Appendix G
Mechanical Lifts

G-1. General

In Germany, France, and Belgium, structures have been built to transfer vessels from one water level to another without using navigation locks. These structures are known as mechanical lifts and move a vessel either vertically upward and downward or upward or downward on an inclined plane. In the early part of the 19th century there were two or three such devices in the United States. However, these “lifts” were quite small and involved moving a small canal boat up an inclined track on a wheeled truck arrangement.

G-2. Types

a. Ship elevators or vertical mechanical lifts have been built in Germany to serve in place of locks where lockage water was not available. One of the first ones was built on the Dortmund-Ems Canal at Henrichenburg in 1899. This mechanical lift was used until 1962 and was then replaced with a new one. It consists of a rectangular tank with a gate in each end. This rectangular tank is supported on two air-filled flotation chambers that move up and down in water-filled shafts underneath the structure. The flotation chambers provide enough buoyancy to balance the weight of the water-filled tank. When the rectangular tank (trough) is at the lower canal level, it connects directly to the end of the canal. The gate in the trough is lowered, the gate in the end of the canal is lowered, and a vessel waiting in the canal enters the trough. When the vessel is moored in the trough, the gates in the ends of the canal and the trough are closed. The trough is raised to the upper canal level by means of motor-driven threaded vertical shafts running through nuts attached to each corner of the trough. Rotation of the shafts are synchronized, and the trough remains level at all times. Since the flotation chambers provide an upward force equal to the weight of the tank, the threaded shafts have only to overcome mechanical friction and control movement of the tank. When the trough is secured to the end of the upper canal, the gates in the ends of the trough and the canal are opened, and the vessel can depart. Transfer of a vessel from the upper canal to the lower canal is accomplished in a similar fashion. The trough is 295 ft long, 39 ft wide, and 10 ft deep, and can transit a 1,500-ton (2,200-pound ton) vessel in about 30 min. The difference in elevation is about 46 ft.

b. Inclined plane mechanical lifts of two different designs have been built in Belgium and France. In the French project a water-filled tank or trough moves sideways up and down on rails on an inclined plane. The action is similar to the Henrichenburg lift, except the trough moves up an incline instead of vertically, and the dead weight of the trough (plus water) is offset by counterweights moving in trenches on the incline. The French project is located on the Rhine-Marne Canal near Arzviller, France. The trough moves through a vertical distance of 44 m (144 ft) over a horizontal length of about 100 m (328 ft). It is designed for 300-ton vessels (2,200-pound tons) and replaces 17 very old, small canal locks.

c. The Belgian inclined plane lift is located in the Brussels-Charleroi Canal. There are two separate parallel tracks at this lift, and the troughs move up endways. The horizontal length of the incline tracks is 4,700 ft, and the vertical distance of the incline is about 220 ft. The travel time for the trough is 20 min. Allowing for a total entry and start-up time of 5 to 10 min and a stopping and exit time of 5 to 10 min, the total transit time would be about 35 to 40 min. The two troughs operate independently and have dimensions of 285 by 39 by 10 ft. Each trough can carry one 1,350-ton (2,200-pound ton) vessel, which has almost the same carrying capacity as a 1,500 ton (2,000-pound ton) barge in the United States.

G-3. Capacity

If three conventional 110- by 600-ft locks were used to overcome the 220-ft difference in elevation, each lock would have a lift of about 73 ft. The transit time for an eight-barge tow through each of these locks would be about 25 min. Adding 15 min for travel time between locks (assuming the locks are 2,500 ft apart) gives a total travel time of 90 min (1.5 hr) to transit 12,000 short tons. To transit 12,000 tons through the incline (moving in the same direction) would require four trips for each two troughs, which would total 5.33 hr (8×40 min). Thus, the net total transit time required to move 12,000 tons through the incline is 3.5 times greater than the time required to move 12,000 tons through three locks and travel a distance of about 5,000 ft. Moreover, the lock system would have more than 3.5 times the capacity of the incline, because all three of the locks would not be in use by one tow at the same time.

G-4. Water Slopes

a. French entrepreneurs have developed and patented a system wherein a wedge-shaped volume of water is pushed up or down a sloping rectangular channel with a vessel floating in a wedge of water. A "water slope" (Figure G-1) is located at Mon Tec, France. The rectangular channel is 20 ft wide, is on a 3 percent slope, and will accommodate a 300-ton vessel with a 7-ft draft. The entire structure replaces five old locks.

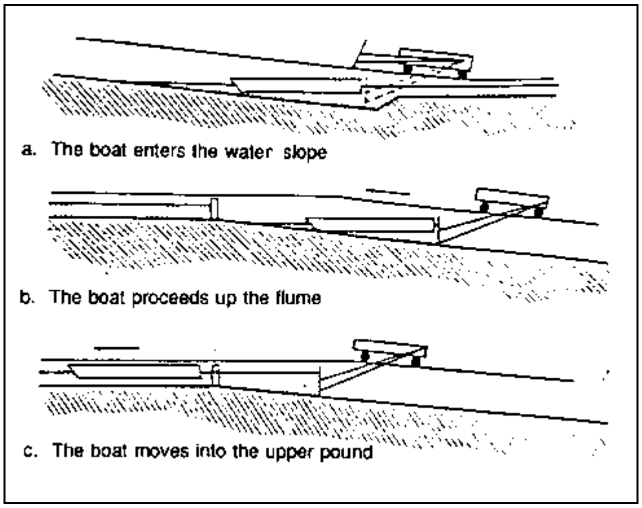

Figure G-1. Water slope

b. The system apparently performs very well in the present situation, but to be commercially feasible in the United States the channel would have to be 4 to 5 times wider, the walls would have to be several times higher in order to provide adequate depth for a 580-ft tow, and structural design problems would be extremely complex for the greater sizes. The system could not possibly be energy efficient.

G-5. Separate Facilities for Recreational Craft

a. At places where recreational craft appear in considerable quantities, the introduction of separate handling facilities may be worthwhile. Ten of these have been noted in paragraph 7-32. This is particularly true when the period of peak recreational demand corresponds to the period of peak commodity movement. Such separate facilities could be canvas slings or steel tanks to lift the craft from one level to another, separate small locks out of the main navigation channel, or an inclined plane moving lock such as has been used in Europe and in the early canal development in the United States. Separation of recreational traffic from towboat traffic would also appear to be a safety improvement.

b. Analyses of alternative small craft lifts were considered at Kentucky Lock and indicated that the inclined-plane type would be more feasible from the standpoint of economics and operation. The inclined plane would be laid out on a steel superstructure that would carry the tracks on a uniform grade up the downstream side of the embankment to an elevation permitting adequate clearance over the railroad and highway. The superstructure would then convey the tracks across the top of the dam to a similar inclined plane on the upstream side. The boat would ride in a tub that would accommodate one craft 24 ft or less in length.

c. Twenty of the Upper Mississippi River locks have partial provisions for a second lock chamber, 100 ft by 360 ft. These provisions include an upper gate sill, upper portion of the river wall, and recesses in the intermediate wall for the lower miter gate and gate machinery. Completion of this lock chamber would involve damming and dewatering the chamber area; removing accumulated debris and providing scour protection measures; constructing the river wall and chamber floor; removing and rehabilitating the upper miter gate; and installing gates, valves, operating machinery, and appurtenances. Commercial traffic would also be able to use the new lock if the main chamber fails.

d. Eighteen of the twenty Upper Mississippi River locks with partial provisions for a second lock chamber include either a roller or tainter flood control gate adjacent to the river wall. At these 18 locks, the completion of a 400-ft auxiliary lock would be possible. The 400-ft chamber would be built by extending the river wall, Dam Pier 2, and possibly the intermediate wall downstream. A new miter gate and tainter gate would be built in a monolith at the lower end of the chamber. The wall and pier extensions would be made from steel sheet-pile cells. The extension of the dam pier and any extension of the intermediate wall would be a solid cell wall. The river wall would be steel sheet-pile cells spaced with 10-ft clearances between cells. The monolith would be keyed into the intermediate wall and the dam pier extension. The area between the river wall and the dam pier extension would function as a flume to fill the lock chamber (the area between the river wall and the intermediate wall). Commercial traffic would be able to use the new chamber if the main chamber fails.

e. A mobile floating lock is a self-contained, fully operational lock structure that can be positioned behind the existing upper miter gates for the auxiliary chamber. This device would be approximately the size of three barges abreast (105 ft by 200 ft). The lock is a steel vessel similar to a dry dock. The sides would be floating tanks housing the operating machinery and controls. The upper and lower gates, integral parts of the dock, would be permanently mounted within the outside tanks. The upper and lower gate types have not been determined but would probably be submerging tainter gates or hinged drop gates, depending on the available depth in the chamber. Filling and emptying would be done through ports in the chamber floor.

f. The small-scale steel lock, 25 ft by 80 ft, would be a double-wall steel structure of 3/8-in. plate with adequate diaphragms. The upper gate bay would include a vertical lift gate and an emptying system. The upper sill elevations would be set to accommodate sailboats up to 40 ft long.

g. The 25-ft by 80-ft concrete and sheet-pile lock would be a concrete U-frame structure on a sand foundation. The structure would include a concrete upper gate bay monolith, a lower concrete gate bay monolith, and a lock chamber of sheet-pile walls with a revetment floor. The inside face of the cofferdam would act as the outer form for the concrete gate bay monoliths and would be constructed on site.

h. The differential railway lift consists of a steel tank (pan) carried up an inclined plane, over a crest, and down a reverse plane without being tilted. The pan is rigidly suspended from a carriage equipped with two sets of wheels to travel on a system of track elevated over the earth dike. The outer set of wheels maintains the pan horizontally while the carriage travels above the downstream face of the dike on a 2.5H to 1V incline. The inner set of wheels maintains the pan horizontally while the carriage travels above the upstream face of the dike on a reverse 2.5H to 1V incline. Both sets of wheels are used as the carriage travels above the crest on a double set of differential rails.

i. The steel tank on inclined rails consists of a steel tank (pan) supported by an overhead crane at each corner. The cranes lift the tank vertically out of the water, travel horizontally along rails across the dike, and then lower the tank into the water on the other side. The crane trolleys on each rail are structurally separated from the trolleys on the other rail and each uses one drive wheel. The four lift motors and both crane drives are electrically synchronized, eliminating overhead clearance restrictions.

j. The mobile boat carrier system is based on a mobile boat carrier presently used for launching certain pleasure craft. The slings could be replaced with a tank (pan) for holding the boats being transported. The modified boat carrier would lift the tank out of the water, travel along a horizontal track across the dike, and lower the tank into the water on the reverse side. The carrier cross member would restrict the overhead clearance. Additional studies would be required to determine if the slings could be safely adapted to various boat shapes.

k. The inclined channel lift is similar to a device in operation at Montech, near Toulouse, France, connecting two canals. Two water levels in the canal are joined by a 480-ft flume or concrete ramp having a U-shaped section. Water at the upper level is held back by a tilting gate. The boat on the lower level enters the approach basin. A large plate at the end of two arms is lowered into the water behind the boat, forming a wedge-shaped body of water in which the boat floats. The plate is then pushed forward by two 1,000-horsepower diesel-electric locomotives, one on each bank.

l. The inclined plane lift resembles Belgium's Ronquieres ship lift located near Brussels. This single structure is 4,700 ft long and raises and lowers craft 225 ft. Two inclined planes raise and lower 1,500-ton barges 225 ft in 22 min. Barges enter a tank (pan) with gates at either end and are pulled or lowered by six 125-kilowatt electric motors connected to the tanks by eight 2.25-in.-diam cables. When loaded, the tanks weigh between 5,500 and 6,280 tons. Counterweights weighing 5,733 tons run up and down in recesses between the tank rails. The tanks measure 49 ft by 300 ft and are 14 ft deep. Both tanks and counterweights ride spring-suspended on flangeless wheels running on steel rails.

m. The version considered for the Upper Mississippi River would have one tank approximately 26 ft by 80 ft and maintain a depth of about 4 or 5 ft. The system would be operated by remote control from the main lock and monitored by television and two-way radio communication.