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ON THE STABILITY OF AN AEROSTATIC BEARING WITH AN ELASTIC SKIRT

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Stability of an aerostatic bearing with an elastic skirt used for transporting objects on the shop floor is considered. Equations of the Timoshenko — Karman theory of equilibrium of an annular diaphragm are used together with the equations describing the variation in the mass of air in an inflatable cavity when the pressure and density are connected by an adiabatic relationship. As a result, approximate equations describing the pressure change in the inflatable cavity and in the air cushion are derived, as well as the nonlinear equations describing the variation in the bearing platform rise height with time and the distances, from the symmetry axis, of the smallest gap between the diaphragm and the fixed plane. Passing to the variational equations yields the characteristic equation and the Hurwitz criterion of stability of the bearing. The latter criterion is verified for a specified range of values of the bearing parameters. A satisfactory agreement of the theoretical graphs of the neutral stability curve and the period of oscillations of the bearing with the data obtained on a special experimental stand and during the practical use of the bearing is noted.

Certain plants use the aerostatic bearings on an air cushion with an elastic skirt, for transporting objects along the shop floor. The construction and working principles of an aerostatic bearing are described in [1—3]. The form of the diaphragm for a steady-state mode and the characteristic features of the flow in a narrow layer in which a sharp pressure change occurs, were given a theoretical and experimental treatment in [1]. The practical usage of the aerostatic bearings shows, together with specially devised experiments, that under certain conditions increase in the flow of air or reduction in the weight of the load transported induces vertical oscillations in the aerostatic bearing, and in some cases the amplitude of these oscillations increases with time. Oscillations of a device on an air cushion with a rigid boundary were studied in [4] for the case when the air consumption was large. Analysis of the relations connecting the volume of air under the dome with its consumption and density, gave a rheological equation for the air cushion and supplied a satisfactory answer to the problem of dynamic stability of ships supported by air cushions. So far, no theory of stability of aerostatic bearings with elastic skirt has been constructed. The known contributions are limited to certain technical recommendations for reducing the amplitude of the oscillations (by means of elastic dampers [5] or by using additional volumes of air [3, 5]). In [5] the study of stability of aerostatic bearings included the experimental relationships connecting the height at which the platform floats and the height at which the damper is situated with the air pressure within the corresponding objects.

1. Differential equation describing the vertical motion of the platform of the aerostatic bearing shown in Fig. 1, has the form

$$Gg^{-1}d^2H / dt^2 = P - G \tag{1.1}$$

Here H denotes the height at which the platform floats, the height changing with time, P is the resultant of the dynamic pressures distributed at the lower side of the diaphragm

$$P = 2\pi \int_0^b (p - p_a) r\, dr \tag{1.2}$$

p is the pressure in the air cushion and p_a is the atmospheric pressure.

To find how p varies with time, we must construct the differential equations describing the variation in the shape of an annular diaphragm, taking into account the large deflections in accordance with the Timoshenko — Karman theory and the relations of Hooke's Law. When the bending moments, the outer tangential forces and the inertial forces of the flexible diaphragm itself are all neglected, then the differential equations assume the form

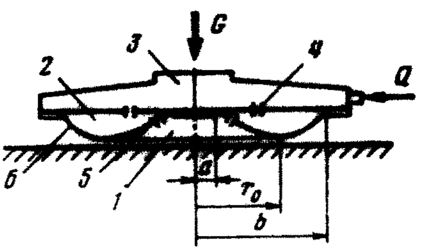

Fig. 1

$$\partial (r^2 N_r) / \partial r - r (N_r + N_t) = 0 \tag{1.3}$$

$$r\partial (N_r + N_t) / \partial r + {}^1/_2 E\delta(\partial w / \partial r)^2 = 0$$

$$r^{-1}\partial (rN_r \partial w / \partial r) / \partial r = -q$$

where N_r and N_t denote the radial and tangential tensions, w is the axial displacement, $q = p_2 - p$, and p_2 is the pressure within the inflatable cavity. The radial displacement u is written, in accordance with Hooke's Law, in the form

$$u = (E\delta)^{-1} r (N_t - \nu N_r)$$

Here E is the Young's modulus of the diaphragm, δ is its thickness and ν is Poisson's ratio. The condition of rigid clamping of the diaphragm along the circles $r = a$ and $r = b$, yields the following boundary conditions:

$$r = a,\ w = 0,\ u = 0;\ r = b,\ w = 0,\ u = 0 \tag{1.4}$$

Let us assume the air enters the region of the air cushion only through the side openings in the diaphragm itself. Let the total area of the side openings be S_2. The air passes into the inflatable cavity through the openings, the area of which is S_3, from a special chamber in which the pressure is assumed to be p_3 and the density ρ_3, neither varying with time. We denote by V_2 the volume of the inflatable cavity bounded from above by a rigid disc, and from below by the surface of the diaphragm. The volume of the air cushion extending from the symmetry axis to the circumference of radius r_0 (the cross sections with a smallest gap h_0) is denoted by V_1. The equations describing the changes in the mass of air within the volumes V_2 and V_1 have the form

$$d(\rho_2 V_2) / dt = Q_3 - Q_2, \quad d(\rho_1 V_1) / dt = Q_2 - Q_1 \tag{1.5}$$

where Q_2 and Q_3 denote the rates of flow of air through the openings S_2 and S_3, respectively, and Q_1 is the rate of flow of air through the crossection with the smallest gap the area of which is $S_1 = 2\pi r_0 h_0$. The rates of flow can be related in an approximate manner to the corresponding pressures using the Bernoulli integral, and this yields the relations

$$Q_i^2 = 2\gamma(\gamma - 1)^{-1} p_i \rho_i S_i^2 [(p_{i-1} / p_i)^{2/\gamma} - (p_{i-1} / p_i)^{(\gamma+1)/\gamma}] \tag{1.6}$$
$$i = 2, 3$$

When an adiabatic relation exists between the pressures and the density, we have

$$p_i / p_{i-1} = (\rho_i / \rho_{i-1})^\gamma \tag{1.7}$$

The problem of vertical motion of an aerostatic bearing is thus reduced to simultaneous solution of the differential equations (1.1) – (1.3), (1.5) and the finite relations (1.6) and (1.7). Averaging the pressures and densities over the volumes, we can accept the assumption of piece-wise constant distribution of the pressure p within the air cushion, described by the relations

$$0 < r < r_0, \quad p = p_1; \quad r_0 < r < b, \quad p = p_a \tag{1.8}$$

2. Let us establish the relations connecting the pressures p_2 and p_1 with the quantities H and r_0, the latter varying with time. Integrating the first two equations of (1.3) from $r = a$ to r and from r to $r = b$ and using the conditions (1.4), we arrive at the following expressions for the tension N_r and displacement u:

$$a \leqslant r < r_0, \quad 4r^2 N_r = 2N_a[(1+\nu)r^2 + (1-\nu)a^2] - \int_a^r X(r, r_1)\, dr_1$$

$$4E\delta r u = 2N_a(1-\nu^2)\left(1 - \frac{a^2}{r^2}\right) - \int_a^r Y(r, r_1)\, dr_1$$

$$r_0 < r \leqslant b, \quad 4r^2 N_r = 2N_b[(1+\nu)r^2 + (1-\nu)b^2] + \int_r^b X(r, r_1)\, dr_1$$

$$4E\delta r u = 2N_b(1-\nu^2)\left(1 - \frac{b^2}{r^2}\right) + \int_r^b Y(r, r_1)\, dr_1$$

$$X(r, r_1) = E\delta\, (\partial w / \partial r_1)^2 (r^2 - r_1^2) r_1^{-1}$$

$$Y(r, r_1) = E\delta\, (\partial w / \partial r_1)^2 [2 - (1+\nu)(1 - r_1^2/r^2)] r_1^{-1}$$

Using now the requirement that the radial tension N_r and radial displacement u be both continuous and passing through the value $r = r_0$ at which the pressure undergoes, in accordance with the assumption (1.8), a jump, we obtain the following expressions for the tensions N_a and N_b :

$$2N_a(b^2 - a^2)(E\delta)^{-1} = \int_a^{r_0} \left(\frac{\partial w}{\partial r}\right)^2 \left[\frac{b^2}{1+\nu} + \frac{r^2}{1-\nu}\right] r^{-1}\, dr + \qquad (2.1)$$

$$\int_{r_0}^{b} \left(\frac{\partial w}{\partial r}\right)^2 \left[\frac{b^2}{1+\nu} + \frac{r^2}{1-\nu}\right] r^{-1}\, dr$$

$$2N_b(b^2 - a^2)(E\delta)^{-1} = \int_a^{r_0} \left(\frac{\partial w}{\partial r}\right)^2 \left[\frac{a^2}{1+\nu} + \frac{r^2}{1-\nu}\right] r^{-1}\, dr +$$

$$\int_{r_0}^{b} \left(\frac{\partial w}{\partial r}\right)^2 \left[\frac{q^2}{1+\nu} + \frac{r^2}{1-\nu}\right] r^{-1}\, dr$$

The assumption (1.8) implies that the right hand side of the third equation of (1.3) will be constant. Integrating this equation from r to r_0 and from r_0 to r and using the condition that $(\partial w / \partial r) = 0$ when $r = r_0$, we obtain

$$(N_r)_{r<r_0} \partial w / \partial r = (p_2 - p_1)(r_0^2 - r^2) / (2r) \qquad (2.2)$$

$$(N_r)_{r>r_0} \partial w / \partial r = (p_2 - p_a)(r_0^2 - r^2) / (2r)$$

Equations (2.1) and (2.2) yield two nonlinear integral equations for determining $\partial w / \partial r$ on the intervals from $r = a$ to $r = r_0$ and from $r = r_0$ to $r = b$. An approximate expression for determining $\partial w / \partial r$ is obtained by replacing the variable multipliers in the left hand sides of (2.2) by a single constant multiplier of intermediate value falling between N_a and N_b. This value is obtained by replacing the integrand expressions within the square brackets in (2.1), by $2r^2 / (1-\nu^2)$, the latter satisfying the inequality

$$[a^2 / (1+\nu) + r^2 / (1-\nu)] \leqslant 2r^2 / (1-\nu^2) \leqslant [b^2 / (1+\nu) + r^2 / (1-\nu)]$$

Computing N_a and $N_{b'}$ from (2.1) with and without change in the multipliers shows little difference in the results, and we can therefore obtain the intermediate value of the tension in the form

$$N(b^2-a^2)(1-\nu^2) = E\delta\left[\int\limits_a^{r_0}\left(\frac{\partial w}{\partial r}\right)^2 r\,dr + \int\limits_{r_0}^{b}\left(\frac{\partial w}{\partial r}\right)^2 r\,dr\right] \qquad (2.3)$$

Equations (2.2) can be integrated after performing the substitution shown above, using the conditions (1.4). Assuming the axial displacement at $r = r_0$ to be approximately equal to the platform rise height H, we obtain

$$4NH = (p_2 - p_1)\zeta = (p_2 - p_a)\eta \qquad (2.4)$$
$$\zeta = r_0^2 \ln(r_0^2/a^2) - r_0^2 + a^2, \quad \eta = r_0^2 \ln(r_0^2/b^2) - r_0^2 + b^2$$

From (2.2) and (2.4) we find

$$r < r_0, \quad \partial w/\partial r = 2H(r_0^2 - r^2)/(r\zeta) \qquad (2.5)$$
$$r > r_0, \quad \partial w/\partial r = 2H(r_0^2 - r^2)/(r\eta)$$

while (2.3) and (2.5) together yield

$$4N = H^2\eta\varphi \qquad (2.6)$$
$$\varphi = 4E\delta(1-\nu^2)^{-1}(b^2-a^2)^{-1}[2r_0^2(\eta\zeta)^{-1} - \eta(r_0^2-a^2)(\eta\zeta)^{-2} + (b^2-r_0^2)\eta^{-3} - 2r_0^2\eta^{-2}]$$

In this manner we obtain the following expression from (2.4) and (2.6) for the pressure difference:

$$p_2 - p_a = H^3\varphi, \; p_1 - p_a = H^3\varphi(1-\psi), \; \psi = \eta/\zeta \qquad (2.7)$$

3. Next we derive the differential equation for the time-dependent parameters H and r_0 of the aerostatic bearing. For the volume of the inflatable cavity

$$V_2 = 2\pi\int\limits_a^b wr\,dr$$

we use (2.5) to obtain

$$V_2 = 2\pi(b^2-a^2)H\chi \qquad (3.1)$$
$$4\chi(b^2-a^2) = (b^2-r_0^2)^2/\eta - (r_0^2-a^2)^2/\zeta$$

Using (3.1) and (1.7), we write (1.5) in the form

$$A_1 dH/dt + A_2 dr_0/dt = Q_3 - Q_2 \qquad (3.2)$$

$$A_1 = \partial (\rho_2 V_2) / \partial H = \rho_3 V_2 (p_2 / p_3)^{1/\gamma} H^{-1} [1 + 3 (p_2 - p_a) / (\gamma p_2)]$$
$$A_2 = \partial (\rho_2 V_2) / \partial r_0 = \rho_3 V_2 (p_2 / p_3)^{1/\gamma} [(\gamma p_2)^{-1} \partial p_2 / \partial r_0 + \partial \ln V_2 / \partial r_0]$$
$$\rho_2 = \rho_3 (p_2 / p_3)^{1/\gamma}$$

Let us assume that the flow of air through all the openings is subcritical everywhere. Then, for $\gamma = {}^7/_5$ we have the following inequalities:

$$p_2 > 0.528 p_3, \quad p_1 > 0.528 p_2, \quad p_a > 0.528 p_1 \tag{3.3}$$

This yields the two-sided inequality for the pressure within the inflatable cavity

$$3.6 p_a > p_2 > 0.528 p_3$$

Assuming now that the pressure in the inflatable cavity is nearly equal to the pressure p_1 within the air cushion, we put $i = 2$ in (1.6) and expand the terms in powers of the pressure differences retaining the first order terms in $(p_2 - p_1) / p_2$. Taking into account (2.7), we obtain

$$Q_2^2 = 2\rho_2 S_2^2 (p_2 - p_1) = 2\rho_2 S_2^2 (p_2 - p_a)\psi \tag{3.4}$$

Relations (1.1), (1.2), (1.6), (2.7), (3.2) and (3.4), yield the following system of two nonlinear differential equations:

$$\begin{gathered} d^2H / dt^2 = \pi g G^{-1} H^3 \varphi (1 - \psi) r_0^2 - g \\ A_1 dH / dt + A_2 dr_0 / dt = S_3 [2\gamma / (\gamma - 1) p_3 \rho_3]^{1/2} [(p_2 / p_3)^{2/\gamma} - \\ (p_2 / p_3)^{(\gamma+1)/\gamma}]^{1/2} - S_2 [2\rho_a (p_2 - p_a) \psi (p_2 / p_a)^{1/\gamma}]^{1/2} \end{gathered} \tag{3.5}$$

where the pressure p_2 appearing in the second equation can be eliminated by using the first equation of (2.7).

4. In the steady-state, (3.4) and (2.7) together yield

$$\pi H^{*3} \varphi^* (1 - \psi^*) r_0^{*2} = G, \quad Q_2^* = Q_3^*, \quad p_1^* - p_a = (p_2^* - p_a)(1 - \psi^*) \tag{4.1}$$

where the asterisk denotes the values of the variables in the steady-state mode. When the weight G, the pressure p_3, the areas S_2 and S_3 and the radii a and b of the diaphragm clamping are all given, (4.1) and (2.7) yield the values on H, r_0, p_1 and p_2. To find the narrowest gap h_0 which determins the maximum roughness of the floor over which the aerostatic bearing can travel, we shall use a formula given in [1] which takes into account the viscosity of the air.

We investigate the stability of the stationary performance of the aerostatic bearing, introducing the variations of the variables and assuming that

$$H = H^* + \delta H, \quad r_0 = r_0^* + \delta r_0, \quad p_1 = p_1^* + \delta p_1 \qquad (4.2)$$
$$p_2 = p_2^* + \delta p_2, \quad p_3 = p_3^* + \delta p_3, \quad Q_2 = Q_2^* + \delta Q_2,$$
$$Q_3 = Q_3^* + \delta Q_3$$

Here δp_3 is assumed given and independent of time. From now on, we shall omit the asterisks referring to the stationary mode. From (1.6), (2.7) and (3.4) we obtain

$$\partial Q_3 / \partial p_3 = -Q_3(\gamma p_2)^{-1} f \qquad (4.3)$$
$$f = [2^{-1}(\gamma + 1)(p_2 / p_3)^{(\gamma-1)/\gamma} - 1] / [1 - (p_2/p_3)^{(\gamma-1)/\gamma}]$$
$$\partial Q_2 / \partial p_2 = Q_2 2^{-1} [(p_2 - p_a)^{-1} + (\gamma p_2)^{-1}]$$
$$\partial Q_2 / \partial p_1 = -Q_2 2^{-1}(p_2 - p_1)^{-1}$$
$$\partial p_2 / \partial H = 3H^{-1}(p_2 - p_a), \quad \partial p_1 / \partial H = 3H^{-1} (p_2 - p_a)(1 - \psi)$$
$$\partial p_2 / \partial r_0 = (p_2 - p_a)\partial \ln \varphi / \partial r_0$$
$$\partial p_1 / \partial r_0 = (p_2 - p_a)(1 - \psi)\partial \ln [\varphi (1 - \psi)] / \partial r_0$$

Substituting (4.2) and (4.3) into (3.4) and neglecting the products of variations and their time derivatives, we obtain

$$d^2(\delta H)/dt^2 + B_3\delta H + B_4\delta r_0 = 0 \qquad (4.4)$$
$$A_1 d(\delta H) / dt + A_2 d (\delta r_0) / dt + A_3\delta H + A_4\delta r_0 = A_5\delta p_3$$
$$B_3 = -3gH^{-1}, \quad B_4 = -2g/r_0 - g\partial[\ln \varphi (1 - \psi)] / \partial r_0$$
$$A_3 = 3Q_3(2H)^{-1}(2fP + P + 1), \quad P = (p_2 - p_a) / \gamma p_2$$
$$2A_4 = Q_3[(2fP + P + 1)\partial \ln \varphi / \partial r_0 + \partial \ln \psi / \partial r_0]$$
$$2A_5 = Q_3\{(\gamma + 1)(\gamma p_3)^{-1} + \gamma p_3 / f [1 - (p_2 / p_3)^{(\gamma-1)/\gamma}]\}$$

and we adopt $t = 0$, $\delta H = 0$, $d\delta H / dt = 0$ and $\delta r_0 = 0$ as the initial conditions for (4.4). Then the time-dependence of δH will be given in the form

$$\delta H = A_5\delta p_3 (A_3B_4 - A_4B_3)^{-1} \times$$
$$\left[B_4 + \Delta^{-1} \sum_{k=1}^{k=3} (\lambda_{k+2} - \lambda_{k+1}) (B_3 - B_4\lambda_{k+1}\lambda_{k+2}e^{\lambda_k t})\right]$$
$$\Delta = \begin{vmatrix} 1 & 1 & 1 \\ \lambda_1^2 & \lambda_2^2 & \lambda_3^2 \\ \lambda_1 & \lambda_2 & \lambda_3 \end{vmatrix}, \quad \lambda_4 = \lambda_1, \quad \lambda_5 = \lambda_2$$

The indices λ_k are roots of the characteristic equation

$$A_2\lambda^3 + A_4\lambda^2 + (A_2B_3 - A_1B_4)\lambda + (A_4B_3 - A_3B_4) = 0$$

The Hurwitz — Routh conditions which are necessary for the real parts of λ_k to be negative, are given by the inequalities

$$(A_4B_3 - A_3B_4) > 0, \quad (A_2B_3 - A_1B_4) > 0, \qquad (4.5)$$
$$- B_4(A_4A_1 - A_3A_2) > 0$$

If the stationary mode of the aerostatic bearing is perturbed not by changing the pressure δp_3 but impulsively, then the initial conditions will become

$$t = 0, \; \delta H = 0, \; \delta r_0 = 0, \; d\delta H \,/\, dt = V_0$$

and the deviation δH will change with time according to the relation

$$\delta H = V_0 \Delta^{-1} \sum_{k=1}^{k=3} (\lambda_{k+2}^2 - \lambda_{k+1}^2) \exp \lambda_k t$$

Using (4.4), we can establish that when the last inequality of (4.5) holds, then the preceding two inequalities will strictly hold. In that case the last inequality can be converted into an equality representing the equation of the neutral curve separating the regions of stability and instability of the aerostatic bearing

$$(1 + 3\mathrm{P}) \,/\, (2fP + P + 1) = d\,(\ln \chi^3 \,/\, \varphi) \,/\, d\,(\ln \psi) \qquad (4.6)$$

If the flow of air from the chamber into the inflatable cavity is supercritical while the remaining flows are subcritical, then the first inequality of (3.3) must be inverted. In this case the rate of flow Q_3 will be independent of the pressures in the inflatable cavity and we obtain the following expression:

$$Q_3^2 = \gamma\,[2 \,/\, (\gamma + 1)]^{(\gamma+1)/(\gamma-1)} p_3 \rho_3 S_3^2$$

while the equation of the neutral curve will assume the form

$$P\partial \ln [\varphi \,/\, (\chi^3\psi^3)]\, \partial r_0 + \partial \ln [\varphi \,/\, (\psi\chi^3)]\, \partial r_0 = 0 \qquad (4.7)$$

To obtain the approximate values of the functions of r_0 appearing in (4.6) and (4.7), we introduce a small parameter of the form

$$\varepsilon = (b^2 - r_0^2) \,/\, b^2$$

and expand the functions φ, ψ and χ and their derivatives with respect to r_0, in powers of this parameter. Then we have

$$\varphi = 32E\delta\,[3l\,(1 - \nu^2)\,(b^2 - a^2)]^{-1}\,(\varepsilon^{-3} - l_2\varepsilon^{-2} + l_3\varepsilon^{-1}) \qquad (4.8)$$
$$\psi = \varepsilon^2\,(1 + l_2\varepsilon), \quad \chi = b^2\,[4\,(b^2 - a^2)]^{-1}\,(l_0 - l_1\varepsilon)$$

$$d \ln (\chi^3/\varphi) \,/\, d \ln \psi = {}^3/_2 \{1 - \varepsilon\, l_1 b^2 \,/\, [l_0 (b^2 - a^2)] - \varepsilon\, l_2/6\}$$
$$l = b^2 \ln (b^2 / a^2) - b^2 + a^2, \quad l_0 = 2 - (b^2 - a^2)^2 \,/\, (l b^2)$$
$$l_1 = {}^2/_3 + [(b^2 - a^2) \,/\, l]^2 \ln (b^2/a^2) - 2 (b^2 - a^2) \,/\, l$$
$$l_2 = {}^3/_4 + {}^3/_8 [2b^2 \,/\, l - (b^2 - a^2)^2 \,/\, l^2], \quad l_3 = {}^5/_{36} + {}^1/_8 [2b^2 \,/\, l - (b^2 - a^2)^2 \,/\, l^2]$$

Using the first equation of (4.2), we can write the parameter ε in the form

$$\varepsilon = 1 - G\, [(p_2 - p_a)(1 - \psi)]^{-1} \,/\, (\pi b^2)$$

Taking into account the second equation of (4.8), we can neglect the subtrahent ψ. Putting

$$\alpha = \pi b^2 p_a / G$$

and replacing $1 - \varepsilon$ by $(1 + \varepsilon)^{-1}$, we obtain the following expression for the parameter ε :

$$\varepsilon = \alpha\, (p_2 \,/\, p_a - 1) - 1$$

When the ratio $b \,/\, a$ is varied from 3.5 to 7, the value of the factor of ε in the last expression of (4.8) varies from 0.65 to 0.85. In what follows, we shall assume the above value to be equal to 0.75μ where $\mu = b^2 \,/\, (b^2 - a^2)$. Solving the equation (4.6) for f and introducing the notation

$$p_2 \,/\, p_3 = x, \quad p_3 \,/\, p_a = y$$

we can write the equation (4.6) of the neutral curve in the following approximate form:

$$f(x) = 1 + [1.5\alpha\mu\, (xy - 1) - 0.5 - 1.5\,\mu]\, [1 + 7xy \,/\, (15\, (xy - 1))]$$

When the conditions of stability are satisfied, we obtain the following expression for the period of oscillations of the aerostatic bearing:

$$T\, (g \,/\, H)^{1/2} = 2\pi\, [{}^5/_7\, (xy - 1) \,/\, (xy)]^{1/2} \times \{1 - 0.5\mu\, [\alpha\, (xy - 1) - 1]\, [1 + 7xy \,/\, (15\, (xy - 1))] \times [{}^5/_7\, (xy - 1) \,/\, (xy) - 0.26]\}$$

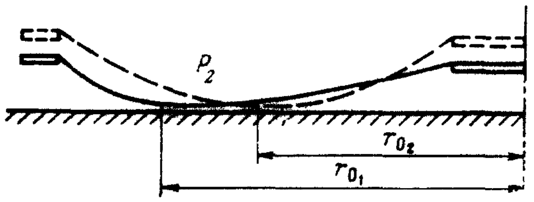

Fig. 2

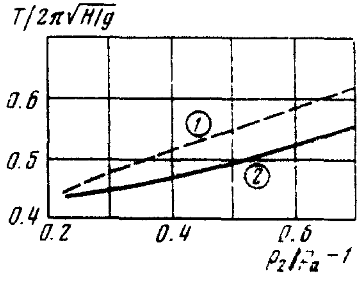

Fig. 3

5. The results obtained were checked experimentally using a special stand, and full scale devices in the industrial environment. In particular, use was made of high speed moving film running at 160 frames/sec. One of the frames showing the shape of the diaphragm at two instants of time half a period of the bearing oscillation apart, is shown in Fig. 2.

The aerostatic bearing is depicted schematically in Fig. 1. Air is fed from a compressor into the chamber 3, passing from there through the nozzles 4 into an inflatable diaphragm cavity 2 and then through the openings 5 into atmosphere through a narrow gap. The bearing oscillated with a frequency varying from 7 to 15 Hz, and the amplitude of the platform height H reached 20 mm.

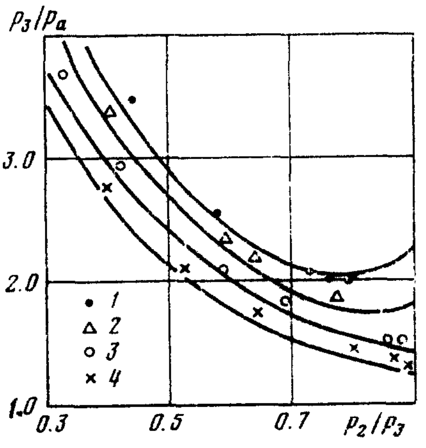

Fig. 4

The limit of stability of the aerostatic bearing and its period of oscillations were determined by varying the load per bearing from 40 to 600 kg. Measurements were taken of the pressure P_3 in the chamber, P_2 in the skirt, P_1 in the air cushion zone and of the period of the bearing oscillations. The supercritical and subcritical flows of gas through the nozzles 4 were studied, with the area S_3 varied from 1 to 5 mm. Fig. 3 and 4 depict the results of the theoretical computations (solid lines) and experimental data for the limits of variation of ε and of the ratio b/a shown in Sect. 4 ($1-\alpha = 2.74$; $2-\alpha = 4.4$; $3-\alpha = 8.2$; $4-\alpha = 22.2$). We found that within the stated limits of variation in the values of ε and b/a, the agreement between the theoretical and experimental results was satisfactory.

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