A Q-SWITCHED NEODYMIUM GLASS LASER

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A description is given of a neodymium glass laser which emits two pulses with a total energy of 8 Joules and a pulse duration of from 25 to 43 nsec. A method for shortening the pulse length and decreasing the number of pulses used is proposed.

WE have investigated a Q-switched neodymium glass laser. Neodymium glass is an extremely attractive material for use as the working substance of a Q-switched laser. The concentration of neodymium ions in glass is usually two orders of magnitude larger than the concentration of chromium ions in ruby, and hence a unit volume of neodymium glass may store a correspondingly larger amount of energy. If the pumping is sufficiently powerful, the neodymium laser will be shorter than a ruby laser and hence the inhomogeneity of the glass and the inhomogeneity due to heating will have less effect on the laser power. Furthermore, glass is more uniform than ruby.

Investigation of the mechanisms for producing extremely short light pulses in neodymium glass is interesting not only from the practical but also from the physical point of view. As was shown by Hellwarth, Q-switching allows one to study the nature of the line broadening[1].

We used a rotating prism to switch the cavity Q[2]. The experimental arrangement is shown in Fig. 1. The roof prism was rotated on a DID-2TA motor at 30 000 rpm. The neodymium glass rod G was 120 mm long, 9 mm in diameter and had a Nd_2O_3 concentration of 6%. The pump excitation was provided by a spiral lamp with a 10 kJ energy per pulse and a 600 μsec duration between the 0.3 power points. The output mirror M was a plane parallel plate made of uncoated K-108 glass.

Two glass plates P_1 and P_2 deflected the laser

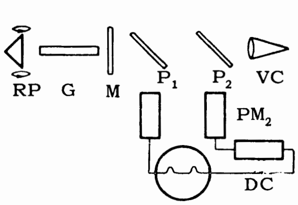

FIG. 1

output onto two photomultipliers PM_1 and PM_2. PM_1 was used to trigger a fast oscilloscope (S1-14); the output of photomultiplier 2 was sent through a delay cable DC and then to the oscilloscope to display the signal. We used FÉU-15 photomultipliers. The transfer characteristics of these photomultipliers have been studied using a Q-switched ruby laser[3]. The FÉU-15 can provide an output pulse no longer than 20 nsec between half-power points. The energy of the laser emission was measured with a vacuum calorimeter VC[4].

The emission consisted of two pulses of approximately equal amplitude 45 nsec between half-power points with from 260-450 nsec between pulses. Under these circumstances the total output energy was 1.5 J.

The laser pulse was sent through a laser amplifier consisting of three neodymium glass rods placed beyond the output mirror M of the cavity. The total length of the amplifying rods was 32 cm. The same kinds of lamps were used to excite the amplifiers and the laser.

In order to prevent the occurrence of ordinary laser action in the amplifier, the end faces of the rods were prepared so as to make an angle of 30′ with respect to each other. The output energy of the whole system was 8 J. Initially two emission pulses 25 to 43 nsec long were observed. Oscilloscope pictures of the pulses from the amplifier and the laser are shown in Figs. 2a and 2b respectively (t_0 is an arbitrary time). The beam from this laser can cause breakdown in air if it is focused with a lens having a focal length up to 70 cm. The beam divergence is not greater than 6′.

In order to increase the speed of Q-switching we employed the following laser variant (see Fig. 3). The totally internally reflecting right-angle prism RP_1 was arranged so that beams perpendicular to the mirror were incident on one of

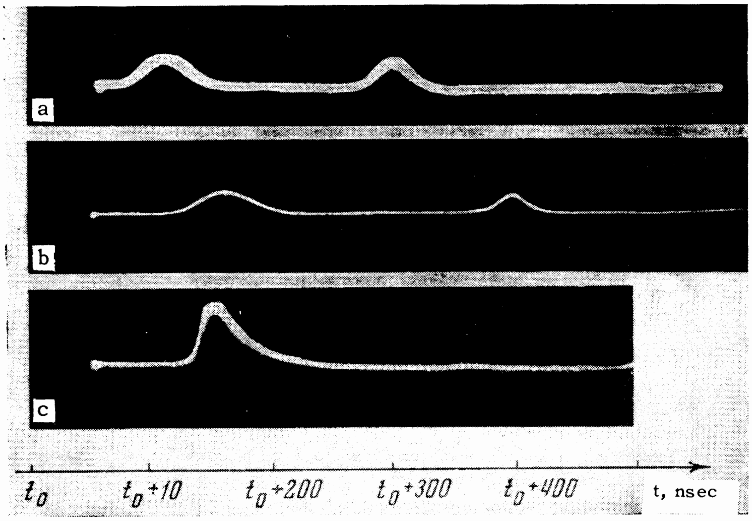

FIG. 2

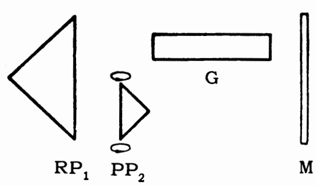

FIG. 3

its faces at an angle almost equal to the angle of total internal reflection. The prism RP_1 thus served to provide increased angular discrimination and hence increased the rate of Q-switching. The edges of the prism RP_1 and the rotating prism RP_2 were mutually perpendicular. G is the neodymium glass rod.

In this experiment a single pulse of variable shape was observed. An oscillogram of this pulse is shown in Fig. 2c. The duration of the pulse between half-power points was 38 nsec and the energy was 1 J. If one were to employ a more complicated arrangement, for example, using a Lummer-Gehrcke plate as was done by Daley and Simms[5], one could hope for additional pulse shortening.

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