6. N. A. Zlatin, G. S. Pugachev, and V. A. Stepanov, "Failure stresses with a brief impact,' Zh. Tekh. Fiz., 49 (1979).
7. I. R. Baikov, A. R. Berngardt, V. K. Kedrinskii, and E. I. Pal'chikov, "Experimental methods for studying the dynamics of cavitation clusters," Zh. Prikl. Mekh. Tekh. Fiz., No. 5 (1984).
8. N. N. Chernobaev, "Features of pulsed failure for liquids with different physical properties," in: Solid Material Dynamics, No. 84 [in Russian], Inst. Gidrodin. Sib. Otd. Akad. Nauk SSSR, Novosibirsk (1988).
9. R. I. Nigmatulin, Bases of Heterogeneous Material Mechanics [in Russian], Nauka, Moscow (1978).
10. V. F. Kuropatenko, "Equation of state for the detonation products of condensed explosives," Chislennye Metody Mekh. Sploshnoi Sredy, 8, No. 6 (1977).
11. I. Sh. Akhatov and P. B. Vainshtein, "Nonsteady-state combustion regimes for porous powders," Fiz. Goreniya Vzryva, No. 3 (1983).
12. A. I. Ivandaev and A. G. Kutushev, "Numerical study of nonsteady-state wave flows for a gas suspension with separation of two-phase regions and contact separations in the supporting gas," Chislennye Metody Mekh. Sploshnoi Sredy, 14, No. 6 (1983).

MECHANISM OF PULSED BREAKDOWN OF A LIQUID VOLUME

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UDC 532.528

From numerous experiments it is well known [1, 2] that with pulsed loading for liquid volumes of finite dimensions there is partial or complete breakdown of the liquid medium followed by formation of a spray stream. Until recently, the physical mechanism of this breakdown process had not been studied. In [3] the energy threshold was determined for pulsed breakdown of a water volume with shock-wave loading. In [4] it was demonstrated that if the loading time t_* is much greater than the time for unloading wave propagation through the liquid t_0, then breakdown is due to development of perturbations in the mobile boundaries of a liquid volume, and if $t_* \lesssim t_0$, then the breakdown stage is preceded by unlimited development of cavitation flow in the medium. In the latter case, the question remains open of the breakdown mechanism since it is not clear how, in the process of cavitation development, there is formation of discontinuities in a bubble medium and decomposition of it into individual fractions. Below this type of liquid breakage will be called cavitation breakdown.

1. In the present work, a phenomenological approach is suggested toward constructing a physical model of cavitation breakdown of a liquid medium taking account of the analysis of experimental results for axisymmetrical shock-wave loading of a cylindrical water volume.

Experiments were carried out in water specimens 1 (Fig. 1) with initial dimensions $R_0 = 2$ cm, $H_0 = 3$ cm. In the original condition the outer surface of the liquid was bounded by a thin paper shell 2 and with the ends rigidly clamped by plane-parallel plates of organic glass 3. A shock wave was generated as a result of an electrical explosion located along the axis of symmetry of the liquid volume by a manganin wire 4 in which a bank of high-voltage condensers with a capacitance of 1 μF was discharged. The explosive energy somewhat exceeded the threshold value [3]. The loading time (duration of shock-wave emission in the liquid, depending on the electrical discharge circuit parameters) is close to $t_0 = R_0/c_0$ (c_0 is sound velocity in water). According to [4] the process occurs in the following sequence: generation of a diverging cylindrical shock wave due to the electrical explosion of the wire; reflection of the wave from the free surface $r = R_0$ (Fig. 1); development behind the unloading wave front of cavitation flow with an unlimited increase in the volume concentration of bubbles; breakdown of the radially expanding cavitating volume into individual fractions. Optical recording of the process was carried out by means of a high-speed photorecorder SFR-1 (the field of exposure in Fig. 1 is marked with a broken circle).

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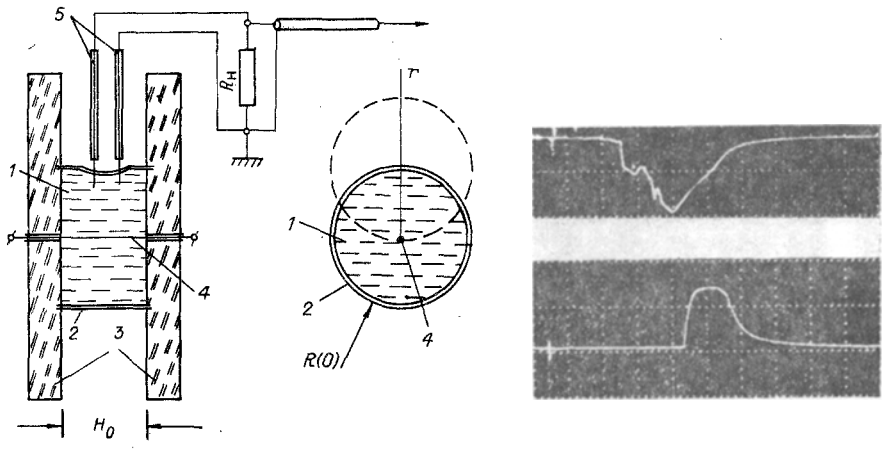

Fig. 1

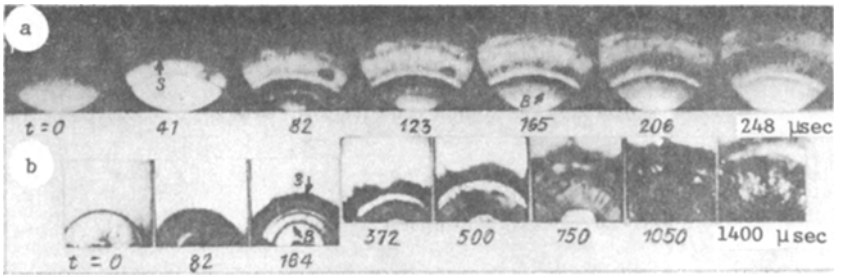

Fig. 2

Presented in Fig. 2 are typical motion pictures of cavitation flow development in an expanding cylindrical water volume behind the unloading wave, where (a) is test light medium on a dark background (illumination was accomplished by self-luminescence of the explosive cavity lasting up to $3 \cdot 10^{-4}$ sec), (b) is a dark material on a light background (illumination by a pulsed lamp), S is mobile outer boundary of the expanding two-phase cylinder layer, B is its internal boundary, i.e., the boundary of the explosive cavity. From motion pictures it can be seen that at least after 123 μsec from the start of explosive loading for a liquid volume (a) in the test two-phase material radial and circumferential discontinuities (dark radial and circumferential bands) become marked; with through illumination of the medium (b) in the early stages of the process discontinuities are not seen, and they may only be seen in the last four frames. However, from motion pictures it is impossible to determine at what instant of time the process of two-phase medium decomposition into individual fractions, i.e., dispersion, commences.

In order to determine the start of the dispersion process, a method was developed of electrometric probing of the gas–liquid medium which is based on the use of the electrification of dispersed polar liquids [5, 6]. It is well known that with relative movement for phases in a dispersed system a difference arises in potentials in the direction of movement, i.e., an electrokinetic effect [7], due to the mobility of the outer (consisting of adsorbed ions) diffusion part of a double electric layer formed at the interface of the liquid and gas phases, i.e., at the boundary of a bubble in a liquid, or (with breakdown) of a droplet in air. Thus, with movement of a bubble in water the outer diffusion boundary of the double electric layer from which adsorbed ions break away is a "liquid boundary," but, conversely, with water droplet movement in air ions break away from the "gas boundary" of the layer. Consequently, in both cases in "dead water" moving particles (bubbles or droplets) form volumetric discharges but of opposite signs.

Recording of the electric potential at a fixed point in the material was accomplished by a double electric probe consisting of two gold-plated electrodes 5 (see Fig. 1), 0.2 mm in diameter and 3 mm long (the rest of electrodes, 10 mm long, were covered by an electrical insulating material). The electrodes were set up in parallel at a distance of 5 mm from each other and soldered to steel rods 2 mm in diameter covered with insulation. The switch-

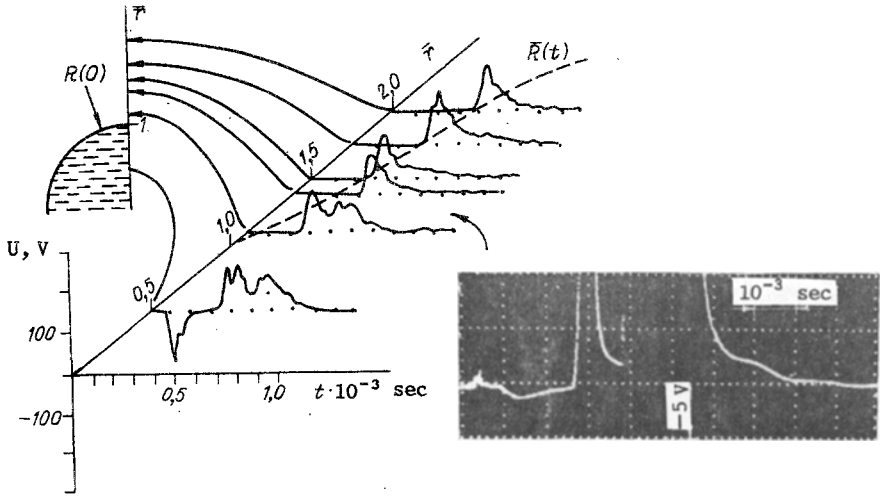

Fig. 3

ing circuit for the probe is shown in Fig. 1, where R_H is a load resistor of 104 kΩ. The signal from the R_H was recorded by an oscillograph (upper oscillogram is the negative electrical signal in a stream of cavitation bubbles, and the lower is the positive signal in a stream of water droplets formed as a result of explosive dispersion of the cylindrical water specimen.

In order to determine at what instant of time in the process given in motion pictures in Fig. 2 dispersion commences, a series of measurements was made of the electrical signal U at points r_* located along coordinate r (see Fig. 1) at different distances from the axis of symmetry of the broken-down volume ($0.5 \leq \bar{r}_* = r_*/R_0 \leq 15$).

Shown in Fig. 3 are oscillograms U(t) recorded in the range $0.5 \leq \bar{r}_* = r_*/R_0 < 2$ [the results of measuring U(t) with $\bar{r}_* > 2$ are not given due to the overloaded picture of the information]; the broken line is an experimental curve $\bar{R}(t) = R(t)/R_0$ characterizing displacement of the outer boundary of the broken-down volume. Analysis of the measured results showed the following. In the region $\bar{r}_* < 1$ (point $\bar{r}_* = 0.5$) at first a negative signal is recorded corresponding to an increase in cavitation bubbles and their relative displacement in the liquid generating a negative volumetric discharge. During the increase in bubbles their volume concentration becomes so large that the difference in phase velocities and, consequently, also the electrical signal, tends toward a zero value. After decomposition of the material into individual fractions the probe again records an electrical signal, but positive polarity. In the region $1 < \bar{r}_* < 1.5$ (points 1.1 and 1.4) the outer boundary of the cavitating liquid approaches the probe (see Fig. 2) having in the zone adjacent to the boundary a quite high bubble concentration and consequently low relative phase velocity. Therefore, the negative signal recorded in the zone is very small: with the magnification selected in the oscillograph (see Fig. 3) it was not seen, and only after the start of material breakdown is a positive signal of high amplitude recorded. Given in Fig. 3 is an oscillogram relating to the case of $\bar{r}_* = 1.2$ but with a greater magnification making it possible to record the weak negative signal in the zone with a high bubble concentration before breakdown of the medium. Naturally, a positive signal emerges at the limits of the oscillograph screen. With $\bar{r}_* \approx 1.5$ and subsequently at the instant of approach of the leading front of the expanding two-phase volume toward the probe, a positive signal is immediately recorded corresponding to the process of breakdown of the medium ($\bar{r}_* = 1.5, 1.75, 2$).

Thus, breakdown commences when $\bar{R}(t) = R(t)/R_0$ reaches a value of 1.5, i.e., about 250 μsec after the start of explosive loading for the liquid volume (throughout the whole volume the start of breakdown is in the range from 250 to 350 μsec, which is evidently due to the inhomogeneous development of the cavitation process along coordinate r with radial extension of the test medium).

Given in Fig. 4 are curves obtained as a result of analyzing motion pictures for the growth of a dimensionless volume $\bar{\Omega}(t)$ of a radially expanding cavitating cylindrical water specimen and the rate of its volumetric expansion $\dot{\bar{\Omega}}(t)$; here $\bar{\Omega} = \Omega/\Omega_0$, $\Omega_0 = 4\pi R_0^2 H_0$ is the initial volume of the liquid specimen; $\Omega = 4\pi(R^2 - r_n^2)H_0$ is the current volume of the radial

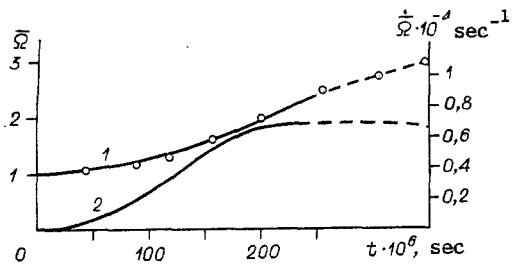

Fig. 4

ly expanding cavitating specimen, $r_n(t)$ is radius of the cylindrical explosive bubble. Specimen length H_0 = const since its actual expansion is limited by the plane-parallel plates 3 (see Fig. 1). The nonuniform nature of the $\dot{\bar{\Omega}}(t)$ curve is due to the different dynamics for increase in R(t) and $r_n(t)$ on which $\bar{\Omega}(t)$ depends. Broken sections relate to the stage of specimen breakdown. It can be seen in Fig. 4 that cavitation breakdown commences with $\bar{\Omega}(t) \approx 2.25$, i.e., with an average volumetric bubble concentration of $\langle\alpha\rangle \approx 55\%$; the rate of volumetric extension of the medium $\dot{\bar{\Omega}}(t)$ reaches a maximum value before the start of breakdown.

Thus, analysis of the curve shows that for cavitation breakdown of the medium into individual fractions the average volume concentration of bubbles $\langle\alpha\rangle$ should reach some critical value $\langle\alpha_*\rangle$ (in this case, $\langle\alpha_*\rangle \approx 55\%$). With an increase in volume concentration of cavitation bubbles the structure and rheological properties of the extended medium should change, which apparently leads to formation in it of discontinuities, i.e., to dispersion of the cavitating liquid volume into individual fractions. On the basis of this assumption, an analysis was made of the dependence of rheological properties of a cavitating medium on the volume concentration of bubbles and a physical model was suggested for the mechanism of cavitation breakdown of a liquid volume.

In the initial stage of expansion of the test volume of water with a low concentration of cavitation bubbles having small sizes and a spherical shape the medium may be considered as a gas suspension. From suspension rheology it is known [8] that with an increase in α in this medium there is an increase in effective viscosity coefficient $\bar{\mu}$. Theoretical study of the relationship $\bar{\mu} = \bar{\mu}(\alpha)$ is connected with very great difficulties, and currently only the equation

$$\bar{\mu} = (1 + \alpha)\mu_0, \tag{1}$$

has been obtained valid with $\alpha \ll 1$ (μ_0 is viscosity coefficient for pure liquid). An experimental study of the relationship $\bar{\mu} = \mu(\alpha)$ made it possible to obtain an empirical equation [9]

$$\bar{\mu} = \mu_0 \Big/ \left(1 - 1.09\sqrt[3]{\alpha}\right), \tag{2}$$

approximating experimental curves up to a value $\alpha \to 0.75$ corresponding to the limiting packing of spherical bubbles. This relationship is valid for bubble suspensions and foams over a wide range of bubble size distribution, but only with shear flows and equilibrium bubble concentrations. According to (2) for equilibrium concentrations with $\alpha \to 0.75$ the ratio $\bar{\mu}/\mu_0$ increases to 119. With radial extension of the liquid cylindrical specimen with gas bubbles the latter expand continuously and in the medium there is additional energy dissipation; consequently, with the same value of α the ratio $\bar{\mu}/\mu_0$ should exceed the equilibrium value $\bar{\mu}/\mu_0\big|_{\alpha=\text{const}}$. In fact, as is well known [8], an increase in the volume of the two-phase medium with radial extension is connected with development of volumetric (second) viscosity, and for many media it is several orders of magnitude higher than the value of shear viscosity $\bar{\mu}\big|_{\alpha=\text{const}}$.

Thus, with extension in an unloading wave of a water volume with bubble nuclei the evolution of rheological properties for test medium should occur in the following sequence. In the original condition $\alpha \ll 1$ and, according to (1), $\bar{\mu} \approx \mu_0$, i.e., for water viscosity may be neglected by assuming the material to be an ideal Newtonian liquid. With initial extension of a water sample with an increase in α there is an increase in effective viscosity $\bar{\mu}$ and the material changes into the condition for a viscous Newtonian liquid. If extension

continues the size of bubbles increases, and by reacting, bubbles start to deform. Since they exhibit elasticity of shape due to surface tension, the medium acquires elastic properties, i.e., it becomes a viscoelastic liquid with a capacity to accumulate elastic energy. The latter is connected with the fact that potential energy of a deformed bubble may change into kinetic energy for the surrounding liquid only for a finite time equal to the time of a bubble acquiring a spherical shape. This time is greater, the greater size of the deforming bubble and, therefore, with an increase in α (with a fixed calculated concentration of bubbles) there should be an increase in the stress relaxation time in this medium.

With radial extension of a cylindrical water volume containing in the original condition bubble nuclei, in view of the axisymmetrical nature of loading the unit vectors of the cylindrical coordinate system, r and θ coincide with the principle axes of the strain tensor ε_{ij} and in time the whole process of stress tensor P_{ij} extension has an orthogonal form. Consequently, in the medium there may only exist radial τ_r and circumferential τ_θ stresses. With changeover of the medium into a viscoelastic condition there is an increase in the stress relaxation time and, therefore, with quite rapid extension, τ_r and τ_θ, by not managing to relax, will increase, which leads to elastic energy accumulation. When the elastic energy reaches the value of free energy for the discontinuity surface there is breakdown of the medium. As already noted, formation of circumferential and radial discontinuities is observed in the motion pictures given in Fig. 2. (In the case of spherical symmetry there should also be formation of radial and circumferential discontinuities; with extension of a cylindrical liquid sample discontinuities should appear along the axis of symmetry in a plane perpendicular to the exis of symmetry of the specimen.) Discontinuities observed in Fig. 2 are like cracks with axisymmetrical explosive loading of cylindrical solid specimens. In contrast to cracks, which in forming retain their shape, discontinuities in a viscoelastic liquid, as can be seen from experiments, may heal and form anew. In addition, in a solid body cracks form in an unloading wave, but in this case the unloading wave, by communicating the distribution of extension rate to the liquid medium, leads it through the process of an increase in volume concentration of bubbles from the condition of an ideal Newtonian liquid into the state of a viscous, and then to a viscoelastic material. With quite high deformation rates the latter accumulated elastic energy required for formation of discontinuities.

Apparently the development of discontinuities may be explained as follows. Local zones of increased bubble concentration are characterized by a longer time for stress relaxation occurring during extension of a cavitating medium and, consequently, more intense accumulation of elastic energy, which leads to coalescence of bubbles in these zones, i.e., to formation of discontinuities. If the medium is extended very slowly, then local inhomogeneity for concentration α, and this also means the pressure field, manages to smooth out, as a result of which during extension of the medium bubbles will retain a spherical shape without accumulating elastic energy. Breakdown only sets in on reaching a value of α corresponding to the limiting packing of bubbles when touching between them leads to formation of phases: the two-phase system changes from a state of "bubbles in a liquid" into a state of "liquid particles in air" with a lower value of free energy. Thus, it is possible to suggest that the greater the extension rate for a cavitating volume of liquid, then discontinuities should form with lower values of $\langle\alpha\rangle$.

2. We consider the question of the possibility of constructing a macrorheological equation for an extended cavitating liquid. In the original condition, let a liquid specimen be a finite volume of water containing bubble nuclei with a volume concentration of $\alpha_0 \ll 1$. In the initial stage of extension of a volume behind the unloading wave front nuclei shift together with the liquid so that its velocity V_1 almost equals the mass velocity of the liquid V_0; consequently, energy dissipation caused by the relative displacement of nuclei cannot be considered. A macroscopic equation for a viscous Newtonian liquid is applied to this medium [8]

$$P_{ij} = -p\delta_{ij} + 2\mu_0\dot{\varepsilon}_{ij}. \tag{3}$$

Since, due to the low viscosity of water with almost any real strain rates, the second term in the right-hand part of Eq. (3) may be ignored, then stress is always isotropic and equal to the hydrodynamic pressure.

During extension of the medium the size and volume concentration of bubbles α increases, and with an increase in the size of bubbles their hydrodynamic resistance increases and V_1

decreases, which should lead to additional dissipation of energy of the main liquid movement and development of an additional nonisotropic term in (3) $P_{ij} = -p\delta_{ij} + 2\mu_0\dot{\varepsilon}_{ij} + \tilde{\sigma}_{ij}$. In fact, according to [10], with a small gas bubble concentration in water and retention of their spherical nature considering the pulsation of an isolated bubble, but without accounting for the viscosity of water with shear flow, the stress tensor has the form

$$\langle\sigma\rangle = -\langle p\rangle \mathbf{I} + \rho_0\alpha\left[\frac{3}{20}\{|\mathbf{V}_1 - \mathbf{V}_0|\}^2\mathbf{I} - \frac{9}{20}(\mathbf{V}_1 - \mathbf{V}_0)(\mathbf{V}_1 - \mathbf{V}_0)\right]. \quad (4)$$

Here, according to the notation used in [10], $\langle\sigma\rangle$ is the stress tensor averaged for a two-phase medium; $\mathbf{I}$ is unit tensor; ρ_0 is the density of pure water; indices 0 and 1 relate to water and gas, respectively. It follows from (4) that although the local stress tensor in each of the phases is isotropic, the average tensor due to the relative phase velocity contains an anisotropic part. If in Eq. (4) we introduce the term $2\mu_0\dot{\varepsilon}_{ij}$ not considered due to the smallness of μ_0, and by transforming $\langle\sigma\rangle = P_{ij}$, $\mathbf{I} = \delta_{ij}$, we write $P_{ij} = -p\delta_{ij} + 2\mu_0\dot{\varepsilon}_{ij} + \eta\sigma_{ij}$ $\left(\sigma_{ij} = \frac{A}{3}|\mathbf{V}_0 - \mathbf{V}_1|^2\ \delta_{ij} - A(V_{0i} - V_{1i})(V_{0j} - V_{1j}),\ A = \frac{9}{20}\rho_0\frac{\alpha}{\eta},\ \eta \text{ is a parameter}\right)$, then it appears to be a particular case of the rheological equation obtained in [11] for a suspension. In fact, if in the latter we ignore terms containing particle density ρ_1 (which is valid for bubbles), then we have

$$P_{ij} = (-p + \mu_0 \operatorname{div}\mathbf{V}_0)\delta_{ij} + \rho_0(V_{0i} - V_i)(V_{0j} - V_j) + \mu_0(\dot{\varepsilon}_0)_{ij} + \mu\sigma_{ij},$$
$$\sigma_{ij} = \frac{A}{3}|\mathbf{V}_0 - \mathbf{V}_1|^2\delta_{ij} - A(V_{0i} - V_{1i})(V_{0j} - V_{1j}), \quad (5)$$

where V_i and V_j are components of the average gas–liquid medium velocity; A is a coefficient depending on bubble concentration; μ is the effective viscosity coefficient for the medium. Equation (5) takes account of viscous stresses occurring during shear flow in a gas suspension with small α, but it does not contain terms describing the reaction of bubbles, and this means it does not consider the elastic properties of a two-phase medium. If in (5) it is assumed that the relative phase velocity instantaneously takes a zero value, then considering the smallness of the term $\mu_0(\dot{\varepsilon}_0)_{ij}$ the stress tensor also instantaneously becomes isotropic, i.e., in a medium described by (5) there is no accumulation of elastic stresses since their relaxation time equals zero. Whence it follows that with low bubble concentrations a two-phase medium relates to the class of general Newtonian liquids with a zero memory.

With further extension of the medium, α increases, and it is necessary to consider the elastic reaction of bubbles as a result of which they deform and elastic stresses grow in the medium. With a sudden stoppage of the main movement of a bubble it cannot immediately take a uniform configuration due to the fact that the medium exhibits a stress relaxation time λ. To a first approximation a Maxwellian liquid can be assumed to be a model for this medium. Known modifications of the macrorheological equation for a Maxwellian liquid [12] only make sense for shear strains with low shear velocities and amplitudes when μ and λ remain constant. In the problem in question parameters μ and λ change continuously during deformation of the medium. An approach to solving this type of problem has been described in [13]. Since μ and λ change in the process of extension, it is necessary to develop an experimental procedure for determining the dependence of μ and λ on α, extension rate, and other parameters of the process.

LITERATURE CITED

1. V. K. Kedrinskii, "Surface effects during an underwater explosion (review)," Zh. Prikl. Mekh. Tekh. Fiz., No. 4 (1978).
2. S. V. Stebnovskii, "Development of initial perturbations for the external boundary of an expanding gas–liquid ring," Zh. Prikl. Mekh. Tekh. Fiz., No. 5 (1982).
3. S. V. Stebnovskii and N. N. Chernobaev, "Energy threshold of pulsed breakdown for a liquid volume," Zh. Prikl. Mekh. Tekh. Fiz., No. 1 (1986).
4. S. V. Stebnovskii and N. N. Chernobaev, "Effect of loading dynamics for a liquid volume on the mechanism of its breakdown," Zh. Prikl. Mekh. Tekh. Fiz., No. 5 (1987).
5. Ya. I. Frenkel', Theory of Atmospheric Electricity Phenomena [in Russian], Gos. Izdat. Tekh. Teor. Lit., Moscow–Leningrad (1949).
6. J. A. Chalmers, Atmospheric Electricity, 2nd edn., Pergamon Press, New York (1967).
7. V. G. Levich, Physicochemical Hydrodynamics [in Russian], Fizmatgiz, Moscow (1959).

8. G. K. Batchelor, Introduction to Fluid Dynamics, Cambridge Univ. Press, New York (1967).
9. H. H. Legner, "A simple model for gas bubble drag reduction," Phys. Fluids, 27, No. 12 (1984).
10. A. Biesheuvel and L. Wijngaarden, "Two-phase flow equations for a dilute dispersion of gas bubbles in liquid," J. Fluid. Mech., 148, 301 (1984).
11. M. Severa and J. Hrbek, "Viscosity of suspensions formulated on the basis of the theory of dissipative disperse systems," in: Rheology and Rheometry of Multiphase Liquid Systems [in Czech], Hydrodyn. Inst., Czech. Acad. Sci., Prague (1979).
12. F. Eirich (ed.), Rheology: Theory and Applications, 5 vols., Academic Press, New York (1956-1969).
13. S. K. Godunov, Elements of Solid Material Mechanics [in Russian], Nauka, Moscow (1978).

SHOCK-INDUCED CONDUCTION WAVES IN ELECTROPHYSICAL EXPERIMENTS

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1. SHOCK WAVES AND ELECTROPHYSICAL EXPERIMENTS. INTRODUCTORY REMARKS

Research and practical developments in controlled thermonuclear fusion and the preparation of new materials with unique properties require high energy densities, necessary for overcoming activation barriers of the corresponding chemical or nuclear reactions, in the material. The solution of these problems led to the creation and rapid development, during the last 10 years, of a new field of scientific research – the physics of high-energy densities, associated with the creation and control of extremely high energy fluxes in powerful, predominantly pulsed, energy systems [1]. Because of the extensive possibilities for conversion of energy into other forms and for transformation, storage, and transfer of energy, sources of electromagnetic energy operating with currents of 10^6-10^8 A, magnetic fields of 10^2-10^3 T, voltages of 10^4-10^6 V, energies of 10^5-10^7 J over times from several nanoseconds to tens of microseconds, and powers of up to 10^{13} W and higher [2-6] have been predominantly developed.

The energy flux in powerful electric circuits is controlled with the help of elements with variable electrotechnical parameters (most often the inductance and resistance). The inductance is determined by the geometric characteristics of the conductors, and the possibilities for changing it rapidly are limited. The resistance expresses both the geometric ratios of a section of the circuit and the physical properties of the state of the matter and can be changed substantially by strong, external actions. This is of great significance for practical applications in pulsed systems (switches operating based on the most diverse physical principles). The main problems in the operation of switching elements are associated with the operation of switching the current off. Thus, the parameters of a switch for interrupting the current in an inductive storage circuit determine the applications of this promising source of energy [7].

The physical properties of matter can be altered by different external actions, such as heating, radiation, electrical breakdown, etc. Among such actions high pressure and the concomitant strong compression of matter stand out especially, since under these conditions the electrical properties change radically. The study of the electric conductivity of materials at high pressure was initiated by Bridgman [8]. Significant progress has now been achieved in this field [9-17]. Progress in research on the electric properties of materials at high pressure is linked with improvement of the measuring technology and the good status of the physical theory, which is sufficient for giving a satisfactory description of the phenomena occurring in some "pure" cases.

Sharp changes in the electric conductivity of condensed materials, induced by powerful shock waves (SWs) and accompanied by the appearance or vanishing of metallic conductivity,

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