

Figure 1

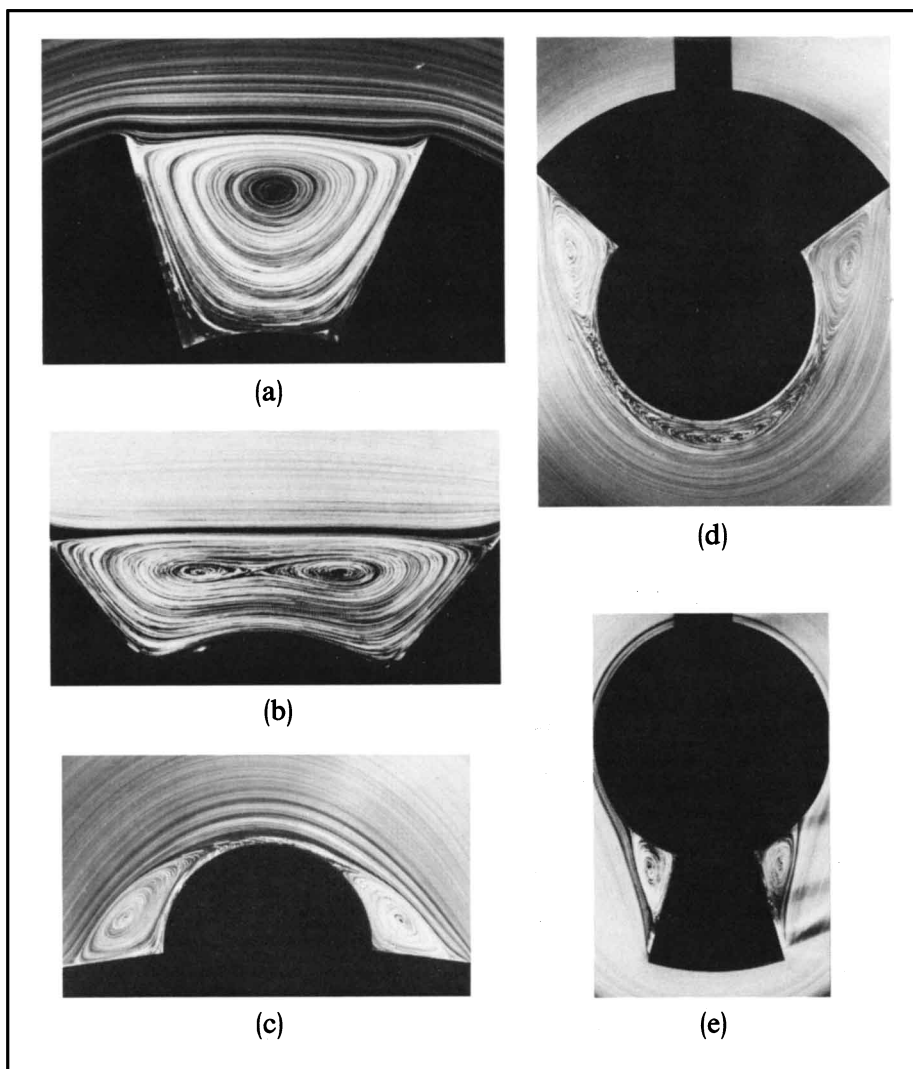


Figure 2

LOW REYNOLDS NUMBER FLOW IN AN ANNULUS WITH A SECTOR NOTCH

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The structure of low Reynolds number flow in an annulus with a sector notch (Fig. 1) depends on the geometric parameters involved. The experimental apparatus that we used to observe these flows contained a rotating cylinder (radius $R_3 = 14.8$ cm, angular velocity ω) and a stationary inner cylinder (radius $R_2 = 0.5R_3$) with a sector notch (angle β , depth $R_2 - R_1 = 0.5R_2$). A nearly inertia-free, two-dimensional flow was produced by floating silicone oil ($\nu = 1000$ cS, $\rho = 0.975$ g/cm³) on salt water ($\nu = 8$ cS, $\rho = 1.4$ g/cm³) giving a Reynolds number of $Re = \omega R_3^2 / \nu \approx 0.8$. Time-exposure photographs (30 sec to 3 min) of small air bubbles in the oil are shown in Fig. 2.

Figure 1 shows the flow geometry for the experiments, while Fig. 2 shows the photographs of flow structures; (a) $\beta = 43^\circ$, (b) $\beta = 76^\circ$, (c) $\beta = 195^\circ$, (d) $\beta = 257^\circ$, (e) $\beta = 325^\circ$.

The structure of the flow depends on the value of β . Numerical calculations for small β show that there is a series

of eddies of decreasing strength in the notch.¹² For somewhat larger β there is one main eddy [Fig. 2(a)]. This eddy remains until $\beta \approx 73^\circ$, at which point it splits into two co-rotating eddies separated by a saddle-type stagnation point [Fig. 2(b)]. This configuration remains until $\beta \approx 158^\circ$, at which point the "figure-eight" structure breaks into two separate eddies [Fig. 2(c)]. Similar results occur for plane shear flow over a wall with a cavity.¹³

For $235^\circ \lesssim \beta \lesssim 265^\circ$, a new structure containing three eddies occurs, with a relatively slender eddy "balanced" on the bottom of the notch [Fig. 2(d)]. (Apparently this three-eddy structure does not occur in the plane case.) This flow is quite sensitive to the geometry. Slight nonsymmetry of the bounding geometry will cause the center eddy to disappear, leaving two eddies of unequal size. Such sensitivity is common for slender eddies in Stokes flow.¹⁴

For $265^\circ \lesssim \beta \lesssim 360^\circ$, the flow contains two main corner eddies [Fig. 2(e)], similar to the plane case of uniform flow past a fence.¹³

The existence of the three-eddy structure and the range of β for the different types of flows are, no doubt, a function of the geometric parameters R_1/R_2 and R_1/R_3 .