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On core flows

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One technique of analysis suitable for determining the motion of self-similar core flows is that which involves lateral integration of the equations of motion over the core cross-section. The resulting integrated equations represent the balance existing between the various bulk properties of the core, and substitution of lateral profile shapes enables the axial dependence of core properties to be determined. This technique is used to examine several aspects of particular core flows.

An analysis is made of the motion of steady turbulent forced plumes issuing from finite sources into an extensive quiescent environment. The effects of different source conditions on the flow are examined and the solutions representing the flow from these finite sources are related to previous conclusions which have unduly emphasised virtual sources. Maximum heights of ascent are determined for negatively buoyant plumes in a stably stratified environment. Typical flow profiles from selected source types indicate the wide range of behaviour represented.

A lagrangian representation is used to analyze the motion of the forced plume produced when slow changes are made in the source emission rate. The resulting flows are unsteady in the mean and the average plume properties in an element of plume at any height are found to depend upon the time of emission of that particular element from the source. Two simple cases are chosen to illustrate the theory which is shown to be valid only for slow rates of emission and upper-bounds are determined for these rates.

The rate of propagation of the front of a turbulent starting plume is calculated, the model comprising a steady plume feeding buoyant fluid into

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a vortex ring, or leading thermal. As a result of the entrainment of plume fluid the bulk properties of the ring change with time and the similarity solution is found to exist only for diffuse concentrations of vorticity and buoyancy within the ring. The calculated value of the ratio of ring velocity to mean plume velocity is found to be consistent with that value obtained from experiment.

Finally, a model of the generation of a leading-edge vortex is developed in which the progressive rolling up of the vortex sheet shed by the leading-edge of a wing forms a concettrated vortical core. The azimuthal velocity field resulting from the progressively increasing angular momentum induces a pressure deficit in the core and this, in turn, induces first an axial acceleration and then an axial deceleration of the core fluid. The model is able to predict axial and circumferential velocities in the core of the same order as those observed for physically reasonable values of the flow parameters.

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