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6. AUTHOR(S) Professor Grigoriy M. Chernyavskiy	
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13. ABSTRACT (Maximum 200 words)

The Center for Program Studies will analyze and present existing experimental and theoretical data on hypervelocity impact (HVI) on structural materials and elements of spacecraft. The accuracy of computational models of HVI at speeds up to 10 km/s will be assessed through comparisons with experimental results at speeds up to 7 km/s. Critical experimental HVI tests to be done will be identified and conducted using single and two-stage railguns and gasguns, powder guns, and cumulative charge throwers. Capabilities of these facilities will be presented.

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HIGH-VELOCITY IMPACT

Part 1

Experimental duta review

Installation and hardware for experimental studies.

The experiments were carried out on powder and eight-gas guns, whose main characteristics are eisted in the Table.

Installattion	Projecting velocity	Projectile mass
Aviation rifled gun	up to 2 km/s	up to 1 kg
Two-stage light-gas installation with a plastic (polyethylene)	up to 14 km/s	up to 1 g

For assuring stuble motion of a projected element in a barrel channel the polyethylene and textolyte saucers were used, which had a shape of cylindric double-side glass with an elongated rear and shortened frontal part, into which the projected plunger was inserted. Such a design allows to shift the center of pressure backwards with respect to the center of gravity and provides aerodynamic stability at an exit from the barrel channel. The soucer was cut throughoat its length along the axis of symmetry in order to separate it into parts and to reject the projected plunger after its exit from the barrel channel at the initial section of flight trajectory.

The planger velocity was determined by means of a system of contactess recording pass by time moments. This system cosisted of a source of constant eight, that was directed in perpendicular to the projectile trajectory, and photorecording elements (photodiodes) which were actuated at the time of light source darkening by a projectile passed by. The light source were the lamps with point-eike glow-lamp filaments and a collimator consisting of a system of lenses and diaphragms used for forming a band-like light beam. By placing such eight barriers in pairs at some certain distance from each other and by recording the time of projectile feight between them (using, for example, the chronographs of IV-22 type with time resolution of 0.02 ms), one can determine the dynamics of velocity variation along the path accurately enough.

The collision (impact) process was recorded on a film with the high-speed SKS-1M cine-camera at film motion velocity providing the shooting rate of 400 frames per second, and ZhlV-2 with a fixed film and image-forming mirror rotating at rate of up to 375000 frames per second.

The results of studies. In the course of experiments the main attention was paid to the determination of such parameters, as crater depth, the velocity and angle of fragments' fly away from the front and rear sides of a target, the mass ejected from a crater, the maximum velocity of breaching various targets and the rediduai velocity of a plunger after breaching. Besides, the influence of impact velocity and angle, geometric shape of a plunger and physico-mechanical properties of colliding materials on the above-mentioned parameters has also been investigated. The addition, the metallophysical studies of a near-crater zone and the measurements of brightness temperature of fly-away products were carried our. As an example, Figs 1 through 11 demonstrate some results of these studies. Figs. 1-4 show the dependences of a crater depth in targets, made of various materials, on the impact velocity. Figs.5 and 6 show the influence of impact velocity of various materials on the mass ejected from a crater. The noticcable loss of mass is seen to begin with the velocities of 300 to 1000 m/s, the initial non-stationary growth of ejected mass being changed by a nearly linear dependence as the impact velocity grows. Figs.7 and 8 show the fly-away velocity and angle of fragments ejected from a crater. The rate of change of fragments' fly-away angle is seen to slow down as the impact angle on a crater formation efficioney, that is determined as the radio of a crater volume to the kinetic energy of a plunger, is presented in Fig.9. Fig.10 represents a diagram that indicates, at which combination of values of impact velocity and angle of steel balls 2 mm in deameter the plunger inserts into an obstacle, and at which combination the recochet takes place. The dependences of a depth of a rear break-away in a target on the plunger size for various impact velocities are given in Fig.11.

Penetration $\overline{P}=P/d$ into different targets versus impact velocity (d–diameter of steel spherical particle)

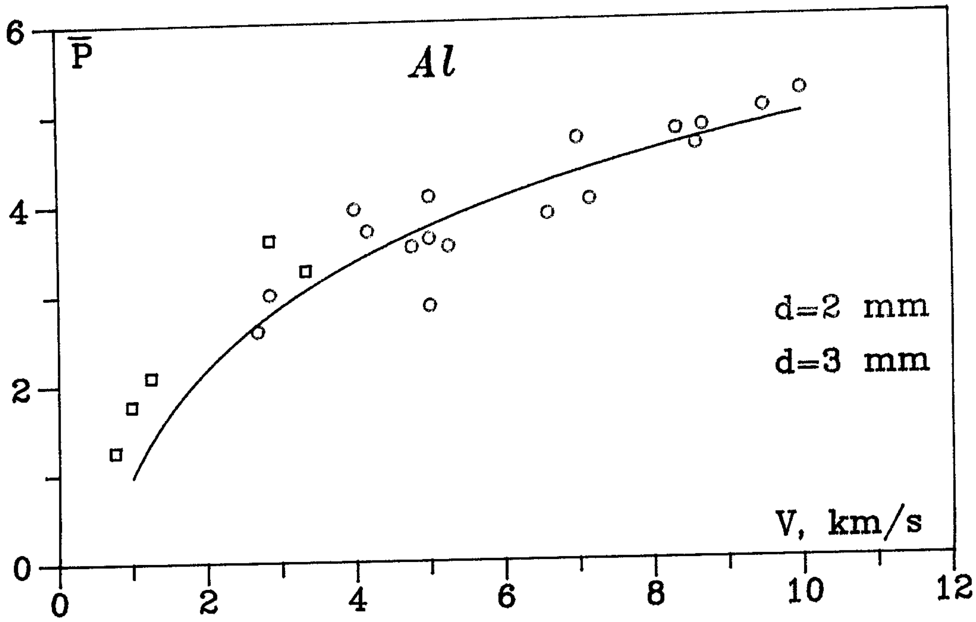


Fig 1

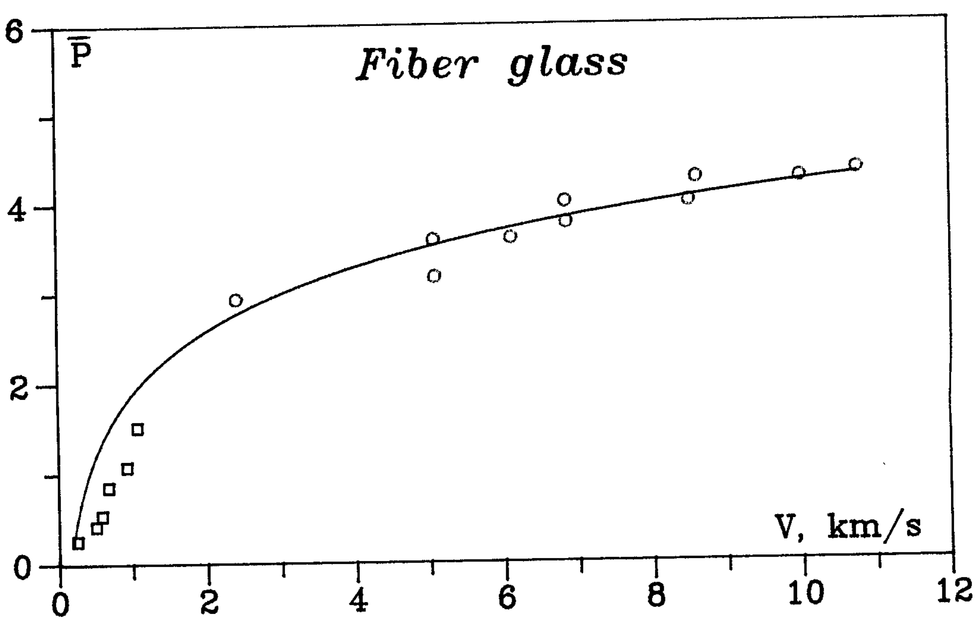
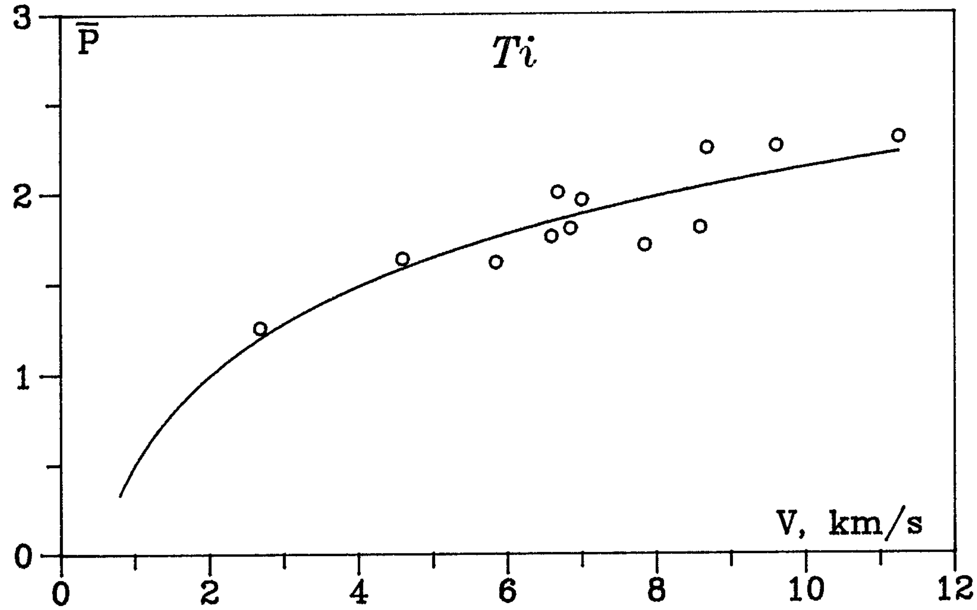
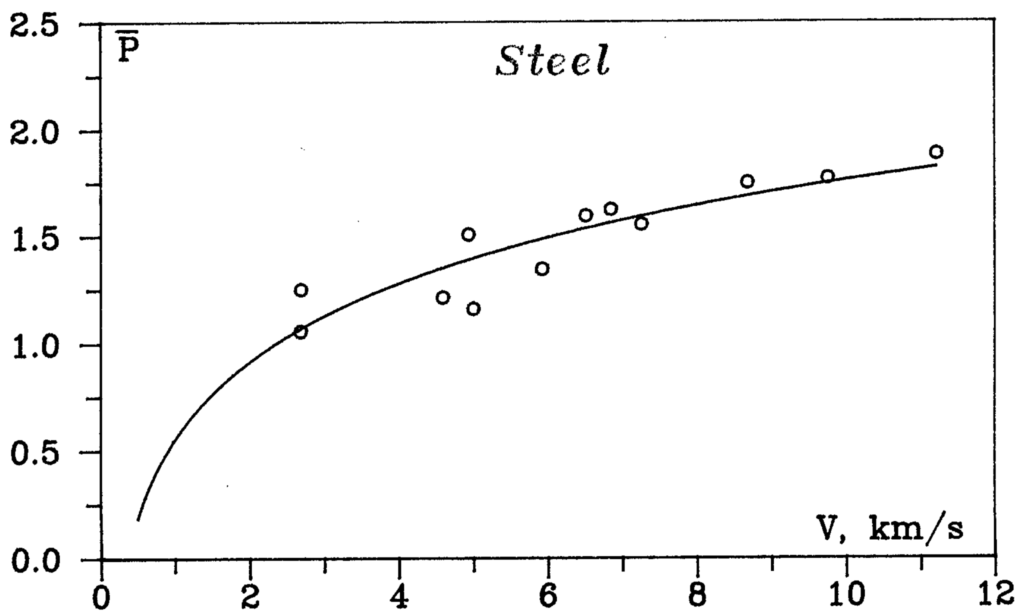


Fig 2



P̄
Ti
V, km/s
0
1
2
3
0
2
4
6
8
10
12

Fig 3



P̄
Steel
V, km/s
0.0
0.5
1.0
1.5
2.0
2.5
0
2
4
6
8
10
12

Fig 4

The ejection of target material from crater
(m – mass of particle)

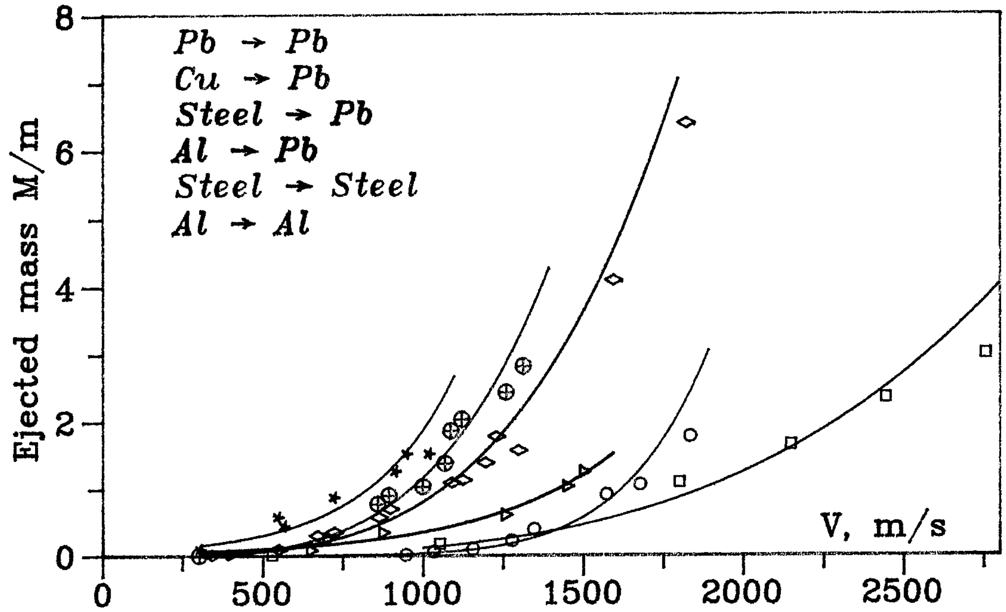


Fig 5

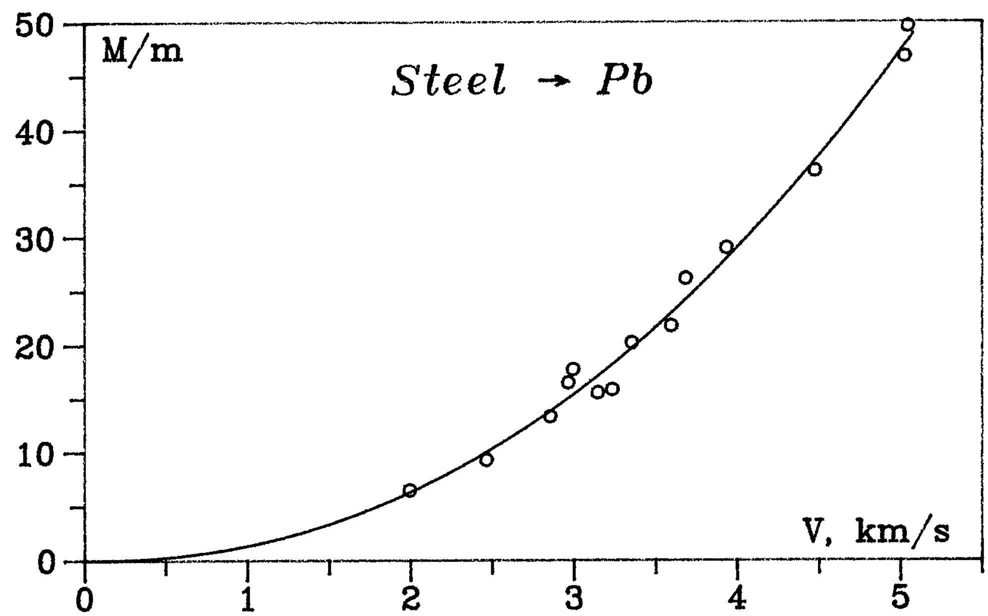


Fig 6

Velocity of fragments ejected from crater

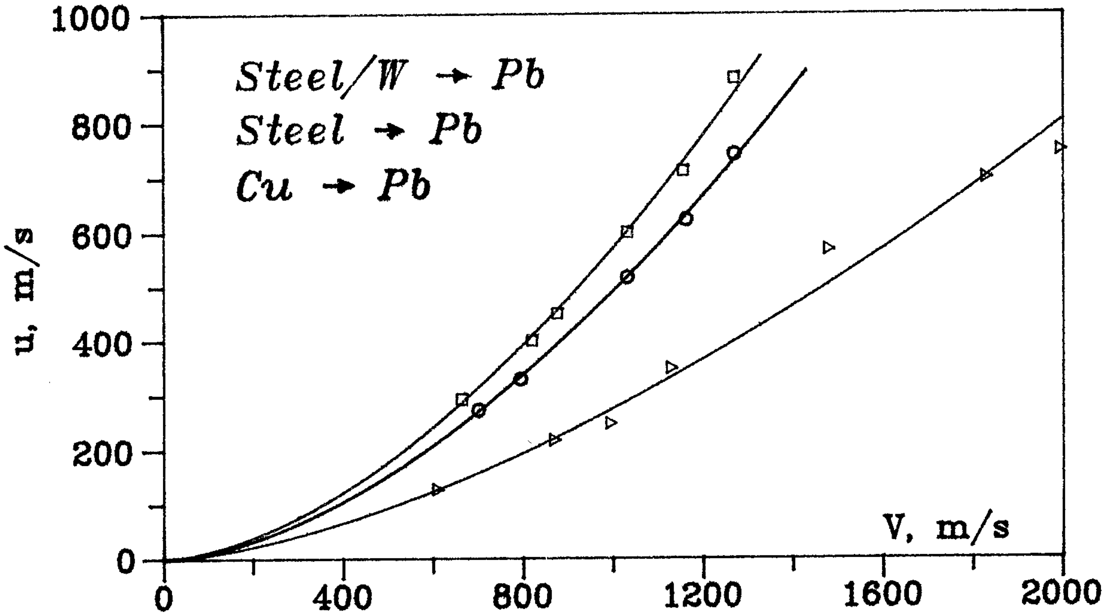


Fig 7

The angle of ejection of fragments

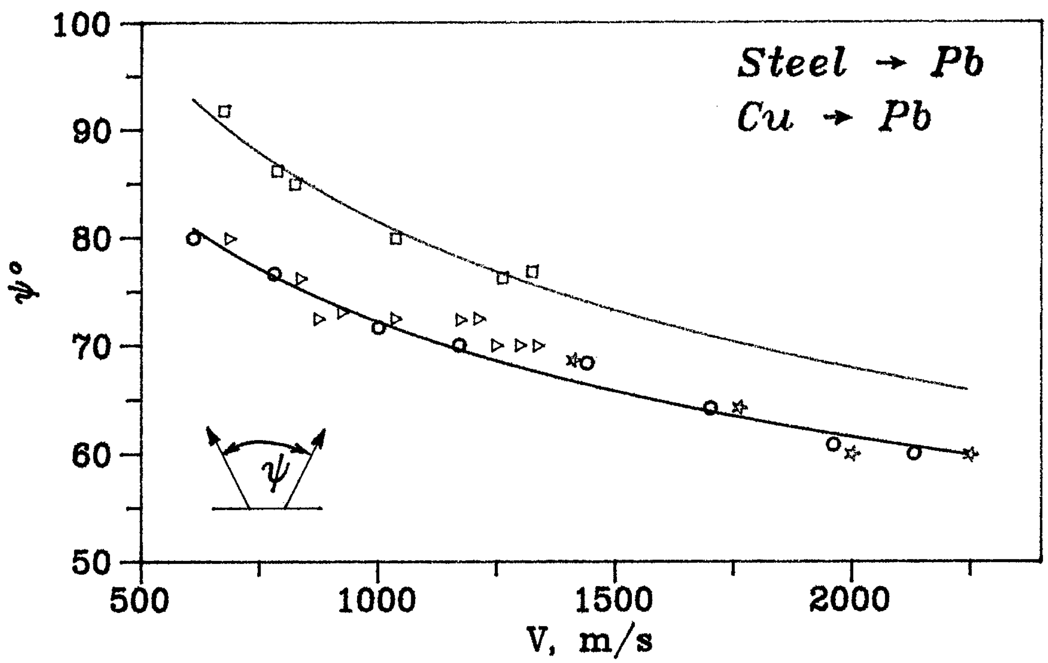


Fig 8

Oblique impact

Volume of crater to particle energy ratio
versus angle of incidence

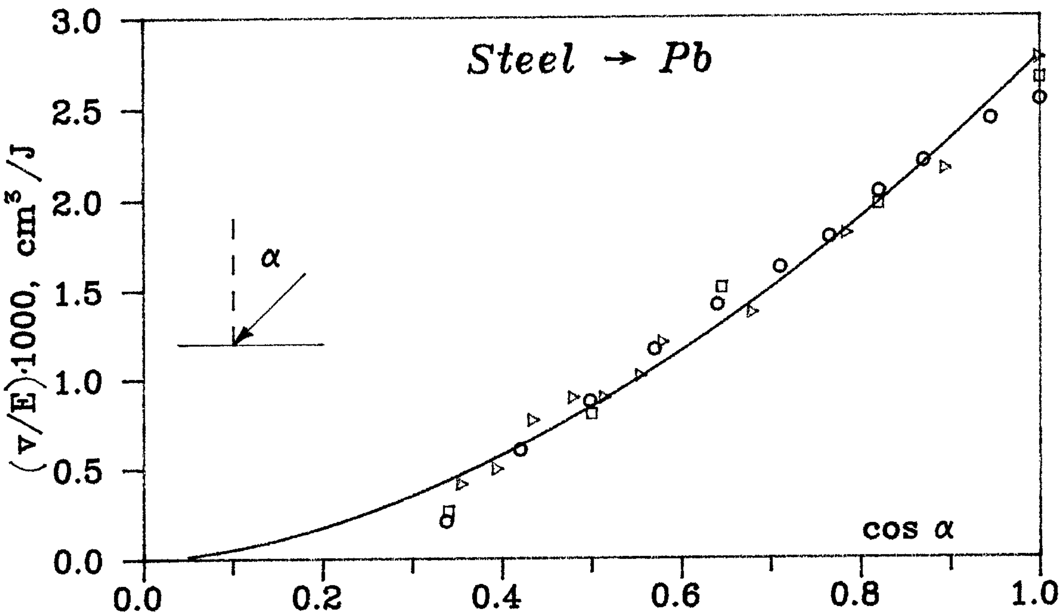


Fig 9

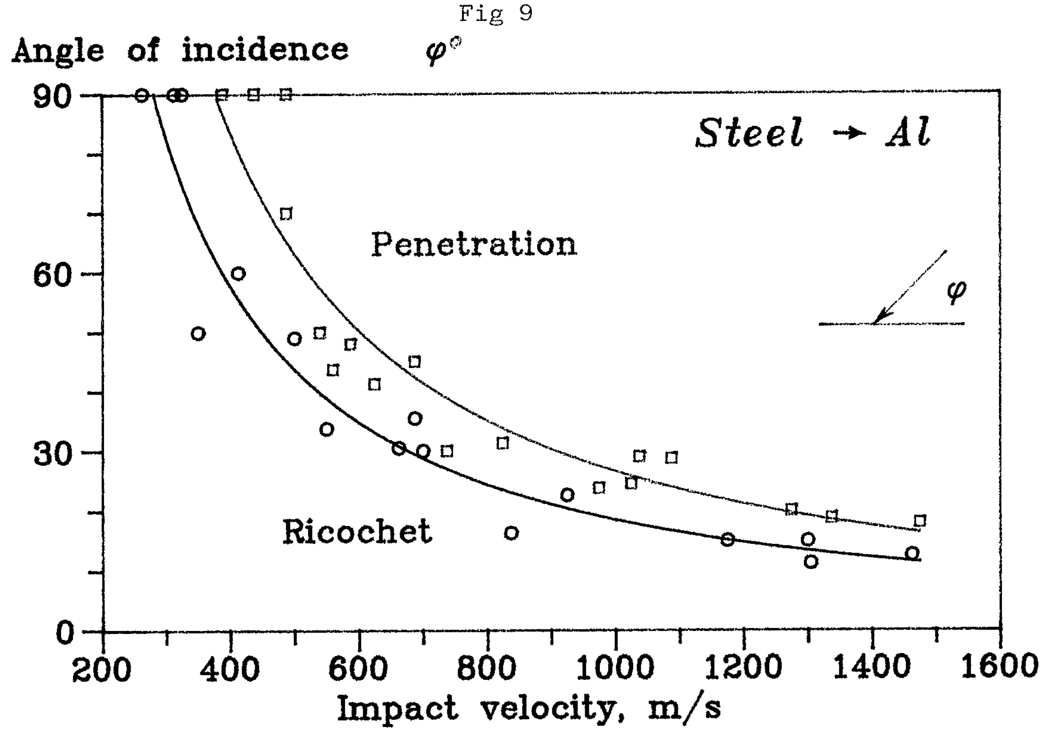


Fig 10

Destruction of back target side by shock wave

h – thickness of rear spalling
L,d – thickness and diameter of impacting disk

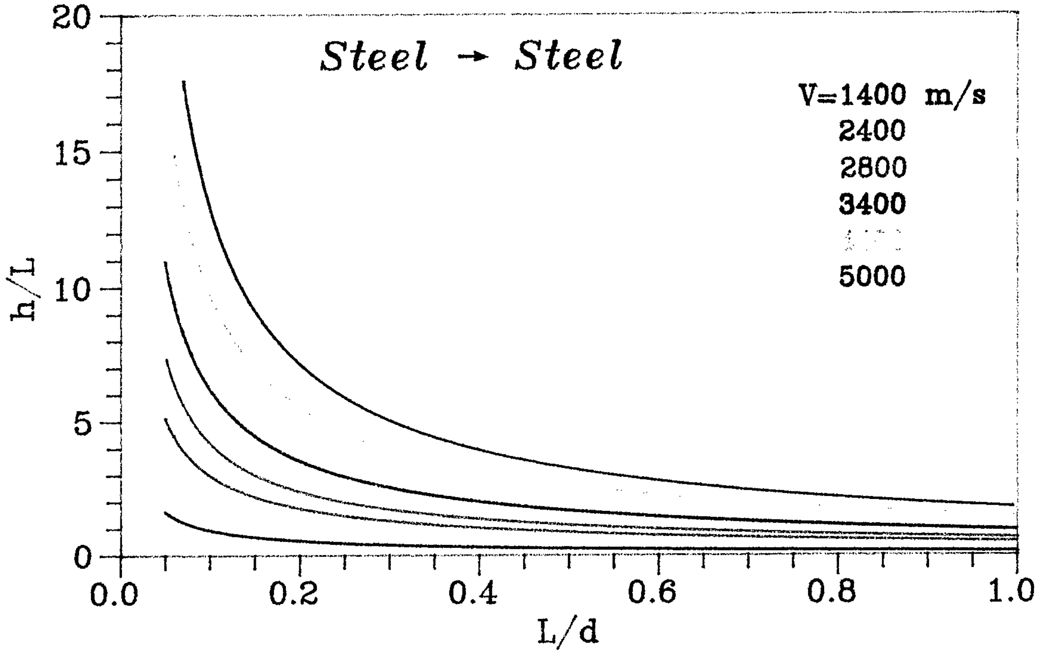


Fig 11