4. CONCLUSION

The following might be concluded:

1. Present results give the reasonable approximation for the variable fluid property effects on the initial transient and steady-state free convection.
2. The simple analytical expressions of the free convection characteristics have been obtained.
3. The time required for purely one-dimensional heat conduction being terminated and the time required to reach steady-state are hardly influenced by the effects of the variable fluid properties.
4. Present method might be able to be improved its accuracy and adaptability by using more accurate form of the profiles and expressions of variable properties.

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STUDY OF ACOUSTIC PHENOMENA ACCOMPANYING NUCLEATE BOILING OF SUBCOOLED DILUTE AQUEOUS ETHANOL SOLUTIONS AND AQUEOUS SURFACTANT SYSTEMS

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INTRODUCTION

A VAST amount of literature has been published describing both the experiments involving nucleate boiling of pure liquids and the elucidation of the heat-transfer mechanism for this boiling process from theory. Relatively little data have been collected for binary liquids and the dominant theoretical contributions in this area have been made by Van Stralen and his coworkers [1]. The study of binary systems is of potential industrial importance since a number of workers have demonstrated that the introduction of a small amount of a second component such as ethanol, 1-butanol etc. to water results in an increase in nucleate boiling heat transfer by as much as 400% [2–4]. Very recently Ponter *et al.* [5] showed for surface tension positive systems that the heat flux vs concentration relationship exhibited a strong maximum which coincided with a maximum in the contact angle measured under boiling conditions and obtained when the vapor and surrounding liquid were of the same composition and not in equilibrium. To obtain more information on the state of the bubble forming under boiling conditions an experimental program was undertaken to examine the sound emissions using a technique similar to that described by Ponter and Haigh previously [6].

EXPERIMENTAL

The liquid systems examined were water, aqueous ethanol mixtures, aqueous lauryl alcohol mixtures and dilute sodium lauryl sulphate solutions. The simple pool boiling apparatus was constructed in which boiling was induced on the surface of a platinum wire immersed in a quiescent pool of water by the passage of an electric current (DC). Details of the electric circuit are similar to those described previously by Haigh and Ponter [7]. The boiling sounds were detected by a Brüel and Kjaer hydrophone—type 8100—containing a lead zirconate pressure transducer having a flat frequency response characteristic over a large frequency range. The hydrophone was immersed in the water and positioned at the same depth as the wire. The signal from the hydrophone was fed to a Brüel and Kjaer—type 2120—frequency analyzer which scanned automatically from 2 to 20 KHz. The analyzer was coupled to a Brüel and Kjaer—type 2305—logarithmic recorder by a flexible drive from the recorder motor so that coincidence between the analyser frequency and the recorder chart calibration resulted. The measuring amplifier—type 2626—were used to simultaneously record the intensity of sound against the frequency on precalibrated paper. Data were collected for a fixed constant bulk liquid subcooling of 6°C, this being achieved by incorporating an additional hot plate into the system which brought the liquid up to the required bulk temperature before measurements were taken.

DISCUSSION

Firstly it was noted for all of the systems examined that changes in liquid concentration affected the intensity of sound emitted by the system but that the frequency spectra was not influenced.

For the ethanol–water mixtures an increase in concentration from zero to 10 mol % resulted in a steady decrease in the sound intensity. As described previously, both the nucleate boiling heat flux and the wettability exhibited a maximum and minimum respectively at approximately 1.9 mpl %. For the surfactant systems there was no detectable change in intensity with concentration for the sodium lauryl sulphate mixtures, and a very small reduction in intensity with concentration when using lauryl alcohol. Thus we deduce that the sound emissions are only dependent on the quality of the vapour inside the bubble, that is for the alcohol system a steady increase in concentration results in a steady decrease in sound intensity. For the sodium lauryl suphate solution, although the surface tension of the system falls significantly with an increase of concentration the vapour will be that of water and no change in intensity is noted. The lauryl alcohol has a small but higher vapour pressure and a slight reduction in intensity occurs.

Since there is no peak in the intensity–concentration curve for ethanol it is evident that the sounds are emitted when the bubbles collapse away from the wire surface. It also demonstrates that the heat transfer is controlled by the bubble formation on the metal surface and not influenced by the bubble implosion away from the wire.

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INFRARED RADIATION PROPERTIES OF NITROUS OXIDE IN THE 4.5 μ REGION

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NOMENCLATURE

T, temperature;
T_r, room temperature;
X, pressure path length.

Greek symbols

ε, emissivity;
λ, wavelength;
τ, transmission coefficient.

Subscripts

c, calibration source;
r, room condition.

INTRODUCTION

IN THIS study the IR emission of the 4.5 μ combination band of nitrous oxide has been measured at temperatures of 1200, 1700 and 1900°K. The high temperature gas was produced in a shock tube and measurements were carried out in the end wall region behind the reflected shock wave for the high temperature cases, 1700 and 1900°K. The region behind the incident shock wave was utilized for the 1200°K case.

Previous spectral measurements of the 4.5 μ band of nitrous oxide have been made by Burch and Williams [1] at room temperature and by Tien, Modest and McCreight [2] at room temperature and at 500°K. There do not appear to be any data available at higher temperatures.

EXPERIMENTAL APPARATUS

The experiments were carried out in a free piston shock tube which uses a piston compression in the driver section to obtain the desired driver conditions of pressure, P_4, and temperature, T_4, behind the diaphragm (cf. Fig. 1). The diaphragm, which separates the driver gas* from the test or driven gas, ruptures due to the pressure difference, $P_4 - P_1$, and a shock wave forms which propagates in the test section. The speed of the shock wave was determined from the outputs from thin film platinum thermometers. A description of the system which includes details of the piston release mechanism and other considerations is presented in [3]. References [4–8] may also be referred to for discussions of free piston shock tubes.

The aluminum test or expansion section is 2.7 m long with a 7.6 cm square cross section and a 3 mm wall thickness. For the measurements that were made behind the reflected shock wave, corresponding to region 5, the optical window was located 3.8 cm in front of the end wall. This was the condition for the 1700 and 1900°K cases. For the 1200°K case, emission measurements were made in region 2 behind the incident shock wave. This was accomplished by using an extension so that the optical window was then located 27.9 cm from the end wall. This long distance between the window and the end wall provided sufficient time for radiation measurements to be made in region 2 before the arrival of the reflected shock wave.

The radiation emitted from the shock heated gas was first passed through a Kodak Irtran 3 window (manufactured by the Eastman Kodak Co.) which had a useful transmission range from 0.4 to 11.5 μ. The rays were then directed and focussed by a combination of plane and spherical mirrors upon the entrance slits of a 0.5 m McPherson grating poly-

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*The driver region behind the diaphragm contained only nitrogen for the 1700 and 1900°K cases, while a mixture of nitrogen and helium was used for the 1200°K case.