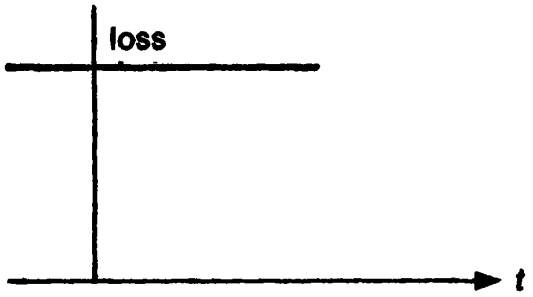
Neodymium Lasers

TABLE 9.3. Optical and spectroscopic parameters of Nd:YAG ($\lambda = 1.064\ \mu m$), $Nd:YVO_4$, Nd:YLF ($\lambda = 1.053\ \mu m$), and Nd:glass (phosphate)

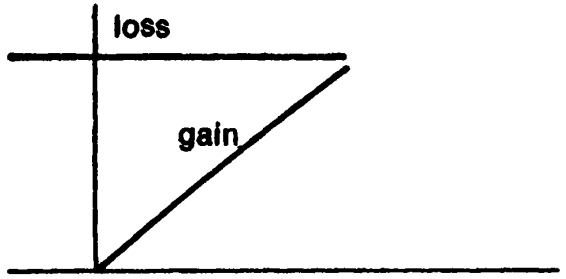
	Nd:YAG $\lambda = 1.064\ \mu m$	$Nd:YVO_4$ $\lambda = 1.064\ \mu m$	Nd:YLF $\lambda = 1.053\ \mu m$	Nd:glass $\lambda = 1.054\ \mu m$ (Phosphate)
Nd doping	1 atom.%	1 atom.%	1 atom.%	3.8% by weight of Nd_2O_3
N_t (10^{20} ions/cm^3)[a]	1.38	1.5	1.3	3.2
τ (μs)[b]	230	98	450	300
$\Delta\nu_0$ (cm^{-1})[c]	4.5	11.3	13	180
σ_e (10^{-19} cm^2)[d]	2.8	7.6	1.9	0.4
Refractive index	$n = 1.82$	$n_o = 1.958$ $n_e = 2.168$	$n_o = 1.4481$ $n_e = 1.4704$	$n = 1.54$

[a] N_t is the concentration of the active ions, [b] τ is the fluorescence lifetime, [c] $\Delta\nu_0$ is the transition linewidth (FWHM), [d] σ_e is the effective stimulated emission cross section. Data refer to room temperature operation.

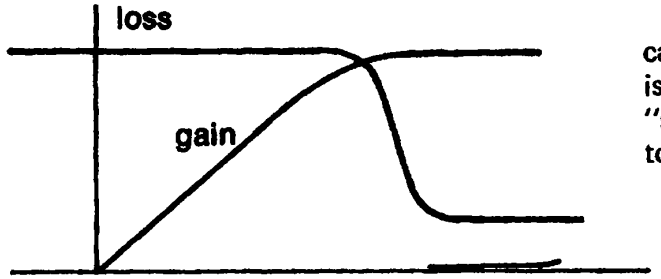
Pulsed lasers- Q-switch



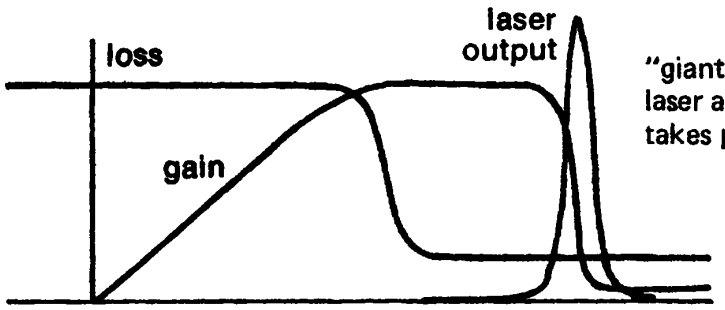
high initial
cavity loss



pumping process
builds up a
large inversion



cavity loss
is suddenly
"switched"
to low value



"giant pulse"
laser action
takes place

Pulsed lasers- Q-switch

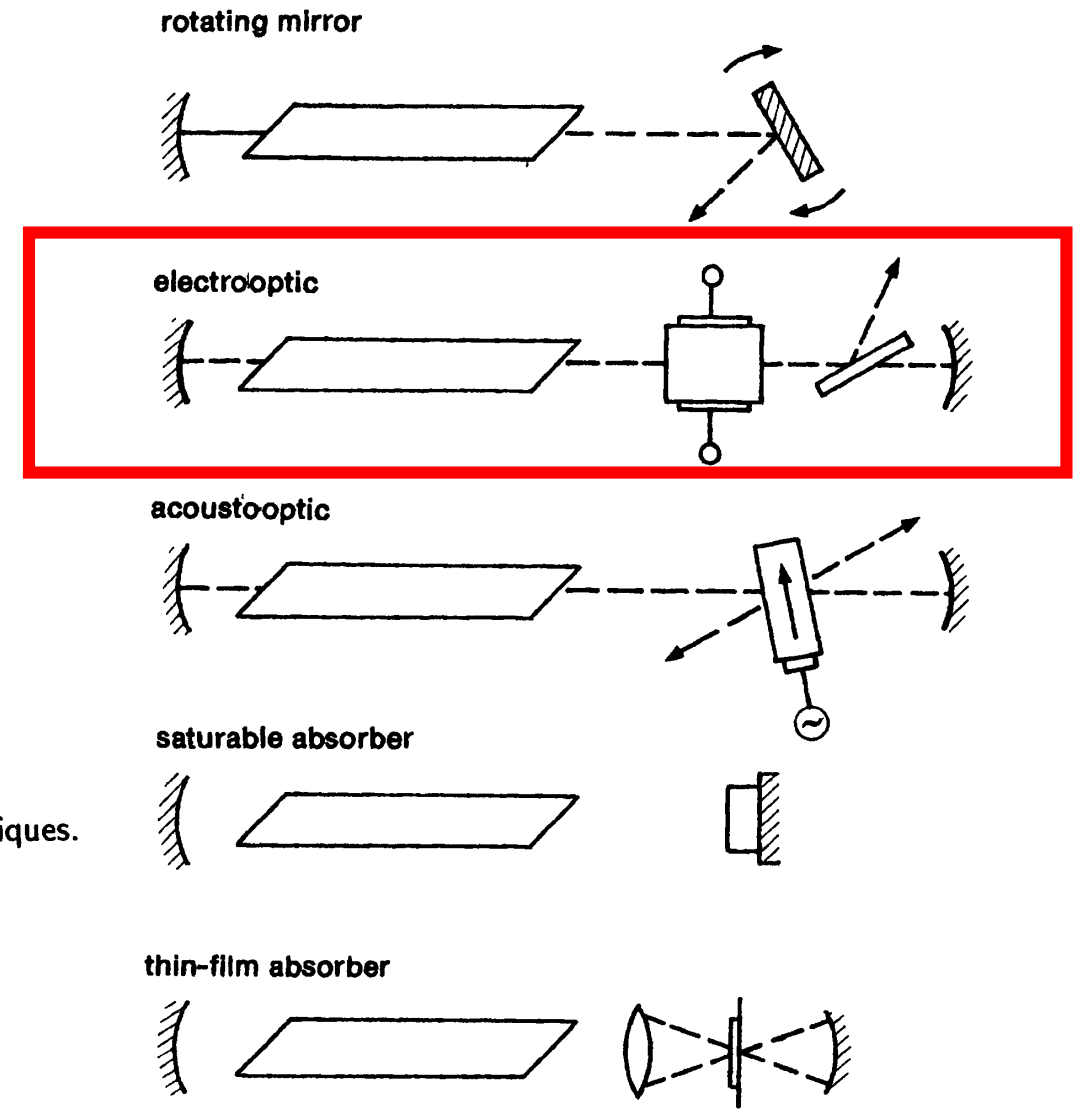


FIGURE 26.2
Laser Q-switching techniques.

Pulsed lasers- Q-switch

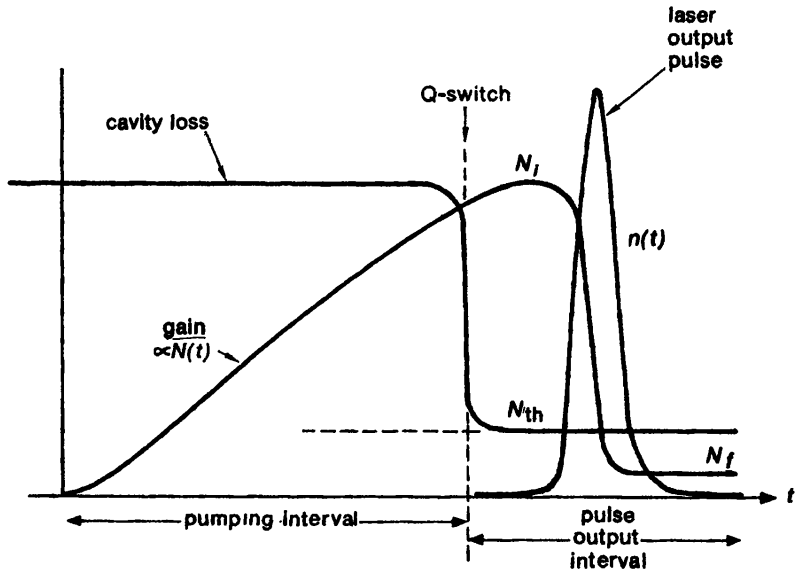


FIGURE 26.3
Schematic illustration of the Q-switching process in a pulse-pumped and Q-switched laser oscillator. In a real laser the pumping interval will typically be much longer than the pulse output interval

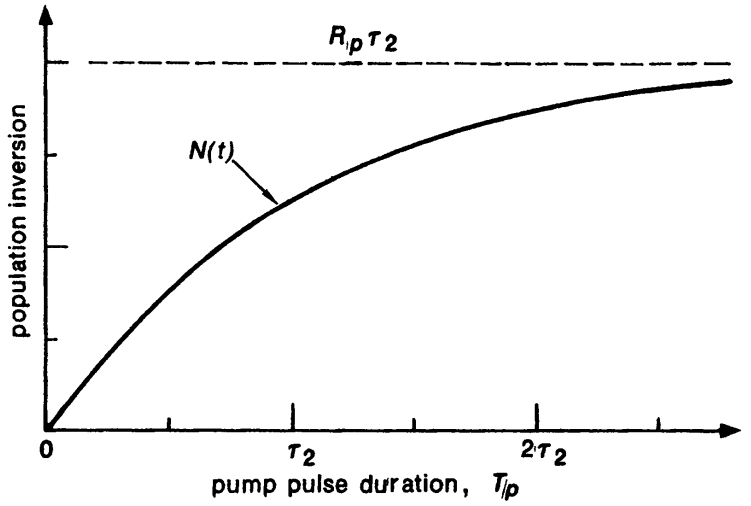


FIGURE 26.4
Energy storage during the pumping interval for a fixed pumping rate.

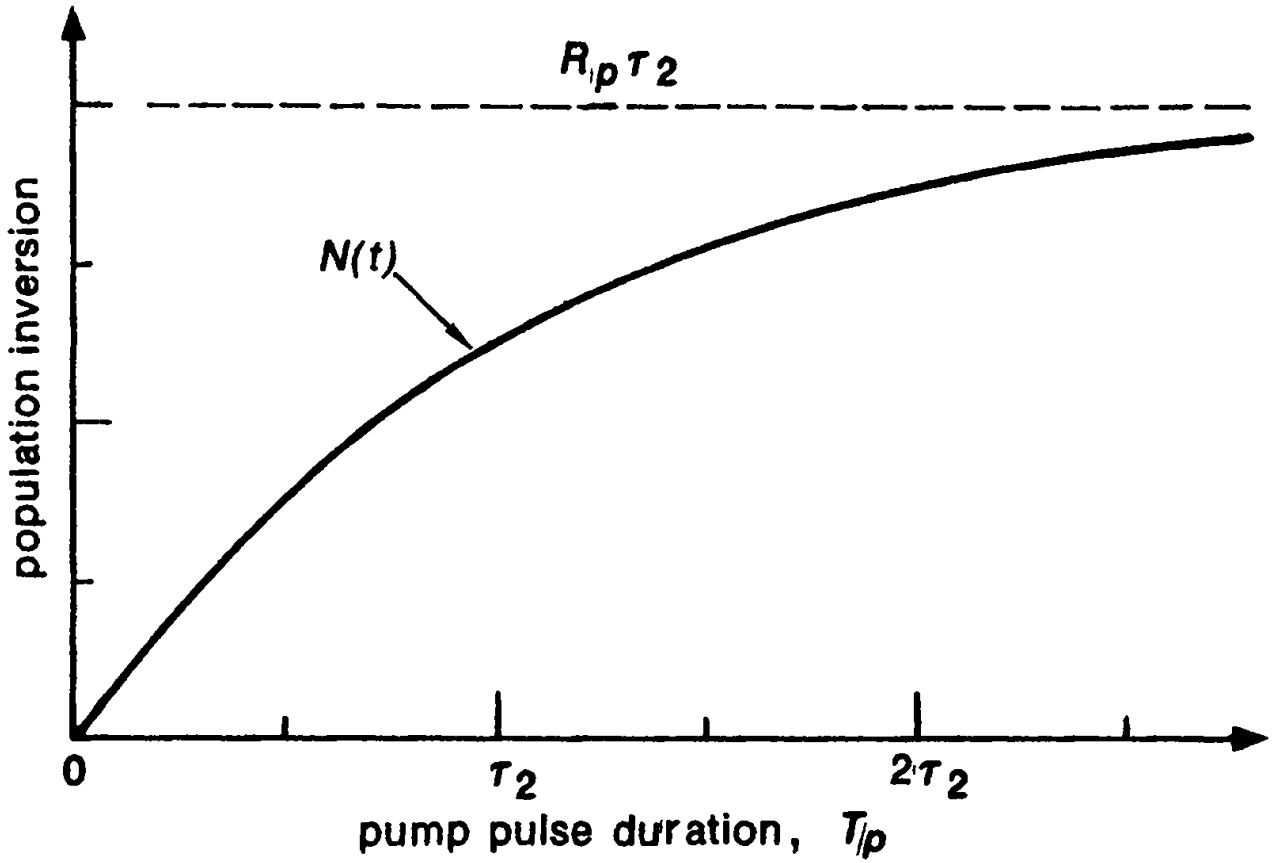


FIGURE 26.4
Energy storage during the pumping interval for a fixed pumping rate.

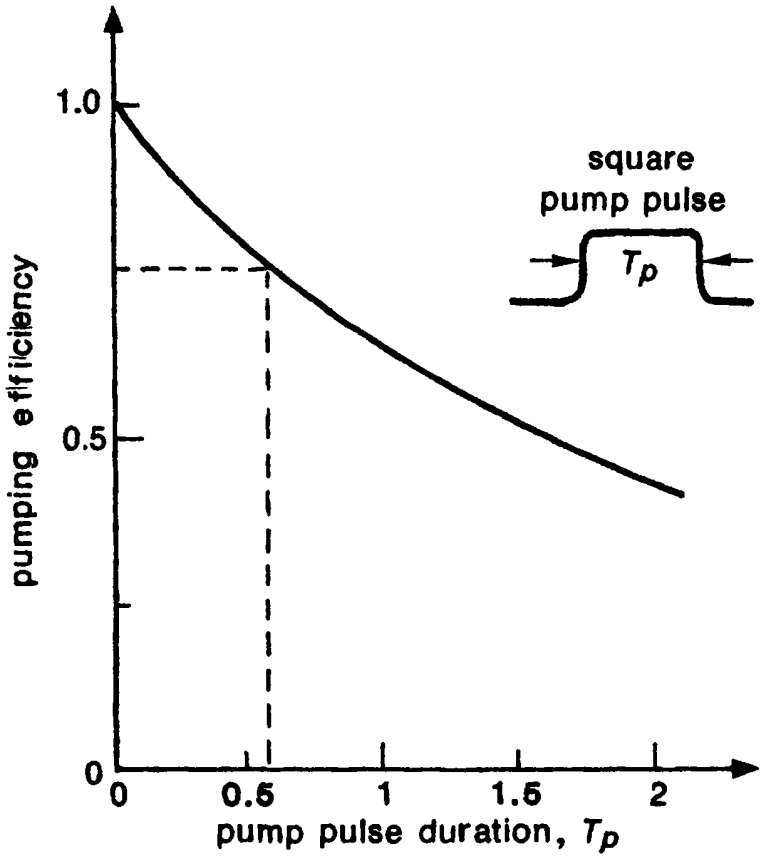


FIGURE 26.5
Pumping efficiency versus pump pulse duration for a fixed total pump energy.

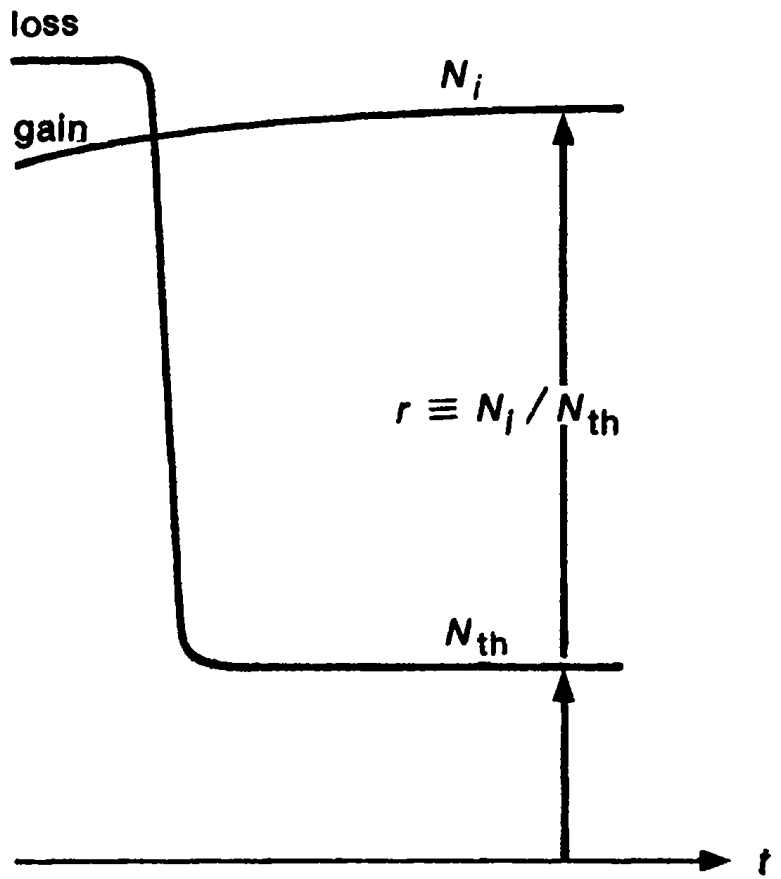


FIGURE 26.6
Inversion values and inversion ratio just after the Q-switch is opened.

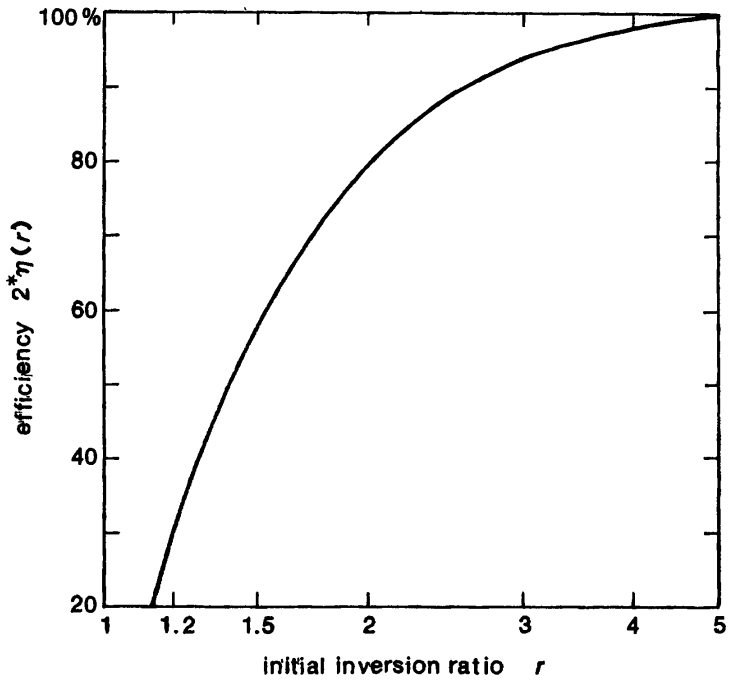
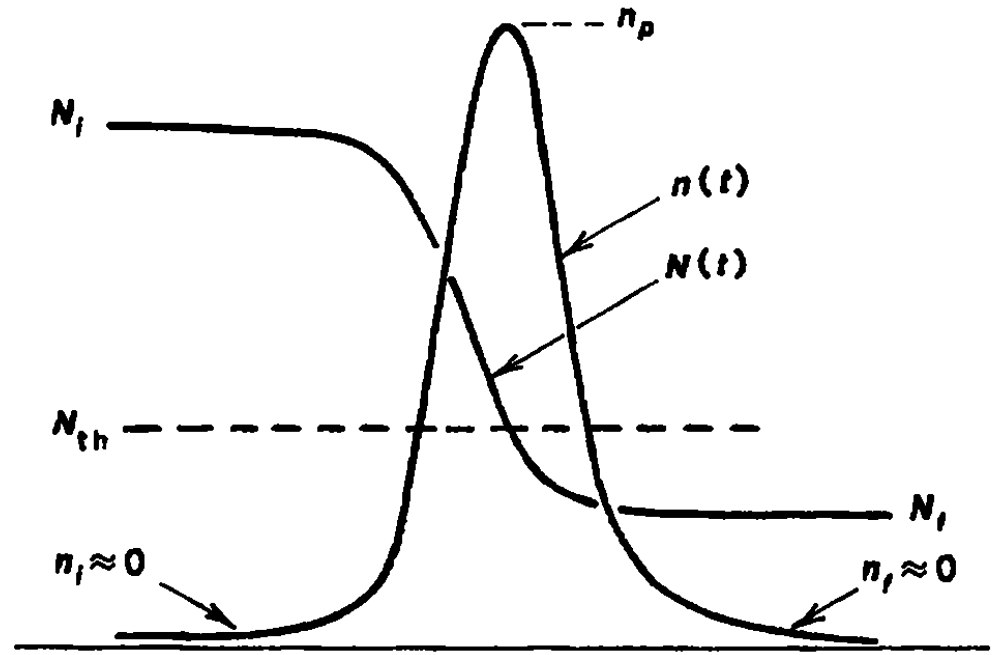


FIGURE 26.8
Energy-extraction efficiency in a Q-switched laser as a function of the initial inversion ratio.

FIGURE 26.7
Variations of $n(t)$ and $N(t)$ during the pulse output interval.



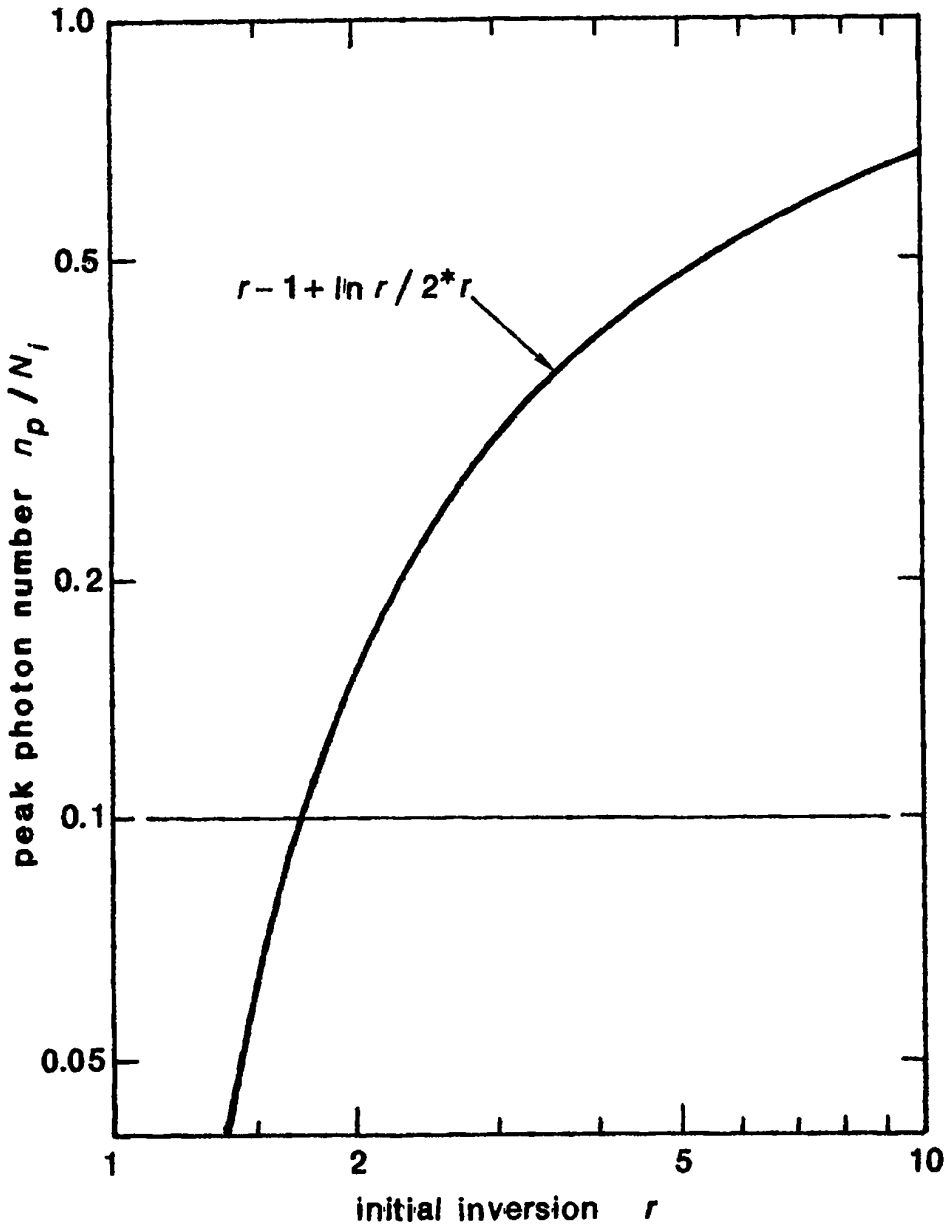


FIGURE 26.9
Peak photon density in a Q-switched laser.

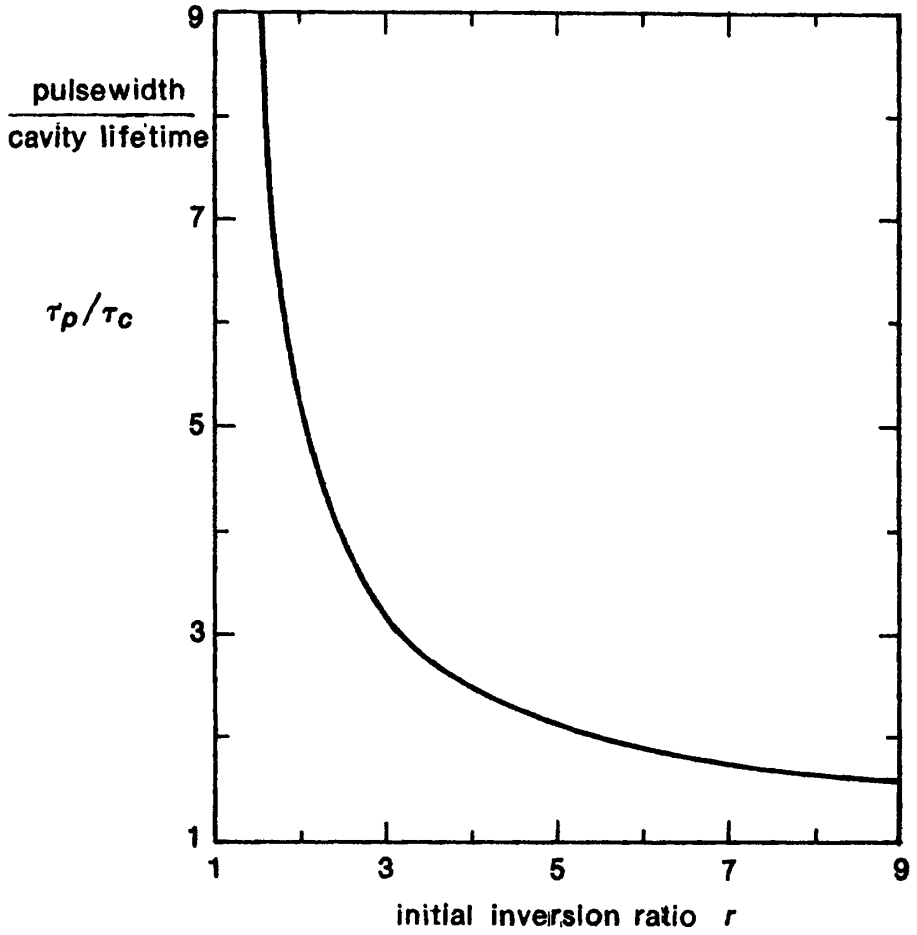


FIGURE 26.11
Q-switched pulsewidth versus initial inversion ratio.

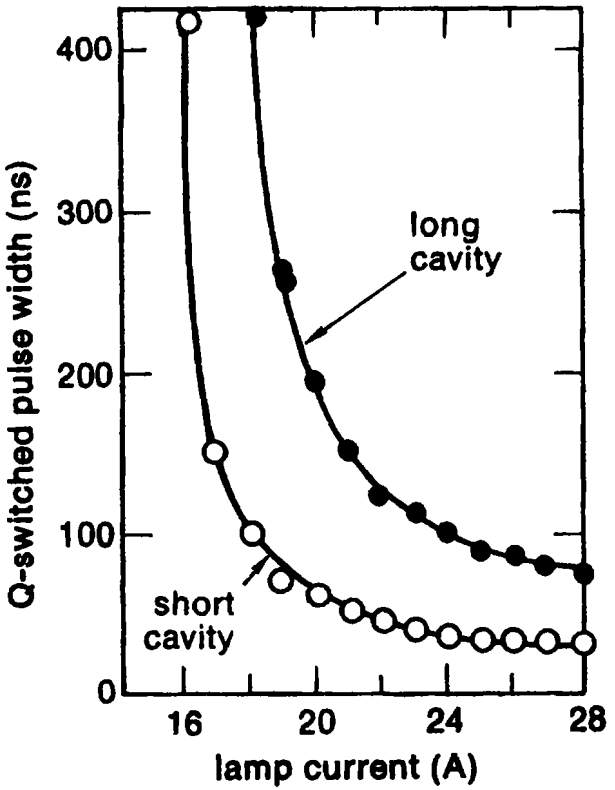


FIGURE 26.12
Pulsewidth versus pumping rate in two typical Q-switched Nd:YAG lasers.

Figure 26.12 shows experimental measurements of the Q-switched pulsewidth versus lamp current in the same two Nd:YAG lasers shown in Figure 26.10. It is evident, as predicted, that the pulsewidth decreases rapidly with increasing pump power or initial inversion r. Moreover, since the two laser cavities use the same laser rod and the same mirror reflectivities, the shorter cavity should have a correspondingly shorter cavity lifetime τ_c and hence a shorter pulsewidth τ_p, exactly as illustrated by the data.

Numerical Solution for Q-switched pulse shape

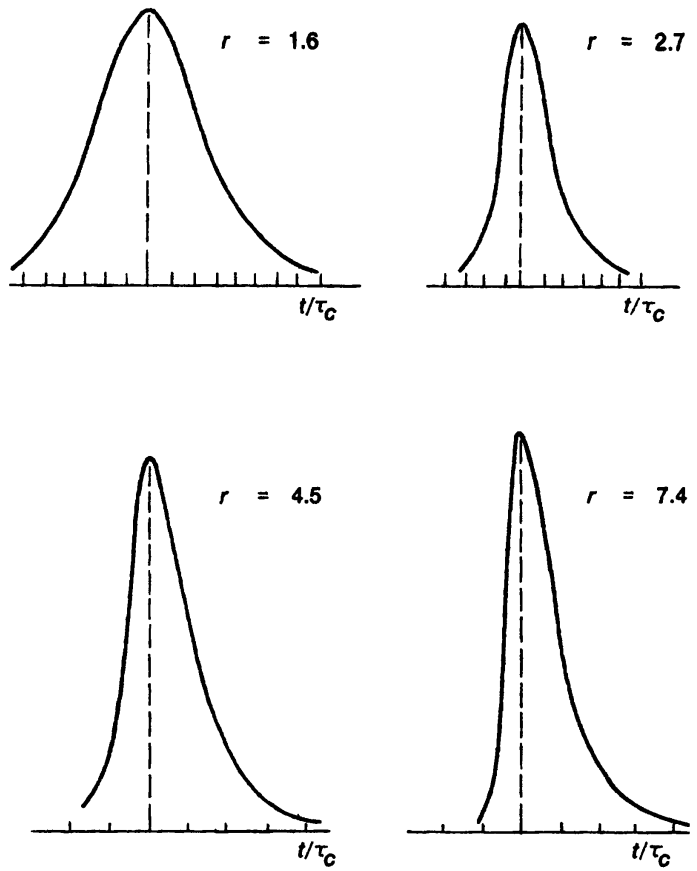


FIGURE 26.13
Exact Q-switched pulse shapes.