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History of Horse Whims, Teamboats, Treadwheels, and Treadmills

HOWARD H. ERICKSON

Department of Anatomy and Physiology, College of Veterinary Medicine, Kansas State University, Manhattan, KS 66506

Postal Address and Contact Details:
Howard H. Erickson
Department of Anatomy and Physiology
College of Veterinary Medicine
228 Coles Hall
1600 Denison Avenue
Manhattan, KS 66506-5802
Telephone: 785-532-4541
Fax: 785-532-4557
e-mail address: Erickson@vet.ksu.edu

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Summary

The horse-whim was first used to turn rotary mills in Greece in 300 B.C. Roman engineers developed capstan machinery to propel boats with paddle wheels about 370 A.D. About 1680, Rupert, a cousin of King Charles II, built the first horseboat using a horse-whim mechanism to tow ships in the Royal Navy. People in America called the vessels "teamboats," because of their close relationship to steamboats. By 1819, 8-12 horse-boats operated between Manhattan and points across the Hudson and East Rivers. Although teamboats were cheaper than steamboats, they had disadvantages: the circular walkways took up a lot of deck space and the horses had to walk in circles. In 1819, the treadwheel-propelled horseboat was invented which placed the turntable below the deck; horses stood on top of the turntable through slots in the deck and drove the wheel backward by walking in place. This eased the burden on the horses, freed up deck space, and allowed the ferry to be built on one hull. In the 1830s, horse-powered treadmills were developed and used with attachments on the farm; they also revolutionized the design of horse ferries. In 1889, Zuntz and Lehmann reported on the chemistry of respiration in the horse during exercise using a revolving platform. Brody, in the 1930s, used a treadmill to study energy metabolism of the horse and in the early 1960s Persson was the first to use a high-speed treadmill to study the physiology of exercise in the horse.

Introduction

The treadmill has been used for scientific studies of equine exercise physiology for over 100 years (Zuntz and Lehmann 1889). Crisman and Cohn (1998) describe the use of horse treadmills in agriculture, manufacturing, and transportation beginning about 1830 and also other animal-powered machines that have been used for over 2,000 years. Two types of muscle-powered machines were used. Vertical treadwheels were designed for people, donkeys, goats, and dogs; ox- or horse-powered versions were rare, because of the size, weight, and limited agility of the latter animals (Shayt 1989). The capstan or windlass consisted of a large drum or axle—vertical for capstans and horizontal for windlasses. The capstan is powered by turning bars in a circle on the horizontal plane to revolve a vertical drum. Capstans built for horses are known as horse whims, horse gins or horse engines (Crisman and Cohn 1998). The earliest horse-whims were used to turn rotary mills in Greece in 300 B.C. and in Roman grain-grinding and olive-crushing mills around 100 B.C. (Singer 1956; Landels 1978).

The war galley *Liburna* (Fig. 1) was developed around 370 A.D. by Roman engineers (Singer et al 1956; Landels 1978). The *Liburna* used three teams of oxen harnessed to whims rotating three pairs of paddle wheels. According to Stuart (1829), a Roman army was transported to Sicily on ox-powered paddleboats. Horse-powered pumps were used in the 17th and 18th centuries to drain swamps and dredge harbors (Singer et. al.1956; Keith 1982). Rotary horse, ox, and donkey machines were used for food production during the 17th and 18th centuries to mill grain, cut chaff, grind turnips and animal feed, and crush apples to make cider (Crisman and Cohn 1998). A mechanical thresher was

developed in the 1770s resulting in the use of horse whims on many Scottish and English farms (Partridge 1973).

Horse Whim Boats

Prince Rupert, a cousin of King Charles II of England, designed and built the first horseboat about 1680 (Crisman and Cohn 1998). This vessel used a horse-whim mechanism and was powered by four to eight horses. This boat was used at the Royal Navy's Chatham Dockyard on the Medway River in 1682 and was capable of towing the largest ships of the Royal Navy (Stuart 1829).

A second animal-powered craft was designed about 1730 by French general Maurice, comte de Saxe. His craft was also based on a horse-whim mechanism and consisted of a pair of sidewheels. Horses, harnessed to radial arms extending out from above the crown gear, provided the power to propel the craft. Maurice planned to use the boat on the Seine River to tow boats from the English Channel to Paris (White 1962).

The first American horse-powered boat is credited to John Fitch (Crisman and Cohn 1998). This was a catamaran with two hulls and a broad deck, on which the animals could walk in a wide circle (Fitch 1976). Propulsion machinery consisted of a horse whim which powered a vertical-paddle apparatus at the stern. In 1794, a boat was built for the Delaware River; Fitch put the horseboat through its trials in the fall of 1794 and made a round trip between Philadelphia and Trenton in ten hours.

The first commercially horse-powered ferry is credited to Captain Moses Rogers of New York City. On 3 April 1814 the Rogers horse ferry cast off from the dock at Catherine Street for the first time (Crisman and Cohn 1998). It was similar to steamboats but the water wheel in the center was propelled by six to eight horses. It crossed the river 12 times a day, in 8 to 18 minutes, averaging 200 passengers each time. The horse ferry could make the crossing in the same amount of time as the New York-Brooklyn steam ferry, the *Nassau*. (Payzant and Payzant 1979). People began calling the vessels "teamboats," a play on the word "steamboat" indicating the close relationship between the two modes of transportation. Horseboats began as a substitute for steamboats, but their utility and cost made them attractive. The cost to build the steamboat, *Nassau*, was $30,000, whereas a horseboat, complete with extra horses and a stable, was $12,000. By 1819 eight to twelve horse-powered boats operated between Manhattan and points across the Hudson and East Rivers (Crisman and Cohn 1998).

European visitors to North America considered horseboats a novel form of transportation, and advocated their adoption in the Old World. England used a horseboat between Hull and Gainesborough on the Trent River around 1818 or 1819 (Crisman and Cohn 1998). In Switzerland a catamaran-hulled vessel served as a ferry and excursion boat on Lake Geneva in 1825. This boat was known as the bateau-manege ("treadmill boat"), or more derisively as *L'Escargot du Lac* ("Snail of the Lake") (Meystre 1967).

Horses had their limitations as a power source, but they were safe (Crisman and Cohn 1998). Horses did not overheat and set the boat on fire, nor did they over pressurize and

violently explode. In 1820, William Bird in Georgia tried to compete with steamboats for long-distance travel. Bird built a boat, called the *Genius of Georgia* with double-hull configuration typical of early horseboats. The principal component of the horse-whim mechanism was a gigantic horizontal wheel, 12.2 meters in diameter that turned two 5.8-meter diameter paddle wheels placed between the two hulls, one before the other. The *Genius* carried an equine crew of twenty-four, harnessed two abreast when they turned the horizontal wheel.

The Horizontal-Treadwheel Horseboat

Horseboats were cheaper than steamboats, but they had disadvantages. The whim mechanism and walkway required considerable deck space. Walking in tight circles all day was hard on the horses, resulting in dizziness or disorientation. Some horses, when put out to pasture, continued to walk in circles (Sutphin and Andre 1991).

The treadwheel brought about a revolution in team-boating. This consisted of a revolving circular platform or turntable, upon which the horses walked in place; instead of the horse turning in a circle, the circle turned underneath the horse (Crisman and Cohn 1998). In 1819 the U.S. Patent Office approved a treadwheel-propelled horseboat design submitted by Barnabas Langdon. The treadwheel consisted of eight radial arms with a planked ring around the outside for the horse walkway; a second ring, closer to the center of the wheel, was fitted with cog teeth to turn the gear on the drive shaft. Langdon's innovation solved the problems of the horse whim mechanism. This design eased the burden on the horses, freed up deck space, and allowed the ferry to be built atop one hull.

Horseboats with horizontal treadwheels became the most common type of horseboat and were used well into the 1850s in many locations; they consisted of two-horse and six-horse boats. Treadwheel boats saw considerable use on the Hudson River and Lake Champlain (Crisman and Cohn 1998). From 1814 until the 1860s, the Hudson's 241 kilometers of navigable water floated an assortment of horseboats. Lake Champlain is a short distance to the north of the Hudson River. The lake is situated between the Adirondack Mountains of upstate New York and the Green Mountains of Vermont, and drains northward into Quebec. The first European to see the waters of Lake Champlain was French explorer Samuel de Champlain in 1609. Lake Champlain is 12 miles wide in some places and offered horseboats more challenging navigational conditions than those encountered on the Hudson River. Nine horse ferry operations at seven crossings have been identified by Crisman and Cohn (1998) on Lake Champlain.

The horseboat *Eclipse* holds three of Lake Champlain's teamboat records: the largest vessel, the longest career for a single boat, and the most famous horseboat of its time (Crisman and Cohn 1998). The *Eclipse* was launched in 1828 and named after a famous race horse; it was powered by a six-horse horizontal treadwheel. One danger horses faced by working on treadwheel ferryboats was breaking through the plank surface of the walkway. In 1847, the *Eclipse* was carrying a heavy cargo, a load of fat cattle on their way to the slaughter house. The *Eclipse* began to collapse before reaching shore, the horses were taken out of their merry-go-rounds, the deck sides knocked off, and horses and cattle plunged into the lake.

By the 1840s the horizontal treadwheel was rendered obsolete by the horse treadmill. In the spring of 1858, a new horseboat, the *Gipsey*, was launched on Lake Champlain that used the four-horse, treadmill mechanism (Crisman and Cohn 1998). The *Gipsey's* mechanism differed from treadwheel boats; each sidewheel was hooked up to a treadmill. This arrangement worked well when the horses walked at the same speed on the treadmills, but if they walked at different speeds the boat would turn in a circle.

Portable Horsepower: The Treadmill Mechanism

Langdon's treadwheel was an advance over whim-type machines, but the treadwheel was cumbersome and subjected to considerable strain from horses walking on its outer rim. Constant maintenance of the treadwheel's wooden structure and regular replacement of mechanical parts was required. Agriculture and industry needed a machine that was portable, adaptable to many uses, and capable of being inexpensively manufactured and maintained (Crisman and Cohn 1998).

A major development in animal-powered machines, the treadmill, arrived in the early 1830s (Crisman and Cohn 1998). A horse-powered locomotive, the *Flying Dutchman*, was invented about 1829; it used a horse-treadmill and operated on the South Carolina Railroad in 1829 and 1830 (Brown 1874). The *Flying Dutchman* carried twelve persons at a pace of 19.2 kilometers per hour on the 9.6 kilometer track. The *Cycloped*, another horse-powered device, was tested in 1829 on England's Liverpool-Manchester Railway (Major 1978). The Baltimore and Ohio Railroad also used a horse-treadmill locomotive in the early 1830s. A similar machine was tested in England in 1838 as a substitute for

steam engines on tracks that did not have enough business to support steam. The trials proved highly successful, with the 3.6-metric-ton locomotive reaching speeds of 25.6 kilometers per hour. The locomotive *Impulsoria* (Fig. 2), was invented in Italy in 1850 and demonstrated on the London and South Western Railway (Major 1978).

There were several patents for portable treadmills in the 1830s (Crisman and Cohn 1898). Rufus Porter's "Portable Horse-Power" illustrated in the New York Mechanic in 1841 (Fig. 3) used a series of roller wheels to support the weight of both tread and horse. Treadmills were built in one-, two-, or three-horse models. In 1837 "Gleason's Portable Horse-power" cost $135 for a single-horse treadmill without attachments. In 1847, "Wheeler's Horse-power" package included a single-horse treadmill, a threshing machine, and a grain "shaker," all for only $110 (the treadmill alone cost just $75). Farmers were the largest market for treadmills; with various attachments the machines could thresh and clean grain, cut silage, churn butter, pump water, saw wood, and fill silos. Most treadmills were built for horses, but smaller versions were powered by cattle, goats, sheep, dogs, and even children for use around the farm and home (Tucker 1847).

The treadmill's compact size opened up new possibilities for transportation on land and water. Treadmills were light, portable, cheap, and easy to maintain because replacement parts were readily available; they also revolutionized the design of horse ferries (Crisman and Cohn 1998). They could be attached to the sides of a boat's hull and did not have to be placed beneath the deck like the horizontal treadwheel. Most new horse ferry designs had two treadmills, one on each side of the boat driving its own paddlewheel. Inclined

treadmills, due to economics and ease of maintenance, powered most horseboats built after 1850.

Treadmill Horseboats

Rufus Porter's "Horse Power Boat," published in the American Mechanic in 1842 (Fig. 4), is the earliest example of a vessel powered by a horse treadmill (Crisman and Cohn 1998). Designed for the shallow rivers, this was a flat-bottomed craft 9.1 meters in length by 1.8 meters in breadth. The horse and machinery occupied the middle third of the boat and were managed by the steersman, who also controlled the rudder. Porter's prototype cost two hundred dollars and the average speed was 9.6 kilometers per hour. Porter said, "We may see farmers harness their horses in a boat, to take a ride up or down a river, as they now do in a buggy or gig" (Lipman 1968).

The two decades, 1840-60, witnessed the shift from the horizontal treadwheel to the treadmill. The most common configuration for a treadmill ferry was two one-horse machines on opposite sides of the hull, with a passage up the middle for deck traffic. There were two variations in design: a sidewheel boat with a single, centrally mounted treadmill (this eliminated steering problems caused by independently powered sidewheels), and a sternwheeler propelled by a pair of two-horse mills placed amidships (Croil 1898).

Most treadmill ferries were employed on the Mississippi and Missouri Rivers in the Midwest, on the Columbia River in the far west and on remote stretches of Canadian

lakes and rivers. A horse ferry at Kansas City hauled a circus over the Missouri River, including a reluctant elephant. Jumbo completed the trip in excellent shape, but the elephant-trodden boat was damaged and the owner sued the circus owner for ten dollars to cover deck repairs (Root 1933).

About 1900, a treadmill ferry operated in an unusual manner on the Columbia River at Wallula Landing, Walla Walla County, Washington (Crisman and Cohn 1998). Because of strong currents, Old Jim, the ferry's single horse, walked along the riverbank towing the boat upstream for 800 meters; the horse would then board the craft, take his place on the treadmill, and the ferry would push off from the bank. The pilot controlled the angle of the boat in the current with a long steering oar as Old Jim churned away on the mill; between them they would bring the ferry into the landing opposite their starting point. The horse would disembark and start the process over again. This affected Old Jim after a while, for a later owner described him as "cockeyed" (Ruby and Brown 1974).

In 1910, to cross the St. Lawrence River to the Ontario shore from Louisville, New York, you likely would have used a horseboat (Bandy 1970). This was small boat with a shallow hull, a narrow deck, a pair of sidewheels, and a railing around the sides. The power mechanism, a single two-horse treadmill, was mounted in the middle of the deck just abaft the sidewheels. The equine-powered boat survived into the twentieth century at obscure ferry crossings in North America. The last horseboat was a small, treadmill ferry propelled by a single blind horse; this boat operated until the late 1920s at the Rome crossing on the Cumberland River (Holmes 1987).

The largest treadmills had a capacity of only three horses, but whim mechanisms could harness many more horses and generate more power. Larger versions were rotated by up to six teams (twelve horses). By the second half of the nineteenth century farm equipment manufacturers were turning out portable whims with folding or detachable arms; known as "sweep powers" or "lever powers," the devices were used to run large-capacity threshing machines, saws, churns, feed mills, pumps, and corn shellers (Didsbury 1968; Johnson 1978). Whims were mechanically simple, this may account for their reappearance on later horse-powered boats. Three horse-whim ferries navigated the Columbia River in Oregon and Washington at the turn of the century.

By the beginning of the twentieth century, the railroad had expanded, and little freight or passenger traffic moved any distance unless it was over the rails. Bridge technology and bridge construction continued; every year new spans drove more sail, horse, or steam ferries out of existence. A new source of power was also introduced in the twentieth century that supplanted both horse and steam: the internal combustion engine.

Treadmills on Stage in Paris

An article in *Scientific American* in 1891 documents the use of mechanical treadmills (Fig. 5) for one of the "hits" of Messrs. Montreal and Blondeau, "Paris Port de Mer" at the Varieties Theatre. The article states "three genuine horses, ridden by three genuine jockeys, start off at full speed, and make the circuit of the hippodrome of Longchamps.

The horses run on three tracks independent of each other, but arranged side by side." The track was made of cocoanut fiber similar to mats used to wipe the feet, but of thicker and closer texture. The belt was three feet in width, running over two drums placed on each side of the stage, and tautened by a third cylinder. It was supported by a series of wooden rollers placed close together and revolved on pivots. The drum mounted to the left was set in rapid motion by an electrometer, which received current from a battery of accumulators on Feydeau Street, in the vicinity of the theater.

The illusion was completed by unwinding a canvas in the rear, 86.9 meters in length, representing the panorama of the country as seen from the stands of Longchamps. The canvas was first wound around a vertical cylinder on the right hand side of the theatre, then unwinds and winds around a duplicate cylinder on the left hand side of the theatre. The two cylinders were set in motion by a windlass maneuvered by manual power and the panorama unwinds in a minute and a quarter. During this time, the belt moved at a velocity of 16-20 meters/sec, or, as stated in Scientific American at the rate of 12 to 15 leagues per hour.

The Scientific Use of Equine Treadmills

The early studies of equine exercise physiology, conducted at the end of the nineteenth century, focused on energy metabolism, with particular relevance to the work of the horse (Zuntz and Lehmann 1889; Zuntz 1896; Zuntz and Hagemann 1898). In 1889, Zuntz and Lehmann, reported on the chemistry of respiration in three horses during rest and work. The work performed in these experiments was carried out on a platform revolving at

different speeds, and the animal was kept in constant communication with the respiratory apparatus, from which samples of the expired air were taken for analysis at rest, walk, and trot. They did two series of experiments, first with a mask and second with a tracheal cannula.

In 1890, Smith also reported on the chemistry of respiration in the horse during rest and work; the paper was based on experiments that began in 1886. Smith evaluated 35 horses in 251 experiments, working the horses over a known distance, then immediately placing the horses on the apparatus for 20-30 seconds. Smith objected to the use of the treadmill and considered it an unnatural method of obtaining work. In 1896, Smith reported on the maximum muscular effort of the horse in the Journal of Physiology. Smith evaluated 80 horses on a dynamometer and found that horses pulled, according to their spirit, from 65 to 78 per cent of their body weight. One of the horses pulled 88 per cent of his body weight or thirteen men.

Proctor *et al*. (1934), at the University of Missouri, studied the efficiency of horses of different ages and body weights pulling graded loads at different speeds on a horizontal plane or treadmill (Fig. 6). They evaluated a large Percheron gelding, a Percheron colt and two Shetland ponies. The energy expenses of rest and work were measured by a closed-circuit oxygen-consumption method. The Percheron gelding exerted a draft up to 500 pounds.

Persson (1967), using Swedish trotters in the early 1960s, was the first to use the high-speed treadmill to study the physiology of exercise. Persson demonstrated how the high-speed treadmill facilitates the study of oxygen uptake during strenuous exercise in the horse and makes it possible to establish the oxygen-uptake/work relationship more precisely in different states of training. Until the mid-1980s, studies utilizing a high-speed treadmill were confined to those conducted at the Swedish University of Agricultural Sciences in Uppsala, Sweden. Today, the high-speed treadmill is used in many laboratories around the world.

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Figure Legends

Figure 1. Roman ox-powered sidewheel war galley (From Singer *et al*., *History of Technology* 2:606-7, Oxford University Press, 1956).

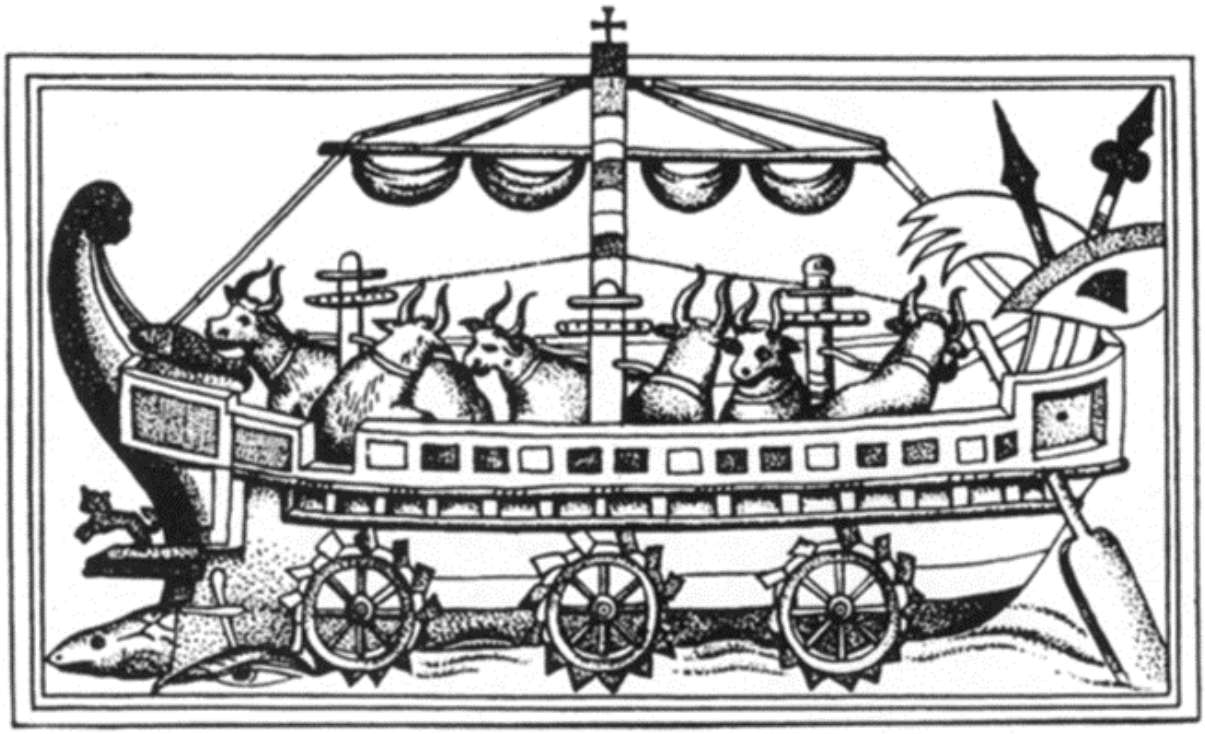

Figure 2. Roman ox-powered sidewheel war galley. From Singer et al., *History of Technology.*

Figure 2. The locomotive *Impulsoria*, invented in Italy in 1850 and demonstrated on the London and South Western Railway (From Major, J. K., *Animal-Powered Engines*, B.T. Batsford Ltd, London, 1978, pp 92-93).

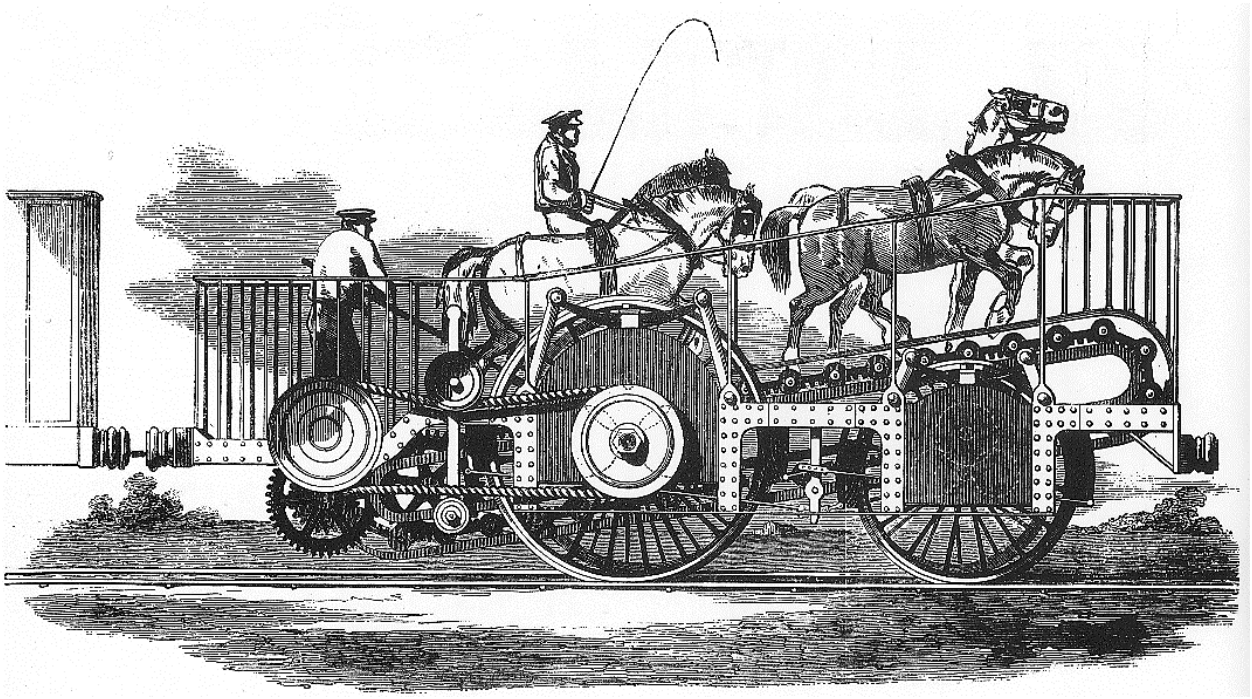

Figure 3. Rufus Porter's Portable Horse-Power for threshing grain, sawing wood, and raising water (From the *New York Mechanic* 1, no. 6 [6 February 1841] 1).

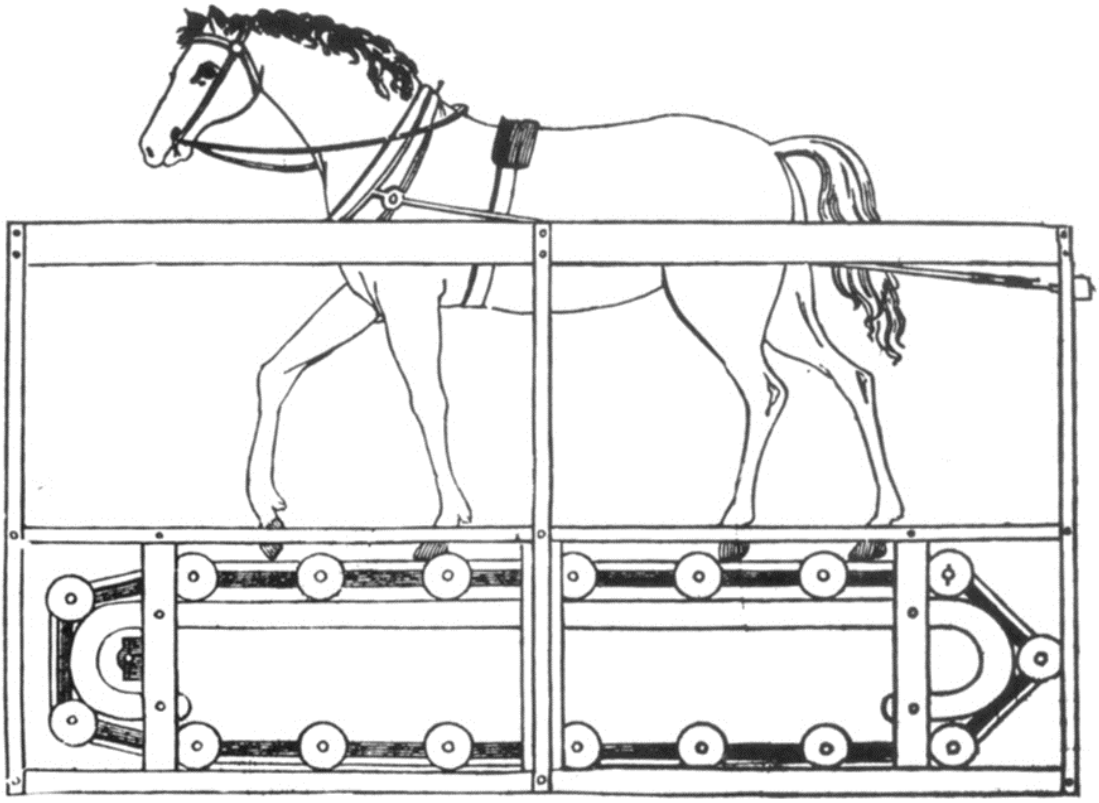

Figure 4. Rufus Porter's Horse Power Boat (From the American Mechanic 2, no. 37 [24 September 1842] 1).

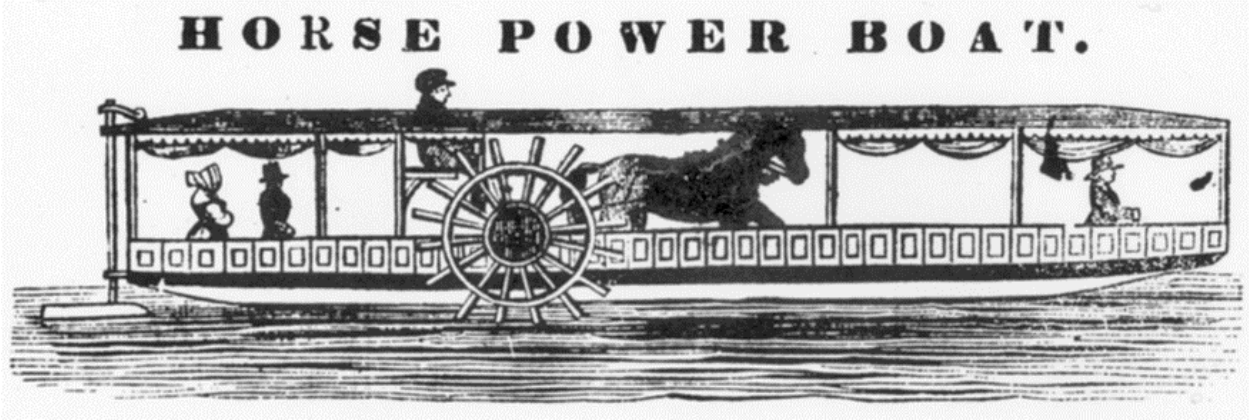

Figure 5. Racing horses on the stage showing the machinery under the stage for driving the endless belt (From Scientific American 64:263-264, 1891).

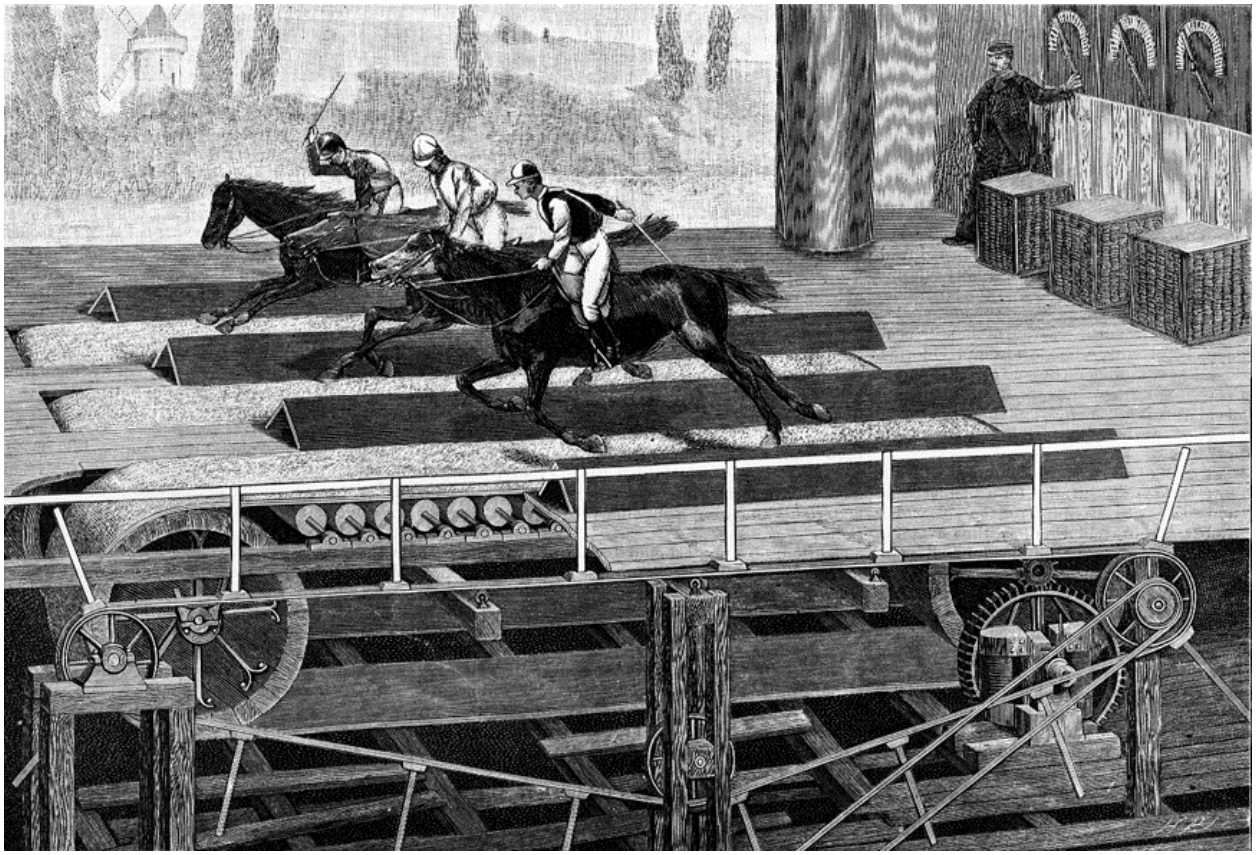

Figure 6. The treadmill and accessories used by Brody and colleagues at the University of Missouri to study the efficiency of draft horses (From Proctor *et al*, Univ of Missouri Ag. Exp. Stat. Res. Bull. 209:1-32, 1934).

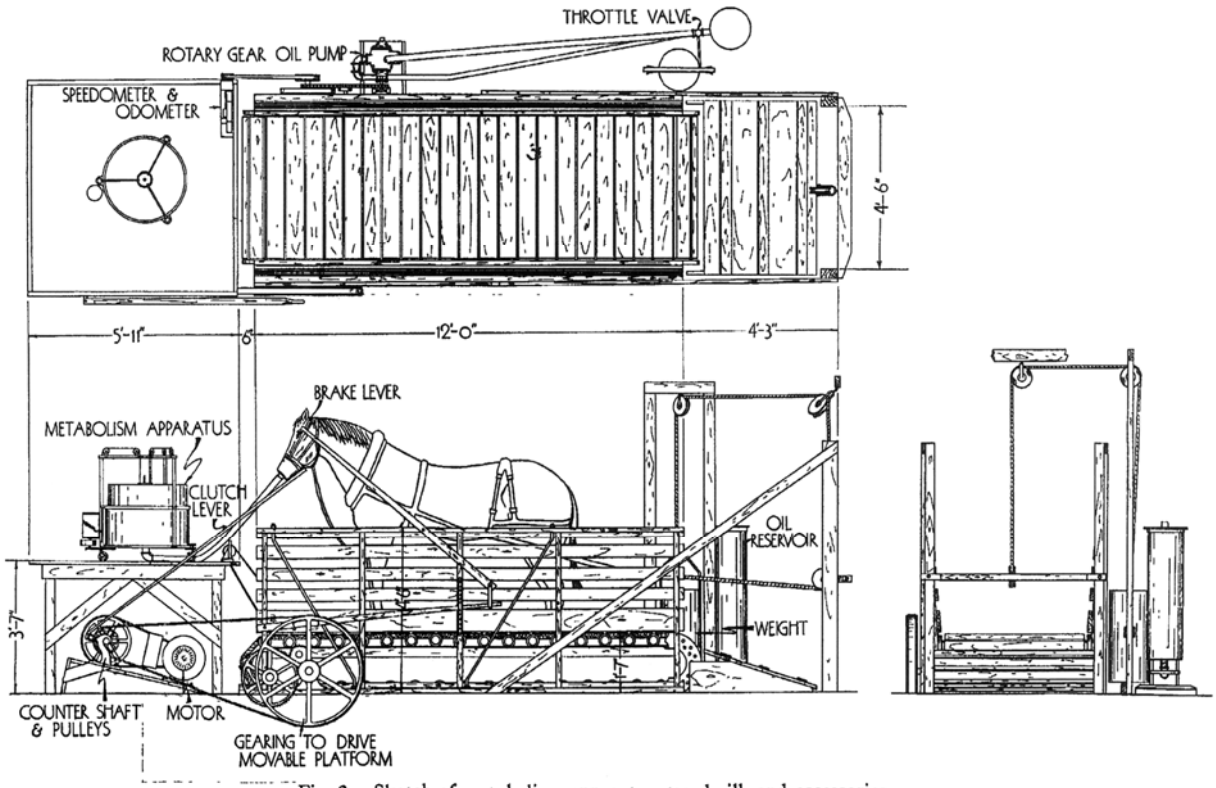

Fig. 2,—Sketch of metabolism apparatus, treadmill, and accessories.