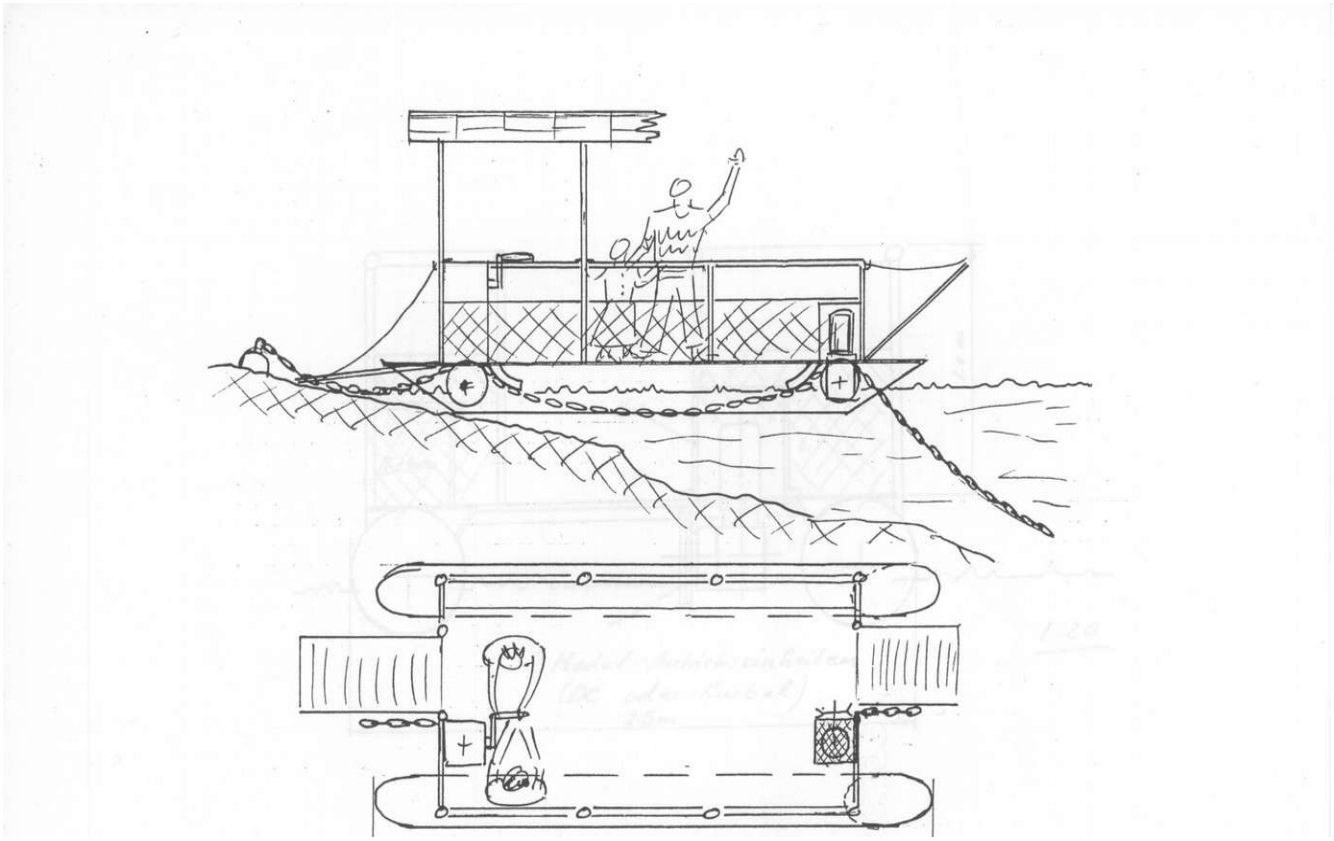
Human Powered Chain Ferries

by Theo Schmidt

Historically most crossings of inland waterways not served by bridges were probably with ferries worked by oars or paddles. Today they are mostly motorized. However many small *cable ferries* still exist, which utilize the river current, human power, or both. Although larger cable ferries are motorized., the use of human power is so efficient, that even many-tonne such ferries can be worked by human power. This includes historic ones in England and USA and modern ones mainly in Germany and the Netherlands.

This article lists some of these, mainly the ones which use chains rather then ropes as cables, and describes how they operate.



Example of a simple human-powered chain ferry with a single central chain.

What is a chain ferry?

Chain ferries belong to the category of cable ferry. Mostly the cables used are wire ropes rather than chains and where feasible the ferries utilize the water current as motive power – they are then called reaction ferries. This involves the use of long ropes suspended over a river, stretched near the surface, or supported by buoys. However it is also possible to use heavy cables which are not stretched but normally lie loosely at the bottom of the body of water, thus invisible and not impeding shipping. In this mode of operation, chains are particularly suitable, as they are very flexible and easy to grip without slipping – by hand or with chain sprockets. In operation, the ferry pulls itself along one or two ropes or chains, or sometimes using one chain for pulling and one rope for extra guidance. Chain ferries are used as crossings, but the technology was also used in the 19th and 20th centuries over long distances in the longitudinal direction of a river run, especially in France and Germany. These highly developed chain boats pulled strings of barges over hundreds of kilometers, much more efficiently than today's shipping. A chain tug is still in operation through the 6km long canal tunnel Riqueval near Saint Quentin in France.

Postcard of a chain tug and barges on the river Elbe

How do chain ferries work?

In contrast to wire ropes, which are often stretched taut over or just beneath the water surface, chains are usually left to rest loosely on the bottom, so that they come to the surface only in the immediate vicinity of the chain ferry and its landings. (With two

exceptions: very short crossings and in those cases where the chains are also pulled from ashore.) The chain on the ground normally provides enough friction to resist the motive force and does not need to be tensioned beyond that tension inherent to its local catenary. In deep water there is of course more tension due to the chain's own weight, both where it enters and where it leaves the ferry. As the weights fore and aft mostly cancel, there is little resistance to motion provided the chains are led over chain wheels, sprockets and low-friction surfaces.

Motion is caused by turning at least one of the chain sprockets. This decreases the slope of the tangent to the front catenary and increases that of the rear catenary. If you draw the force diagrams, the motive force is shown as the vector sum of the tangents, equating to the difference between the front and back horizontal force components. This is balanced by the sum of the boat's resistances.

Chain is more expensive than rope; this explains perhaps why cable ferries using wire rope are generally more popular than chain ferries, except in very large sizes, where the greater flexibility, durability and resistance to corrosion probably over weigh.

The chain(s) require(s) no special mountings except being attached at the landings. In deep water they act in the same way as anchor chains. The chain ferry is permanently "anchored", yet it can travel forwards and backwards at any time. Further maneuvers are normally not possible and not necessary. The chain(s) lead(s) the ferry exactly to the landing, where it is held without having to be additionally attached.

Moving and maneuvering

The chain ferry moves forward as the front part of the chain is raised from the ground, passes through the boat, and is released at the back to descend again to the bottom. Due to its weight, the chain's slope is relatively steep and it poses no hindrance for other vessels. The considerable front and back weights are largely balanced, so that the driving sprockets need provide, in addition to a small amount to overcome friction, only the force for propulsion. At the typical low speeds this is small and transmitted almost without loss, so that even multi-tonne ferries can be moved with the power of a single person.

Most of the smaller chain ferries are cranked by hand with a windlass attached to one side and there is only one chain. For larger chain ferries, there are usually two chains and the propulsion is motorized.

In calm waters, the ferry follows the chain exactly,. In the case of current, there is a small offset downstream. The ferry does not need to be steered as it will automatically end up at its designated landing even in a strong current. (This in contrast to chain boats traveling long distances; these can influence their course to a small extent. There is also one type of freely maneuvering and steerable chain boat which uses an endless chain loop, but I know of none in existence.) Maneuvering is very simple: to stop the ferry, the drive is stopped, to reverse, the drive is reversed. Except for the adjustment of the cateneries, these movements are effected almost immediately. The position of the ferry along the chain is relatively precisely defined at all times.

The chain ferry over the river Avon (GB) is cranked by hand on one side. It is sufficiently slow for the boat on the left to pass safely.

Landing(s)

Chain ferries land with the bow square to a landing which can be a slip, pier, quay, pontoon, beach or other natural shore. A slip or beach is is convenient if the water level varies. When approaching the landing, the vertical angle of the front part of the chain(s) change(s). The weight of the rear part of the chain now contributes to propulsion, “pushing” the ferry to a certain extent. After arriving at the landing, the ferry is then also partially held in place by the weight of the chain. Even without fixation, it won't drift away. When leaving it is the opposite: a little extra force is required. These inherent features contribute to safety. In practice the ferry is held even more firmly against the land if the chain sprockets are fixed, so no further mooring is then required.

All known chain ferries have a blunt bow and approach the landing squarely, so it is easy to embark and disembark, over a front flap in the case of a slip. With a suitable design this ensures a perfect connection at every water level, also accessible for bicycles, strollers and wheelchairs. As a chain ferry must be of a symmetrical roll-on, roll-off design with flaps both fore and aft, this is particularly convenient: vehicles do not need to be turned around for disembarking.

Chain ferries using two chains or one centrally-run chain are automatically well-positioned by the blunt bow pulled against the landing. In the case of only one chain running on one side, the fixation is however insufficient and requires further measures. This can be a kind of funnel dock, a secure corner, railings, or a series of piles.

The Reedham Ferry in Norfolk GB is typical for many river crossings in England and Germany. Before 1950 (photo) it was cranked by hand over the approximately 45m wide river Yare. Today it has a motor on one of the chains. See also here and further historic photos.

Power

The majority of chain ferries are human-powered. This includes almost all small ones for up to 24 passengers. Historically even chain ferries for cars were hand-operated, but today most of these have been fitted with motors. Large chain ferries have always been motorized.

None of the human-powered propulsion systems use pedals: almost all use hand cranks or direct pull on the chain. Some use crankless smooth wheels with enough inertia to act as flywheels. All seem to be designed for operation by a single person and thus the power is limited to a few hundred Watts and is mostly below 100 W. Treadmill-cages have been proposed but like capstans or other multi-person arrangements have probably never been built – in comparison to the multiple oars or poles of free-moving craft.

It is interesting to compare the chain ferries which were once human-powered and are now motorized. Today those with displacements of 15-45 tonnes are fitted with internal combustion engines of 5-25 kW. Very occasionally, there are also electric drives, for example 15 kW for 60 passengers / 6 cars. This is over ten times more than human-powered, although they are probably faster today. Also, it used to be very hard work moving these heavy ferries and it is easily understandable why they were converted.

In spite of the tenfold increase when motorized, chain ferries need about ten times *less* installed power than equivalent free moving ferries with propellers.

These relatively small powers are possible because of two reasons:

- The transfer of force and power is virtually perfect at all speeds, as is the case with horses that pull a tram or boat from the shore. The power of two real horses is enough to pull a boat with 100 people with up to 10 km/h. The efficiency of the best propellers is about 90% at the best operating point, but in practice it is usually lower, especially when maneuvering this is only a few percent.
- At slow speeds very little power is needed, none at all when stopped, even in the strongest current. This is in contrast to boats with propeller or paddle wheel drives: here a lot of reserve power is needed to maneuver, brake, or even just remain stationary in wind or current flow. These hardly affect a chain ferry, since the force is transmitted to the (fixed) land and not to the (moving) water.

The Baldur is one of four Lippeferries which can transport 2-8 persons "do-it-yourself" over the Lippe in Germany, using flywheels rather than cranks. Besides the one drive chain, the ferries have an additional wire rope for extra guidance.

Safety

- Chain ferries have a number of safety features in comparison to free-moving ferries and, in part, to cable ferries:
- In the case of mechanical damage or a human ailment, the chain ferry just stops and does not drift downstream into a danger zone.
- Even with a low power drive, the ferry can be moved against a strong current or wind. Flow and often also wind come mainly from the side, so that the drive must overcome only a fractional component thereof.

- There are no difficult maneuvers, so that the operator can concentrate on the observation of vessels and floating objects. If necessary, it is only needed to stop or at worst go backwards, which can be done without any nautical skill.
- The geometry of the chains stabilizes the landed chain ferry, as described above.
- The chains are for the most part on the ground or low enough to not be an obstacle for other vessels.
- Operation in poor visibility or darkness is possible, as long as the prescribed acoustic signals and lights are given and received, because the chain ferry cannot lose its course or position.
- The rupture of a chain is very unlikely, of two chains extremely unlikely. Unlike mooring chains, they can easily or automatically be examined with every crossing.
- For the operation of a chain ferry, no special skill is required, just some attention and endurance. Most small chain ferries are provided for self-driving, even on navigable waters.

Definitely not human-powered, one of the Torpoint Ferries, by far the world's largest chain ferry crossing, near Plymouth (GB). Three identical ferries side by side, each with two chains and a capacity of 73 cars, cross the almost 600m wide strait Hamoaze (river Tamar). They run 24h every day, every 10 or 15 minutes to a timetable, one, two or all three as traffic requires. This satellite image shows all three ferries in operation. The other large English chain ferries are the Cowes Floating Bridge (Isle of Wight), the King Harry Ferry (Cornwall) and the Sandbanks Ferry (Poole Harbour).

Documented operational Chain Ferries

Chain ferries are very unevenly distributed in the world and most countries have none at all, although most have cable ferries using wire ropes. Apart from one small car ferry and two hand-operated chain ferries, Great Britain or more precisely southern England is known for four crossings with probably the seven largest motorized chain ferries worldwide. The USA apparently once had many chain ferries; now only one is left. Germany has several - now mainly motorized. - car ferries and about a dozen newly built self-operated passenger and cycle ferries. In the Netherlands there are even more of these. In the following I try to list the human-powered chain ferries in operation today.

USA:

The seasonally operated Saugatuck Ferry transports, with a guide, up to 24 persons as well as bicycles over the 95m wide navigable river Kalamazoo. The single chain drive is cranked and seems to require about 3 turns per meter; the tourists seem happy to help.

England:

The smallest English "do-it-yourself" chain ferry is the only access to 29 houses on the private Trowlock Island (River Thames) in Richmond, London. The 10m crossing takes about 40s. It can also be fetched from the other side.

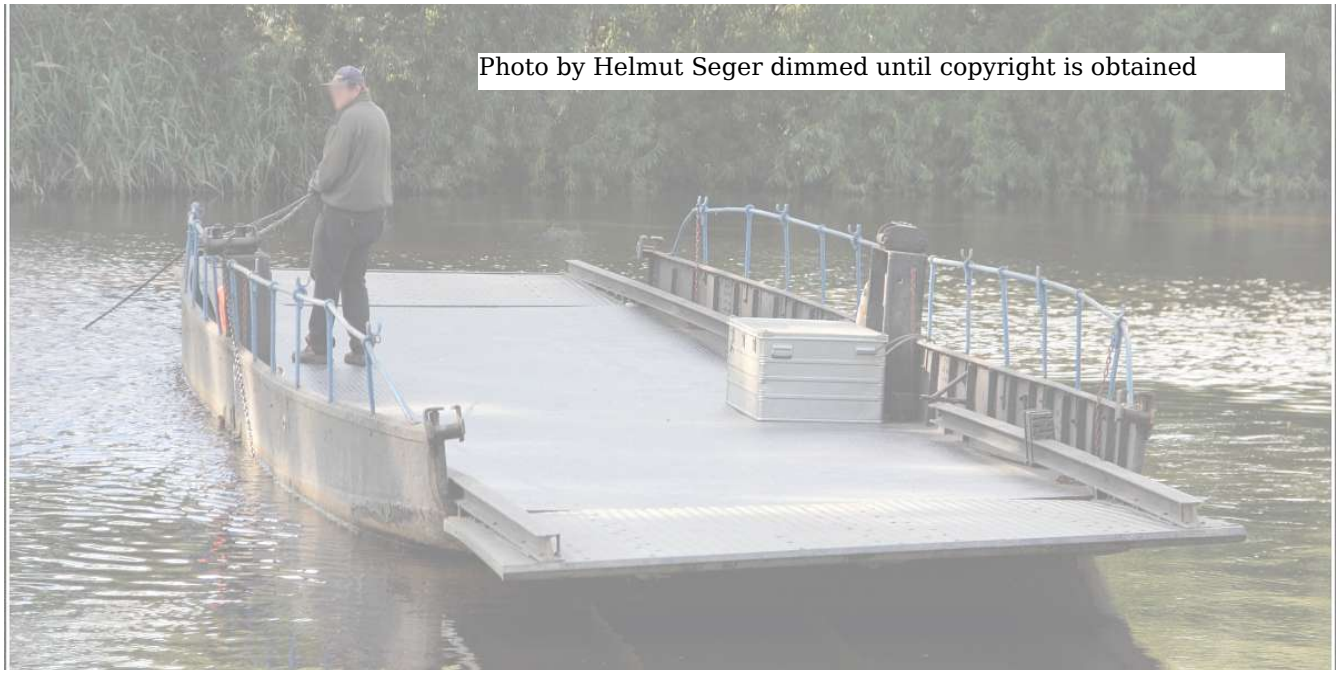
The seasonally operated Stratford-upon-Avon Ferry (see photo further up) for a maximum of approx. 20 people, carries up to 100'000 persons per year over the approximately 45m wide navigable river Avon. It is side-cranked by the crew and appears to give almost 1 meter per revolution.

Germany:

The smallest chain ferries in Germany are self-operated "Pünten", e.g. 30m over the river Vechte near Echteler and two over the Marscher Tief by Bedekaspel, as part of a touristic cycle route (see decription and instructions). They are not pure chain ferries, having also two wire ropes as guidance. The chains can also be pulled from shore, in order to fetch the ferry empty from the other side.

The four self-operated Lippe-Ferries are available seasonally for 2-8 persons. The chains are operated by crankless flywheels, on the ferry or from the shore. In addition, each has a guidance wire, and one of them a longitudinal rope in order to utilize the current.

The Gräpel-Ferry crosses the 40m wide Oste and can take 30 Persons or 2 cars. There are no cranks; the chain is pulled by hand. By changing the belaying points, the ferry's yaw can be adjusted and the river current partially utilized.



Netherlands:

In Duifpolder (between Delft and Rotterdam) there is a small self-propelled chain ferry (video), about 40m over a channel. A second very similar crossing is over the 40m wide river Tjonger near Heerenveen.

On this page 31 similar "Zelfbedieningskettingveerponts" are described, as well as 54 with ropes instead of chains, 5 of these however being in Belgium.

This video shows the function of the "Kettingpont Aanloophaven Zeewolde".

This "Kettingpont" across the channel Vaarste Rijn near Utrecht can even be powered by small children. It is not clear whether this is near by the Museumswerf Vreeswijk, or whether there is a second identical ferry.

The Dutch love their little cable ferries, most operated with ropes and some with chains. Here is a college design competition with dozens of design studies including a small typology.

Two identical "Pontjes" near Molletjesveer-Knollendam and Oostknollendam-Starnmeer are part of a cycle route. Here a Video of this.

This page also lists 4 electrically powered small ferries in Valkenburg near Leiden or this partly solar self-operated hybrid chain ferry over the river Vechte.

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