A New Configuration Of Irregular Reflection Of Shock Waves.

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The results of a study of a new configuration of shock waves in steady supersonic flow is presented in the report. This three shock wave configuration with a negative angle of reflection has been found by the authors [1,2,3], in addition to the well-known: two shock (regular reflection) and three shock wave configurations (irregular or Mach reflection).

Three shock wave configurations are shown in Figure 1. Typically, the predicted and observed flow pattern looks as in Figure 1 (a), i.e., the reflected wave AR is located above the line of incoming flow. This configuration we will call a configuration with a positive angle of reflection ($\omega_2 > 0$). It has been shown that in a steady supersonic flow of gas at high Mach numbers and small values of the adiabatic index γ, the reflected wave must be located below the direction of inflow stream ($\omega_2 < 0$); this constitutes a new configuration with a negative angle of reflection (Fig. 1 b).

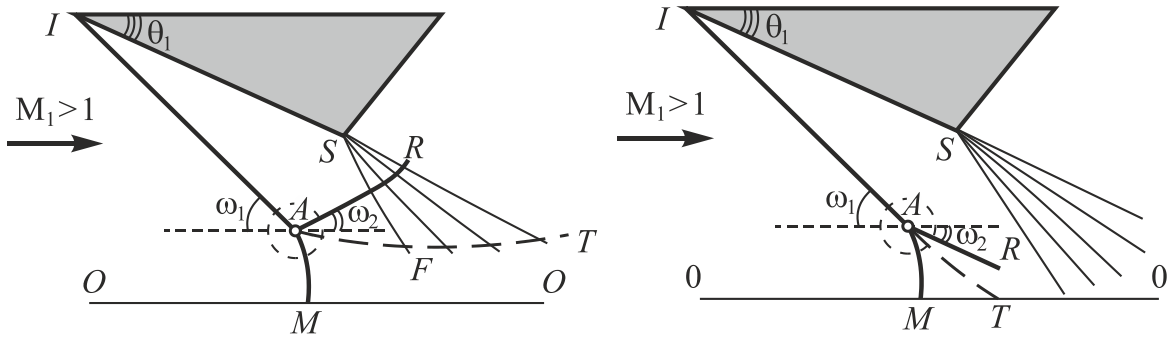

Fig. 1. Three-shock wave configuration with a positive $\omega_2 > 0$ (a) and negative $\omega_2 < 0$ (b) reflection angle. IA — incident shock wave, AR — reflected shock wave, AT — tangential discontinuity surface, AM — Mach wave, ω_1 — angle of incidence, ω_2 — angle of reflection, A — triple point, O-O — line of symmetry, M_1 — free-stream Mach number .

The arrangement of waves is defined by the Mach number of flow M_1, the angle of incidence ω_1 and the effective adiabatic index of gas γ. Boundaries and areas of existence of this new configuration have been analytically defined. The new configuration can occur at Mach numbers greater than 3 and the adiabatic index smaller then 1.4.

In the paper, the dependence of the boundaries and areas of the regular and Mach reflection on the adiabatic index have been also defined. It has been shown that the region of dual solutions, where there may be as the regular as Mach reflection, increases as the adiabatic index decreases. Besides since at adiabatic index smaller than 1.4 a new form with a negative angle can exist, there is one more area of the hysteresis. In this region the existence as a regular reflection, and as an unstable configuration with a negative reflection angle is possible. Thus the dependence of all types of reflection on adiabatic index has been found and a new field of dual solutions where hysteresis is possible has been determined.

Numerical calculations have confirmed the existence of the new configuration. It has been shown that this new configuration can be unstable and leads to a radical change of the total flow pattern. It has been found that the configuration can have several different subspecies. For the first time double Mach reflection with a negative reflection angle has been determined numerically in a steady supersonic flow.

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References

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