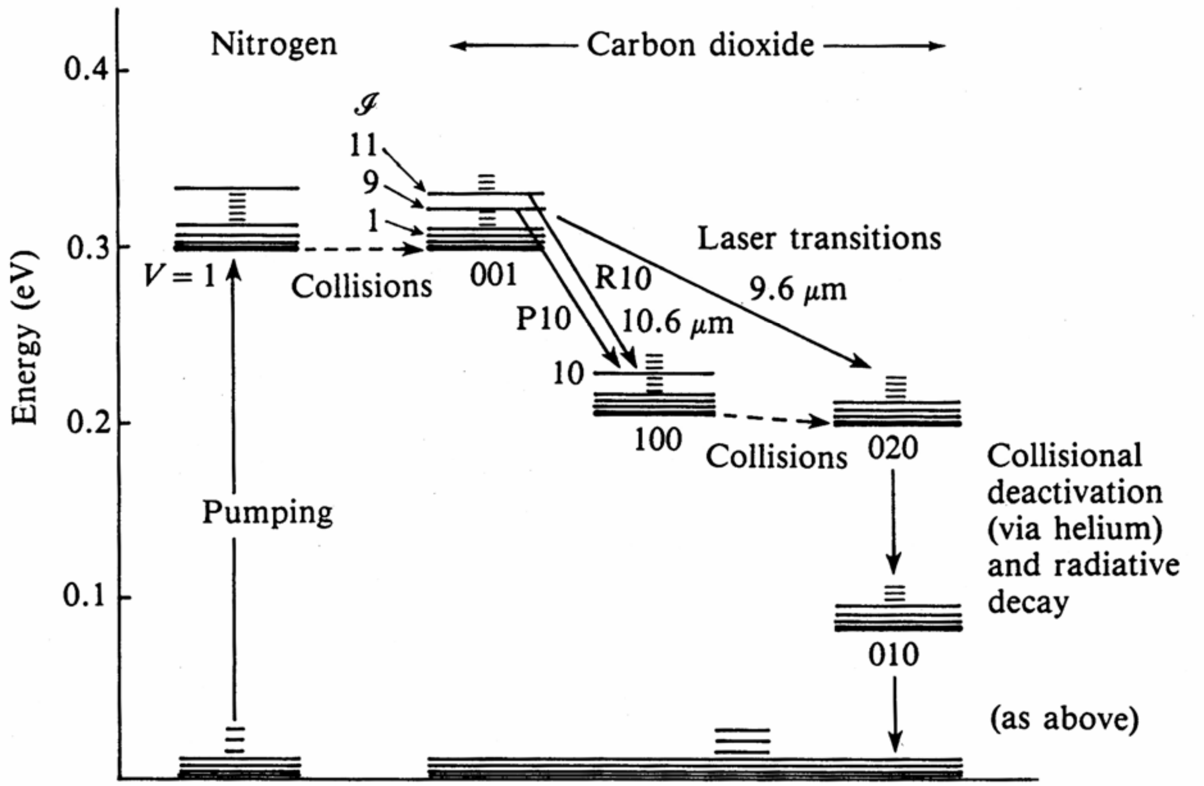


Fig. 2.32 Simplified energy level diagram for the carbon dioxide laser. Each vibrational level has many rotational levels associated with it. $\mathcal{J} = 1, 2$, etc. The letters P and R represent transitions where $\mathcal{J}$ changes by $+1$ and -1 respectively.

Carbon Dioxide Lasers

- Sealed tube lasers: like He-Ne: <100 W
- limited by cooling
- Transversely Excited Atmospheric TEA
- High voltage due to high pressure
- Excite across tube width
- Pulsed: 50 nsec, up to 100 J
- GasDynamic Laser
- Gas heated and compressed then expanded
- Creates the vibration levels & high power
- Mostly of military interest

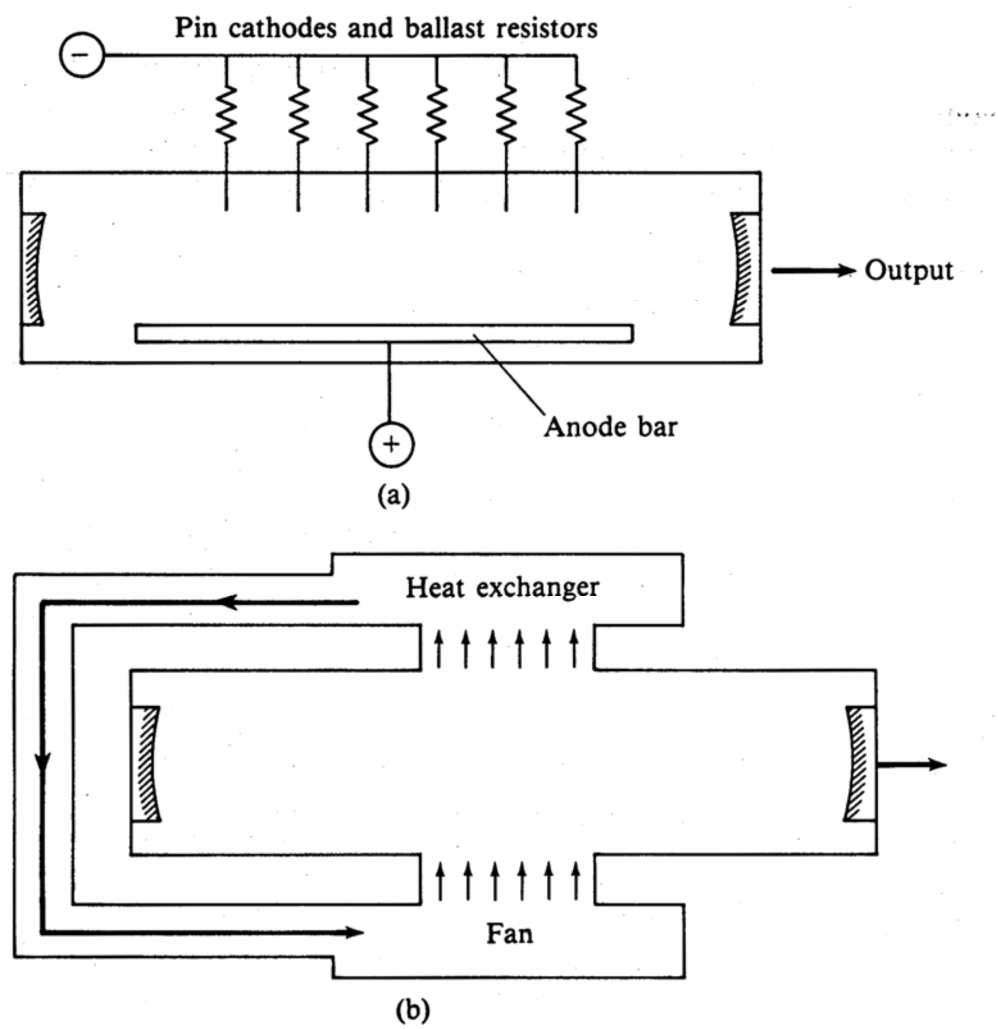


Fig. 2.33 Schematic diagram of a TEA CO_2 laser; the discharge is perpendicular to the axis of the laser cavity ('side' view (a)). A high gas flow is required whch can also take place perpendicular to the axis ('top' view (b)).

Carbon Dioxide Lasers Major types

- Waveguide with few mm wide tube
- Uses radio frequency field stimulation
- Low power (50W) low price ($1000)

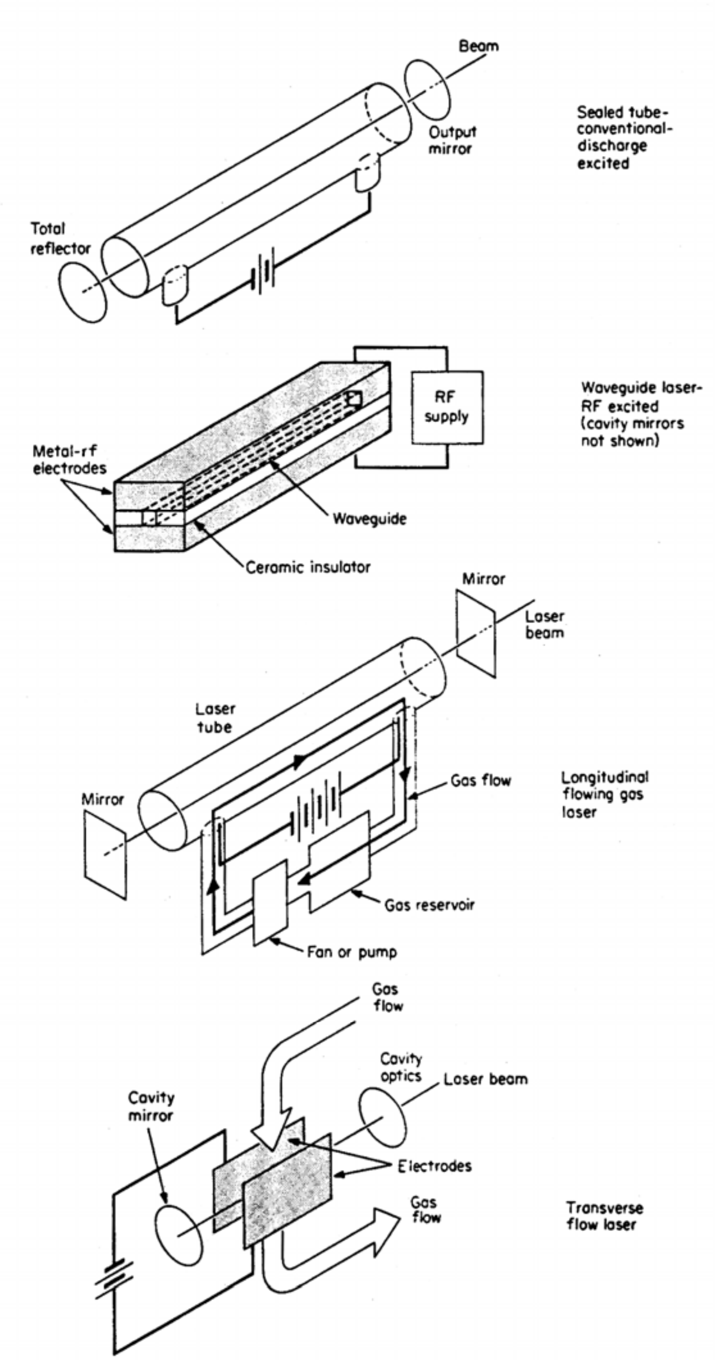


Figure 10.2 Major types of CO_2 lasers are (top to bottom) sealed-tube conventional laser with longitudinal dc discharge excitation, waveguide laser with radio-frequency excitation, longitudinal flowing-gas laser, and axial-flow laser. Slow and fast axial-flow lasers differ in gas speed through the tube; in the latter the laser runs cooler and more efficiently and thus can generate more power.

GasDynamic Carbon Dioxide Lasers

- Gas heated and compressed then expanded
- Typical 1100°K, 17 Atm
- Obtained from combustion of Hydrocarbon fuels
- Expanded through a nozzle
- Rapid cooling creates population inversion
- Creates the vibration levels & high power
- Mostly of military interest

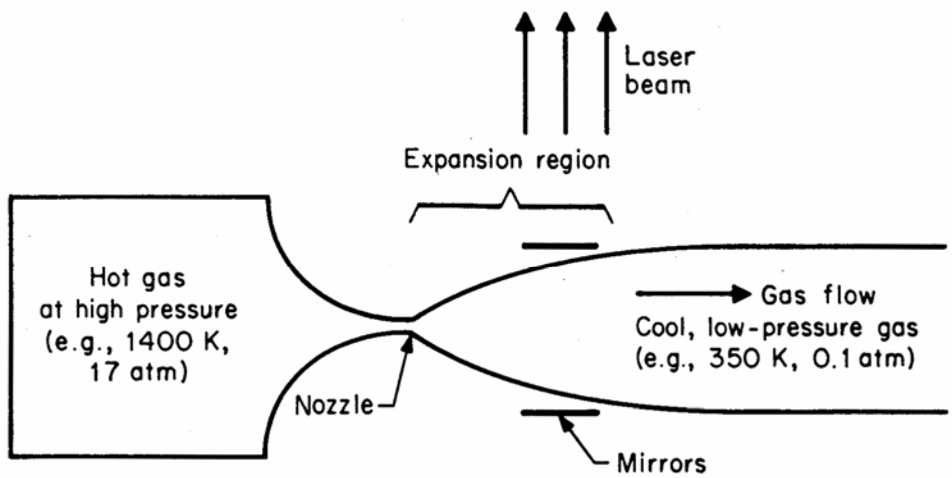


Figure 10.4 Basic structure of a gas-dynamic laser.

Nitrogen Gas Lasers

- UV laser first built in 1963 by Heard: commercial 1972
- N_2 at 20 Torr or 1 atm
- Electrical discharge like TEA lasers
- Very fast current pulse ~20 KV
- Top level only 40 nsec lifetime
- Short pulse output 337.1 nm – first powerful UV source
- Very high gain: 50 db/m
- Does not need cavity to lase: Superradiant
- Often used gas flow, though some sealed tubes
- Easy to build: Scientific America Amateur column 1973

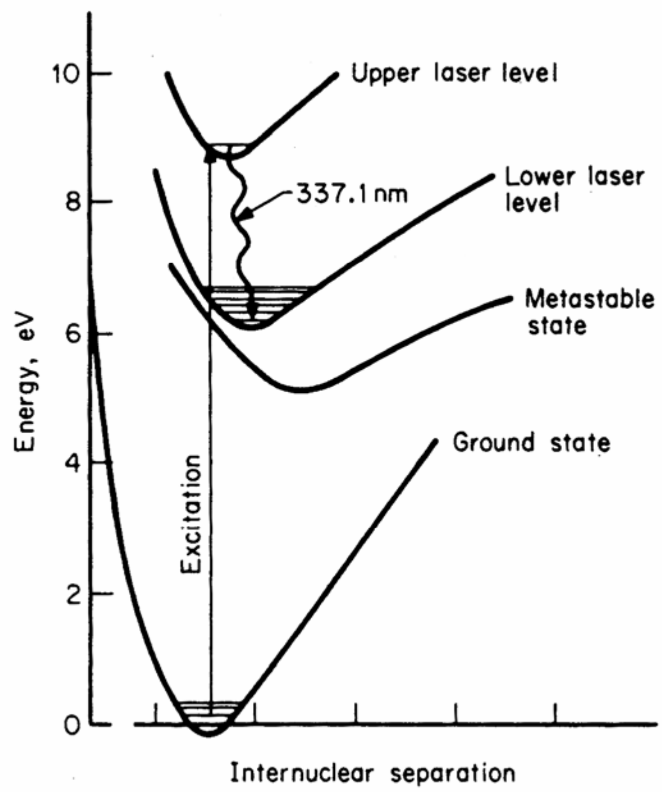


Figure 14.1 Energy levels in neutral nitrogen molecules involved in the 337.1-nm laser transition. The broad curves represent electronic energy levels, with the lines in the potential wells representing vibrational energy sublevels. The laser transition is a vibronic one with changes in both electronic and vibrational energy levels.

Nitrogen Gas Lasers

- Typical system 100% rear mirror, 5% front
- Doubles power with cavity
- Pulse 20 nsec at 20 torr to 300 psec at atm
- Repetition rate: 10 - 100 Hz
- 10 μJ to 9 mJ energy
- Peak power 10 KW to 2.5 MegW
- Efficiency low: 0.11%
- Very poor beam quality: cannot be Q switched
- Price: $1000 to $20K
- Typically used to pump other lasers

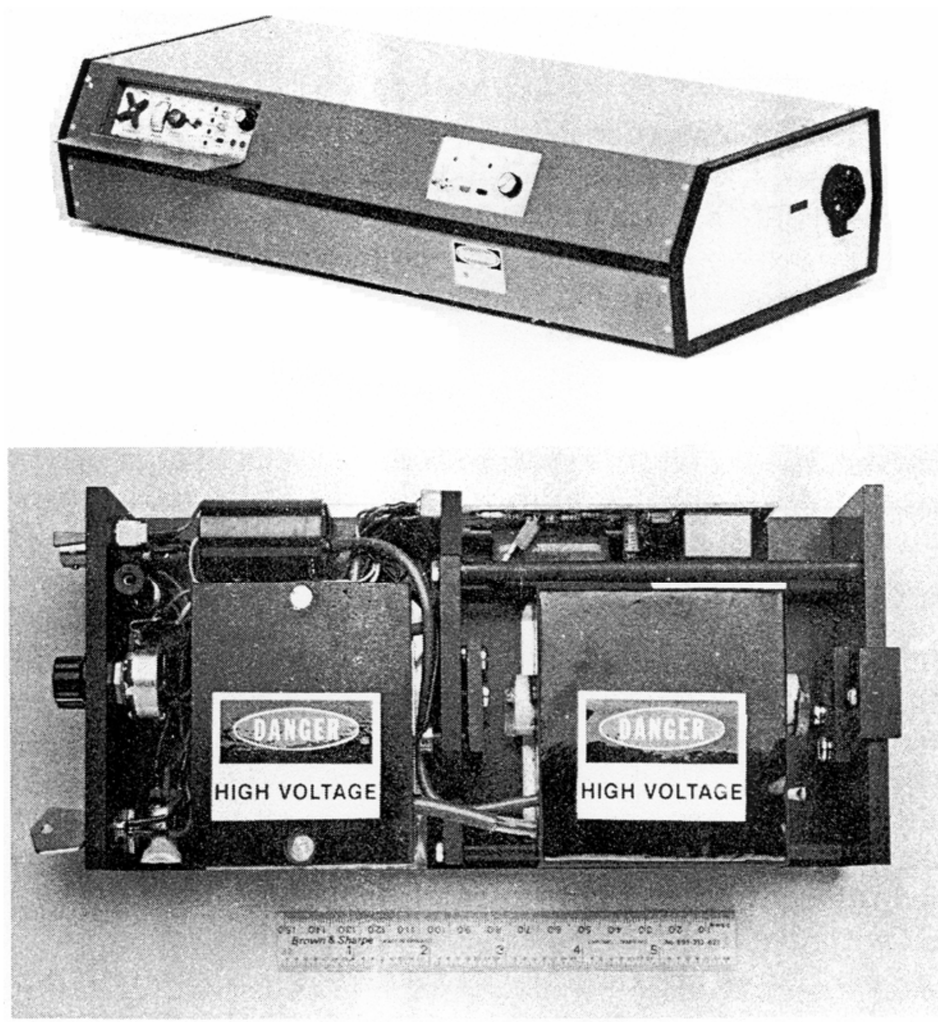


Figure 14.2 A pair of commercial nitrogen lasers. *Top*: A 1.2-m-long version delivers several-millijoule pulses. (*Courtesy of Laser Photonics.*) *Bottom*: A modular sealed laser about 25 cm long produces 0.1-mJ pulses. (*Courtesy of Laser Science Inc.*)