PREDOMINANTLY UNIDIRECTIONAL MOTION OF A COMPRESSIBLE SOLID BODY IN A VIBRATING LIQUID

V. L. Sennitskii

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Experimental results were given in [1] which confirmed the existence of the phenomenon of predominantly unidirectional motion of a gas bubble in a vibrating liquid. In this phenomenon, a gas bubble in a liquid which is contained in a closed vessel is displaced in a given direction as a consequence of the imposition of matched oscillations and deformation of the vessel (in the positive or negative direction of the axis along which the vessel oscillates). In this work, experimental results are presented which demonstrate that under these conditions, a solid compressible (compared with the liquid) body is also displaced in the prescribed direction.

Figure 1 shows a diagram of the experimental setup. Closed vessel 1 is filled with liquid (water) 2, in which compressible solid body 3 is placed (an elastic air-filled balloon with a flyweight attached). The density of the body is close to that of the liquid. The vessel is made of elastic membrane 4 and solid walls which are rigidly fastened to one another. The vessel can oscillate along the horizontal axis Z and when oscillating, it can deform by compressing and expanding. Realization of a prescribed deformation of the vessel when oscillations are imposed on it is ensured by joining membrane 4 with a fixed wall by means of filament 5 or filaments 6, 7 and batten 8.

The prescribed deformation of the vessel is done in such a way that on the average the body neither rises nor sinks.

Observation of the body shows the following. During execution of the prescribed matched oscillations and deformation of the vessel, the body moves primarily in one direction along the Z axis: it is displaced in the positive direction if the vessel is compressed during

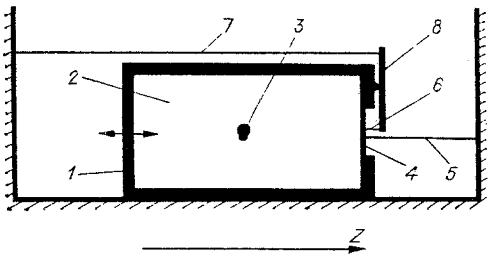

Fig. 1

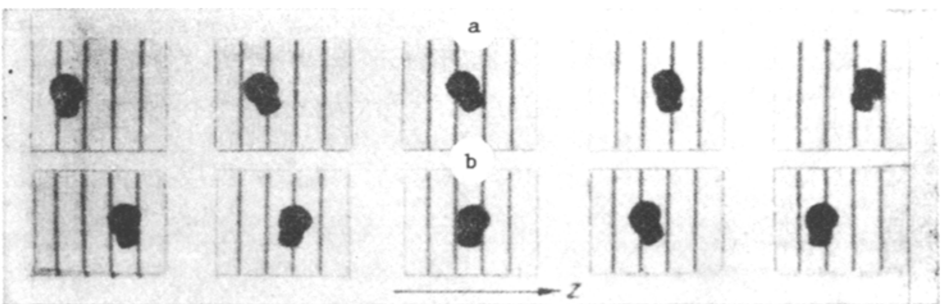

Fig. 2

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motion in the positive direction, or if the vessel is extended during motion in the negative direction (membrane 4 is connected to the fixed wall by means of filament 5). The body is displaced in the negative direction if during its motion in the positive direction the vessel is extended, or if it is compressed during its motion in the negative direction (membrane 4 is connected to the fixed wall by means of filaments 6, 7 and batten 8).

Figure 2a, b shows two series of snapshots demonstrating the motion of the body along the Z axis with respect to the vessel when prescribed matched oscillations and deformation are imposed on the vessel. In Fig. 2a, the body is displaced in the positive direction; in Fig. 2b, it is displaced in the negative direction. The distance between adjacent vertical subdivisions is 0.5 cm (these scale divisions are fixed with respect to the vessel). The framing frequency is 5 shots/sec. The amplitude and period of the vessel oscillation is 0.3 cm and 0.25 sec, respectively.

Comparison of results given here and those of [1] shows that the predominantly unidirectional motion of the compressible solid body and a gas bubble are qualitatively the same. The predominantly unidirectional motion of the compressible solid body can be explained in the same way as the analogous motion of a gas bubble (see [1.2]). From this it may be concluded that there exists a phenomenon of predominantly unidirectional motion of a compressible inclusion in a vibrating liquid.

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ANALYTICAL SOLUTION OF THE ONE-DIMENSIONAL PROBLEM OF MODERATELY STRONG EVAPORATION (AND CONDENSATION) IN A HALF-SPACE

A. V. Latyshev and A. A. Yushkanov

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We obtain for the first time an exact solution of the problem of evaporation (and condensation) of a liquid occupying a half-space and evaporating into a vacuum. We use the one-dimensional Boltzmann equation with the collision operator in the BGK (Bhatnagar–Gross–Krook) form, linearized about the equilibrium distribution function far from the surface between the phases.

The history of this problem, for which there is no available analytical solution even in the linear formulation using the one-dimensional BGK equation, has been described in [1, 2], where the exact solution of the problem was considered for so-called strong evaporation of a liquid into a vacuum. The problem was linearized about the equilibrium distribution function far from the surface of evaporation and the effect of the translational motion of the gas on its behavior in the Knudsen layer was taken into account in the linear approximation. The escape velocity of the gas (and other parameters) appear nonlinearly in the distribution function. This approach can be called quasilinear. In spite of its crudeness, it correctly describes a number of important qualitative features of evaporation such as the special position of the Mach number equal to unity.

In [1] the problem was solved using the resolvent method, in [2] it was reduced to a boundary-value problem, and in [3] the methods of functional analysis were used to show that the problem has a solution when $U < \sqrt{3/2}$ and does not have a solution when $U \geq \sqrt{3/2}$. Here

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