pump power density at high dye concentrations amounted to not more than 1 MW/cm^2 and could be lowered by using a cell of good quality. At near-threshold pumping the lasing pulse consists of several spikes each 5 -- 7 nsec long.

An estimate of the gain in the dye at high concentrations yields a value not less than 10 cm^{-1}. At such a high gain, naturally, lasing of the dye occurs in a resonator made up of only the glass walls of the cell, as was indeed observed by us experimentally. The divergence of the dye-lasing beam did not exceed 10^{-2} rad under the conditions of our experiment. The polarization of the lasing radiation was predominantly perpendicular to the polarization of the pump radiation. The lasing of a polymethine dye explains the changes of the shape of a neodymium-laser pulse passing through a cell with dye, observed in our experiments [3][2] the smooth pulse passing through the cell acquires a complicated form with several intensity dips. Indeed, the power density of the neodymium laser in [3] (100 MW/cm^2) is sufficient at the employed concentrations (7×10^{16} cm^{-3}) to excite lasing of the dye by the glass walls of the cell. The lasing occurring in the cell changes in the transmission of the dye, and consequently also the pulse shape.

Analogous pulse shape changes connected with the dye-lasing were observed by us also in the output radiation of a laser in which the polymethine dye was used as a passive shutter for Q-switching.

[2] V. I. Malyshev and A. S. Markin, Zh. Eksp. Teor. Fiz. 50, 1458 (1966) [Sov. Phys.-JETP 23, 968 (1966)].
[3] N. G. Basov, V. S. Zuev, P. N. Kryukov, V. S. Letokhov, Yu. V. Senatskii, and S. V. Chekalin, ibid. 54, 767 (1968)[27, 410 (1968)].
[4] N. G. Basov, V. S. Zuev, and Yu. V. Senatskii, ZhETF Pis. Red. 2, 57 (1965) [JETP Lett. 2, 35 (1965)].

CERTAIN EXPERIMENTS WITH WATER AT HIGH PRESSURES AND TEMPERATURES

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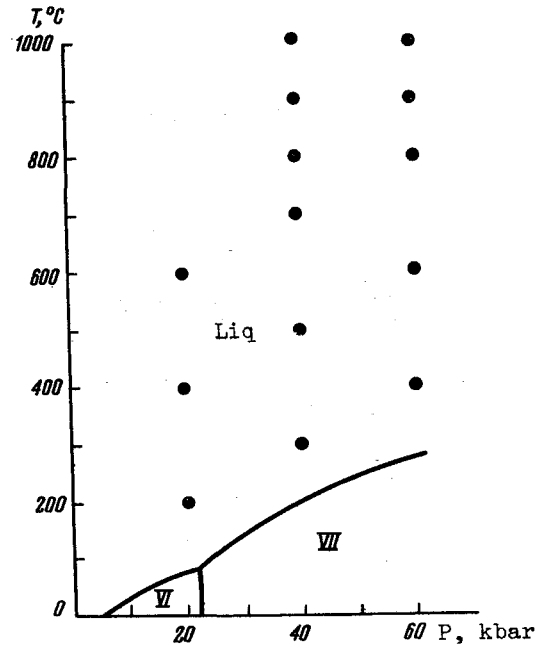
B. V. Deryagin and co-workers [1, 2] reported recently that they obtained so-called "anomalous" or "modified water," which differed greatly from ordinary water in its physical and chemical properties. Judging from the increased viscosity, the higher density, the larger coefficient of thermal expansion, and the sharply reduced saturated-vapor pressure, the authors propose that the changes in these properties are due to the presence of a different structure, determined by the polymerization of the normal molecules of the water [2].

Taking into consideration the much higher density (by approximately 40%) of "modified water," one might attempt to obtain this liquid by applying high pressure, all the more since P. Bridgman advanced at one time [3] the hypothesis that liquid water under pressure

[2] The polymethine dye was used in [3] as a saturable filter to decouple the amplification stages in a powerful neodymium-glass laser.



Phase diagram of water after [5,6]. The points correspond to the conditions of our experiments.

can have a definite peculiar structure.

A procedure developed in recent years, which permits investigations of liquids at pressures up to 120 kbar and at temperatures up to 2000°C [4], has made it possible to set up a series of experiments in order to obtain a dense water modification, analogous to the "anomalous water" described in [1, 2]. The experiments were performed at pressures up to 60 kbar in the range from room temperature to 1000°C. Triply distilled water was poured into a hermetically sealed platinum ampoule of 0.6 ml capacity, which was then placed in a high-pressure chamber and served simultaneously as the heater.

The figure shows part of the phase diagram of the water, corresponding to the pressure and temperature region used in the experiments (the diagram is based on the data of P. Bridgman [5] and Pistorius and co-workers [6]). It is seen that at a pressure close to 10 kbar and room temperature the water freezes to form ice-VI, which experiences a polymorphic transformation into ice VII with further increase of pressure to 22 kbar. Accordingly, all the attempts at obtaining "modified water" reduced to shifting the system into the region of the existence of the liquid phase by creating the necessary pressure and subsequent heating to the required temperature. The chamber was maintained at specified conditions (see the points on the diagram) for two hours, after which the temperature and pressure were reduced to normal by two methods. In first case, the temperature was decreased after exposure to the working conditions at a specified pressure, at a rate of 100 deg/min, to approximately the melting point of the ice, but without reaching it. Both parameters were then further decreased such as to exclude the formation of the solid phase, i.e., the system returned to the normal conditions along the melting curves of both ice modifications. In the second case, the working temperature was decreased directly to room

temperature either at the same rate of 100 deg/min, or by quenching at a rate of 200 deg/sec, leading to crystallization of the ice, which melted after the removal of the pressure. The return of the system to normal conditions by the two different methods, i.e., via the solid phase and bypassing the solid phase, was dictated by the possible appearance of kinetic singularities of the phase transformations in the water, connected with the choice of the direction along which the interchange of the liquid and solid phases takes place [3].

The controlled parameter of the water before and after the experiments was the refractive index, which is known to be linearly connected with the density[1)], the measurements being performed with a refractometer with accuracy to 0.001.

It was established that in none of the experiments did the produced liquid have a refractive index different from that of the initial triply distilled water.

Taking into account the indications of the authors of [1, 2] concerning the possible role of the quartz surface as a substrate in the formation of the "modified water," several experiments were performed with quartz powder added in the working vessel. These experiments, however, did likewise not lead to the production of the sought phase.

Analysis of the conditions of formation of "modified water" in the experiments of [1, 2] shows that its chemical potential cannot be much higher than the chemical potential of ordinary water at the same values of P and T, which are close to normal. Consequently, from the thermodynamic point of view, the water should go over completely into the modified state at room temperature even at pressures on the order of 1 -- 5 kbar. In our experiments the water was compressed to a state in which its density became higher than the density of the "anomalous water", the temperatures attained in this case exceeded the values 700 -- 800°C needed in accordance with [2] to overcome the kinetic barrier between the ordinary and modified gas phases at low pressures. It is possible that in this case the pressure in the unfavorable kinetic factor, since it is known [7] that it is capable of both accelerating and hindering the polymerization process to which the authors of [2] attribute the formation of "modified water."

[1] B. V. Deryagin, S. V. Nerpin, and M. A. Arutyunyan, in: Issledovaniya v oblasti poverkhnostnykh sil (Research on Surface Forces), 1967, p. 11.
[2] B. V. Deryagin, I. V. Churaev, N. N. Fedyakin, M. V. Talaev, and I. G. Ershova, Izv. AN SSSR ser. khim. No. 10 (1967).
[3] P. Bridgman, The Physics of High Pressure, Bell, 1949.
[4] N. A. Bendeliani, S. V. Popova, and L. F. Vershchagin, Geokhimiya, No. 5 (1966).
[5] P. W. Bridgman, J. Chem. Phys. 5, 964 (1937).
[6] C. W. Pistorius, J. P. Blakey, and L. J. Admiraal, ibid. 38, 3 (1963).
[7] M. G. Gonikberg, Khimicheskoe ravnovesie is skorost' reaktsii pri vysokikh davleniyakh (Chemical Equilibrium and Reaction Rates at High Pressures), AN SSSR, 1960.

[1)] According to a communication from B. V. Deryagin, such a dependence was observed also in the case of "modified water."