HEAT TRANSFER AND TURBULENT BUOYANT CONVECTION

D.B. Spalding

Imperial College, London, U. K.

It is well known that the turbulence models which engineers use in order to predict fluid flow and heat transfer provide only imperfect predictions of the real phenomena. For shear-dominated flows, experimental data on which were largely used in the selection of the turbulence-model constants, their agreement with reality is closest; however, for those turbulent flows which are strongly influenced by body forces resulting from gravity, rotation or other acceleration, the predictions leave much to be desired.

This was already apparent when the ICHMT decided to hold its 1976 symposium (then called 'seminar') on turbulent buoyant convection. Indeed it was the reason for the choice.

The practical importance of the ability to predict such flow phenomena accurately is very high, especially in relation to man's precarious control over the natural environment. Thus the spread of polluting smoke plumes through the atmosphere depends strongly on the extent to which thermal gradients stabilise or de-stabilise the air through which it spreads; and the warm-water effluent from power stations travels large distances from its point of entry, often with deleterious effects on wild-life, because the stabilising temperature gradient suppresses the turbulence which would cause mixing with the lower and cooler waters.

A related phenomena, fraught with even more hazardous consequences, is the movement of smoke from fires, especially those taking place in buildings from which people must be swiftly evacuated. The smoke rises from the fire; it then travels rapidly along the ceilings of rooms and escape corridors, often outpacing the retreating crowds. High-level building obstructions may then cause smoke to plunge downwards in frightening billows, confusing the escapers and often driving them back into the flames. Could the movement of smoke be better predicted, architects and fire-inspection authorities jointly would be able to devise more certain methods of evacuation; and the loss of life would be greatly diminished.

The 1976 ICHMT Symposium Proceedings contains papers related to the above-mentioned practical applications, and to others; and it also concerns more idealised situations, the study of which assist to promote understanding. Perusal of the appended titles of sessions and papers will confirm this. Some of the papers contain

ideas and data which are still referred to by research workers; and others deserve to be re-examined in the light of more recent knowledge.

I am of course a highly partial scrutineer of these old papers; it is therefore rather apologetically that I report my gratification on finding that it was in the 1976 Symposium that I first described how computational-fluid-dynamics techniques could be extended to cover two-phase phenomena. The inclusion of the paper in the turbulent-buoyancy symposium may have seemed rather idiosyncratic at the time; yet the inkling that I had then has matured into the strong belief that there is an intimate connexion between buoyancy-influenced turbulence and two-phase flows. What is now called the "two-fluid model of turbulence" is the result, a subject about which there is alas no space to write more here.

It is however not (needless to say) the above paper, nor any concerned with environmental applications, that I single out as being the paper to be included in this volume. Instead I have selected the paper by Professor B.S. Petukhov of the Institute of High Temperatures of the USSR Academy of Sciences, entitled "Turbulent flow and heat transfer in pipes under considerable effect of thermogravitational forces". This author, now sadly deceased, devoted much of his life to the assembly of reliable experimental data in the field of heat and mass transfer. This paper is a very suitable one to remember him by.

•