We consider the system constituted by a rigid body $B$ having a hollow cavity which (strictly) contains a homogeneous rigid ball $B_R$. The gap between these rigid bodies is completely filled by a viscous incompressible fluid, whose motion is governed by the Navier-Stokes equations. We assume that the whole system $S$ of rigid bodies with a fluid-filled gap is constrained to move (without friction) around the center, $G$, of the ball $B_R$. For a large class of configurations for the fluid and the solid $B$, we show that the long-time behavior of weak solutions corresponding to initial data having (arbitrary) finite kinetic energy is characterized by a steady state. In this steady state, $S$ rotates as a whole rigid body with constant angular velocity. In particular, the velocities of the fluid relative to $B$ and to $B_R$ tend to zero as time approaches to infinity, respectively. (Received January 16, 2017)