Then points on the rheological curve τ_i and $\dot{\gamma}_i$ were calculated (in the ranges measured with the rheometer) and fitted to the corresponding models. Results: $\hat{\nu} = 5$, $\hat{\tau}_0 = 9.47$ Pa, $\hat{\mu} = 1.248 \cdot 10^{-2}$ Pa·sec, and $\hat{n} = 2$. Calculated shear stresses $\hat{\tau} = \{10.35;\ 15.96;\ 17.38;\ 18.63;\ 20.91;\ 24.68;\ 28.72;\ 32.09;\ 38.92\}$ Pa.

The standard deviation between the calculated and experimental values on the proposed method was 0.9%, as against 5.6% in the method based on estimating $\dot{\gamma}$ or 4.0% in the [3] method. The maximal errors on these methods were correspondingly 3.7, 9.2, and 32.5%. The methods based on approximating $\dot{\gamma}$ [1, 3] for high shear rates usually give systematic errors. The best interpretation performance in this range from [1, 3] is provided by the latter method. The [3] method differs from the proposed one in being very sensitive to the data volume and to the extrapolation to low shear rates.

The data were processed with the covariance matrix from experiment and by the [1, 3] methods (without the matrix), which showed that the differences in the estimators were more substantial, and sometimes there were errors in interpreting the model.

NOTATION

ω, angular velocity of outer cylinder; τ and a, shear stresses on the inner and outer cylinders; $\dot{\gamma}(\cdot)$, rheological model; $\dot{\gamma}$, shear rate gradient; p_ν, rheological-parameter vector, dimensions $1 \times m_\nu$; A, direct treatment operator (vector, dimensions $1 \times N$); n_ν, random-discrepancy vector, dimensions $1 \times N$; I, unit matrix, dimensions $N \times N$; P_ν, constraint on rheological-parameter vector; $2N_1$, number of quadrature nodes in segment $[a, \tau^j]$; A', derivative matrix, dimensions $m_\nu \times N$; A'*, matrix conjugate to A', dimensions $N \times m_\nu$; O, rheological-parameter estimator covariance matrix, dimensions $m_\nu \times m_\nu$.

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MEASUREMENT OF TEMPERATURE DISTRIBUTIONS IN A CONVECTIVE FLOW INDUCED BY POWERFUL OPTICAL RADIATION

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Results are presented from an experimental study of the convection which occurs within a liquid upon heating by a powerful light beam. The dependence of temperature on the convective jet axis upon power of the heating radiation is obtained.

When a powerful light beam propagates through an absorbing medium the latter heats up, its density changes, and as a result, convective flows develop. The low thresholds required for development of convection have attracted the attention of researchers to this phenomenon. Study of the mechanisms of photoabsorption convection may be of interest not only from the viewpoint of consideration of the processes accompanying propagation of powerful optical radiation through natural media (the atmosphere, ocean) but also as a new easily realized method for orienting flows in various industrial apparatus.

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TABLE 1. Silicone Liquid Properties

Liquid	PES-4	PMS-20	PMS-1000
ν, m^2/sec	$4{,}5\cdot10^{-5}$	$2\cdot10^{-5}$	$1\cdot10^{-3}$
C_p, J(kg·K)	1863	1717	1633
λ, W/(m·K)	0,147	0,138	0,157
n_0	1,4390	1,4000	1,4019
dn/dT	$4{,}8\cdot10^{-4}$	$5{,}3\cdot10^{-4}$	$5{,}9\cdot10^{-4}$

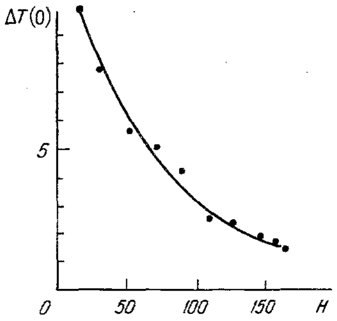

Fig. 1

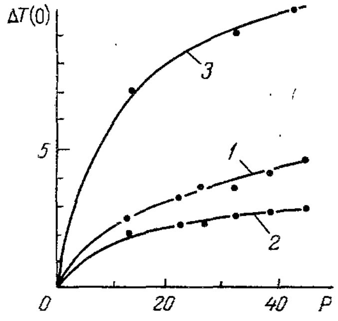

Fig. 2

Fig. 1. Vertical profile of induced temperature on axis of photoconvective jet. H, mm.

Fig. 2. Temperature on jet axis vs heating radiation power: 1) PES-4, 180 mm column, section 90 mm from free surface; 2) PMS-20, 180 mm column, 90 mm section; 3) PMS-1000, 90 mm column, 45 mm section. P, W.

Photoabsorption convection has been studied theoretically and experimentally. However, the experimental studies [1-4] were limited to high speed flow characteristics, and temperature within the jet was not measured. The structure of the induced temperature field was modelled in [5].

The goal of the present study is to experimentally investigate the temperature fields induced in a liquid layer upon vertical propagation therein of a powerful light beam. Use of direct contact methods for temperature measurement would lead to distortion of the flow and would be impossible in the region irradiated by the light beam. Thus, the contactless optical method of determining changes in the index of refraction of the medium was used [6, 7], which changes in the present case are uniquely related to the spatial temperature distribution. When a narrow probe light beam propagates through the liquid it is refracted on inhomogeneities in the index of refraction caused by interaction of the heating radiation and the convective flow. In the experiments the angle of refraction ε was measured as a function of the impact parameter. With consideration of the cylindrical symmetry of the experiment (a consequence of the corresponding symmetry of the heating beam) the index of refraction was reconstructed from the data in the following manner:

$$n(r) = n_0 \exp\left\{-\frac{1}{\pi}\int_r^\infty \frac{\varepsilon(p)}{\sqrt{p^2-r^2}}\,dp\right\}.$$

The change in temperature at the measurement point is uniquely related to the change in index of refraction:

$$\Delta T(r) = T(r) - T(0) = \frac{n(r)-n_0}{\frac{dn}{dT}}.$$

The media studied were types PES-4, PMS-20, and PMS-1000 silicone liquids. These were selected for their high transparency, low absorption coefficient, and the possibility of varying viscosity while using liquids of a single homological series. The physical properties of the liquids used are presented in Table 1.

The heating source was a continuous mode IAG laser, producing power levels up to 80 W. The beam diameter at the exit window was 4 mm. The experimental vessel was made of glass, with dimensions of 60 × 60 × 200 mm.

During the experiments temperature distribution profiles were determined at various sections of the induced convective flow. The vertical temperature profile for the liquid PES-4 is shown in Fig. 1. The liquid column height was 180 mm, with heating power of 45 W, radiation propagating vertically downward.

A study was also made of the dependence of temperature on the jet axis on heating radiation power (Fig. 2). It was found that for all liquids these curves can be approximated well by the expression

$$\Delta T(0) = AP^{0.36},$$

where A depends on the height of the column and physical properties of the liquid.

NOTATION

ε, refraction angle; p, impact parameter; n, index of refraction; n_0, index of refraction of undisturbed medium; $\Delta T(r)$, temperature change at measurement point; dn/dT, temperature dependence of index of refraction; ν, kinematic viscosity; C_p, specific heat; λ, thermal conductivity; P, heating radiation power; A, experimental constant.

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NONLINEAR WATER TRANSPORT IN INTRASOIL IRRIGATION

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Solutions have been obtained for nonlinear capillary diffusion from instantaneous planar, line, and point sources with allowance for plant root uptake.

New irrigation methods have various advantages over traditional spray and trench ones, as a system of perforated tubes or droplet feeds is buried at a certain depth, which reduces the water loss by evaporation by comparison with surface supply. Such buried irrigation can be optimized if various aspects of hydrodynamics and transport theory can be resolved for unsaturated soil with allowance for uptake by the roots.

General principles and methods have been given in heat and water transport theory for porous media in [1-3]. Even under isothermal conditions, the transport in an incompletely saturated medium involves extremely complicated nonlinear boundary-value problems. These difficulties have led to various linearization techniques being used [4-6] or various numerical methods [7-9]. Many detailed aspects are thereby neglected. Here we consider these boundary-value problems containing marked nonlinearity for planar, axial, and central symmetries without resort to linearization, although we neglect the bound water (and thus the space excluded from the transport) and the nonzero retained water content (at which the plants

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