6. V. M. Teshukov, "Central waves in three-dimensional gas flows," in: Dynamics of a Continuous Medium [in Russian], No. 39, Inst. Gidrodinam. Sib. Otd. Akad. Nauk SSSR, Novosibirsk (1979).
7. V. M. Teshukov, "Three-dimensional problem of contact discontinuity propagation in an ideal gas," in: Dynamics of a Continuous Medium, [in Russian], No. 32, Inst. Gidrodinam. Sib. Otd. Akad. Nauk SSSR, Novosibirsk (1977).
8. V. M. Tekushov, "Construction of a shock front in the three-dimensional problem of a piston," in: Dynamics of a Continuous Medium [in Russian], No. 33, Inst. Gidrodinam, Sib. Otd. Akad. Nauk SSSR, Novosibirsk (1978).

DETONATION-GENERATED SHOCK WAVE

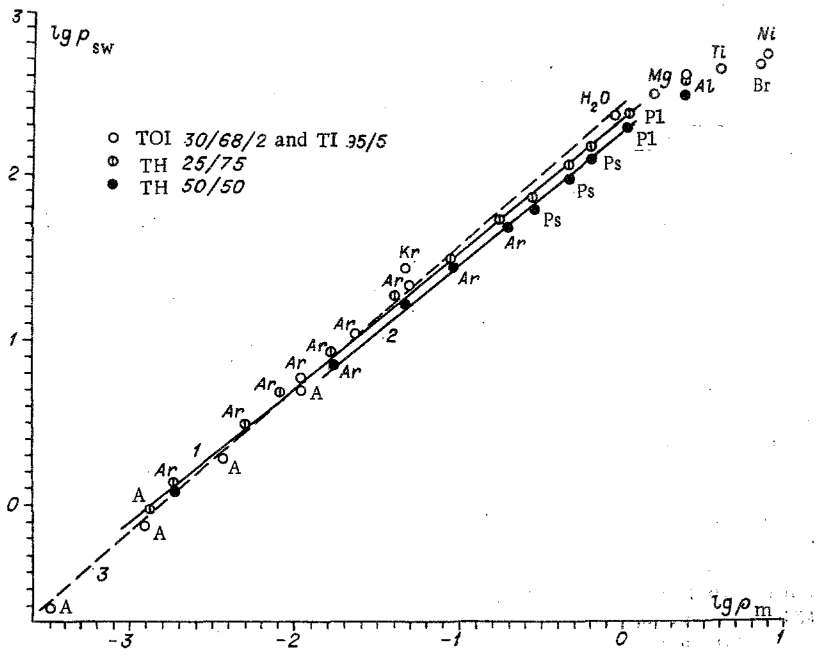
N. N. Kalitkin and V. M. Sinenko

UDC 533.932

Let us consider a cylindrical explosive charge of sufficiently large dimensions in which a plane detonation wave traveling along the axis is initiated. When this wave emerges at the charge endface, decay of the discontinuity occurs. Let a condensed explosive charge be in contact with an inert medium of lower dynamic stiffness (gas, water, organic material). Then a shock will appear in the inert medium, and inversely in the explosion products (EP), an unloading wave with two weak discontinuities.

There are some experiments of similar type in which the detonation and shock wave parameters have been measured. Processing the experiments using explosions of a trotyl-hexogene (TH) [1] and a trotyl-octogene-inert (TOI) mixture [2], clarified an interesting regularity.

Plotted along the axes in Fig. 1 are logarithms of the shock wave pressure p_{sw} and the initial density of the inert medium ρ_m in which this wave emerged (the letters denote the composition of the inert medium, including A for air, Ps for polystyrene, Pl for Plexiglas, Br for brass, and the numbers 1-3 are numbers of the corresponding equations. All the experimental points for an explosive of definite composition and initial density ρ_0 lie on a line independently of the composition of the inert medium if an unloading wave returns backward in the EP.



Moscow. Translated from Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, No. 2, pp. 133-135, March-April, 1980. Original article submitted May 4, 1979.

0021/8944/80/2102-0267$07.50 © 1980 Plenum Publishing Corporation

This regularity is conserved with high accuracy. The experimental points in Fig. 1 correspond to air, argon, water, Plexiglas, and polystyrene, where many substances are taken with different initial densities. All these points lie on practically one line for each explosive despite the differences in composition and aggregate states of the inert medium and the very broad range of pressure and density variation (10^4 times). The sole noticeable deviation from this regularity is the point for xenon; this is apparently explained by the inaccurate primary processing of the experiments in the paper [2] itself because a theoretical equation of state is used therein for xenon and there are no reliable theories for a strongly compressed nonideal plasma at this time.

In general, a straight line corresponds to each explosive composition and its initial density. For the three mixtures which are represented in Fig. 1, the equations of these lines have the following form:

$$\text{TH } 25/75,\ \rho_0 = 1{,}72,\ D = 8.15,\ \lg p_{sw} = 2{,}30 + 0.80 \lg \rho_m \tag{1}$$

$$p_{sw} = 200\rho_m^{0.80};$$

$$\text{TH } 50/50,\ \rho_0 = 1.65,\ D = 7.55,\ \lg p_{sw} = 2.23 + 0.80 \lg \rho_m \tag{2}$$

$$p_{sw} = 170\,\rho_m^{0.80};$$

$$\text{TOI } 30/68/2,\ \rho_0 = 1{,}775,\ D = 8.21,\ \lg p_{sw} = 2.38 + 0{,}85 \lg \rho_m \tag{3}$$

$$p_{sw} = 240\ \rho_m^{0.85}.$$

Here the pressures are measured in kbar, the density in g/cm^3, and the detonation wave velocity in km/sec. Let us note that if the dimensionless variables $p_{sw}/\rho_0 D^2$ and ρ_m/ρ_0 are introduced analogously to [3], then the lines (1) and (2) agree in these variables, but the line (3) will be distinct.

A theoretical explanation has not been found successfully to explain the regularity detected. It is evident that it is not extended to the case of high-density inert media: As $\rho_m \to \infty$ the shock pressure cannot grow without limit. It just tends asymptotically to a value corresponding to the incidence of a detonation wave on a fixed wall. This is seen from Fig. 1 where experimental points on the emergence of a shock in light and heavy metals are also presented; they exhibit a deviation from rectilinearity and a rapid tendency to the limit pressure.

These metals have a high dynamic stiffness as compared to the explosive products so that in this case the shock goes back during the decay of the discontinuity but the unloading wave does not. Water and Plexiglas, which are slightly less dense than magnesium, lie on the rectilinear section. Hence, the boundary between the rectilinear regularity and the emergence at the asymptotic pressure should be established by the equality between the dynamic stiffness of the explosive products and the inert medium.

The regularity established permits a radical reduction in the number of measurements needed in the experimental investigation of new explosives. It is sufficient to make just two to three measurements by using inert substances studied well, for instance, argon at 1- and 20-atm pressures and normal-density Plexiglas, to find the line $\log \rho_{sw} - \log \rho_m$. Furthermore, by placing the data on substances with different initial densities and known shock adiabats on this line, a detailed description of the appropriate points can be obtained by a numerical method that will supplant experiments with these substances.

LITERATURE CITED

1. M. V. Zhernokletov, V. N. Zubarev, and G. S. Telegin, "Broadening isentropy of explosion products of condensed high explosives," Zh. Prikl. Mekh. Tekh. Fiz., No. 4 (1969).
2. I. W. S. Allan and B. D. Lambourn, "An equation of state of detonation products at pressures below 30 kbar," Proc. Fourth Symp. on Detonation, White Oak, Maryland (1965).
3. V. F. Kuropatenko, "Equation of state of detonation products of condensed high explosives," VV. ChMMSS, 8, No. 6 (1977).