CONTENTS

1. INTRODUCTION

Calculation methods for turbulent flow can be developed at any one of four levels.

(1) Empirical algebraic formulae connecting turbulence properties and mean-flow properties. Examples; eddy-viscosity formulae, entrainment and dissipation-integral methods.

(2) Empirical differential equations ("transport" equations) for one-point turbulence properties. Examples; shear-stress transport equations, length-scale transport equations.

(3) Empirical differential equations for two-point correlation or spectrum tensor. Examples; Kraichnan "Direct Interaction " model[1], Deissler's linearized models[2].

(4) Direct numerical solution of time-dependent Navier Stokes equations. Examples; Deardorff[3], Schumann[4].

Practising engineers are just passing from level 1 to level 2. Studies at level 3 refer mainly to isotropic turbulence, and the only attempts to treat shear layers have necessarily been so simplified as to reduce almost to level 2. Progress at level 4 is exciting, but even with lower-level approximations for the small-scale motion the calculations are very time-consuming (as a result, coarse finite-difference grids have to be used and the plotted results look remarkably like scattered experimental data). I see the main use of level 3 as providing better small-scale modelling for level 4 computations, enabling the latter to be used as "numerical experiments" for development and testing of level 2 models. Like the other lecturers, I see engineering calculations being confined to level 2 for the immediate future.

Calculation methods at levels 1 and 2 are most simply explained as attempts to "close" the exact Reynolds-stress transport equations for $-\rho\overline{u_i u_j}$ which can be derived by manipulating the Navier Stokes equations and time averaging. The equations are given in Appendix 1: here we need merely note that the terms represent the processes shown in Fig. 1.