Starting jets of finite width and formation time of vortex dipoles
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two-dimensional flow induced by a jet ejected from a nozzle of finite size is studied
experimentally. Vortex dipole forms at the front of the developing flow and then
moves forward with constant speed. Trailing jet establishes behind the dipole. The
dynamics of the flow is discussed on the basis of detailed measurements of vorticity
and velocity fields which are obtained using particle image velocimetry. It is found
that within the range of control parameters used in our experiments the dipoles
never separate from the jet which is in contrast to the behavior of vortex rings
reported previously by other authors. However, the formation time for the dipoles
can be introduced such that after the formation the dipoles start moving away from
the nozzle. Their dynamics after the formation is characterized by a reduced flux of
vorticity from the jet. A value of the ratio of the speed of propagation of the dipole
to the mean velocity of the jet is found to be 0.5 for later times of the evolution of the
flow. A theoretical model is offered to predict quantitatively the initial propagation
of the dipole as well as its steady-state regime.