Nevertheless, they were experimentally observed by Mikheeva *et al.* [3] The theoretically predicted nontrivial—on the fact of it—result that the resistance and T_c should undergo antiphased oscillations is in complete agreement with the dependence found in[2]. Among the results obtained in[2,3], of special interest is the observation of a critical sensitivity of the oscillatory pattern to the simultaneous covering of the metal with nonmetallic films on both sides. The ideas developed in the preceding section allow us to understand that this effect is connected with the phase difference in the boundary conditions that is introduced by the independent size effects in the two nonmetallic films.

Let us note, in conclusion, that the remarks made in Sec. 4 about the variation of T_c in an isolated metallic film enable us to understand the possible nature of the different—in sign—dependences of T_c on d in different metals.

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New measurements of the viscosity of water behind a shock wave front

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A new method is put forward for measuring the viscosity of shock-compressed dielectrics, based on magnetoelectric recording of the velocity of cylindrical conductors behind the shock front. The viscosity of water at pressures between 30 and 80 kbar was determined. The measured viscosity was found to be greater by five orders of magnitude than the viscosity of water under normal conditions.

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Viscosity under high dynamic pressures was determined in[1–3] from the violation of similarity in the attenuation of perturbations on a shock wave front. This method was used to determine the viscosity of water for pressures in the range 80–250 kbar and the results were found to lie in the range between 1.5×10^4 and 3×10^4 P. Other values of the viscosity of water, lower by a factor of a million, are reported in[4]. The latter are based on measurements of the electrical conductivity of shock-compressed water electrolytes. In this paper, we describe a new and more direct method of measuring the viscosity of dielectrics behind a shock wave front. The method has been used to determine the viscosity of water at pressures in the range 30–80 kbar.

The method is based on recording the acceleration of "heavy" cylindrical bodies by the flow of a lighter material behind a shock wave front. Plane waves were produced by detonating a charge, 100 mm in diameter, in a layer of water, 30 mm deep. The bodies to be accelerated were in the form of copper and tungsten wires, 0.3–0.5 mm in diameter. They were placed in the central cross section of the layer, parallel to the plane of the shock wave front. The velocity of the wires dragged by the flow of compressed water was recorded by a magnetoelectric method.[5,6] To do this, the entire assembly was placed in a constant uniform magnetic field of 350 Oe, and the emf induced in the wire as it cut the magnetic lines of force was recorded by an oscillograph. In analogous experiments using a 0.1-mm aluminum foil instead of the wire, measurements were made of the mass velocity $u(t)$ of water in the central cross section of the layer. A change in the length of the wires from 10 to 20 mm did not lead to a change in the recorded ac-

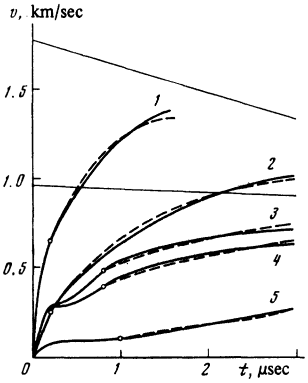

FIG. 1. Acceleration of cylinders in water behind a shock wave front. Thin lines—velocities of foils, thick lines—measured velocity of cylinders, broken curves—velocity of cylinders calculated from (1). Numbers against curves correspond to the numbers of experiments in the table.

celeration curves and this indicated the absence of edge effects. The velocity profiles obtained in two series of experiments are shown in Fig. 1 by the solid lines. The initial velocity u_0 of water in these experiments was found to be 1.77 and 0.96 km/sec.

During the initial time interval of ~ 0.3–0.7 μsec, the acceleration of the wires is determined by wave processes, and the subsequent increase in velocity is governed by viscosity forces associated with the flow of compressed water past the wires. The equation of motion of a unit length of a cylinder of density ρ_c will be written in the form

$$\rho_c \frac{\pi d^2}{4} \frac{dv}{dt} = fd, \tag{1}$$

where d is the cylinder diameter, v its velocity, and f the resistive force. Neglecting possible distortion in the shape of the cylinder, and assuming that the cylinder and the medium behind the shock wave front are incompressible, we can describe the motion of water relative to the cylinder by the Navier-Stokes equation for a viscous fluid. The expression for the force of resistance is known to be[7]

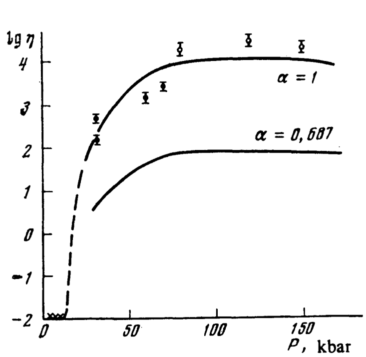

FIG. 2. Viscosity of water under high dynamic pressure: ×—static measurements from[10], o—viscosity of shock-compressed water according to[2,3], ●—present results. Solid lines represent calculations based on (3), using the indicated values of α; broken line represents interpolation between static and dynamic data.

TABLE I.

u_0, km/sec	No. of expt.	Cylinder material	d, mm	Pressure range, kbar	η, 10^3 P
1.77	1	Cu	0.47	81–61	2.4·(2.0–3.4)
	2	W	0.50	81–41	1.5·(1.25–2.0)
0.96	3	Cu	0.36	31–28	0.5·(0.35–0,70)
	4	Cu	0.47	31–28	0.5·(0.40–0.65)
	5	W	0.50	31–27	0.16·(0.12–0.18)

$$f = {}^1/_2 \rho (u-v)^2 \, \mathrm{sign}(u-v) \varphi(|R|). \tag{2}$$

In this formula, $R = \rho d(u - v)/\eta$ is the Reynolds number, ρ and η are, respectively, the density and viscosity of the medium surrounding the cylinder, and $\varphi(|R|)$ is a universal resistance function which has been established experimentally and was taken from[8].

Substitution of (2) in (1) gives the equation of motion of the cylinder. The viscosity of the medium is then found by comparing the experimental acceleration curve with a series of curves calculated from the equation of motion for different viscosities. Since the velocity of water behind the shock wave front was not constant in our experiments, the velocity of water along the trajectory of the cylinder in the simple rarefaction wave was calculated using experimental water profiles in the central cross section of the layer and its equation of state.[9] The contribution of the pressure gradient in the medium was taken into account in calculations of the motion of the cylinder.

To establish the sensitivity of the method to experimental uncertainties, calculations were performed both for the recorded velocity distributions and for distributions altered by 5% in either direction. The viscosities found within these limits are listed in the table together with the nominal values. The corresponding acceleration curves are shown in Fig. 1 by the broken lines. The viscosities measured in this way are lower by roughly an order of magnitude as compared with those reported in[1,3], and are higher by five orders of magnitude than those given in[4] and the values obtained under normal conditions.

In terms of the hole theory of liquids,[11,12] the main contribution to the activation energy of viscous flow at high pressures is due to the work PV_v which must be done to produce vacancies of volume V_v against the external pressure P. The volume of a vacancy is a fraction of the volume of a molecule. Let us represent by α the ratio of these volumes and by V_0 and V the molar volumes in the initial and compressed states. We then have

$$\eta = B \frac{V_0}{V} \exp\left(\alpha \frac{PV}{RT}\right) \tag{3}$$

The values of P, V, and T on the shock adiabatic curves are known with good accuracy.[9] The coefficient α can be found by assuming, in accordance with[13], that the radius of the vacancy is $r_v = 1.70$ Å (radius of a molecule of ice VII), which corresponds to $\alpha = 0.687$. The coefficient B is an adjustable parameter.

The viscosity of water calculated from (3) for $B = 0.002$ P is compared on a semilogarithmic scale with the data taken from[2,3] and with the new experiments in Fig. 2. The curve runs close to the results obtained by static measurements at pressures of $P<10$ kbar, but differ by 1.5–2 orders of magnitude from the data characterizing the viscosity of water behind the shock wave front. The agreement between the predictions of the hole theory of liquids and the experimental data is achieved by assuming that $\alpha=1$ at high pressures, i.e., the vacancy volume is equal to the volume of a molecule. This value of α corresponds to the upper curve in Fig. 2. According to[3] and in agreement with[14], the dramatic increase in the viscosity of water behind the shock wave front is due to partial or complete freezing. In our view, the more probable reason is the formation at high pressures of strongly interacting molecular associations in the liquid phase.

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Conditions for parametric excitation of spin waves in a sample with regular domain structure

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A theoretical and experimental investigation has been made of parametric excitation of spin waves in a single-crystal nickel ferrite sample in the presence of a domain structure. The results of the theory developed by Pil'shchikov (Sov. Phys. JETP **39**, 323, 1974) are used. A computer is used to determine the dependence of the threshold field on the constant field and to obtain the spectrum of the stable spin waves for the case of parallel and perpendicular pumping. It is shown that the conditions for the instability of the spin waves are determined by the following: 1) singularities of the spectrum of the spin waves in the domains, 2) the conditions for the excitation of homogeneous precession in samples with a domain structure. The experimental data obtained at 9400 and 3050 MHz confirm the main conclusions of the theory.

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INTRODUCTION

A theory of the instability of spin waves (SW) in a ferrite sample with a domain structure (DS) was proposed in[1]. The calculation of the threshold field h_{thr} was carried out for a spherical single-crystal sample of cubic symmetry with a negative first anisotropy constant ($K_1<0$) at arbitrary orientation of the pump field. It was proposed that a sample magnetized by an external constant field (H) applied along the [110] axis has a two-phase plate-like DS with domain walls perpendicular to the (001) plane and making an angle α with the [110] axis.[2] In this case the magnetization in the constant field is due only to the rotation of the magnetization in the domains, without a change in their relative volumes.

The following assumptions were used in the calculations: a) the domain walls do not move; b) there is no interaction between the SW of neighboring domains; c) the SW in each domain are regarded as plane waves (the boundary conditions on the sample boundaries and on the domain walls are disregarded). For a perpendicular DS ($\alpha=90°$), in the case of three types of pumping (parallel $\mathbf{h}\parallel\mathbf{H}$, perpendicular and symmetrical $\mathbf{h}\perp\mathbf{H}$ and $\mathbf{h}\parallel[1\bar{1}0]$, and perpendicular antisymmetrical $\mathbf{h}\perp\mathbf{H}$, $\mathbf{h}\parallel[001]$), expressions were obtained for the homogeneous precession (formulas (16)–(19) of[1])1) and an approximate qualitative analysis of $h_{thr}(H)$ was carried out.

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