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ELECTRICAL EXPLOSION OF THIN CONDUCTORS (PARADIGM CHANGE) *)

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The study of the electrical explosion of thin metal wires (EEWs) in a vacuum and in various media has a very long history and is stimulated by both a large number of practical applications and fundamental interest in matter with extreme thermophysical parameters. The ability to obtain experimental data far beyond the limits of “normal conditions” is absolutely invaluable in constructing the corresponding equations of state. The use of increasingly powerful diagnostic tools — laser probing, including at different wavelengths, high-resolution radiography, high-speed photography, etc. made it possible to establish a number of the most important patterns and features of EEW, such as the formation of a core-corona structure, a tubular or foam-like (depending on the energy input) structure of the core, as well as the presence of a noticeable amount of scattering microparticles in the explosion products [1–3].

The processes being studied are extremely complex, and we are still very far from constructing a full-fledged theory that would adequately describe the phase transformations of a metal when it is heated by a high-power electric current. At the same time, many early concepts have firmly taken root among researchers and, despite their unprovenness and sometimes direct contradictions with the results of modern experiments, continue to be uncritically used to describe and interpret experimental data. Thus, the idea of complete evaporation of the conductor material, supposedly achievable with a sufficiently large energy input, is obviously refuted by data on the scattering of probing laser radiation in explosion products. In general, the very possibility of optical shadowgraphy of an exploded wire (and this is one of the main diagnostics for EEW) excludes the presence of the expanding core in a gaseous state. The idea of a uniform distribution of substance parameters over the cross section of a thin wire core, which underlies almost all MHD simulations of the explosion process, does not agree with radiographic data on the tubular structure of the core. The concept of strata (regions of high density) as flat disks also requires revision — new data indicate, rather, their development on the surface of the core and a ring (torus) shape.

Relatively late theories of “phase” and “cavitation” explosions, on the contrary, are in quite good agreement not only with experiment, but also with the results of corresponding molecular dynamics calculations. However, the ideas expressed there are apparently too unusual and have not yet been able to replace the traditional, greatly simplified ideas of the phase transformation of a substance among EEW researchers as a simple sequence of heating-melting-evaporation processes occurring throughout the entire volume of the conductor.

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