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Letters to the Editor

Neodymium glass laser emitting an ordered sequence of light pulses*

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Neodymium glass laser operating in the free-generation mode emits an irregular sequence of light pulses with total duration ranging from about 100 μm to a few miliseconds. Such a laser is a light source not always suitable for studying various phenomena occurring when high-power light beams interact with the matter, i.a., with metals. A generation of capillary waves in the irradiated region of the molten metal [1–4] is one of such phenomena. When studying mechanisms of the wave generation, a source emitting an ordered sequence of high-power light pulses is very useful.

In order to obtain single pulses or an ordered sequence of short and high-power light pulses various methods of loss modulation (resonator Q-factor modulation [5–8]) are used in laser optics.

By introducing losses changing periodically and fast into the resonator the emission of the gathered energy during optical pumping in the form of an ordered sequence of light pulses with a given duration may occur. This method

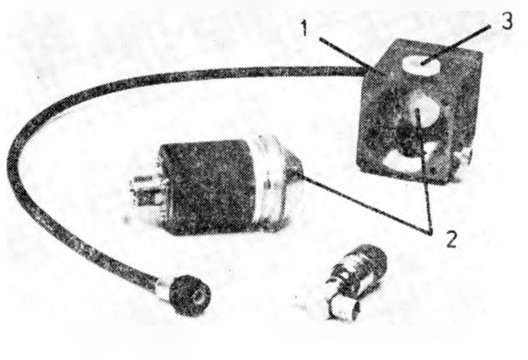

Fig. 1. SRQ-modulator elements: 1 – modulator frame, 2 – aluminium cases of transducers, 3 – optical window

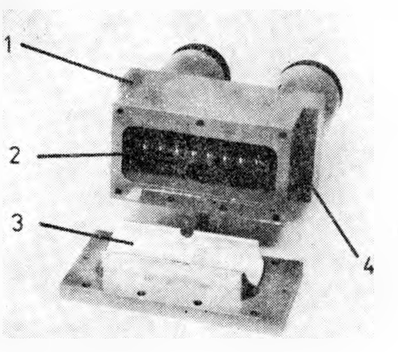

Fig. 2. Laser-head elements: 1 – laser-head frame, 2 – CQX12S10A spiral lamp, 3 – reflector, 4 – active medium

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of loss modulation can be realized, i.a., with a supersonic resonator Q-factor (SRQ) modulator [6–15].

The frame of SQR modulator designed and made by us (Fig. 1) was a brazen vessel of a cubic shape with the segments 54 mm long. In the brazen frame appropriate holes were drilled serving for mounting transducers and BK-7 optical-glass windows allowing the light to pass through the supersonic field. The modulator was filled with CCl_4. Piezoceramic transducers operated in the push-pull system, their resonance frequency ranging from 750 to 830 kHz. When testing the device it appeared that the modulator can also operate in a frequency range of about 40 kHz–10 MHz.

In order to obtain the laser emission characterized by time ordering of light pulses (or reproducibility) a neodymium glass laser was built and the modulator made by us was placed into the laser resonator. The laser resonator was formed by two mirrors with transmittivities of $T_1 = 0\%$ and $T_2 = 40\%$ which were placed at a 250 mm distance. In the investigations a laser lead (Fig. 2), was used in which Verre et Quartz VOX 12S10A pumping lamp with E-type electrodes could be mounted elastically (with a simering) according to the producer's instructions. The 130 mm-long ΓΩC–1 glass rod of 6 mm diameter, with mutually parallel bases and mat lateral surface, mounted along the lamp axis, constituted the active medium. In order to enhance pumping efficiency a cylindrical reflector surrounding the lamp spiral was applied. The laser head and other elements used in the investigations were mounted on tables which made it possible to move these elements smoothely in horizontal and vertical planes and to turn them round vertical and horizontal axes.

Besides the wavelength of the emitted radiation which must be known in order to study physical mechanism of the processes accompanying interactions

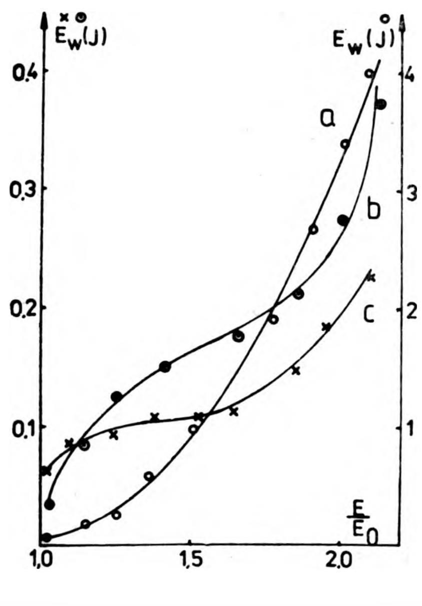

Fig. 3. Energy (E_w) emitted by the laser as a function of pumping energy E. a – SRQ modulator removed from the resonator, threshold pumping energy $E_0 = 1460$ J, b – SRQ modulator placed in the resonator ($U_m = 0$ V, $E_0 = 1250$ J); the modulator filled with CCl_4, c – SRQ modulator placed in the resonator ($U_m = 6$ V, $f = 816$ kHz, $E_0 = 1460$ J)

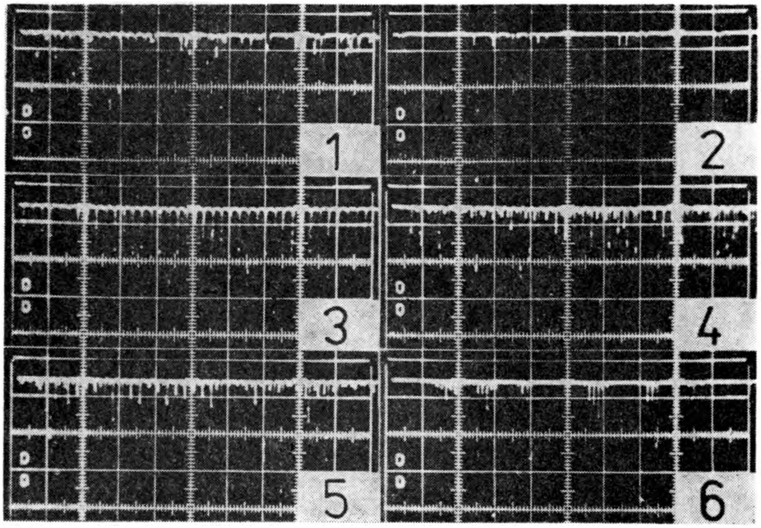

Fig. 4. Emission oscillograms of the neodymium glass laser operating with SRQ modulator ($U_m = 6$ V, $f = 816$ kHz). Photograph 1 taken for pumping energy E 2.08 times higher than the threshold energy E_0, the remaining photographs are for the respective ratios of E/E_0: 1.88, 1.68, 1.50, 1.32 and 1.15. Time base of oscilloscope equaled 5 μm/div

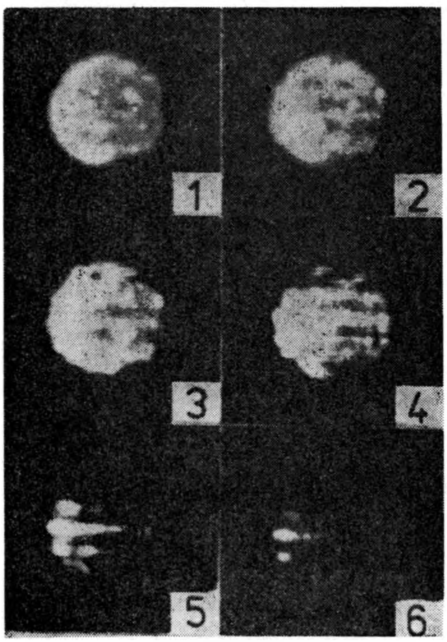

Fig. 5. Beam traces (in near field) of the neodymium glass laser operating with the SRQ modulator ($U_m = 6$ V, $f = 816$ kHz). Photograph 1 taken for $E/E_0 = 2.08$, and remaining photographs, for $E/E_0 = 1.88$, 1.68, 1.50, 1.32 and 1.15, respectively

between high-power laser radiation and metals, other main parameters of the laser emission, are the following: emission energy, its time characteristics and beam cross-sectional power distribution or beam trace at its cross-section [16, 17].

For measurements of the above parameters of the neodymium glass laser operating with SRQ modulator, the apparatus and procedure of the investigations presented in [18] were used.

A large number of investigations and measurements of these parameters for various pumping energies (E), voltage amplitude (U_m) feeding the transducers, and its frequency (f) were performed. Some of the obtained results are shown in Figs. 3, 4 and 5.

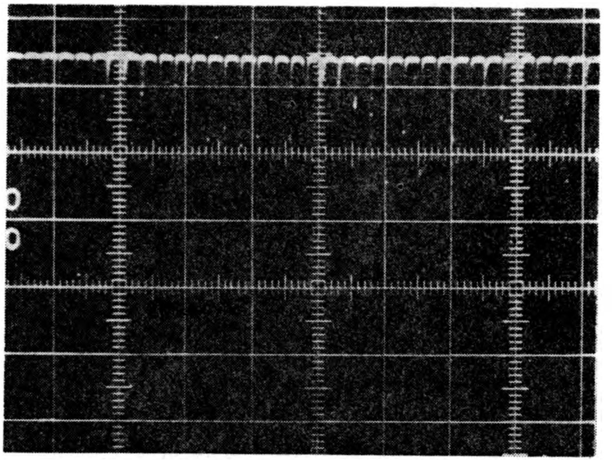

Fig. 6. Emission oscillogram of the laser used in the investigations presented in [3] (enlarged photograph 3 from Fig. 4)

The radiation emission most useful for our investigations on capillary wave generation was obtained for $E = 1.68\ E_0$, $U_m = 6$ V, $f = 816$ kHz. The laser built by us then emits a light pulse with total duration of 0.8 ms and with energy of 0.13 J. This pulse exhibits a scintillation ordering (Fig. 5), the scintillation duration and reproducibility frequency being 0.6 μm and 0.8 HMz, respectively. In the region of steel irradiated with the ordered sequence of light pulses, capillary waves [3] were generated. Then, there probably arises a periodical reaction force of vapourizing metal, acting on the surface of the molten region, which is perhaps one of the reasons of the occurrence of the capillary waves observed by us.

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