

## Drag Propulsion

It seems likely that the earliest techniques devised by humans to propel themselves in vehicles through a fluid environment were paddles, perhaps originally inspired by the use of hands to swim through water using a breast-stroke or dog-paddle. Eventually this technique evolved to using oars in unison to propel longships or canoes. Then when human power was superseded by engine power, the technique was further expanded in the exploitation of paddles to propel paddle steamers. As we will show in section (Ddc) that follows, the efficiency of such a propulsion device increases as the ratio of the size of the paddles to the size of the ship increases. Consequently the trend was for ever larger paddles relative to the size of the ship or boat. The problem was where to place these huge paddles and this led to two alternative strategies namely the *sternwheeler* exemplified in Figure 1 and the *sidewheeler* exemplified in Figure 2. These two designs



Figure 1: Paddle steamer "Natchez", a typical sternwheeler, on the Mississippi.



Figure 2: Paddle steamer "Ryde", a typical sidewheeler, built on the River Clyde by William Denny and Brothers and launched in April 1937. She saw service as a ferry for over 30 years.

alternatives originated independently in both the east and the west as shown by the same two Chinese designs shown in Figure 3.



Figure 3: Models of two Chinese paddle steamers, a sidewheeler in the foreground and a sternwheeler in the background.

It is, however, much more efficient to use the lift force rather than the drag to move water or to propel a boat in water. Though Archimedes used screws to lift water in 220BC, Leonardo da Vinci sketched a helicopter raised by a helical screw at the end of the 15th century and the sculling technique was known in ancient times and used by gondoliers (and others), the first practical quantitative design was suggested by Bernoulli in 1752 and finally, in 1798, Robert Fulton mounted a four-bladed propeller on a ship. Thus, the idea of using lift did not undergo serious development until the rotating propeller was invented. In the next section we demonstrate why this propulsion strategy is so much more efficient than the techniques based on drag.