Mechanics of solid body, hydromechanics and gas dynamics in conic sections as a way for solution of the problems
Part 4: The conics in gas flow near axisymmetric body

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It is offered series of examples for profiling of sharp-nosed axisymmetric body by means of evolvent of circumference. It is given physically adequate explanation of plane shock wave in front of a blunt body at M = 1 in atmosphere

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Introduction

Traditional method for decrease of a drag coefficient of sharp-nosed axisymmetric body is to the effect that a profiling is carried out by means of a circumference arch on length about two diameters of the body. At the same time circumference is too simple curve because of its radius as its sole parameter. In contrast to it, a circumference evolvent is curve with natural equation, in which length of way is bound with a curvature radius as analogue of velocity in formula of free fall. Variable quantity of the evolvent curvature radius allows profiling with increase or decrease of its curvature along the body axis for ensuring of minimum drag coefficient.
Next problem – on interaction of the body with atmosphere at velocity M = 1 – is to the effect that plane shock wave is placed in some distance in front of the body, in contrast to Mach acoustic diagram adduced in course of aerodynamics more 100 years.

Figs.1, 2, offer examples in construction of sharp-nosed profile of axisymmetric body with increase and decrease in the evolvent curvature along the body axis.

Fig.3 shows two diagrams of a flow field in front of circular cylinder, oriented across the air flow – in upper part of the figure and oriented along the air flow – in lower part of the figure. A circumference evolvent, in left part of the upper diagram, restricts a near-axial stagnation zone on frontal part of the cylinder cross-section; such constructing corresponds to experimental results, obtained by A. Ferry (1942), and ones are adopted from book [1, fig.92]. Part of air flow in the pointed stagnation zone is a gaseous body having its mass, elasticity and viscosity and, under action of velocity head, the gaseous body is in state of self-excited oscillations; lateral surfaces of the body, formed by the evolvent arches, are radiators of these oscillations; amplitude of these oscillations is neglecting at low velocity of air flow, but at M = 1 the amplitude is sharply increased up to resonance level: maximum intensity of the radiation reaches level of velocity head in running air flow, what is accompanied by normal shock wave at front edge of the gaseous body and by yawing of the body in transversal direction relative to the cylinder longitudinal axis. Distinction in interaction of the radiation field with running air flow in comparison with interaction of two flow fields, directed against each other, is in that such two flow fields stop one another in its forward motion; at the same time, oscillatory nature of the

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radiation field leads only to some deceleration of the running air flow (but one not stops it), what is accompanied by corresponding increase in static pressure. The gaseous body yawing excites transversal to the air flow oscillations and, as its consequence, vibrations (flatter) of the cylinder. Successive increase in the air flow velocity, M > 1, makes the flow not only supersonic but also super-resonant, and one is accompanied by decrease in drag. Graphical and physical compatibility of the circumference evolvent and hyperbola allows using its combination for construction of profile of shock waves at M > 1, as it is showed in right part of the diagram. The same device is used in construction of the flow field fragments when longitudinal axis of the cylinder coincides with direction of air flow, what is showed in lower diagram of the figure.

Fig.4 shows fragment of the flow field in front of a ball at subsonic, sonic and supersonic velocity of the running air flow.

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[1] Modern developments in fluid dynamics high speed flow, Ed. by L. Howarth, Vol. II, Oxford, 1953

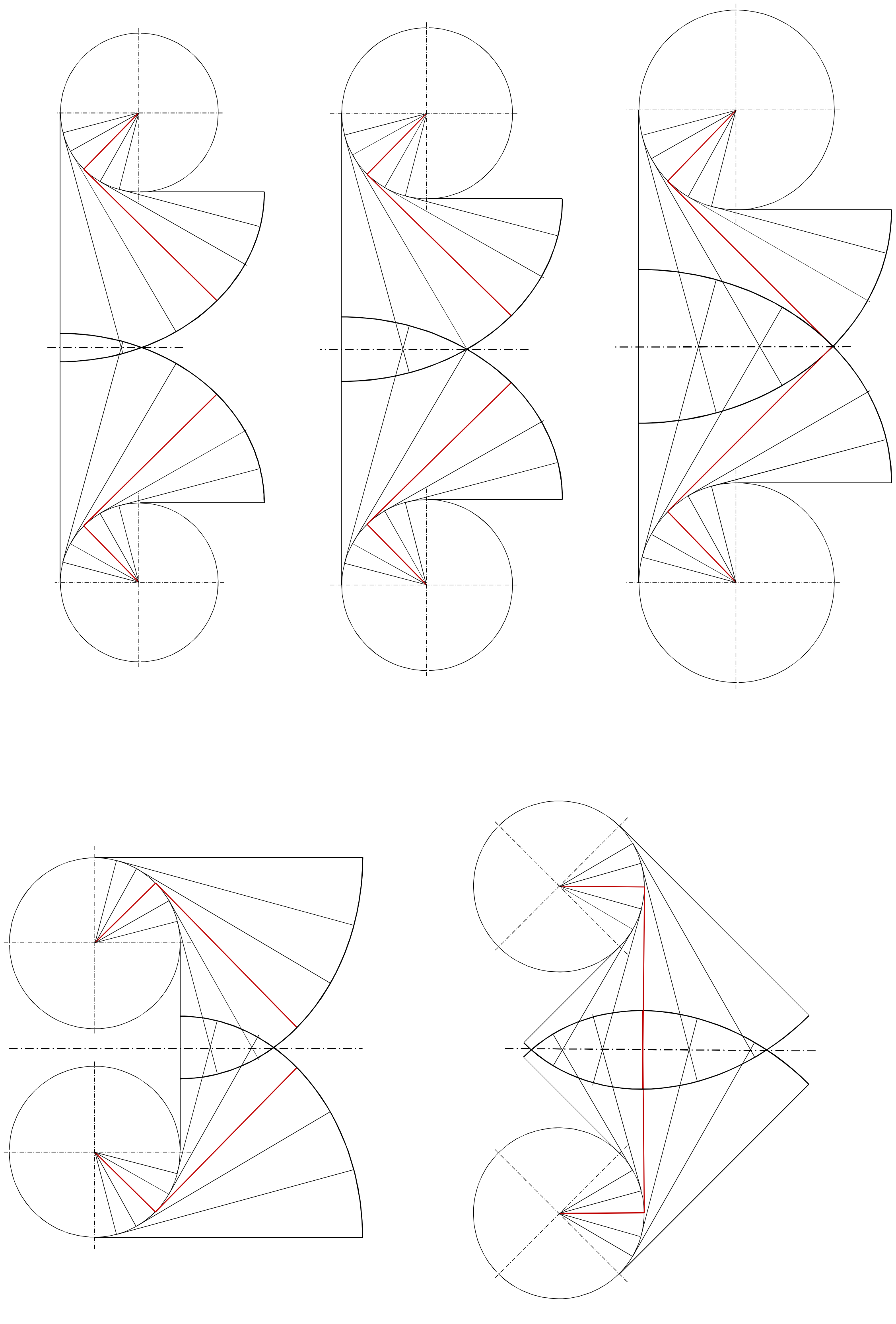


Fig.1

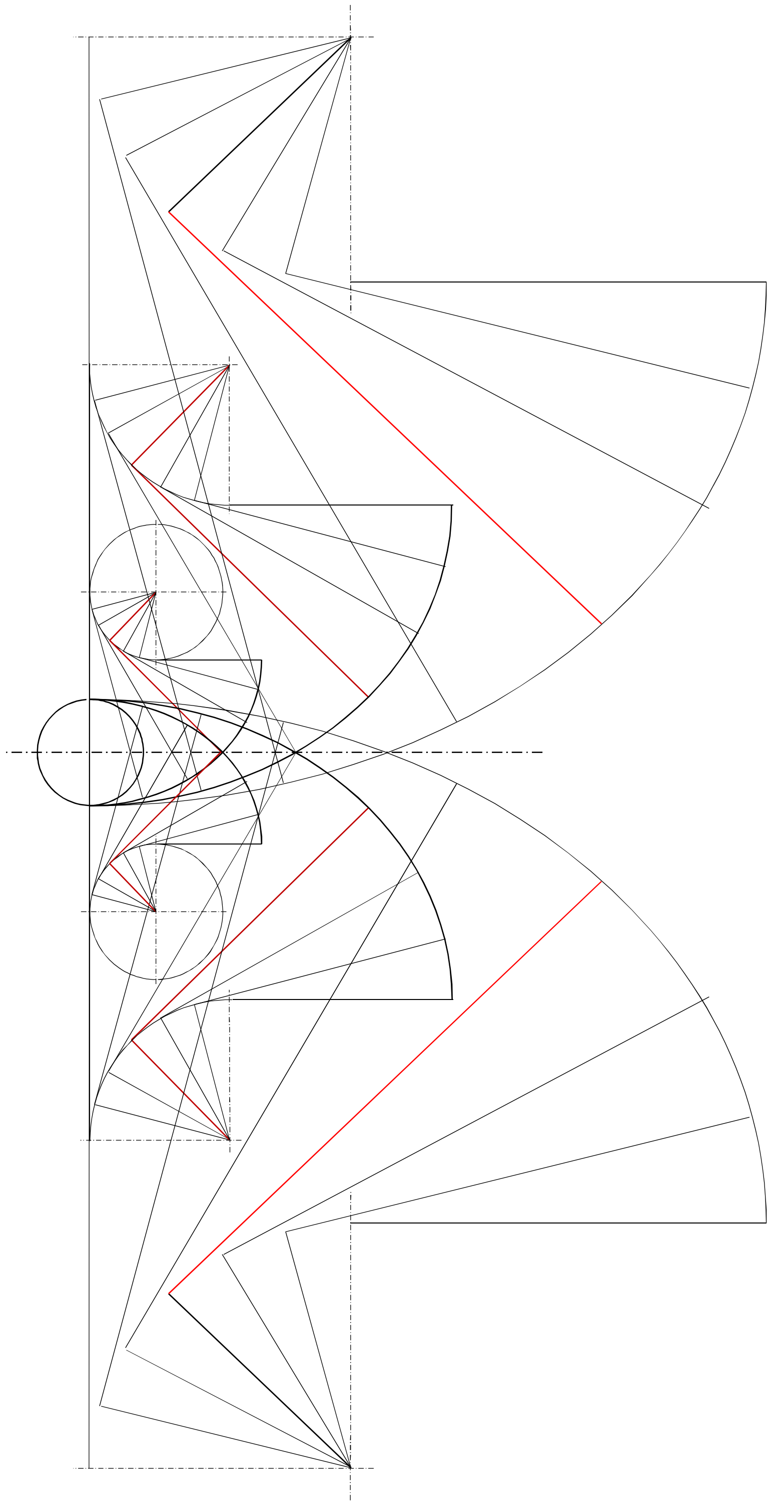
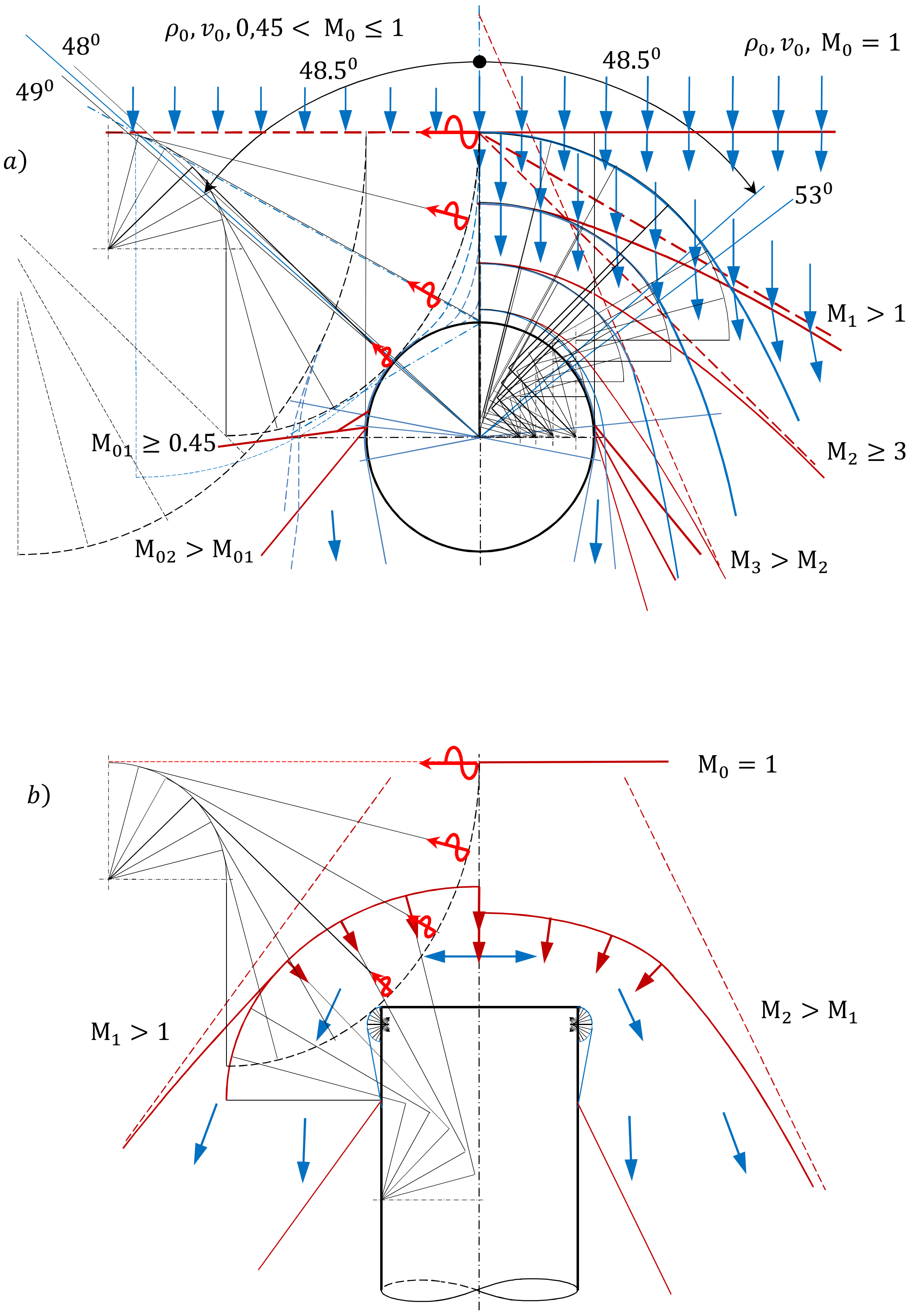
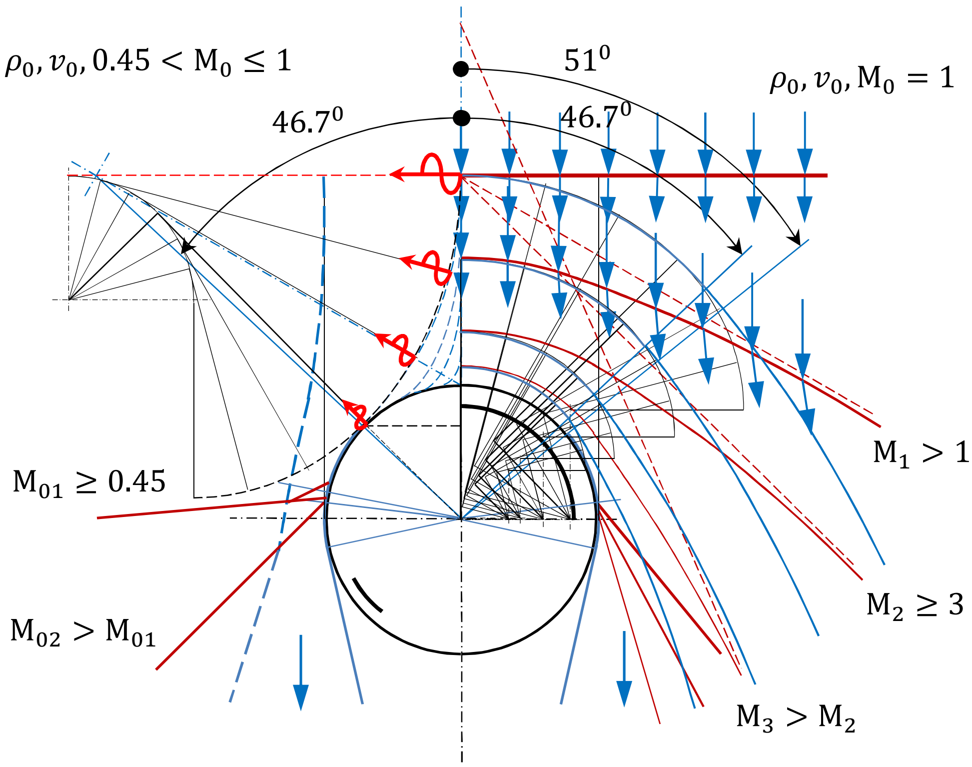


Fig.2



$\rho_0, v_0, 0{,}45 < M_0 \leq 1$
48^0
49^0
48.5^0
48.5^0
$\rho_0, v_0, M_0 = 1$
$a)$
53^0
$M_1 > 1$
$M_{01} \geq 0.45$
$M_2 \geq 3$
$M_{02} > M_{01}$
$M_3 > M_2$
$b)$
$M_0 = 1$
$M_1 > 1$
$M_2 > M_1$

Fig.3



$\rho_0, v_0, 0.45 < M_0 \leq 1$
51^0
$\rho_0, v_0, M_0 = 1$
46.7^0
46.7^0
$M_1 > 1$
$M_{01} \geq 0.45$
$M_2 \geq 3$
$M_{02} > M_{01}$
$M_3 > M_2$

Fig.4