\[ \ddot{u} = m \dot{\varepsilon}_1^0 + \dot{\varepsilon}_1^0 \dot{\varepsilon}_3^0 \frac{\partial}{\partial x}, \quad \ddot{\varepsilon} = m \dot{\varepsilon}_2^0 \frac{\partial (\varepsilon_1^0 + \dot{\varepsilon}_1^0 \dot{\varepsilon}_3^0)}{\partial x} + \varepsilon_2^0 \frac{\partial}{\partial x} \]

\[ \dot{\varepsilon}_1^0 = \varepsilon_1^0 + \mu \eta \varepsilon_2^0; \quad \varepsilon_2^0 = \eta (\varepsilon_2^0 + \mu \varepsilon_1^0); \quad \varepsilon_1^0 = \varepsilon_3^0 - 2k \varepsilon_1^0; \quad \eta = E_3/E = \mu_1/\mu; \]

\[ \varepsilon_1^0 = \varepsilon_1^0 + (\dot{\varepsilon}_1^2 + \dot{\varepsilon}_3^2)/2; \quad \varepsilon_2^0 = \varepsilon_2^0 + \dot{\varepsilon}_2^0/2; \quad 2 \varepsilon_3^0 = \varepsilon_3^0 + \varepsilon_3^0 + \varepsilon_3^0 \]

I

Fig. 1. Diagrams of displacements and dimensionless stresses.

Fig. 2. Dependence of the critical time on V, R, h, η.

\[ \chi_{11,0} = \chi_{11} = -\partial \varepsilon_1 / \partial x; \quad e_{11} = \partial u / \partial x; \quad e_{22} = -w / R; \quad e_{13} = \partial w / \partial x; \quad e_{21} = -\alpha; \]
\[ m = (c_1 / c)^2; \quad k = (1 - \mu^2 \eta) k_0 G / E; \quad c_1^2 = c_0^2 (1 - \mu^2 \eta); \quad c_2^2 = c_0^2 (1 - \mu^2); \]
\[ c_0^2 = E / \rho; \quad E = E_1; \quad \mu = \mu_2; \quad x = X / L; \quad t = c T / L. \]

(1.4)

Here, u, w, and α are the axial, radial, and angular displacements; η and ρ are the coefficients of tangential anisotropy and the density of the material; E_1 and E_2 are the principal moduli of elasticity (E_1 along the axis of the shell; G is the shear modulus in the meridional plane normal to the middle surface; μ is the coefficient of transverse strain in the circumferential direction for tension (compression) along the generator; k_0 is the coefficient of shear stress distribution; R and h are the radius of curvature of the middle surface and the thickness of the shell; V is the velocity of impact; M_0 and M_1 are the masses of the shell and the load; X and T are the absolute values of the linear quantities and physical time. Dots denote differentiation with respect to the dimensionless time t.

Equations (1.1), the initial (1.2) and boundary (1.3) conditions are written in the dimensionless form: The velocity of impact is expressed in units of the velocity of sound c, the linear quantities are referred to the length L of the generator, while the time is referred to the period of propagation of the deformed front of the pressure wave along the isotropic shell. Judging from (1.1)-(1.4), the problem is solved in a geometrically nonlinear formulation, taking into account the wave character of propagation of deformations [Eqs. (1.1) belong to a hyperbolic type]. In contrast to equations known earlier, the system (1.1) takes into account the additional forces connected with the rotation of normal sections of the shell during bending. It is not difficult to show that these corrections in problems of the type being considered are of the same order of smallness as the other nonlinear terms.

§2. In view of the extreme complication of the problem (1.1)-(1.4), analytical techniques of investigation are of little effect. Therefore, in the present work the problem was solved numerically on the digital computers Minsk-22, BESM-4, and M-222. The time and coordinate derivatives were represented by means of the expressions of central differences of the first approximation. An explicit scheme of the usual grid method (without singling out the front discontinuities) was investigated. The grid parameters, ensuring the stability of the method and convergence of the computational process, were chosen on the basis of the data of the work [6]. The basic results of the investigation are presented below.

§3. In Fig. 1 we have presented, at time instants indicated, the diagrams of the axial (u) and radial (w) displacements. The dotted curves are \( w(x, t) \) for the isotropic shell. There we have also indicated the distribution, along the generator, of the dimensionless axial \( (\varepsilon_{11}) \) and circumferential \( (\varepsilon_{22}) \) stresses \( (V = 0.06, \mu = 0, \eta = 0.1, R = 0.3, h = 0.02) \). The scales of the corresponding axes are as follows: \( u = 0.20, w = 0.04, \varepsilon_{11} = 0.20, \varepsilon_{22} = 0.02 \).

We see that the general pattern of impact buckling of orthotropic shells is analogous to that described in other works by the author [7-9]. Just as for isotropic shells, the process of axisymmetric deformation here tentatively be decomposed into two phases—the precritical and postcritical phases (for the description of them see the works just mentioned). As an objective boundary between the precritical and postcritical phases of buck-