Since $a_1 > U > c_0$ for all materials in which a shock wave is possible, the quantities A and B are positive. Then it follows from (3.10) that when $V_2(p) > V_1(p)$ the shock wave will accelerate if $(\partial p/\partial t)_h > -B(V_2 - V_1)\partial\alpha/\partial t$ and die out if $(\partial p/\partial t)_h < -B(V_2 - V_1)\partial\alpha/\partial t$. When $V_2(p) < V_1(p)$ the shock wave will die out if $(\partial p/\partial t)_h < B(V_1 - V_2)\partial\alpha/\partial t$ and accelerate if $(\partial p/\partial t)_h > B(V_1 - V_2)\partial\alpha/\partial t$.

One can see that in both cases the wave will be steady if the change in state behind its front corresponds to the Michelson straight line $p = \rho_0^2 U^2 (V_0 - V)$.

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DYNAMIC COMPRESSIBILITY, ELECTRICAL CONDUCTIVITY, AND SOUND VELOCITY BEHIND A SHOCK FRONT IN KAPROLON

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UDC 537.311:539.58:534.614

In the present article we summarize the results of an experimental study of the properties of shock-compressed Kaprolon at pressures up to 570 kbar. The initial density of the samples was 1.14 g/cm^3, and the initial resistivity was $2.0 \cdot 10^{14}$ $\Omega\cdot$cm. The dynamic compressibility of the Kaprolon was investigated by the reflection method using an electrical contact technique [1] to measure the shock velocity in the samples. The experimental results characterizing the shock compressibility of Kaprolon are given in Table 1, in which u_{bar} is the particle velocity in the barrier, D and u are the shock and particle velocity in the Kaprolon, p is the pressure at the shock front, and $\delta = V_0/V$ is the compression ratio. Starting with $u \approx 1.5$ km/sec, the dependence D(u) is practically linear for Kaprolon and can be described by the relation

$$D = 3.30 + 1.32u.$$

For u < 1.5 km/sec the curve of D versus u exhibits a curvature similar to that observed earlier for Teflon (Soviet Fluoroplast-4) [2].

The electrical conductivity of shock-compressed Kaprolon was measured by a procedure similar to one used earlier [3], which permits one to trace the evolution of processes taking place in the substance after passage of a shock through it. The measurement configuration

Moscow. Translated from Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, No. 5, pp. 122-126, September-October, 1977. Original article submitted October 5, 1976.

0021-8944/77/1805-0689$07.50

TABLE 1

Barrier material	ubar, sec	D, km/sec	u, km/sec	p, kbar	$\delta = V_0/V$	c, km/sec
Copper	0,34	3,50	0,62	24,5	1,215	
Aluminum	1.14	5,56	1,65	105	1,422	6.24±0,05
"	1.50	6,04	2.14	149	1,549	7,29±0,07
"	2.70	8,21	3,71	348	1,824	
Iron	2.82	9,94	5.02	569	2.018	

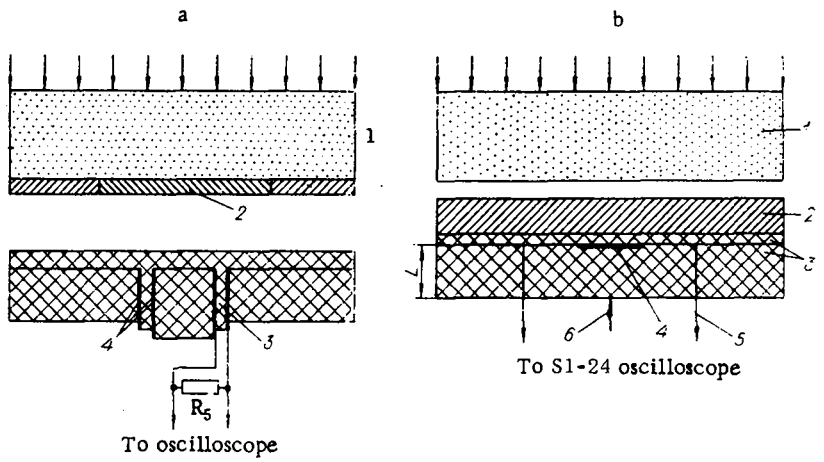

Fig. 1

used to investigate the conductivity of Kaprolon is shown schematically in Fig. 1a. The sample 3 is subjected to impact by the metal plate 2, which is driven by the detonation products of a cylindrical high-explosive charge 1 to velocities of several kilometers per second. The pliability of Kaprolon makes it possible to construct the measurement configuration without air spaces and without any lateral-unloading effects. The contacts are two coaxial copper cylinders 4. Because the cylindrical surfaces of the copper contacts are perpendicular to the shock front, voltage continues to be recorded at the contacts throughout the entire time of motion of the shock along the contacts. The discharge of a large-capacitance capacitor across a resistance R_S shunting the sample is used to supply a voltage pulse to the contacts a few microseconds prior to the driver shock at the contacts. The voltage drop across R_S due to the sudden decrease in resistance of the sample as the shock traverses it is recorded, making it possible to determine the resistivity ρ of the shock-compressed Kaprolon at times t according to the expression

$$\rho = \frac{2\pi}{\ln \frac{\Phi_1}{\Phi_2}} \frac{D}{\delta} \frac{R_S}{z_0} \frac{z_x^2}{\left(\frac{dz_x}{dt}\right)_t},$$

in which Φ_1 and Φ_2 are the outside and inside diameters of the sample, R_S is the sunting resistance, z_0 is the initial beam deflection on the oscillogram (Fig. 2a), z_x is the same quantity after a certain time t, and $(dz_x/dt)_t$ is the slope of the beam trajectory at that time.

Typical oscillograms obtained in the conductivity measurements for Kaprolon at pressures of 350, 460, and 570 kbar are given in Fig. 2a-c, respectively. The frequency of the reference sine wave in the oscillograms is 5 MHz. It is interesting to note the inconsyancy of the post-shock resistivity. The shape of the distribution function $\rho(x)$ depends on the pressure; the lower the pressure, the sharper is the minimum of $\rho(x)$ and the farther it occurs from the shock front (Fig. 3). The conductivity pulse width has an upper bound of 0.5 or 0.6 μsec. It is very likely that these effects are attributable to the fusion and dissociation processes following shock fronts in polymers.

The dissociation of organic compounds produces a considerable growth of the heat capacity with increasing temperature. This effect has been observed experimentally [4] at atmospheric pressure. Direct measurements of the temperature in Plexiglas (polymethyl methacrylate) behind a shock wave have been performed by Zel'dovich and others [5], who also showed that the temperature realized in Plexiglas up to pressures of ∿1 Mbar are considerably lower than what

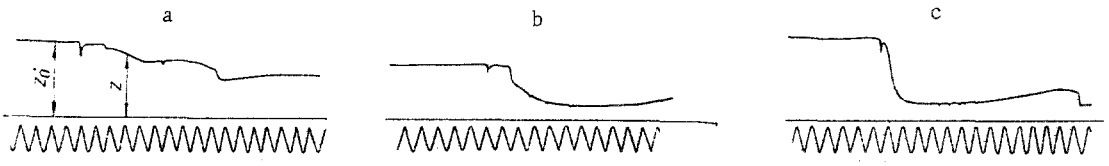

Fig. 2

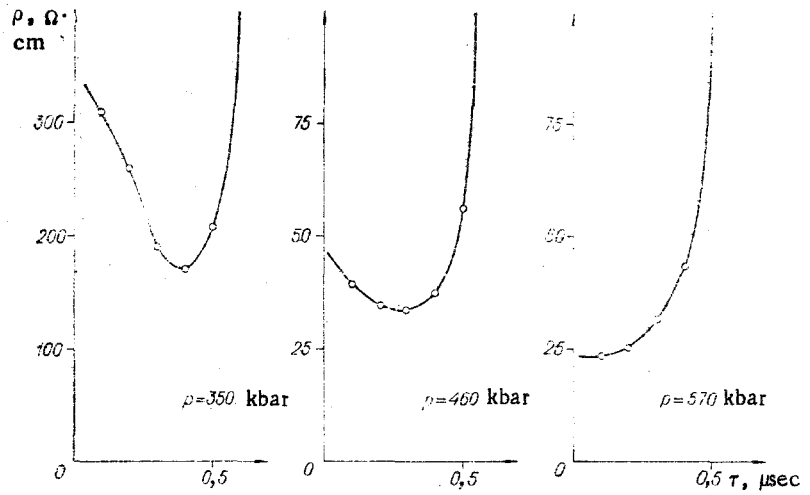

Fig. 3

would be computed on the basis of a constant initial heat capacity. The temperature values obtained the assumption of dissocation of the substance at indepent atoms turn out to be too low. It is clear that Kaprolon has a similar temperature dependence of the heat capacity. The similarity between such characteristics of Kaprolon and Plexiglas as the density and initial heat capacity, as well as the identity of the D–u curves, suggests that they will also have equal temperature increases for equal shock amplitudes. Therefore, in order to compare the conductivity data for Kaprolon with corresponding temperatures, we used the experimental dependence T(p) for Plexiglas from [5]; see Table 2, in which p is the pressure, T the temperature, and σ_0 the initial value of the conductivity behind the shock front. In coordinates (T log σ_0, T^{-1}) the data of Table 2 form a straight-line segment with slope corresponding to an activation energy of 1.2 eV.

The investigations of the dynamic compressibility and conductivity were augmented with measurements of the propagation velocity of rarefaction waves through shock-compressed Kaprolon. The experimental setup is shown schematically in Fig. 1b, including the explosive charge 1, the aluminum barrier 2 with a thickness of 10 mm, the Kaprolon test sample 3, and the manganin pressure pickup 4, which comprises a sinusoidal corrugated manganin foil with a thickness of 0.05 mm bonded in between the inner faces of the sample by means of epoxy adhesive. The initial resistance R_0 of the manganin pickup is $\sim$2 Ω, and the total resistance of the copper leads 5 is R_L = 0.02 Ω. The same electrical circuit as in the conductivity experiments is used to supply a voltage pulse to the manganin pickup a few microseconds before arrival of the shock wave. The voltage variation induced across the pickup leads due to variation of the pickup conductivity under impact loading and in the rarefaction wave is recorded on an oscilloscope. The recorded signal is delivered without preamplification directly to the deflection plates of the cathode-ray tube. The electrical contact sensor 6, which is located on the free surface of the Kaprolon sample, is used to obtain an oscillographic time marker corresponding to arrival of the shock front at the free surface of the sample. A representative oscillogram is given in Fig. 4 (the frequency of the reference sine wave is 5 MHz).

The maximum propagation velocity of the rarefaction wave in the shock-compressed Kaprolon is calculated according to the equation

$$c = u + \frac{L - u(t_1 + t_2)}{t_1 + t_2 - L/D} = \frac{L}{\delta t_2},$$

in which L = 15 mm is the initial thickness of the sample (see Fig. 1b), t_1 is the time inter-

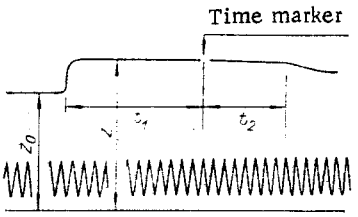

Fig. 4

TABLE 2

P, kbar	T, °K	σ_0, $\Omega^{-1} \cdot cm^{-1}$
350	2000	$(3,0\pm0,7)10^{-3}$
460	2400	$(2,1\pm0,2)10^{-2}$
570	2750	$(4,4\pm0,6)10^{-2}$

val from arrival of the shock wave at the manganin pickup to closure of the electrical contact, and t_2 is the time interval from closure of the same contact until arrival of the rarefaction wave at the manganin pickup. The rarefaction wave velocities c obtained in Kaprolon are summarized in Table 1.

By recording the time interval t_1 it is possible to determine the wave velocity $D = L/t_1$ in the sample, and the measured ratio z/z_0 between the amplitudes of the beam deflections in the oscillogram provides a means for finding the resistance of the shock-compressed manganin: $R = (R_0+R_L)_L(z/z_0) - R_L$; then the pressure dependence of the electrical conductivity of manganin in [6] can be used to determine the pressure realized in the investigated sample. If the "lateral unloading tangent" $\tan\alpha = \sqrt{\left(\frac{c}{D}\right)^2 - \left(\frac{D-u}{D}\right)^2}$ [7] is calculated from the data of Table 1, a value of 0.9 to 1.0 is obtained, which is considerably higher than the published values (0.7) for several metals [7] and sodium chloride [8] but agrees quite well with the values obtained for paraffin, polyethylene, Plexiglas, and Teflon [8]. Such high rarefaction wave velocities and the concomitant high values of tan α are clearly characteristic of polymer materials.

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