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Potential Complex-Lamellar Decomposition
of Fluid Flows

Final Report
June 30, 1980

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The application of the potential complex-lamellar decomposition to the velocity field of a fluid flow was investigated. It was hoped that this decomposition would aid in understanding flows where both irrotational and vortical motions are occurring simultaneously (turbulence, aerodynamic noise, three-dimensional boundary layers). Furthermore, a decomposition such as this might become the basis of computational methods for predicting these flows.

Some preliminary work on the general nature of the decomposition and its application to turbulence was given in Ref. 1. In this work it was noted that the decomposition is not uniquely defined. It was assumed that one additional condition of a local nature, that is, the condition would hold at each point in the flow, could be used to fix the decomposition. It was this aspect that also gave the decomposition some interesting possibilities. The local condition would be specified by a physical consideration so that it would simplify the mathematics of the governing equations. The object of this research was to define the most appropriate local condition, and the problem of three-dimensional boundary layers was studied for this purpose.

After considerable preliminary study it was found that the basic premise of the work was invalid. It overdetermines the problem if one applies a local uniqueness condition to the decomposition. At most, a uniqueness condition is allowed only on a reference surface which is chosen so that it cuts across all vortex lines in the flow. Reference 2 (Appendix) gives a fuller explanation of the situation.

This result means that the flexibility of the decomposition is not as great as anticipated, and that further work on three-dimensional flows with viscous forces is not appropriate. Work on applying the decomposition to inviscid, vortical, three-dimensional flows (plasmas) is being pursued by other researchers.

References:

1. Panton, Ronald L., "Potential/complex-lamellar velocity decomposition and its relevance to turbulence". J. Fluid Mech. 88, p. 97-114, 1978.
2. Panton, Ronald L. "Erattum: Potential/complex-lamellar velocity decomposition and its relevance to turbulence", submitted to J. Fluid Mech.