STRUCTURE OF A THERMAL PERTURBATION IN A VERTICAL CHANNEL CONTAINING WATER

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Results are presented from an experimental study of the effect of exciting pulse energy on the form of a thermal perturbation propagating in a vertical cylindrical channel containing nonmoving water at atmospheric pressure and room temperature.

In various industrial and laboratory pieces of equipment one often finds a situation in which thermal energy is liberated in the form of a pulse and removed from the energy-producing section through a region of space filled with a nonmoving liquid medium. The case where this region has the form of a channel or narrow slot is of great interest. The features of formation and propagation of the thermal perturbation under such conditions have remained unclarified up to the present.

In [1] the present authors studied propagation of an impulsive thermal perturbation in a vertical cylindrical channel containing water at excitation pulse energies up to 5 J and found the characteristic properties of such a perturbation at low energy levels. It was also noted in that study that at excitation pulse energies of more than 3 J the thermal perturbation propagating through the water loses stability and a secondary local maximum appears in the signal recorded by the detector. However [1] did not clarify how further increase in excitation pulse energy affects the structure of the thermal perturbation.

To continue those studies experiments were performed with increased excitation pulse energies up to 20 J. As in the preceding experiments the equipment consisted to a glass cylindrical channel with internal diameter of 8 mm, filled with distilled water at atmospheric pressure and room temperature. The impulsive thermal perturbation in the water was induced by an electric heater, driven by a rectangular current pulse 1.0-2.0 sec in duration, and was recorded by a thermoelectric detector located 5 mm above the heater. The uncertainty in determining excitation pulse energy was no greater than 3%. A more detailed description of the experimental apparatus was presented in [1].

The results obtained during the course of the experiments indicate that increase in excitation pulse energy leads to an increase in the slope of the leading edge and the amplitude of the signal recorded by the detector, and to the development of a complex multipeak structure in the perturbation. Characteristic oscillograms of the response signal recorded by the thermal perturbation detector for various excitation pulse energies are shown in Fig. 1. It was established by analysis of a large number of oscillograms that the number of local maxima in the detected signal is essentially determined by the energy of the excitation pulse. This allowed us to distinguish energy intervals of relative thermal perturbation stability for the given experimental conditions.

The first stability region exists for excitation pulse energies less than 3 J. In this case the perturbation propagating through the channel produces a response in the form of a single peak asymmetric pulse with steep leading edge and gradually decreasing trailing edge (Fig. 1a). At an excitation pulse energy of 3-4 J the response decays into two closely spaced pulses. The second thermal perturbation stability region lies in the energy range of 4 to 6 J. Here the signal recorded by the detector has two local minima (Fig. 1b), while within the limits of the stability region with increase in excitation pulse energy the amplitudes of the maxima and the distance between them increase. The "two-peak" perturbation loses its stability at an excitation pulse energy of 6-7 J. At such energies the response begins to show a third local maximum. In the energy interval from 7 to 11 J we have the third stability interval for thermal perturbations, where the detector signal shows three local maxima. As the

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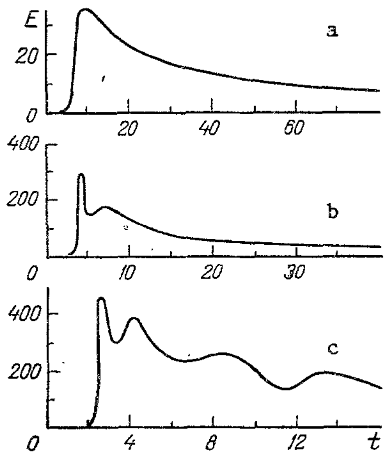


Fig. 1. Oscillograms of signals recorded by thermal perturbation detector for various values of Q, the excitation pulse energy: a) Q = 1.6 J; b) 6; c) 16.

excitation pulse energy is increased above 13 J the detected signal becomes more complicated (Fig. 1c) and the difficulty of resolving the lcoal maxima increases as well. At the maximum excitation pulse energies achieved in the experiments, 20 J, five local maxima could be distinguished in the thermal perturbation signal. The boundaries of these characteristic regions are quite diffuse, with change in the structure of the perturbation upon transition from one region to another occurring over a quite broad energy interval as a rule. With increase in excitation pulse energy within the limits of each stability region there is an increase in the speed of perturbation propagation, the amplitudes of the local maxima, and the intervals between them.

The behavior of the impulsive thermal perturbation in a vertical column containing water described above was observed only with a channel orientation such that the detector was located above the heater, which indicates the dominance of the natural convection mechanism in transmitting the thermal perturbation under the conditions of the experiments performed.

## NOTATION

E, value of thermoelectric detector signal, μV; t, time, sec; Q, excitation pulse energy, J.

## LITERATURE CITED

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