A method of investigating fluctuations of the interface by means of a laser is developed and the results of measuring the thickness of the vapor film in film boiling of Freon-113 on a horizontal tube are presented.

According to current concepts, heat transfer from a wall to a liquid in film boiling is accomplished through a laminar vapor film by heat conduction. In the case of high temperatures it is necessary to take into account also heat transfer by radiation. In the relationships obtained by Kutateladze [1] and Bromley [2] it is suggested that the heat transfer coefficient be determined by the time-averaged thickness of the vapor film, and the wave motion on the interface is not taken into consideration.

However, at heat loads insignificantly exceeding the minimum heat flux on a heating surface only several millimeters long the interface in film boiling becomes rough and wave motion is observed almost on the entire interface. Fluctuations of the interface can lead to a change of the heat transfer coefficient. As Kapitsa [3] showed, the coefficient of heat transfer through a film of running liquid should be greater in a wave regime than in a waveless laminar flow.

The need to take into account wave motion on the interface in the case of film boiling is pointed out in the experimental investigation of Coury and Dukler [4]. The authors noted fluctuations of the temperature of the heating surface and heat flux in film boiling of Freon-113 on a vertical plate and showed that they are due to fluctuations of the interface.

At present there are no investigations in which the motion of the interface during film boiling was studied in detail. It is natural that a well-founded consideration of the effect of wave motion on heat transfer is possible if the average thickness of the vapor film and the regularities of the change of amplitude and frequency of the fluctuations as a function of the density of the heat flux are known. Experimental investigations must be conducted to find these characteristics.

High-speed filming and photography are used widely in studying the mechanism of liquid boiling. High-speed filming, for example, was used for studying the motion of a vapor layer during film boiling of various liquids on a vertical surface by Borishanskii and Fokin [5]. However, the experience of using high-speed filming in this study showed that on analyzing the photographs it is not possible to determine the exact position of the heating surface, and so, to find the actual thickness of the vapor film.

To investigate the motion of the interface during film boiling we developed a method based on the use of continuous laser radiation. The method permits, first, observing the behavior of the interface at a quite small distance from the wall (up to 10 μm) and, second, obtaining the characteristics of the fluctuating motion (film thickness, amplitude and frequency of fluctuations). As the experimental section we selected a horizontally positioned tube of diameter 2 × 0.5 mm which moved relative to the light beam. The position of the fluctuating interface in time was registered due to reflections from it of the beam of continuous laser radiation, whose cross section by means of optical devices was reduced to a size considerably smaller than the minimum thickness of the vapor film. The luminous flux was recorded by a photomultiplier (PM) located at the exit port of the working vessel (Fig. 1).

At a fixed distance from the lower generator of the tube, equal to $\delta_{\text{ins}}$, as long as the interface moves from $\delta_{\text{ins}}$ to $\delta_{\text{min}}$ and back ($T_{\text{tr}}$) the light beam passes through the liquid and the PM signal is equal to $U_{\text{max}}$. When the interface moves from $\delta_{\text{ins}}$ to $\delta_{\text{max}}$ and back the light beam is reflected and scattered from it and the PM signal is equal to $U_{\text{min}}$. In the case of an increase of the distance from the tube $\delta_{\text{ins}}$ the time of interruption of the light beam by the vapor film decreases. Such a $\delta_{\text{ins}}$ when the vapor film ceases to interrupt the light beam, which is determined by the constancy of the PM signal, equal to $U_{\text{max}}$, corresponds to the maximum deviation of the interface (Fig. 2a).

To determine the duration of interruption of the light beam by the vapor film, the PM signal was calibrated by mechanical choppers (rotating sector disks) and by an electrooptical light modulator.

During calibration in the case of the mechanical choppers we determined the dependence of the magnitude of the PM signal on the ratio $\phi/2\pi$ (Fig. 2c). The sum of the angles of the sectors $\phi$ was found as $\sum_{i=1}^{n} \phi_i$. Calibration was done at a chopping frequency equal or close to the experimentally observed frequency of fluctuations of the vapor film.

In Fig. 2c the average beam transmission time through the liquid is laid out on the horizontal line for various distances from the tube, determined so:

$$T_{\text{tr}} = (\phi/2\pi)T,$$

where $T$, the average period of fluctuations of the vapor film, is found from the recording of the PM signal on a loop oscillograph at a distance between the light beam and tube equal to the average thickness of the vapor film.

The resolution of the method developed depends on the size of the light beam and characteristics of the apparatus. To obtain greater sensitivity of the method the light beam must be focused to a size considerably...