Oscillations of gas bubbles in a liquid are studied using a shock tube. Beside observing the bubble wall motion with the help of a camera, a pressure wave field in the liquid is investigated in detail. The rise time of the driving pressure step turns out to be rather large. This pressure step is also accompanied by a precursor whose origin is still unclear. The waves propagating into the liquid behind the pressure step appear to be strongly disturbed; clean waveforms can be obtained only in the immediate vicinity of the bubble. Examples of several waveforms recorded this way are presented.

1. Introduction

When a shock wave passes a gas bubble in a liquid, the suddenly increased pressure in the liquid will cause an oscillation of the bubble. Such an excitation of the bubble for free oscillations can be conveniently used in laboratory studies concerning bubble dynamics. The shock waves used in these experiments can be generated by underwater explosions [1], by underwater electric discharges (sparks) [2, 3], or by a shock tube [4 – 7].

Here experiences with the last method, i.e. with the bubble excitation in a shock tube, are reported. Whereas in Refs. [4–7] the emphasis was laid on photographic investigation of bubble dynamics we have gone a step further and encompassed a detailed study of the pressure waves radiated by oscillating bubbles as well. This was made possible by using a recently developed needle hydrophone [8, 9]. In the following paper the shock tube and the associated apparatus are described in detail. Also several waveforms radiated by oscillating bubbles are presented.

2. Experimental setup

The experimental apparatus used for studies of gas bubble dynamics is schematically shown in Fig. 1. Main feature of the apparatus is a vertical shock tube (total length 4 370 mm) consisting of three sections:

- The high pressure section, which is to be filled with the driver gas (nitrogen) at a pressure $p_4$. This pressure can be varied from 0.1 to 2.4 MPa.
- The low pressure section, which is normally filled with air of ambient pressure ($p_1 = 0.1$ MPa).
- The last (and lowest) section containing the working liquid, which is filled from a supply container, whose height with respect to the tube end wall can be varied (thus controlling the level of the liquid).
To prevent formation of undesirable bubbles the liquid was filled in very slowly (approximately for 30 minutes). Tap water was used as a working liquid for preliminary experiments. However, most of the work was done with diluted glycerine (85% C₃H₅O₃).

The high- and low-pressure sections were separated by a hostaphane diaphragm of thickness \( h \). This thickness \( h \) was selected in such a way as to ensure sufficient diaphragm sagging and stressing at a given pressure \( p_4 \). The sagged diaphragm touched two resistance heating wires (Cronix 80 E, \( \varnothing 0.3 \) mm) stretched below the diaphragm in a cross. When a condenser battery (600 \( \mu \)F; 200 V) was discharged across the resistance wires the stressed diaphragm melted and tore along the contact line with the wires. Thus, the moment of shock wave initiation could be set very precisely.

The following empirical relation was found to be valid between high pressure \( p_4 \) and diaphragm thickness \( h \):

\[
h[\text{mm}] = 0.125 \ p_4[\text{MPa}] .
\]

It follows from this relation that the suitable diaphragm thickness ranged from 0.0125 to 0.3 mm.