



Up she rises

Next month sees the opening of the world's first revolving boat lift, the Falkirk Wheel in Scotland. Although hardly a crane in the true sense, this remarkable structure makes use of some highly specialised crane componentry. David Taylor reports

Lifting boats in and out of the water is all in a day's work for many cranes. Even small ships can be lifted by the largest floating cranes. But what crane has ever had to lift a vessel plus the water it was floating in?

Such lifting devices do exist, but they are hardly cranes. The world's first was the Anderton Boat Lift in Cheshire, England, built in the 1870s to lift canal boats out of the Manchester Ship Canal and up several metres to the Trent and Mersey Canal. Still working and currently undergoing a full refurbishment, the Anderton Boat Lift now has a 21st Century rival: the Falkirk Wheel.

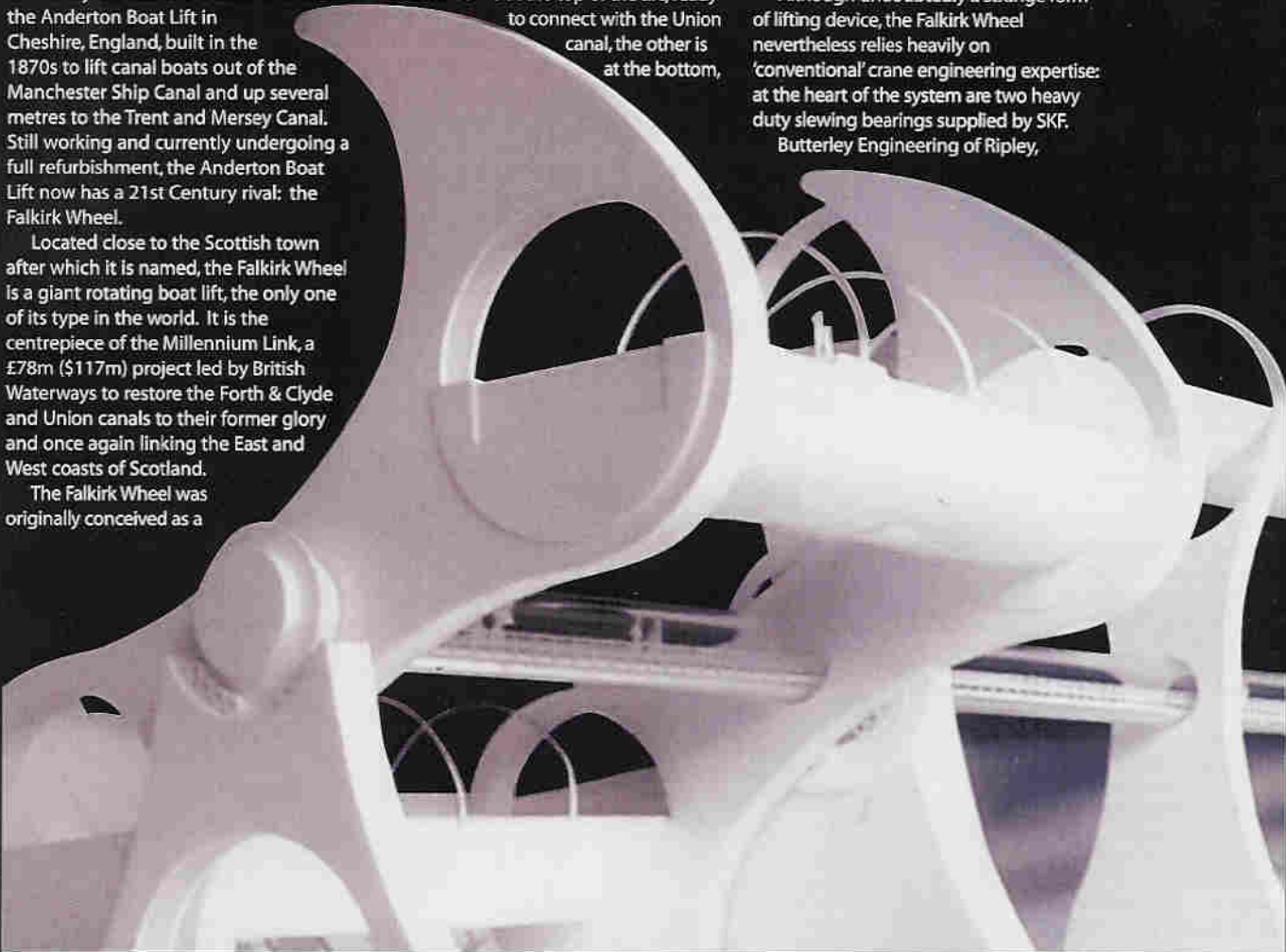
Located close to the Scottish town after which it is named, the Falkirk Wheel is a giant rotating boat lift, the only one of its type in the world. It is the centrepiece of the Millennium Link, a £78m (\$117m) project led by British Waterways to restore the Forth & Clyde and Union canals to their former glory and once again linking the East and West coasts of Scotland.

The Falkirk Wheel was originally conceived as a

type of Ferris wheel, lifting boats in suspended gondolas. The final design, however, has more in common with the chamber of a revolver than a wheel as such. It comprises a rotating structure – said to resemble a Celtic axe-head – which carries two cylindrical caissons in a continuous circle, 180° at a time. When one caisson is at the top of the arc, ready to connect with the Union canal, the other is at the bottom,

connected to the Forth & Clyde. The vertical distance between the two levels is 32m, and the Wheel measures 35m in diameter. The two 22m long caissons each carry a payload of 300t comprising water and up to four boats. A series of synchronous gears keeps the caissons in the horizontal plane as the wheel revolves.

Although undoubtedly a strange form of lifting device, the Falkirk Wheel nevertheless relies heavily on 'conventional' crane engineering expertise: at the heart of the system are two heavy duty slewing bearings supplied by SKF. Butterley Engineering of Ripley,





The Falkirk Wheel, here under construction by Butterley Engineering, is due to be opened next month

Derbyshire, won the contract to build the lift, and its engineering design consultant, Bennett Associates of Rotherham, Yorkshire, invited SKF to provide the bearing solution. To support the wheel, SKF developed a design which uses a pair of purpose-designed 4m diameter, three-row slewing bearings – one at either end of the wheel. The outer rings of these bearings are bolted to the support structure and the inner rings are fixed to the axle-shaped arms. The inner ring of one bearing is equipped with gear teeth to transmit the drive to the wheel.

The use of slewing bearings is an unusual solution, as this sort of bearing is normally used in applications with heavy axial loads, such as those encountered in the rotational movement of large cranes, says Butterley's marketing director Colin Castledine. Because the Wheel revolves around a horizontal axis, the bearings used on this project are subject to heavy radial loads, as well as axial loads. When fully loaded, the Wheel weighs 1,800t and exerts a radial load of more than 9,000kN on each bearing. Hence they each have three rows of cylindrical rollers, one for the radial load, and two with smaller rollers for the axial loads.

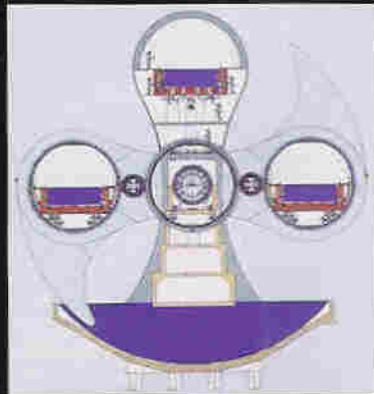
The Wheel is rotated by 10 hydraulic gearboxes via the geared slewing ring and completes a half-revolution in about 15 minutes, lifting the boats at roughly 4m/min. Although the loads imposed upon the axis bearings are large, the lifting effort is negligible due to the careful counterbalancing of the two



caissons. With the watertight doors in the caisson and canal both open for loading and unloading, the water levels in the caissons will depend on the level in the canals to which they are connected. Anybody familiar with the story of Archimedes in his bath will realise that, when a vessel enters a caisson, it displaces its own weight in water back into the canal, and so has no net effect on the load in the caisson. Therefore, when the caisson and canal doors are closed, a pump system equalises the water levels in the two caissons, to establish a near-perfect balance.

The drive system has been designed to handle a degree of imbalance due to differing water levels in the caissons. However, even allowing for this potential imbalance, the very low friction torque of the bearings means that a rated torque of only 2,972kNm is needed to rotate the Wheel. Protected with their own integral seals, the bearings have a design life of 120 years – but nothing is being left to chance. To ensure maximum protection from water ingress SKF is supplying additional 4m and 2.5m diameter heavy duty seals.

Besides the two main bearings, SKF has also supplied cross roller bearings to support the idler gears which keep the caissons level throughout their rotation around the main axis. The caissons themselves run on a wheel arrangement



on circular rails with each wheel mounted on two sealed spherical roller bearings.

The Falkirk Wheel works out to be a lot more expensive than most 600t capacity lifting machines, but this is no ordinary structure. It has been hailed as a 'future international landmark' by British Waterways, the organisation that looks after the canals of the UK, and it has even drawn admiration from the Royal Fine Art Commission for Scotland. When HM Queen Elizabeth II opens the Falkirk Wheel next month, the eyes of the British public, and of engineers much further afield, will be focused on one of the most remarkable lifting machines ever built.

A video showing how the boat lift works is available by clicking on 'Falkirk Wheel' at: www.millenniumlink.org.uk

The Wheel has been hailed as a future international landmark

The team

Client/team leader: British Waterways
Main contractor: Morrison-Bachy-Soletanche JV
Consulting engineer: Ove Arup
Steelwork designer/fabricator: Butterley Engineering
Engineering design: Bennett Associates
Concept architect: Nicholl Russell Studios
Project architect: RMJM