observed, indicating that the plasma batches produced in the spikes of the laser generation move rapidly. When a magnetic field is produced (with mirror or anti-mirror configuration) near the target, the overlap becomes stronger and longer, this being attributed to an increase in the plasma concentration resulting from limitation of leakage or from accumulation.

A 15-turn coil of 40 mm diameter located 7 cm away from the target in the vacuum was used to register the diamagnetic signals. Figures 1d and 1e show the characteristic diamagnetic signal from the plasma of a titanium target for magnetic fields of different magnitudes and different configurations. Individual bursts of diamagnetism from plasmoids emitted by strong spikes can be seen. The diamagnetic signal for not very weak fields decreases with increasing magnetic field like ~1/H, apparently indicating that the pressure due to the magnetic-field gradient limits the transverse dimension of the plasma jet or that the magnetic field suppresses the diamagnetism and the conductivity of the plasma.

The results show that a sufficiently dense and long-lived plasma can be obtained with the aid of non-Q-switched lasers, and that such a plasma interacts quite strongly with magnetic fields and radio waves; it can be used to produce antennas, reflectors of directional elements, magnetohydrodynamic devices, sources of sets of plasmoids from many radiation spikes, etc.

FORMATION OF SHOCK WAVES WITH THE AID OF POWERFUL LASER RADIATION

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When radiation of density exceeding 10^{11} W/cm^2 (corresponding to a focused Q-switched laser beam) interacts with the surface of a solid target, a plasmoid (flare) heated to hundreds of thousands of degrees is produced [1,2]. After the termination of the laser pulse, the flare scatters in vacuum with a speed $\sim 10^7$ cm/sec, and at the end of the laser pulse the internal energy and the energy of kinetic motion of the heated matter constitute comparable fractions of the total heating energy [3,4]. From the physical point of view, it is of interest to use also the kinetic part of the energy to heat the substance.

We have investigated the scattering of a flare in air at a pressure of several millimeters mercury. With this, formation of a strong nearly-spherical shock wave was observed. The shock waves were recorded by shadow photography [2] in the beam of a ruby laser synchronized with neodymium, the radiation of which was used to heat the substance. The ruby-laser beam was divided into five beams which, after passing through an optical delay, converged in the plane of the film in such a way that five spatially-separated frames were obtained on the film. The frame exposure was equal to the ruby-laser pulse duration (3 nsec), and the instant of exposure was determined by the path of the corresponding beam to the flare.

Figure 1 shows a five-frame shadowgram of the shock wave produced by expansion of the flare in air at a pressure of 2 mm Hg. The neodymium-laser radiation energy was 6 J at a pulse duration 15 nsec. The frames follow in 50-nsec intervals, the fifth frame being in the center. Starting with the second frame we see a spherically-diverging shock wave produced on the edge of the flare. The front velocity at a radius of 1 cm is 1.8×10^7 cm/sec. The width of the shock does not exceed 0.3 mm.

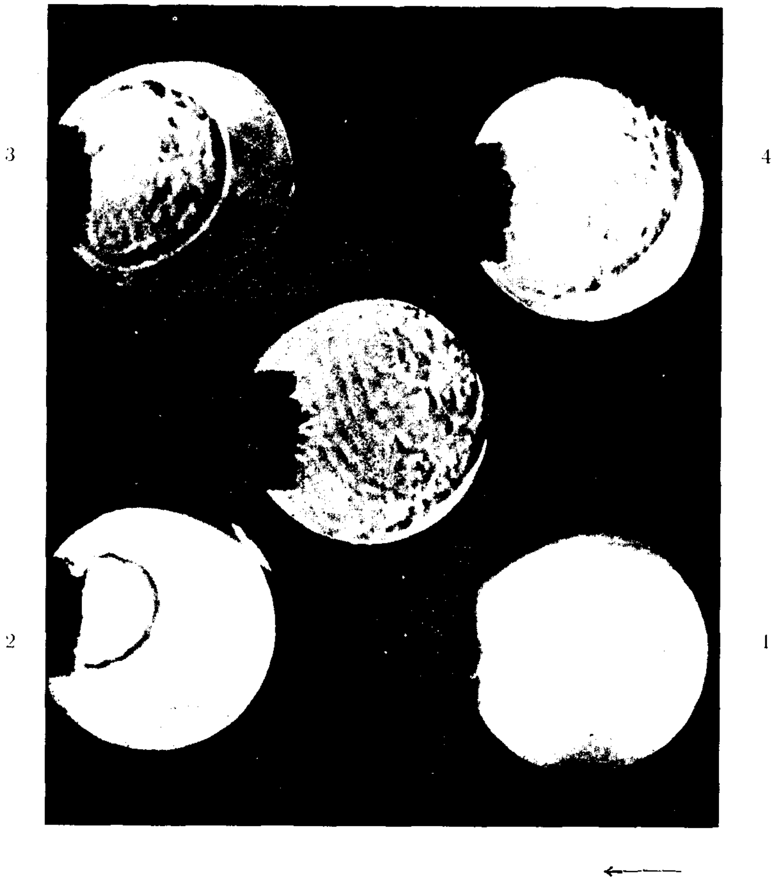

Fig. 1. Shadowgram of shock wave in air. Carbon target. The numbers indicate the numbers of the frames. The first frame corresponds to the end of the pulse of the neodymium laser. The arrow indicates the direction of the neodymium-laser beam. The illuminating ruby-laser beams were directed perpendicular to the plane of the figure.

An interferometric investigation of the plasma produced when the gas is heated by the shock wave has shown that the effective charge of the ions is $z \approx 5$ (for air). The motion of the wave front during the last stage corresponds approximately to self-similar motion of a spherically-diverging shock wave from a point explosion in a homogeneous atmosphere. The temperature can be estimated by using the calculations for a strong shock wave [5] and the experimentally determined value of the effective charge. In our case the temperature in the shock wave is ~50 eV.

The propagation direction and the form of the shock wave are determined by the geometric form of the surface of the target. This makes it possible to form shock waves of specified configuration. In particular, for inclined incidence of the radiation on the surface of the target, the wave front retains its form and moves symmetrically relative to the normal to the surface. This indicates that the light radiation has little influence on the dynamics of the flare motion. This circumstance greatly facilitates the realization of experiments on shock-wave collision. Figure 2 shows a shadowgram of the collision of two shock waves, obtained by focusing two laser beams on the surfaces of a target in the form of an open book with 90° angle. The radiation energy in each beam is 1.5 J and the duration is 15 nsec. Increased density and velocity are observed in the plane of convergence of these waves.

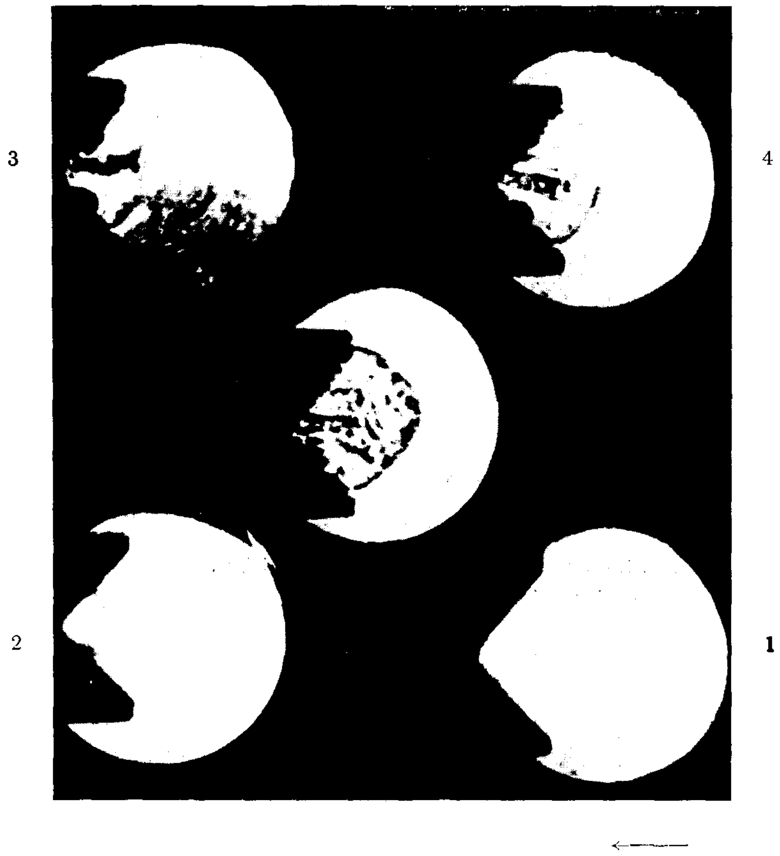

Fig. 2. Shadowgram of collision of two shock waves. Distance between beam focusing points 7 mm. All other photography conditions are the same as in Fig. 1.

Thus, it is possible to produce shock waves with the aid of laser emission, including converging waves (spherical and cylindrical), with velocities close to the limiting values obtained [6] in modern electric-discharge devices and with different configurations, making it possible to effect energy cumulation as a result of scattering of heated matter and to study high-temperature cumulation effects [7] produced when shock waves are focused.

A more detailed description of the procedure and of the results of the investigation of the dynamics of heating and scattering of a plasma produced by focusing powerful laser radiation on a solid will be published in a separate article.

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ANGULAR DEPENDENCE OF THE BRIGHTNESS OF STREAMER TRACKS

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It was shown in [1] that a streamer chamber can be used to measure the ionizing ability of charged particles, and that the most characteristic parameter defining the ionizing ability is the track brightness.

However, when particles having a definite ionizing ability pass through the chamber when the latter is in a fixed operating mode, the track brightness is a function of the angle α between the particle trajectory and the electric-field intensity vector $\vec{E}$. We have investigated the character of the variation of the brightness of streamer tracks varying the angle α, and also the dependence of the limiting angle α_n on the ionizing ability of the charged particles (α_n - angle at which the chamber operation goes over from the streamer mode to the tracking mode). To determine the influence of the duration of the high-voltage pulse on these characteristics, the measurements were made at two high-voltage pulse durations ($\tau_1 \approx 40$ nsec, $\tau_2 \approx 42$ nsec), and at electric field intensities $\vec{E} = 10$ kV/cm.

It is known that streamer development occurs during the last few nanoseconds of the total track-formation time τ. Taking furthermore account of the fact that the brightness of the track increases sharply with increasing streamer, it becomes clear that even as small a difference in the pulse duration as 2 nsec greatly affects the total brightness of the track. Protons of known energy were passed through a chamber filled with neon to a pressure of 1 atm at a definite angle α. The angle was varied by rotating the chamber relative to the beam. The photography was carried out in two projections, A and B (Fig. 1). The obtained images of the streamer tracks in the projection A were measured with a microphotometer (MF-4), after which the logarithmic density D was calculated.

At present there is no rigorous theory describing the mechanism of formation of inclined tracks in spark chambers. However, a semiqualitative analysis of these questions [2-5] indicates that the angle α_n depends on the operating mode of the spark chamber, namely, α_n increases with increasing amplitude and with decreasing duration of the leading front of the high-voltage pulse. In addition, it is noted in these papers that α_n should depend also on the ionizing ability of the particles.

Our experimental data are listed in the table. It is seen that with decreasing α the track brightness first increases relatively slowly, and then when $\alpha \sim \alpha_n$ the brightness increases sharply, although subsequently it reaches saturation at small angles. It is also seen from the table that α_n depends on the ionization, too. Indeed, $\alpha_n \sim 58°$ when $I = 1.2I_{min}$