Instability influence upon lean hydrogen-air flames

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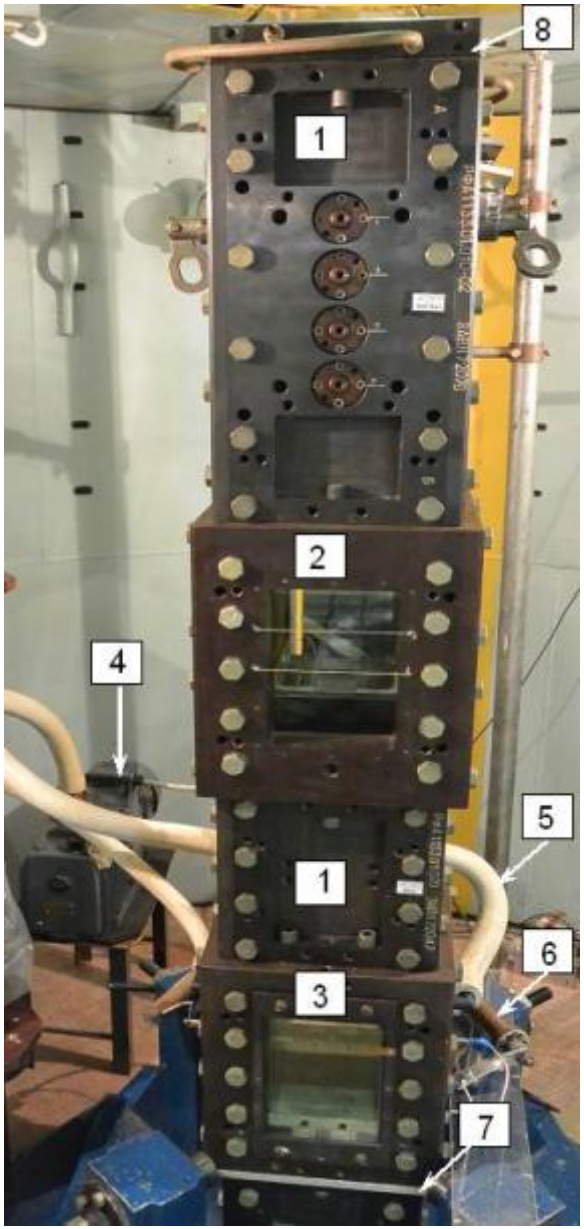
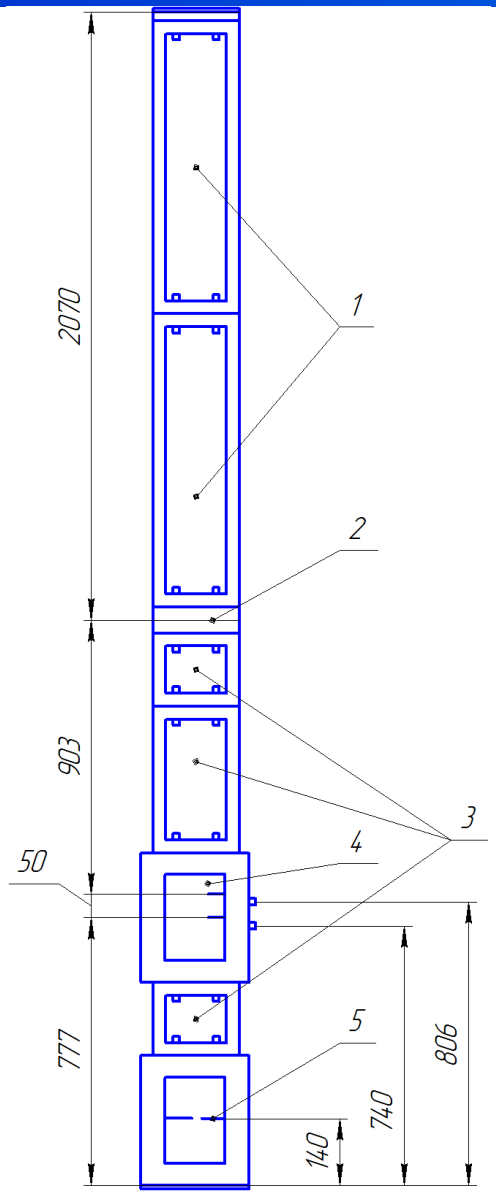
Multi-purpose shock tube



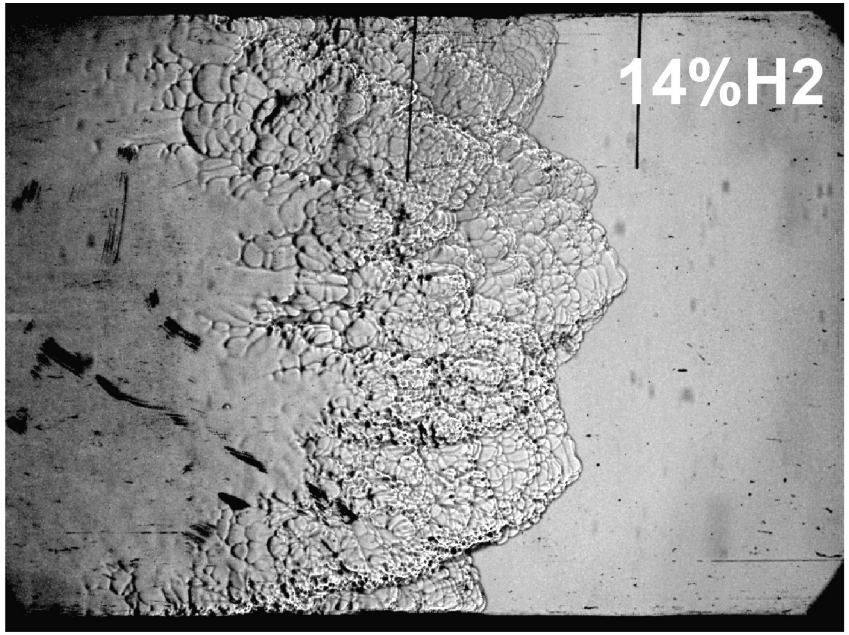
Shock tube facility (to the left) *Система газонаполнения*
1 *– operational chambers;* ***2*** *– measurement chambers;* ***3*** *– measurement chamber with initiating electrodes;* ***4*** *– forvacuum pump;* ***5*** *– to the vacuum-pumping and gas-filling system;* ***6*** *– current shunt;* ***7*** *and* ***8*** *– blind walls of shock tube* 60 (80) mm, 30KhGSA steel, windows - 40 square mm, glass.

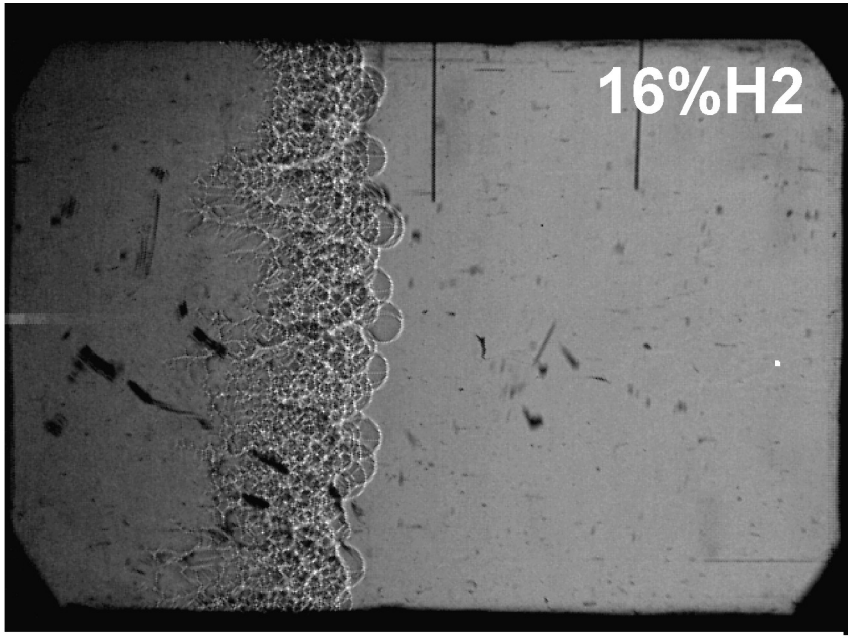
Schematic multi-purpose shock tube for experiments with a rarefaction wave

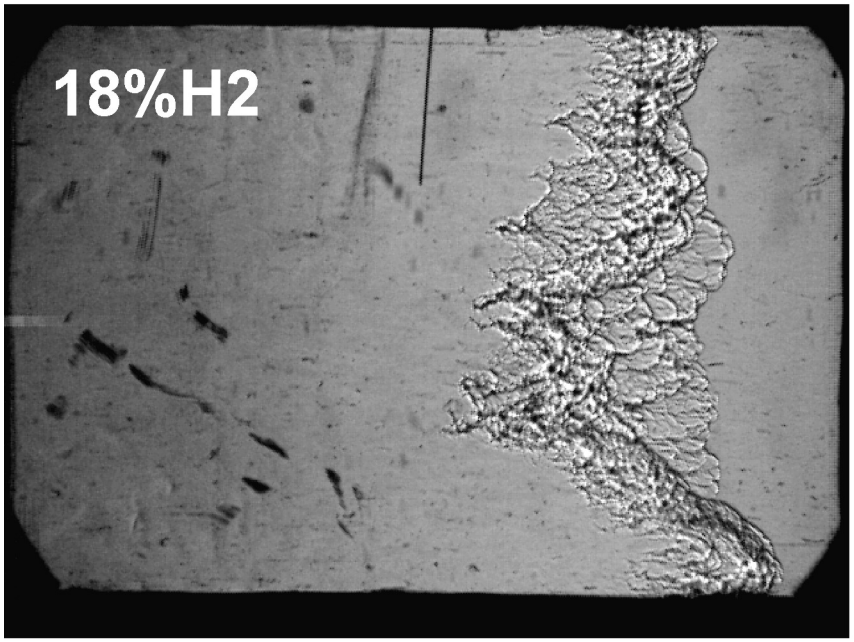


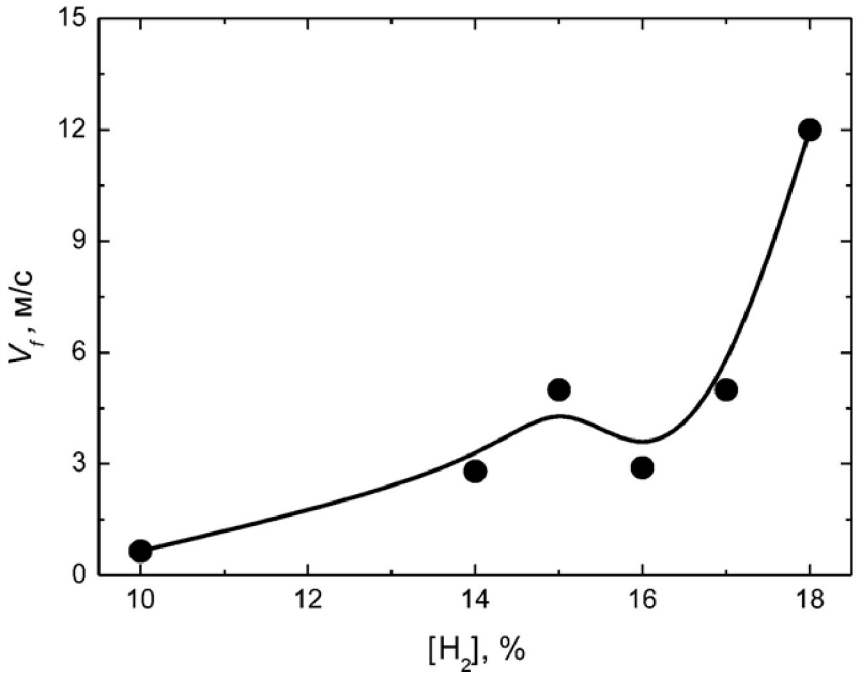
1- vacuum-evacuated chambers of the rarefaction driver
2- vacuum membrane
3- chambers filled with hydrogen-air mixture
4- measurement chamber
5- spark gap

Flame in the hydrogen-air mixture(X=740 mm)

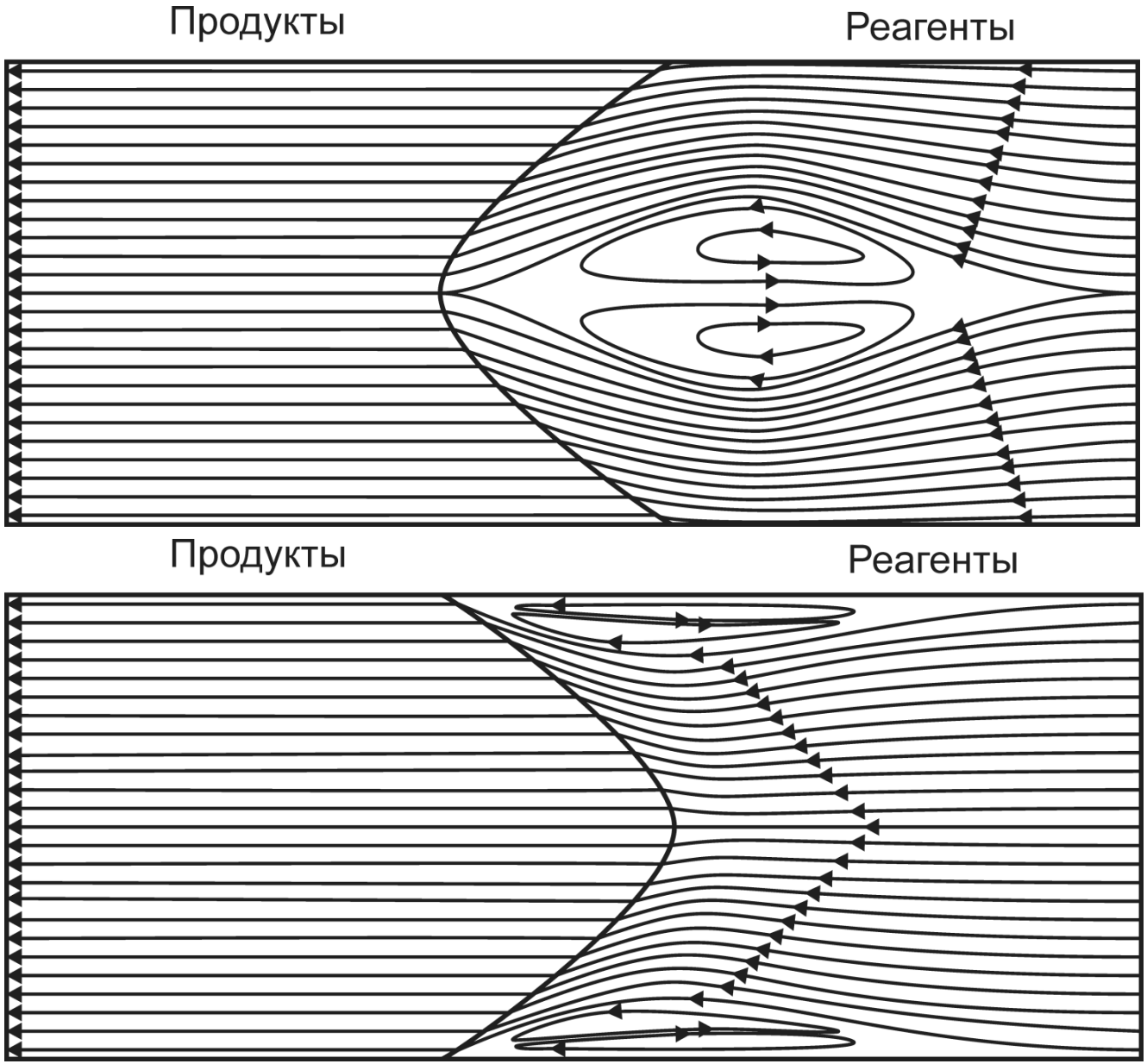








Schemes of convex and concave flames



16% Hydrogen in air

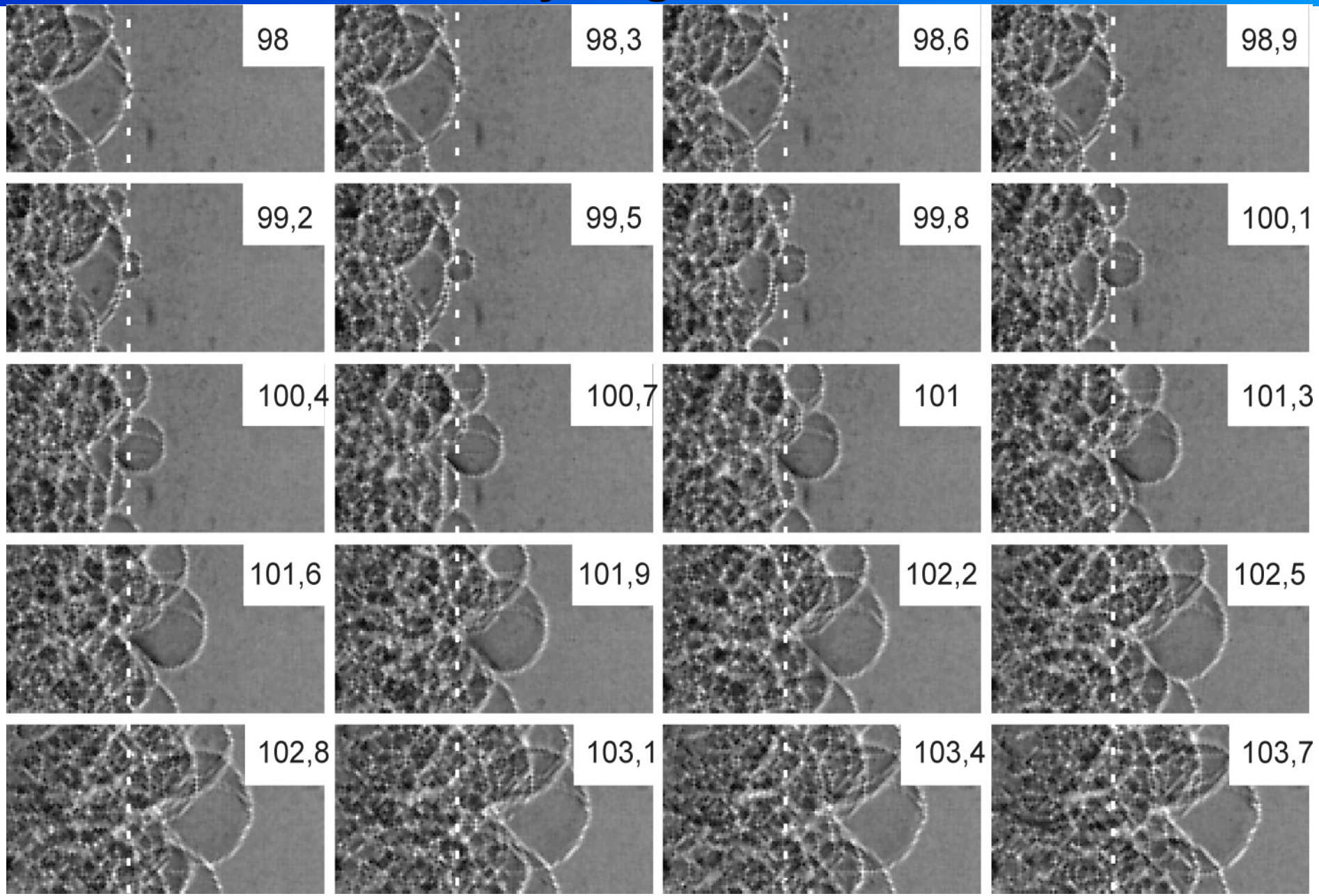
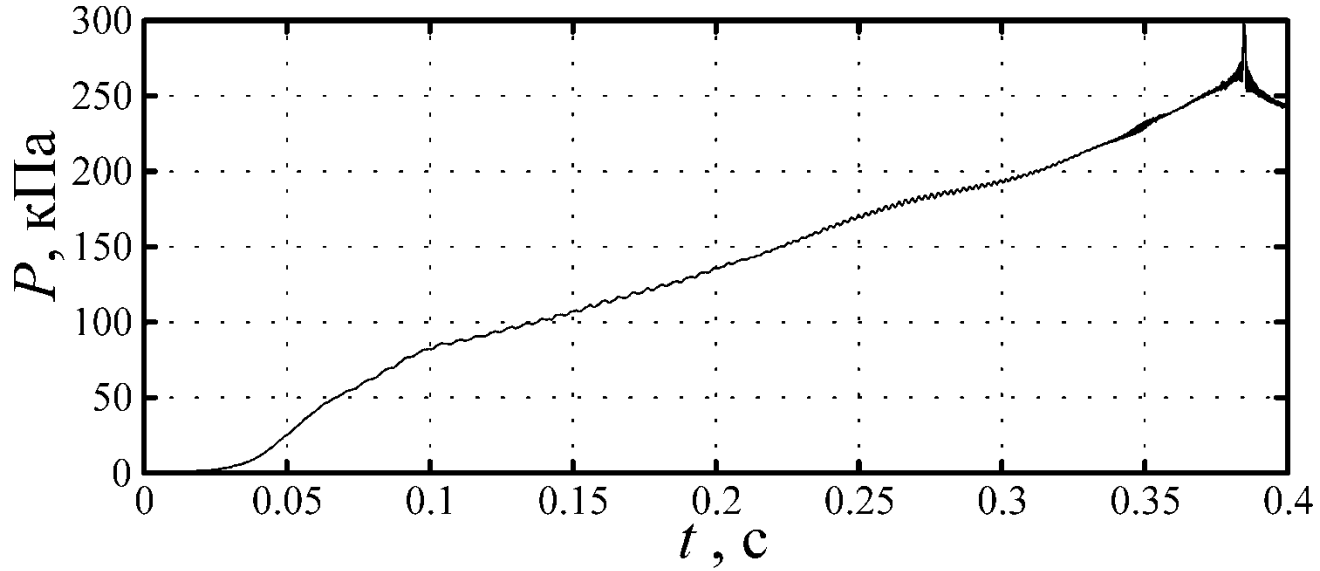
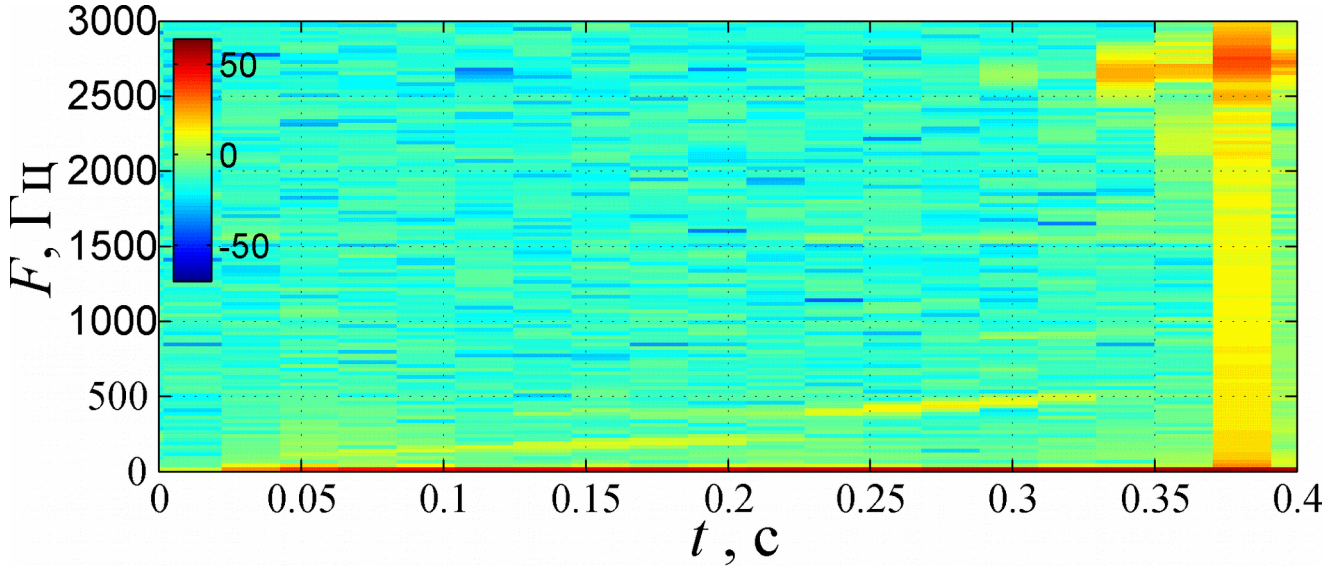


Image 43,4 mm × 21,7 mm *0,3 ms between frames*

16% hydrogen in air, without rarefaction wave



а)

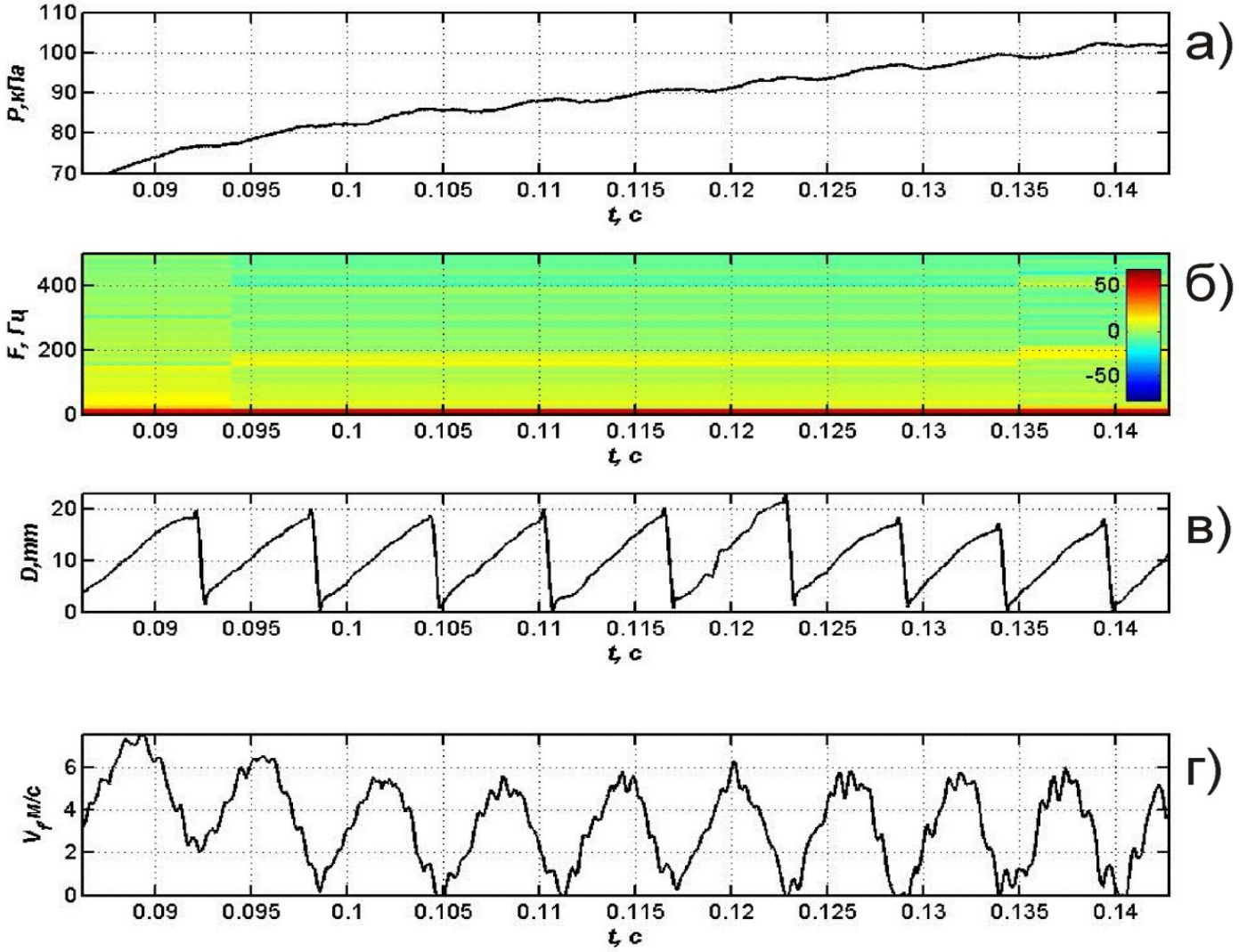


б)

а) – Pressure profile

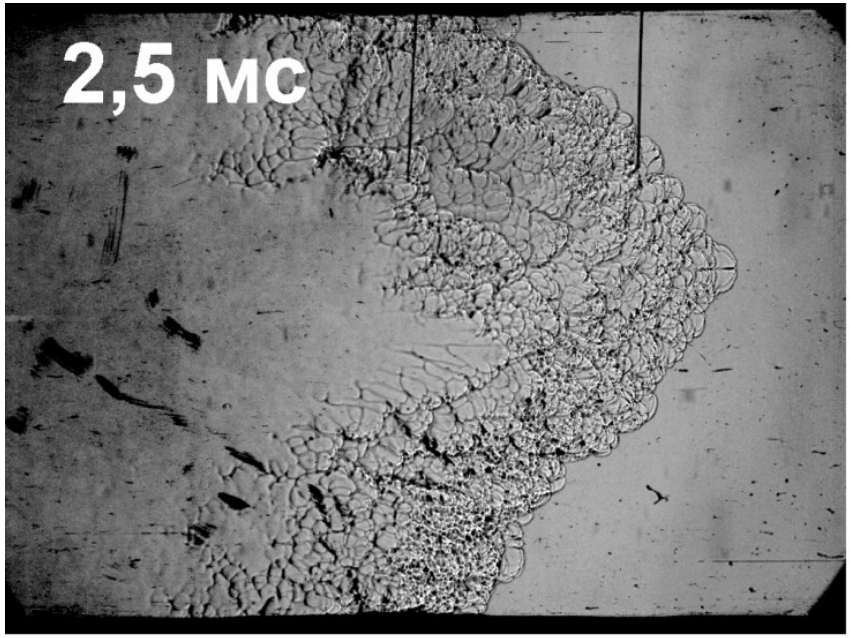
б) – Pressure spectrum (intensity in DB)

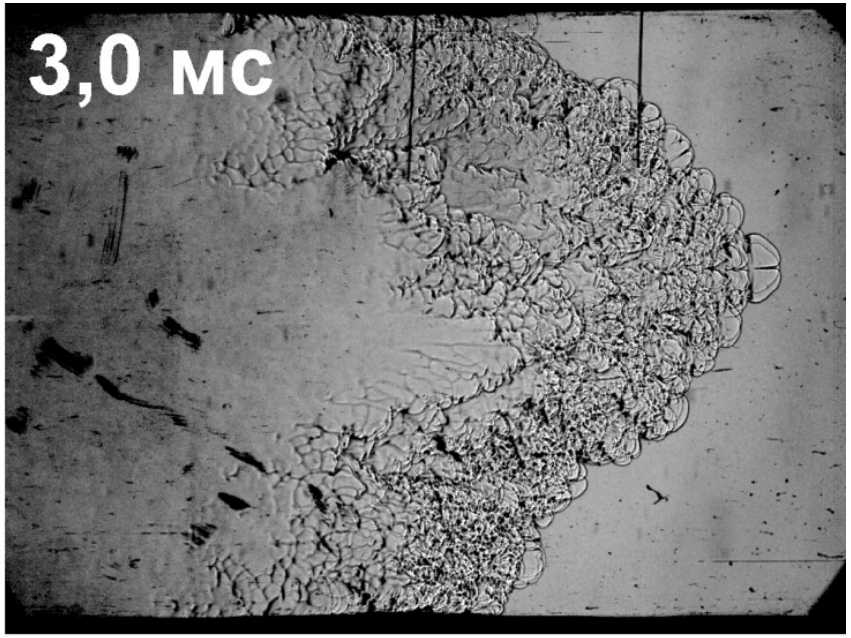
16% hydrogen in air, without rarefaction wave

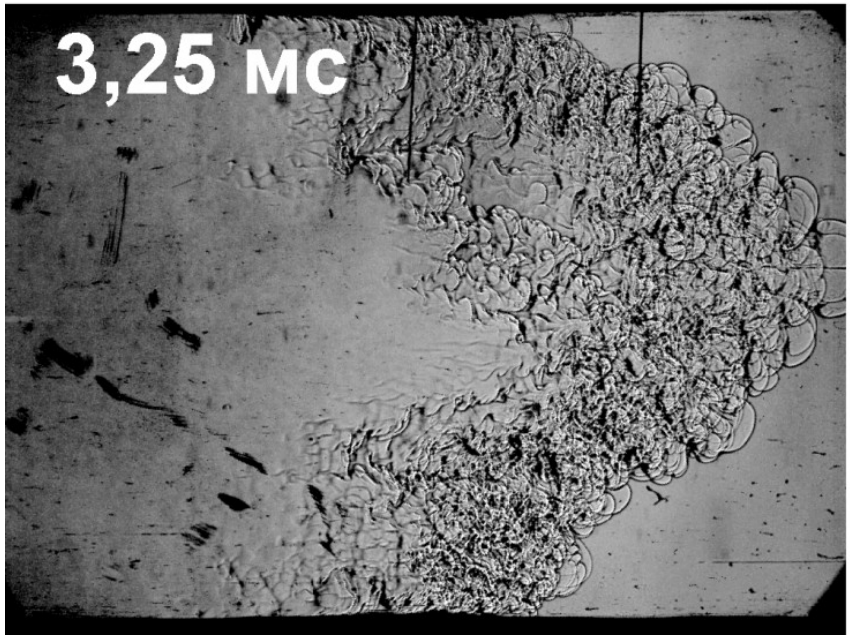


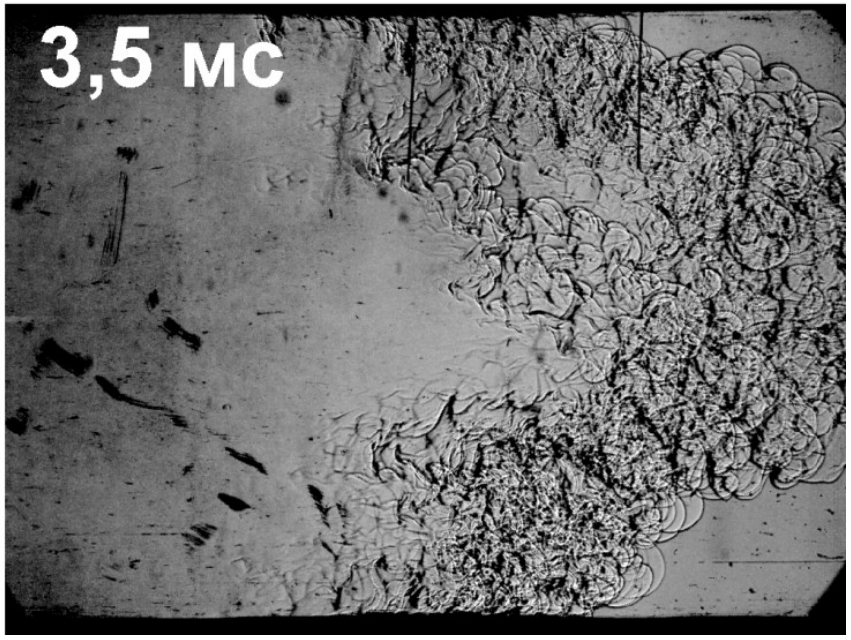
- Amplitude of longitudinal acceleration of flame ~ 250g
- Rate of increase in flame diameters dD/dt≈2.9 m/s

14% hydrogen in the air, with rarefaction wave

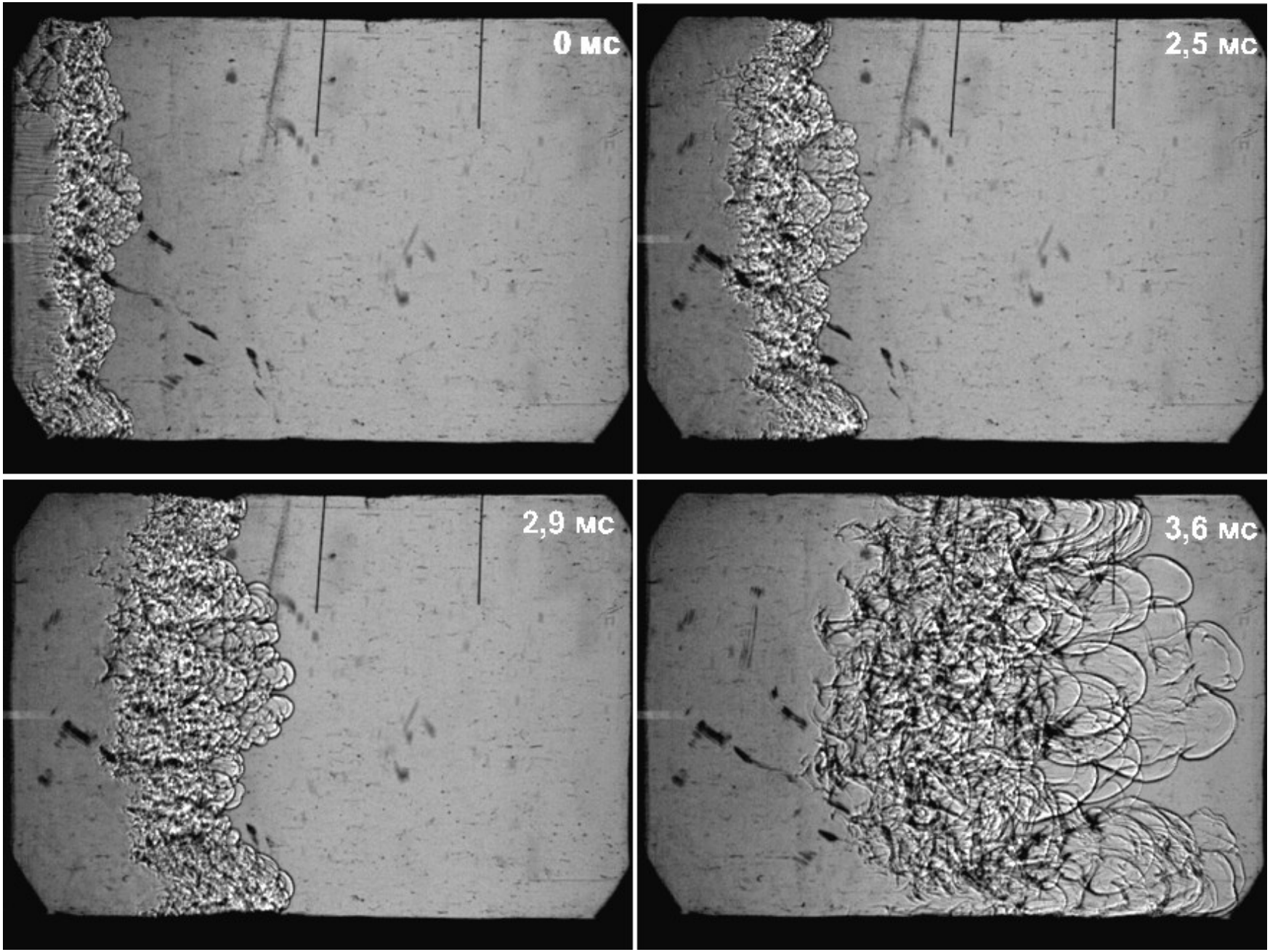




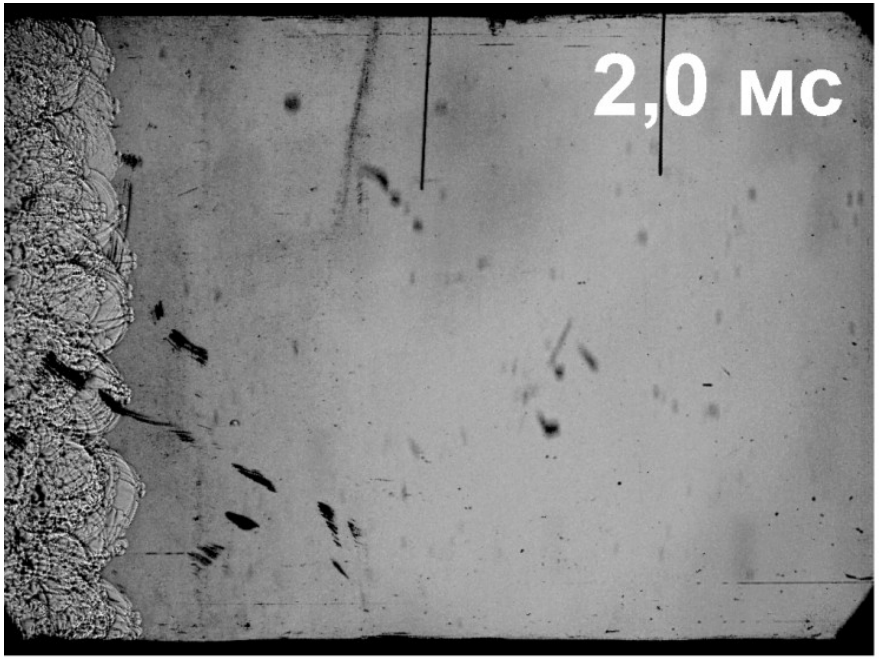


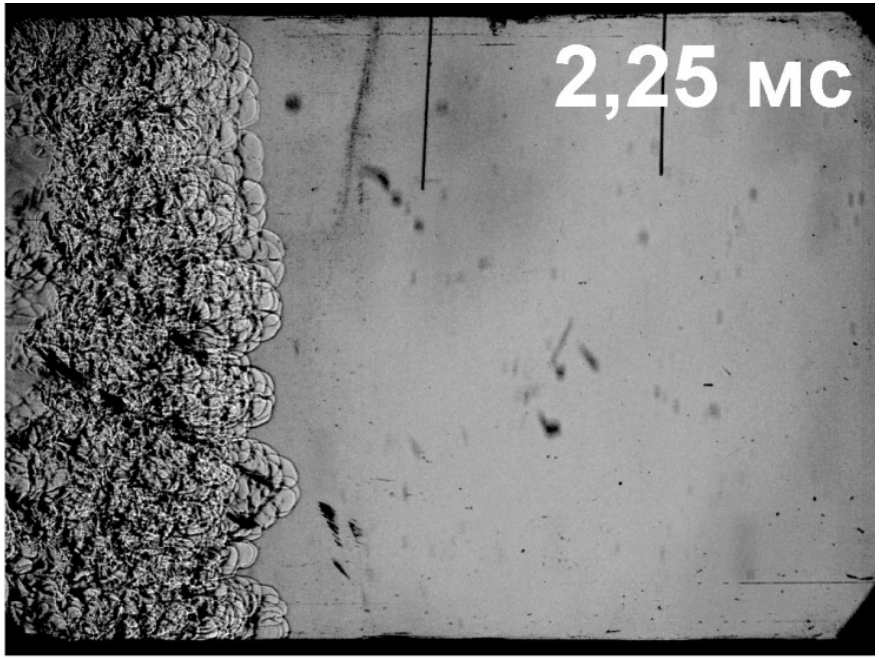


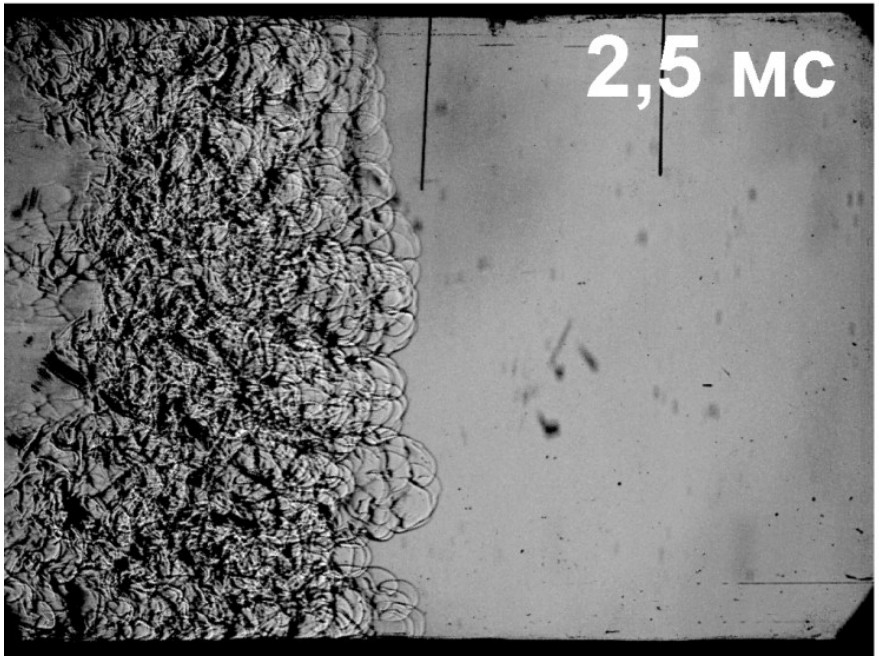
18% hydrogen in the air, with rarefaction wave

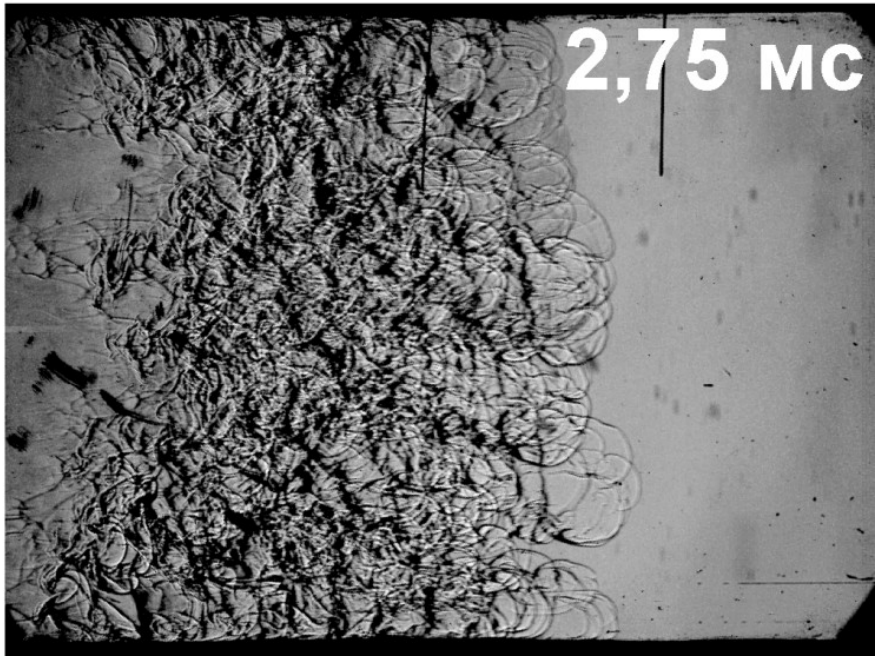


16% hydrogen in the air, with rarefaction wave



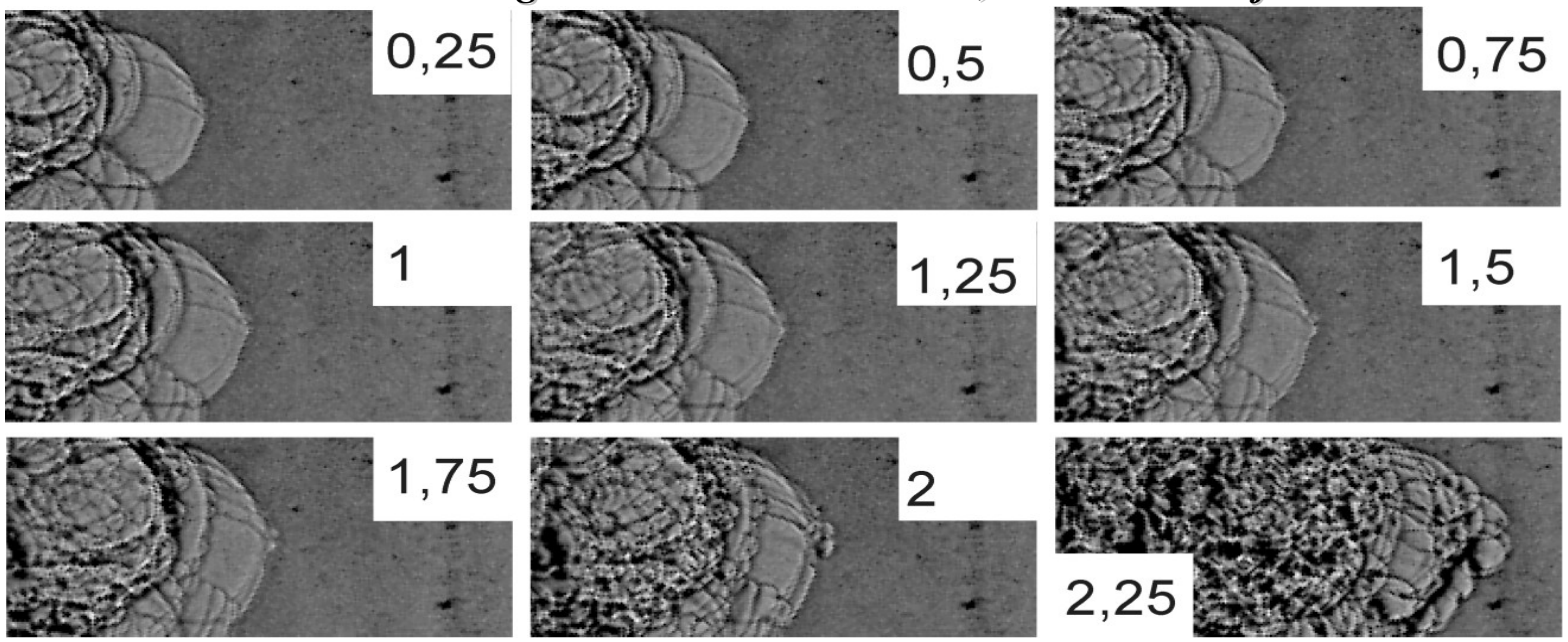


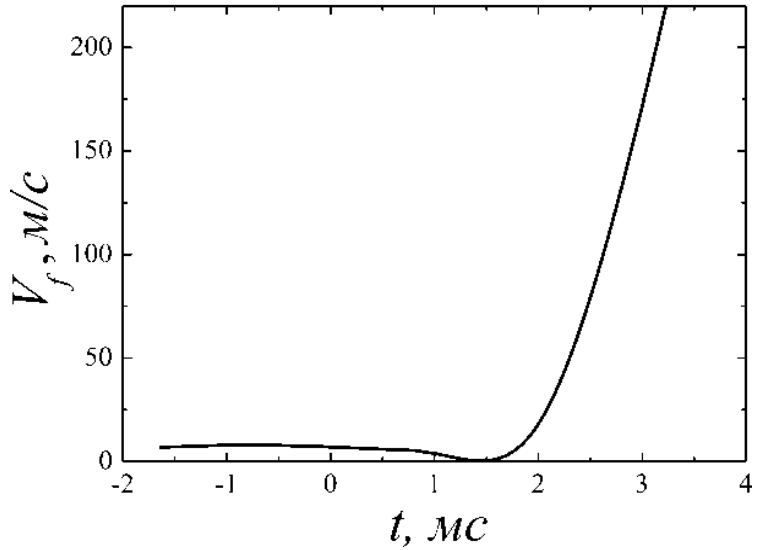


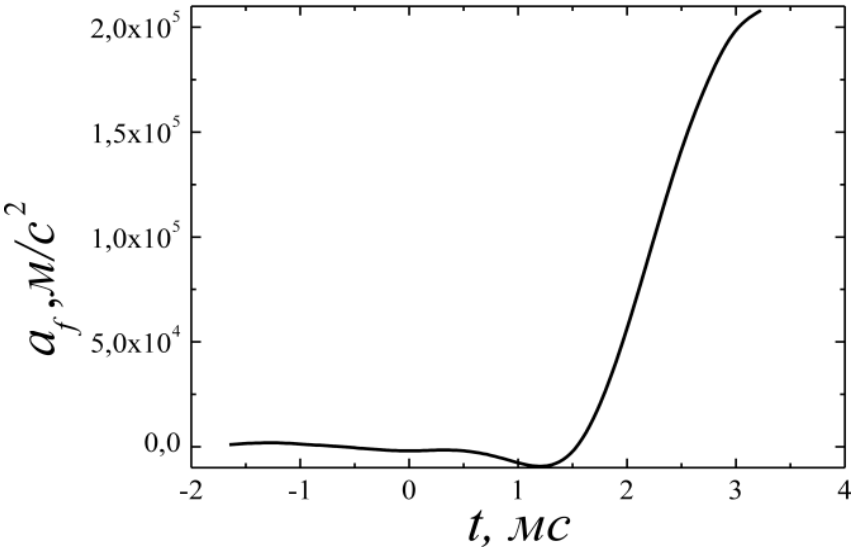


16% hydrogen in the air, with rarefaction wave

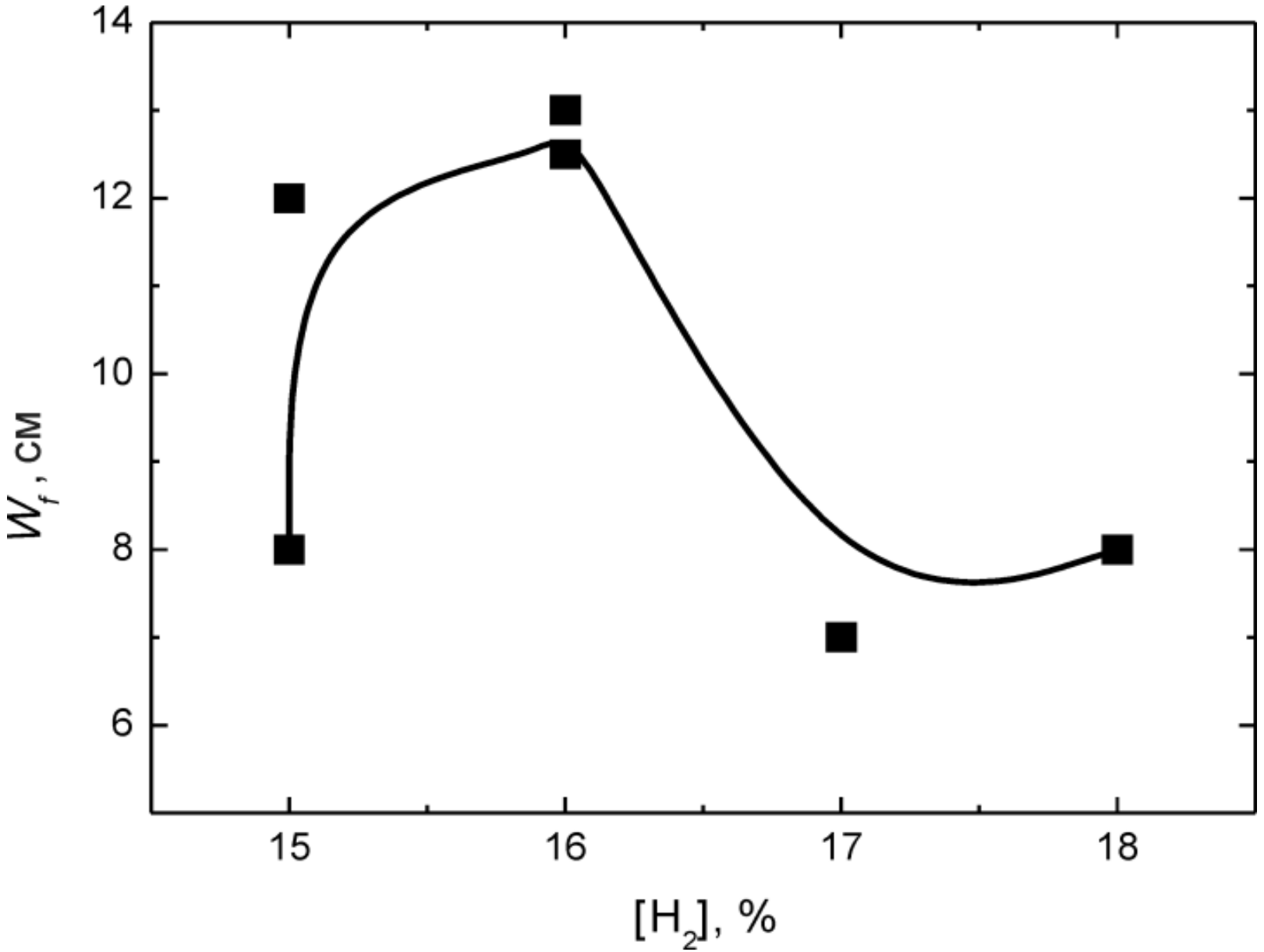
Image 58 mm × 27 mm *0,25 ms between frames*



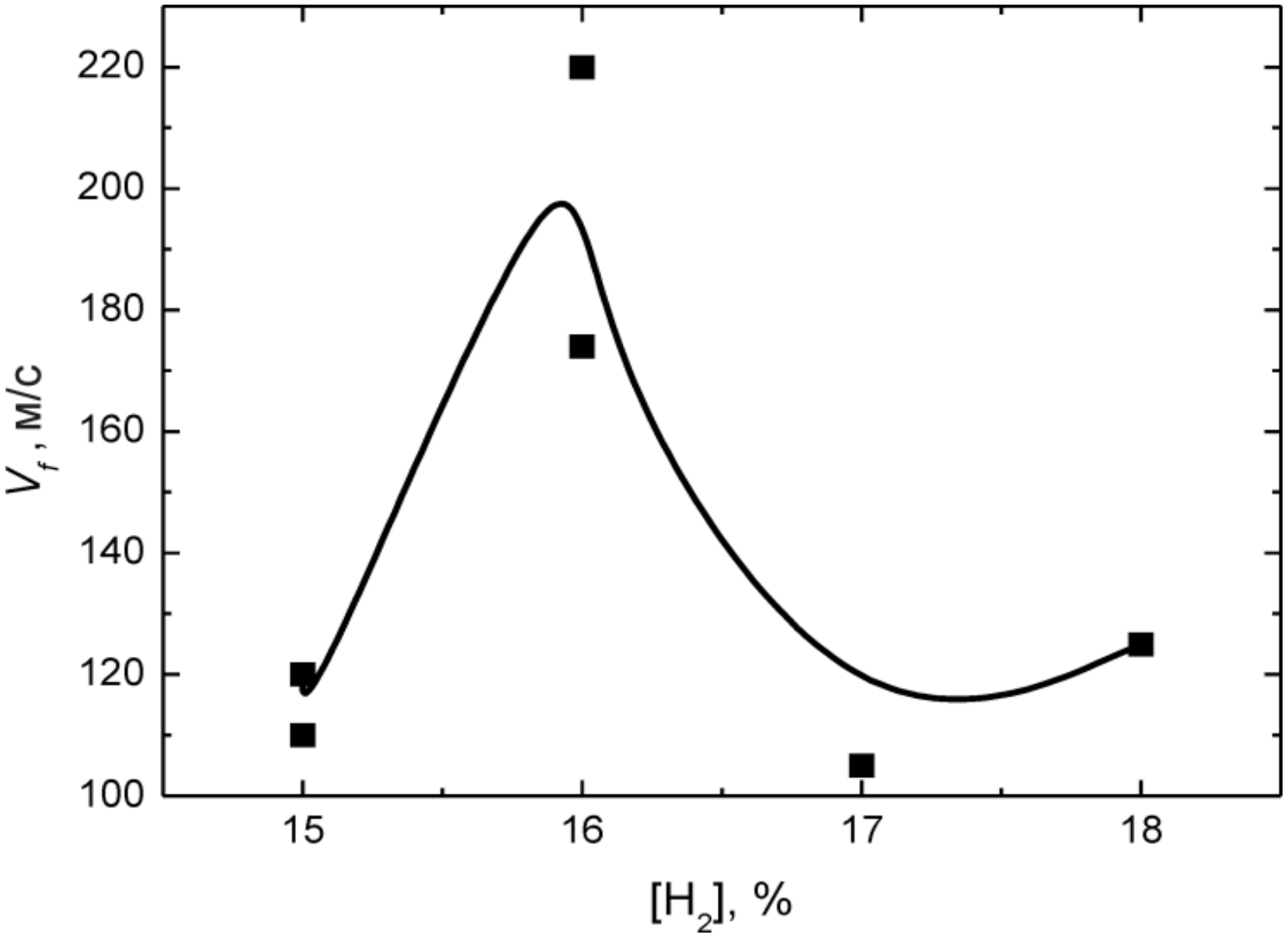




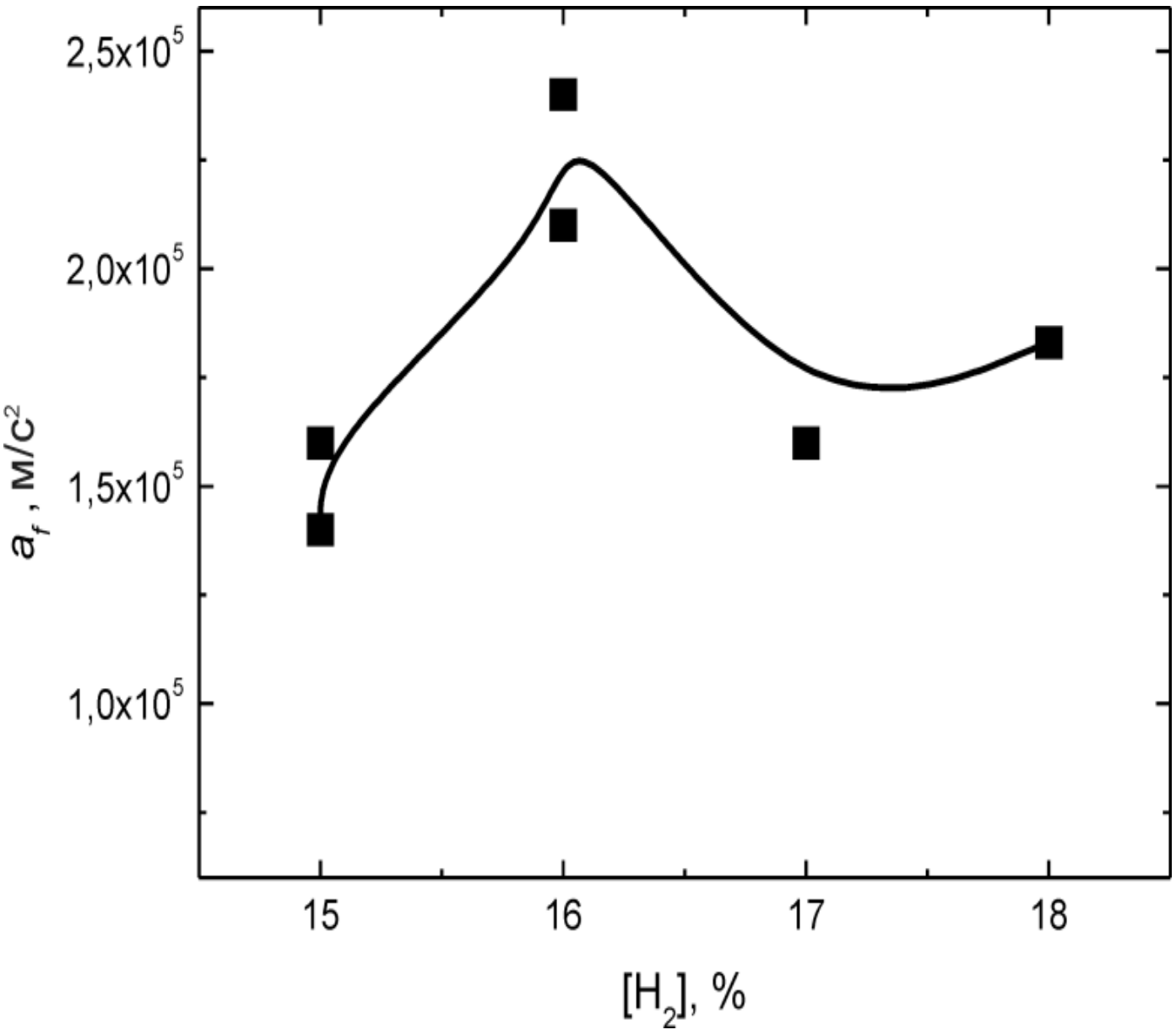
“Flame width” in rarefaction wave



Apparent flame velocity in rarefaction wave



Apparent flame acceleration in rarefaction wave



Conclusions

•Flame propagation in lean hydrogen-air mixtures were experimentally studied in the multi-purpose shock tube;

•Extensive data are obtained on how flame development depends on Rayleigh-Taylor instability under conditions of the superimposed artificial-G field.

•Two modes of turbulent flame development are identified, i.e. convex and concave flames. Modes depend on the mixture concentration. Transition between modes takes place at hydrogen concentration of 16±2% in the air. Convex flame mode is realized below 16 % hydrogen in the air and concave flame mode is realized above 16 % hydrogen.

• 16% hydrogen concentration realizes the transition mode of the periodic oscillating flame having spherical shape on a small scale and plane shape on the scale of the channel cross-section. Flame development in the transition mode is probably driven by Rayleigh-Taylor instability as far as superposition of the artificial-G field sharply intensifies flame evolution in this mode.