serve as the basis in a calculation of the sensitivity of induction flowmeters at large magnetic Reynolds numbers.

Additional experimental studies with different configurations of the external magnetic field are needed for a final conclusion concerning the applicability of the modified equation for the electric potential.

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PROCESS OF OPENING OF AN INELASTIC DIAPHRAGM IN A SHOCK TUBE

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The problems connected with the mechanism of opening of diaphragms in shock tubes are discussed in [1-3], where a "hinge" model is analyzed. It is usually assumed that after breaking along the incisions the leaves of the diaphragm do not undergo deformations and only perform rotational motion about the point of attachment to the tube; the resistance of the diaphragm at the points of attachment is not taken into account. To calculate the process of opening of a diaphragm we used the model of a so-called freely linked chain, where it is assumed that the pressure forces on the diaphragm are much larger than the elastic forces of the material and the elastic forces can be neglected. Such a situation can arise in explosive and electric-discharge shock tubes, shock wind tunnels, etc.

Photography of the process of opening of a copper diaphragm 1.5 mm thick and 50 mm in diameter at the end of an electric-discharge shock tube [4] was carried out in the present work. An SFR camera was used in the mode of framewise photography with a frequency of $5 \cdot 10^5$ frame/sec. Diaphragms of such a type with a cross-shaped incision 1 mm deep withstood pressures of up to 90 atm. Before the discharge the chamber with a volume of 200 cm^3 was filled with helium to 10 atm and within it occurred the discharge of a battery of capacitors at a voltage of 5.5 kV with a total energy of 30 kJ. According to the estimates of [4], the pressure in the chamber increased to $\sim$400 atm.

Sequential photographs of the opening process every 8 μsec (exposure time 2.5 μsec) are shown in Fig. 1. It is noteworthy that almost from the moment of breakage along the incisions the open section has a strictly cross-shaped form and retains it until full opening. It was also established experimentally that the leaves are elongated by about 1.5 times owing to their elongation in the process of motion.

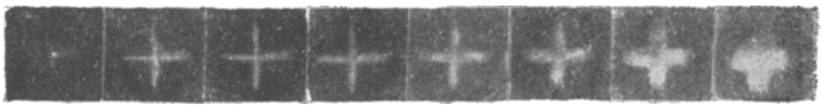

Fig. 1

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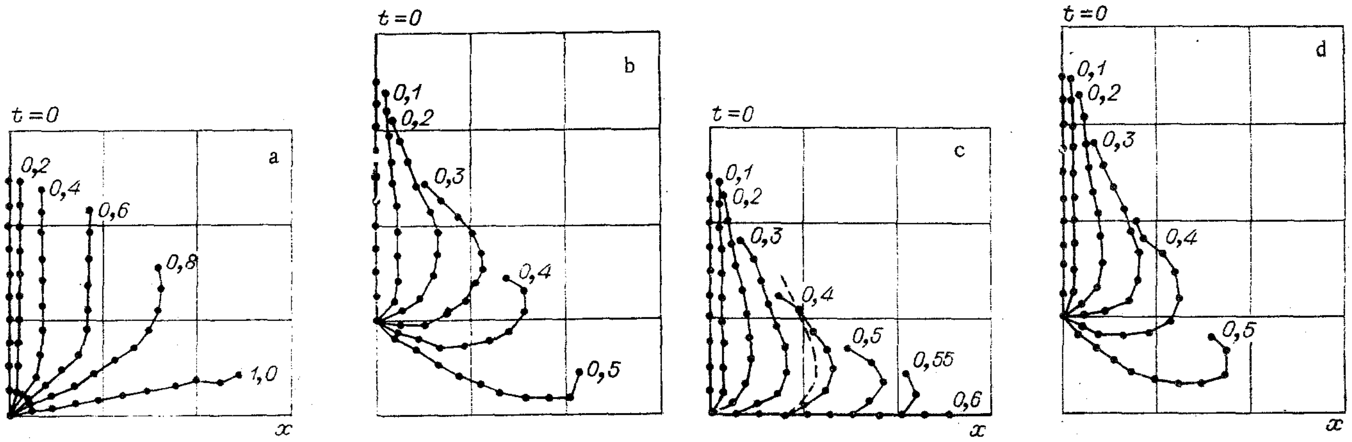

Fig. 2

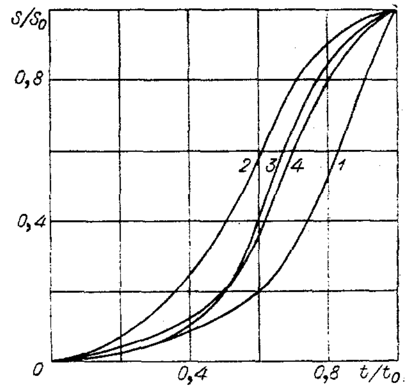

Fig. 3

We analyze the motion of a chain consisting of N links, each of mass m_i and length l_i; the mass of a link is assumed to be concentrated at its end. With $i \to \infty$ such a chain is a model of an inelastic diaphragm with a given mass distribution.

The kinetic energy of such a system is expressed in the form

$$T = \sum_{i=1}^{N} \frac{m_i}{2} \left\{ \left[\sum_{j=1}^{i} l_j \cos \varphi_j \cdot \dot{\varphi}_j \right]^2 + \left[\sum_{j=1}^{i} l_j \sin \varphi_j \cdot \dot{\varphi}_j \right]^2 \right\},$$

where φ_i are the angles between the direction of the force of gravity and the axis of link i. Then with allowance for the fact that the potential energy U of the chain does not depend on the velocity of its motion one can write the equation of motion [5] as

$$\frac{d}{dt} \frac{\partial T}{\partial \dot{\varphi}_k} = \frac{\partial T}{\partial \varphi_k} - \frac{\partial U}{\partial \varphi_k}$$

or

$$\sum_{i=1}^{N} m_i \left\{ \left[\sum_{j=1}^{i} l_j \left(\cos \varphi_j \cdot \ddot{\varphi}_j - \sin \varphi_j \cdot \dot{\varphi}_j^2 \right) \right] l_k \cos \varphi_k \cdot \theta_{ki} + \right.$$
$$\left. + \left[\sum_{j=1}^{i} l_j \left(\sin \varphi_j \cdot \ddot{\varphi}_j + \cos \varphi_j \cdot \dot{\varphi}_j^2 \right) \right] l_k \sin \varphi_k \cdot \theta_{ki} \right\} - \frac{\partial U}{\partial \varphi_k}, \qquad (1)$$

where

$$\theta_{ki} = \begin{cases} 1 & \text{for} \quad k \leqslant i, \\ 0 & \text{for} \quad k > i, \end{cases} \quad k = 1, 2, \ldots, N.$$

Equations (1) written in finite differences for links of the same length l have the form

$$\sum_{i=k}^{N} m_i \sum_{j=1}^{i} \varphi_j (z+1) \cos[\varphi_j(z) - \varphi_k(z)] = \sum_{i=k}^{N} m_i \sum_{j=1}^{N} \{[2\varphi_j(z) - \varphi_j(z-1)] \cos[\varphi_j(z) - \varphi_k(z)] + [\varphi_j(z) - \varphi_j(z-1)]^2 \times \sin[\varphi_j(z) - \varphi_k(z)]\} - \frac{(\Delta t)^2}{l^2} \frac{\partial U}{\partial \varphi_k},$$

$$k = 1, 2, \ldots, N,$$

where $\varphi_j(z)$ is the value of φ_j at the time $z\Delta t$ ($z = 1, 2, 3, \ldots$). It is convenient to choose the combination $(2L\rho\delta/pt^2)$ as the similarity parameter for motions of this kind and to express the time in the units $(2L\rho\delta/p)^{1/2}$.

The motion of the chain is calculated for several particular cases:

1. The fall of a chain, consisting of links of equal mass and fastened at one end, from a horizontal position under the effect of gravity. This corresponds to the opening of a rectangular leaf under the effect of a force acting along the axis of the tube:

$$\frac{\partial U}{\partial \varphi_k} = gl \sin \varphi_k \sum_{i=k}^{N} m_i,$$

where g is the acceleration of gravity.

The successive positions of the chain at time intervals $\Delta t = 0.2$ obtained through a calculation for the case of $i = 10$ are shown in Fig. 2a. The initial conditions here and later are $\varphi_i = \pi/2$ and $\dot{\varphi}_i = 0$ for $i = 1, \ldots, 10$.

2. Let us consider the motion of a chain with $i = 10$, fastened at one end, under the effect of forces P_i on the point masses m_i normal to the direction of the link l_i, which corresponds to the motion of a leaf in a tube under the effect of pressure forces:

$$\frac{\partial U}{\partial \varphi_k} = \sum_{j=k}^{N} P_j l \left\{\cos \varphi_j \sum_{l=k}^{j} \cos \varphi_l + \sin \varphi_j \sum_{l=k}^{j} \sin \varphi_l\right\}.$$

The results of the calculation are shown in Fig. 2b. The initial conditions are the same as for case 1.

3. The motion of a chain for which the mass of the links grows in proportion to the distance of the link from the unfastened end of the chain is calculated. This case corresponds to the motion of a triangular leaf. The results of the calculation are presented in Fig. 2c, d for the case when there is no confining wall and in the presence of one. The profile of a leaf of aluminum foil which opens under the effect of a shock wave reflected from it in a pneumatic shock tube (experiments) is presented in Fig. 2c (dashed line).

The calculations conducted showed that the time of complete opening as a function of the pressure and the properties of the diaphragm is expressed by the equation

$$t_0 = 0.6 \left(\frac{2L\rho\delta}{p}\right)^{1/2}.$$

The time of complete opening for the "hinge" model on the assumption of constancy of the acting pressure can be written in the form

$$t_0 = \left(\frac{\pi}{4}\right)^{1/2} \left(\frac{2L\rho\delta}{p}\right)^{1/2}.$$

Numerical coefficients of 0.91 and 0.95 were obtained in analogous expressions in [1, 2] respectively, with allowance for the pressure actually acting on the diaphragm. The model of a freely linked chain gives a value ∼1.5 times lower for the time of complete opening than the "hinge" model.

The relative value of the through cross section at different stages of the process of opening of the diaphragm calculated for the "hinge" model and the freely linked chain is shown in Fig. 3 {1) model of "hinge" opening; 2) inelastic opening; 3) experimental dependence for a thick copper diaphragm; 4) experiment of [3]}.

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TRANSIENT HEAT–MASS EXCHANGE NEAR A SPHERICAL PARTICLE

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1. Statement of the Problem and the Basic Equations

The spherically symmetric problem is discussed in which phase transitions occur only on the surface of a particle, and the mass velocities which arise in the gas are many times smaller than the speed of sound. In this case it makes sense to use the condition of pressure uniformity over space (appropriate justification occurs in [1]). The gas which surrounds the drop or particle is a single-component gas and is the vapor of the material of the drop or particle (there is no diffusion in the system). Let the particle be incompressible, motion be absent in it, but thermal conductivity occur. We will assume the gas or vapor to be a perfect gas. The system of equations which describes this process has the form

$$r > r_\sigma,\ p = p(t),\ p = \rho RT; \tag{1.1}$$

$$\frac{\partial \rho}{\partial t} + \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 \rho v) = 0; \tag{1.2}$$

$$\rho\frac{\partial c_V T}{\partial t} = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\lambda_1\frac{\partial T}{\partial r}\right) - \rho v\frac{\partial c_V T}{\partial r} - \frac{p}{r^2}\frac{\partial}{\partial r}(r^2 v); \tag{1.3}$$

$$r < r_\sigma,\ \rho_2 = \frac{\partial c_2 T}{\partial t} = \frac{1}{r^2}\left(r^2\lambda_2\frac{\partial T}{\partial r}\right),\ \rho_2 = \text{const}, \tag{1.4}$$

where ρ is the density, T is the temperature, p is the pressure, v is the velocity, R is the gas constant, λ is the thermal conductivity coefficient, r is the radius, and t is the time. The subscripts 1 and 2 correspond to the values of the parameters in the vapor and in the particle, and the subscript σ corresponds to values on the surface of the particle.

The first of Eqs. (1.1) is the pressure uniformity condition over space, which is a corollary of the momentum equation upon neglect of inertial forces, (1.2) is the continuity equation in the gaseous phase, and (1.3) and (1.4) are the heat flux equations in the vapor and the particle, respectively.

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