CHAPTER II

LITERATURE SURVEY

Nicklin *et al.* (1962) studied the properties of long bubbles in vertical tubes. It has been shown that these bubbles rise relative to the liquid ahead at a velocity exactly equal to the rising velocity of wakeless bubbles of the type studied by Dumitrescu and Taylor. For 1 in. tubes, this velocity is closely predicted by motion of bubbles in moving liquid streams has been studied, and the results applied to the problem of two phase slug flow. An expression for the voidage in steady two-phase slug flow has been derived, and this predicted voidage agrees well with the experimental results.

The study carried out by Davies *et al.* (1950) can be divided into 2 parts. Part I describes measurements of the shape and rate of rise of air bubbles varying in volume from 1.5 to 200 cm^3 when they rise through nitrobenzene or water. Measurements of photographs of bubbles formed in nitrobenzene show that the greater part of the upper surface is always spherical. A theoretical discussion, based on the assumption that the pressure over the front of the bubble is the same as that in ideal hydrodynamic flow round a sphere, show that the velocity of rise, U, should be related to the radius of curvature, R , in the region of the vertex, by the equation $U=(2/3)\sqrt{(gR)}$; the agreement between this relationship and the experimental results is excellent. For geometrically similar bubbles of such large diameter that the drag coefficient would be independent of Reynolds's number, it would be expected that U would be proportional to the sixth root of the volume, V ; measurements of eighty-eight bubbles show considerable scatter in the values of $U/V^{1/6}$, although there is no systematic variation in the value of this ratio with the volume.

Part II Reveals that though the characteristics of a large bubble are associated with the observed fact that the hydrodynamic pressure on the front of a spherical cap moving through a fluid is nearly the same as that on a complete sphere, the mechanics of a rising bubble cannot be completely understood till the observed pressure distribution on a spherical cap is understood. Failing this, the case of a large bubble running up a circular tube filled with water and emptying at the bottom is capable of being analyzed completely because the bubble is not then followed by a wake. An approximate calculation shows that the velocity U of rise is $U=0.46\sqrt{(ga)}$, where a is the radius of the tube. Experiments with a tube 7.9 cm diameter gave values of U from 29.1 to 30.6 cm/sec, corresponding with values of $U/\sqrt{(ga)}$ from 0.466 to 0.490.

The investigation of Spedding *et al.* (1998) on two-phase flow consists of 2 parts. Part I focus on Flow regimes. For vertical air-water flow, five flow regimes were identified by a combination of visual/video techniques and pressure loss fluctuation characteristics in an 0.026 m i.d. tube. Checks against existing how regime maps indicated that it was unlikely that a universal map will be derived that will correctly predict phase regimes in vertical flow. Existing theoretical transition equations were shown to have difficulty in handling the effect of diameter on the slug to churn transition. The churn to annular transition proved hard to predict at higher liquid rates. Two new relations are presented that predicted the transitions for the slug to churn and churn to annular regimes.

Part II involves the experiments on experimental semi-annular flow and hold-up. An experimental rig was constructed that enabled vertical co-current two-phase flow to be studied in a 0.026 m i.d. tube. For vertical air-water flow, pressure loss fluctuation characteristics were useful in helping to identify phase patterns present and ensuring consistent operational conditions. Details are presented on the semi-annular flow regime, which formed between churn and annular flows. Liquid hold-up was measured using the quick closing valve technique. Measurements showed the liquid hold-up to be flow regime dependent in agreement with published work. The Nicklin and Bonnecaze relations for intermittent flow and the Spedding-Chen relation for annular type flows achieved prediction.