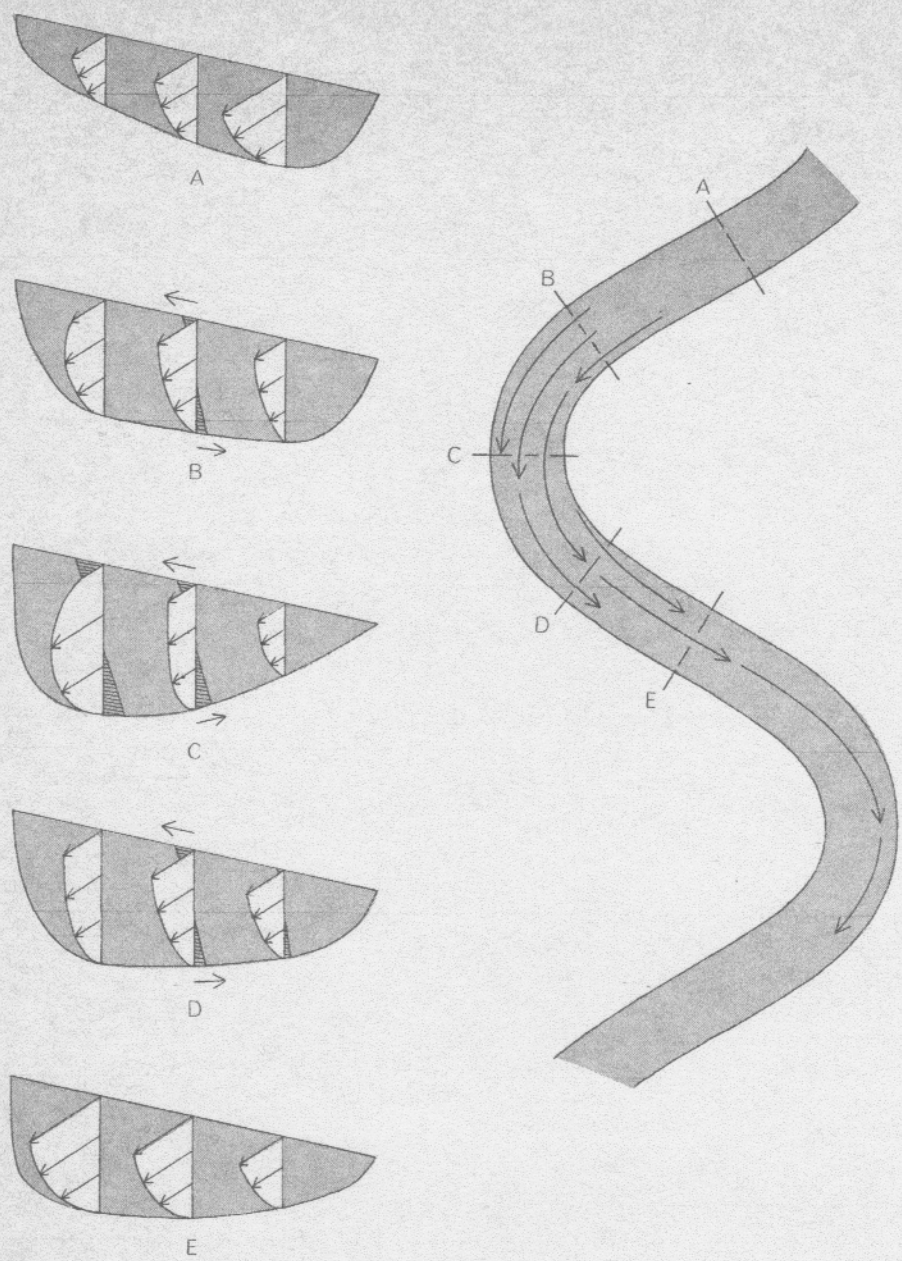
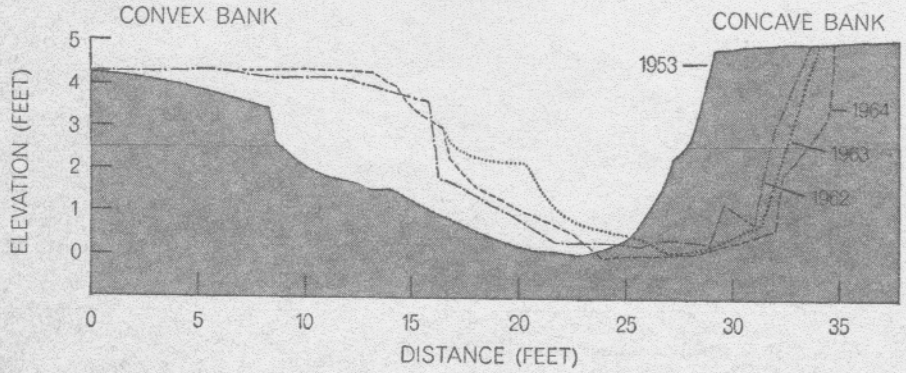


IDEALIZED FLOW PATTERN of a typical meander is shown here. The left side of the illustration indicates the velocity vectors in a downstream direction for five cross sections across the curve; the lateral component of the velocity is indicated by the triangular hatched areas. The right side of the illustration shows the streamlines at the surface of the meander.



LATERAL MIGRATION of a typical meander is demonstrated in this drawing, made up of four successive cross sections surveyed between 1953 and 1964 on Watts Branch, a small tributary of the Potomac River near Washington. The lateral migration of meanders by the erosion of the concave banks and deposition on the convex banks over many years results in a river channel's occupying every possible position between the valley walls.

closely approaches uniformity in the rate of work over the various irregularities of the riverbed than a straight channel does. Of course the slope of the water surface is, with a slight correction for velocity, an accurate indicator of the rate at which energy is lost in the form of frictional heat along the length of the stream. Therefore a uniform longitudinal water-surface slope signifies a uniform expenditure of energy for each unit of distance along the channel.

A meander attains a more uniform rate of energy loss by the introduction of a form of energy loss not present in a straight reach, namely the curved path. It is evident that work is required to change the direction of a flowing liquid. Thus the slope of the water surface should increase wherever a curve is encountered by a river. In a meander it is at the deep pools, where the water-surface slope would be less steep than the average, that the introduction of a curve inserts enough energy loss to steepen the slope, thereby tending to make the slope for each unit of river length nearly the same. Accordingly the alternation of straight shallow reaches with curved deep reaches in a meander appears to be the closest possible approach to a configuration that results in uniform energy expenditure.

It is now possible to say something about the development of meandering in rivers. Although one can construct in a laboratory an initially straight channel that will in time develop a meandering pattern, a real meandering river should not be thought of as having an "origin." Instead we think of a river as having a heritage. When a continent first emerges from the ocean, small rills must form almost immediately; thereafter they change progressively in response to the interaction of uplift and other processes, including irregularities in the hardness of the rock.

Today the continuous changes that occur in rivers are primarily wrought by the erosion and deposition of sedimentary material. As we have seen, rivers tend to avoid concentrating these processes in any one place. Hence any irregularity in the slope of a river—for example a waterfall or a lake—is temporary on a geological time scale; the hydraulic forces at work in the river tend to eliminate such concentrations of change.

The formation of meander curves of a particular shape is an instance of this adjustment process. The meandering form is the most probable result of the processes that on the one hand tend to