

# HIS 2129



Technology, Society and  
Environment since 1800  
(Winter 2014)



# Canals, Raftsmen, and Snakeheads

- The Industrial Revolution (1750-1850) was an incremental process, at first; in North America as in Europe, the economy long remained predominantly agricultural
- Therefore, economic growth during the early Industrial Revolution was driven not only by manufacturing improvements but also by agricultural and infrastructure improvements
- The American axe combined with the expansion of a canal network to underpin an agricultural boom, characterized by new settlements and new exports



# The problem with roads (1)

- Because public roads were everybody's problem, they often ended up being nobody's in particular
- Upkeep frequently devolved to locals: the more a road was used, the more it suffered and the more it cost farmers, landowners, and villagers who drew little benefit from it
- As a result, roads were uneven in quality; designs from Roman times (an overlay of fine crushed rock over a roadbed of paving stones) did not work as well in colder climates, with freezing cycles pushing up the larger stones through the surface layer

# The problem with roads (2)

- Other North American designs were even less useful
- John L. MacAdam (1756-1836) advocated the use of crushed rock laid in three compacted layers (small and smaller); it required the use of heavy rollers at each stage to lock the crushed rock together
- In the United States, one of the first macadam roads was completed in 1823 in Maryland on the Baltimore to Ohio route
- In Lower Canada, the first macadam road connected St. John (St-Jean) on the Richelieu river to Laprairie on the St. Lawrence in 1832

Early designs for partial macadam roads in the U.S.

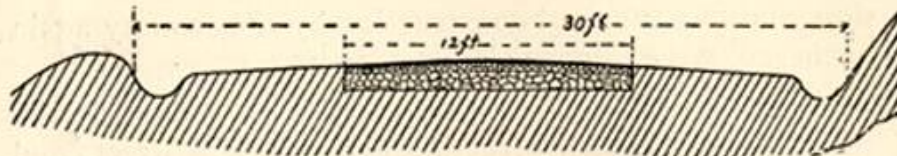


Fig. 51.—Road with Macadam in Centre.

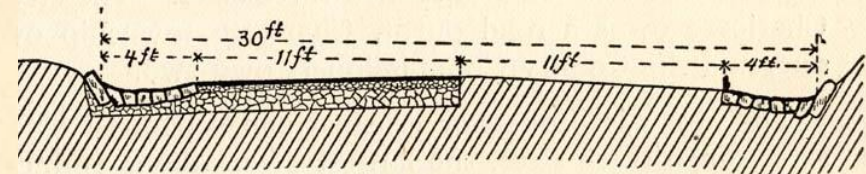


Fig. 52.—Road with Macadam at One Side.

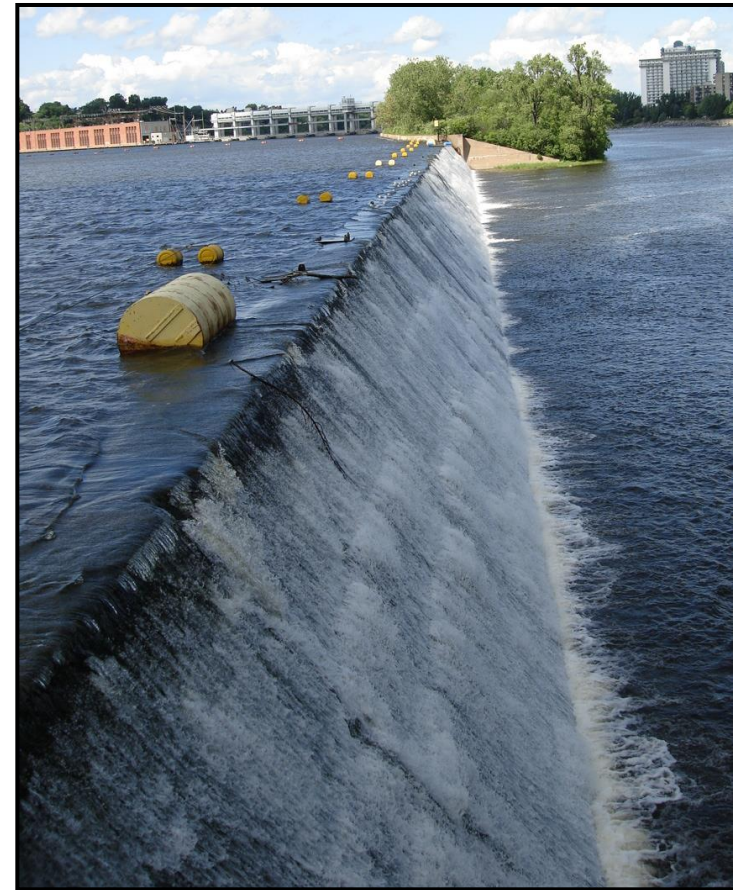


# Outline

- Inland navigation on rivers
- Inland navigation on canals
  - — Early history in Europe
  - — Jump-starting the Industrial Revolution
- Mechanizing navigation
  - — Traditional watercraft in North America
  - — Steamboats for inland navigation
  - — Horseboats: from hope to dead end
- North American canals
  - — U.S. canals, from boom to bust
  - — Canadian canals

# Inland Navigation

- Before motorized land transport, transportation by sea or by river was more economic, and often more rapid than any alternative for hauling goods over great distances
- As a consequence, trade was often boat-borne or ship-borne
- If a river was not entirely navigable, it could be improved (with weirs, flash locks, levées, channels or even side canals and pound locks)
- If there was no river in the right spot, one could be made—by digging, flooding, or doing a combination of both



Weir in Montreal (© Jean-Louis Trudel, 2007)

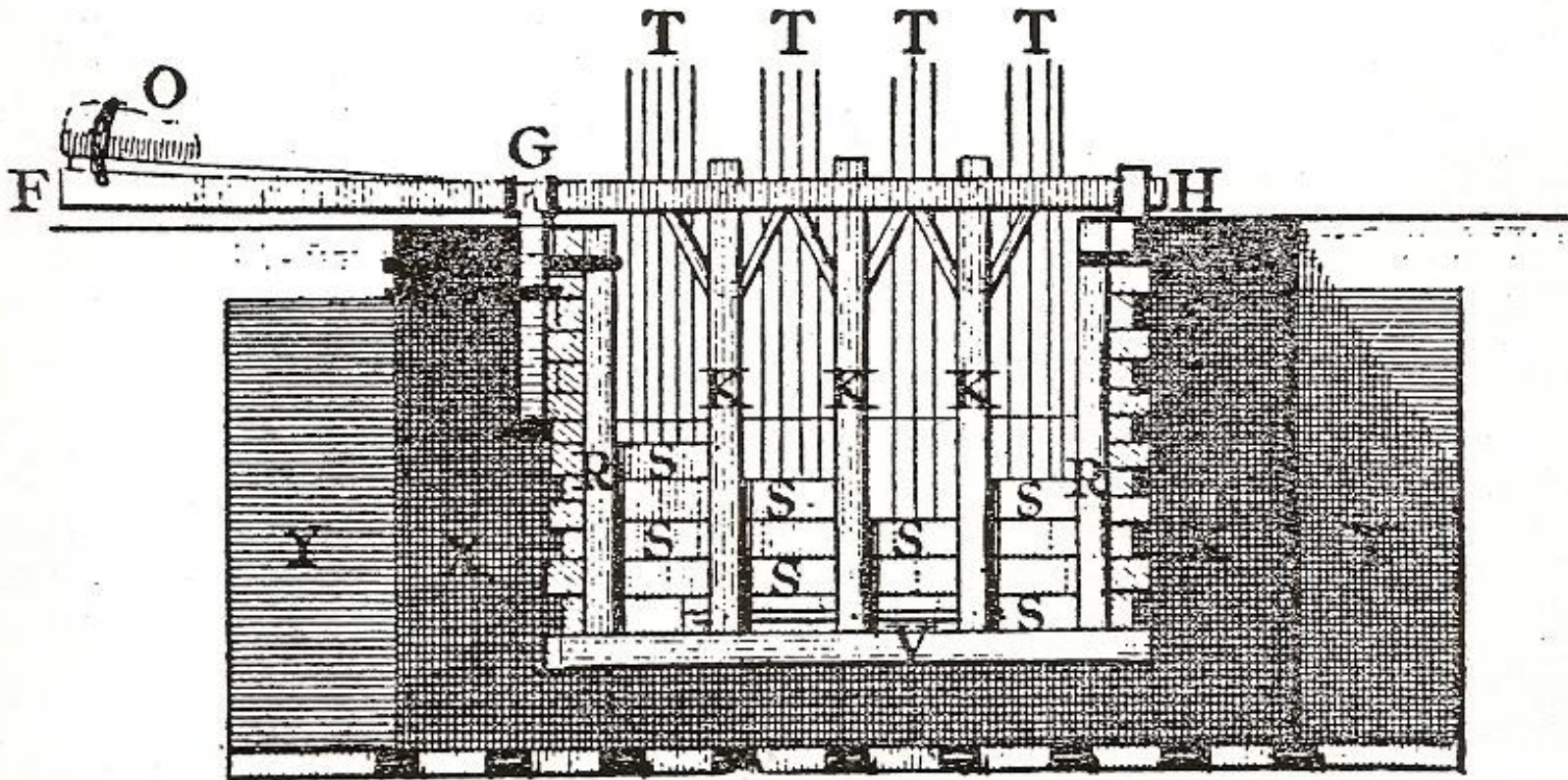


# Experimenting with Canals

- A canal is an **artificial waterway**; therefore, it may include cuttings (trenches) as well as stretches of river improved by weirs, locks, etc.
- Cuttings for irrigation are at least as old as civilization itself; navigation was possible, but true navigation canals are more recent
- In Antiquity, canals were built by various civilizations around the Mediterranean (such as the one connecting the Nile to the Red Sea) and in China; much of the Grand Canal, a network of navigable waterways extending over 2000 km in China, was built in the 7th and 8th centuries by the Sui and Tang dynasties
- In Europe, canal-building started anew in Italy and the Netherlands; the pound-lock was adopted

# Flash and Pound Locks

An early lock such as the single-gated flash locks could be set in the middle of a river or open onto a canal. The later double-gated pound lock, however, practically defines the modern canal.



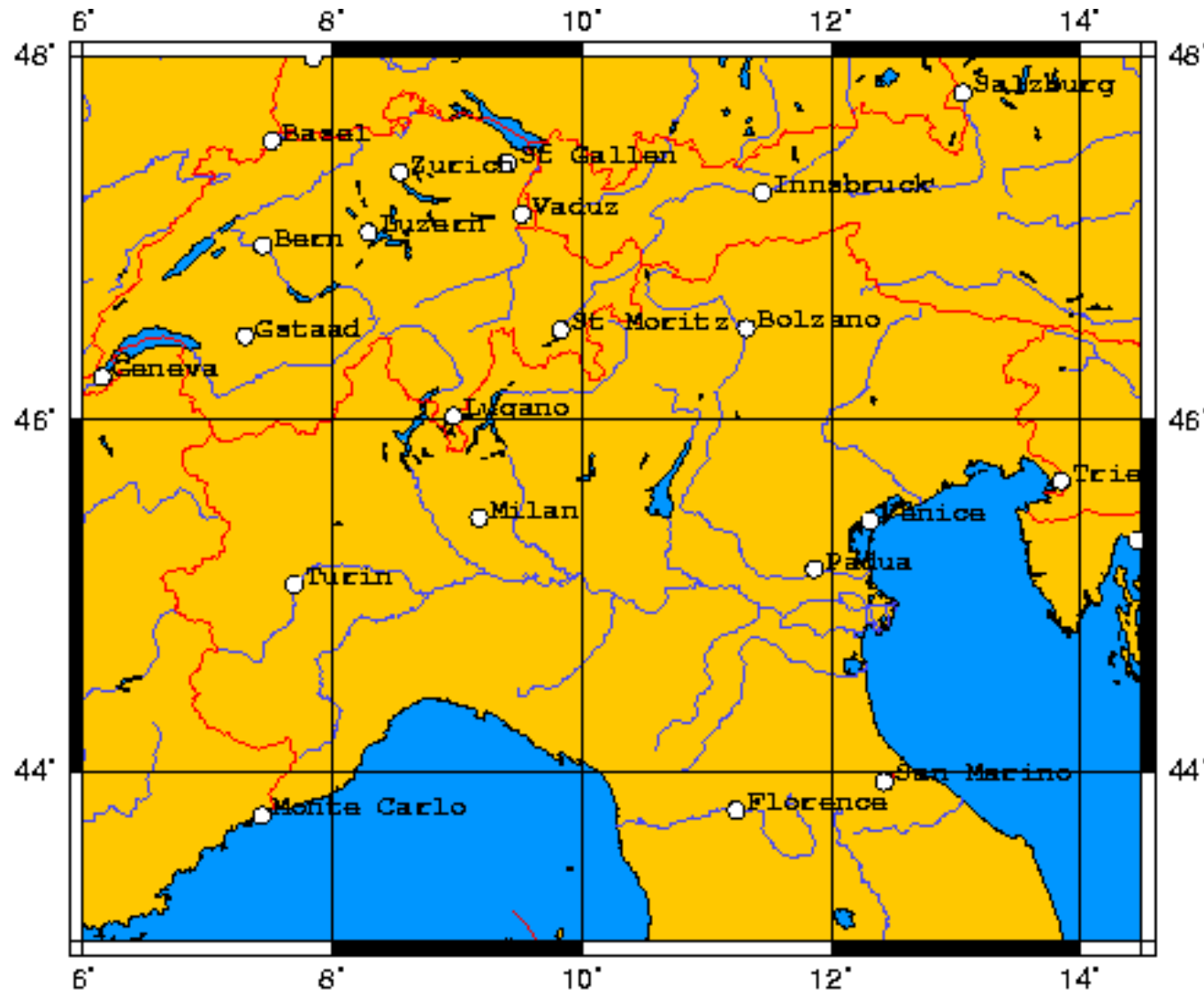


# To recapitulate (1)

- Was moving goods over a macadam road cheaper than on water?
- Can a river or lake be part of a canal?
- In what U.S. state do we find the first macadam road?
- In what Canadian province do we find the first macadam road?
- Name one Mediterranean country where a canal was built in Antiquity?
- Name one country in Asia where canals were dug in the first millennium A.D.?

# The Milanese “Naviglio Grande”

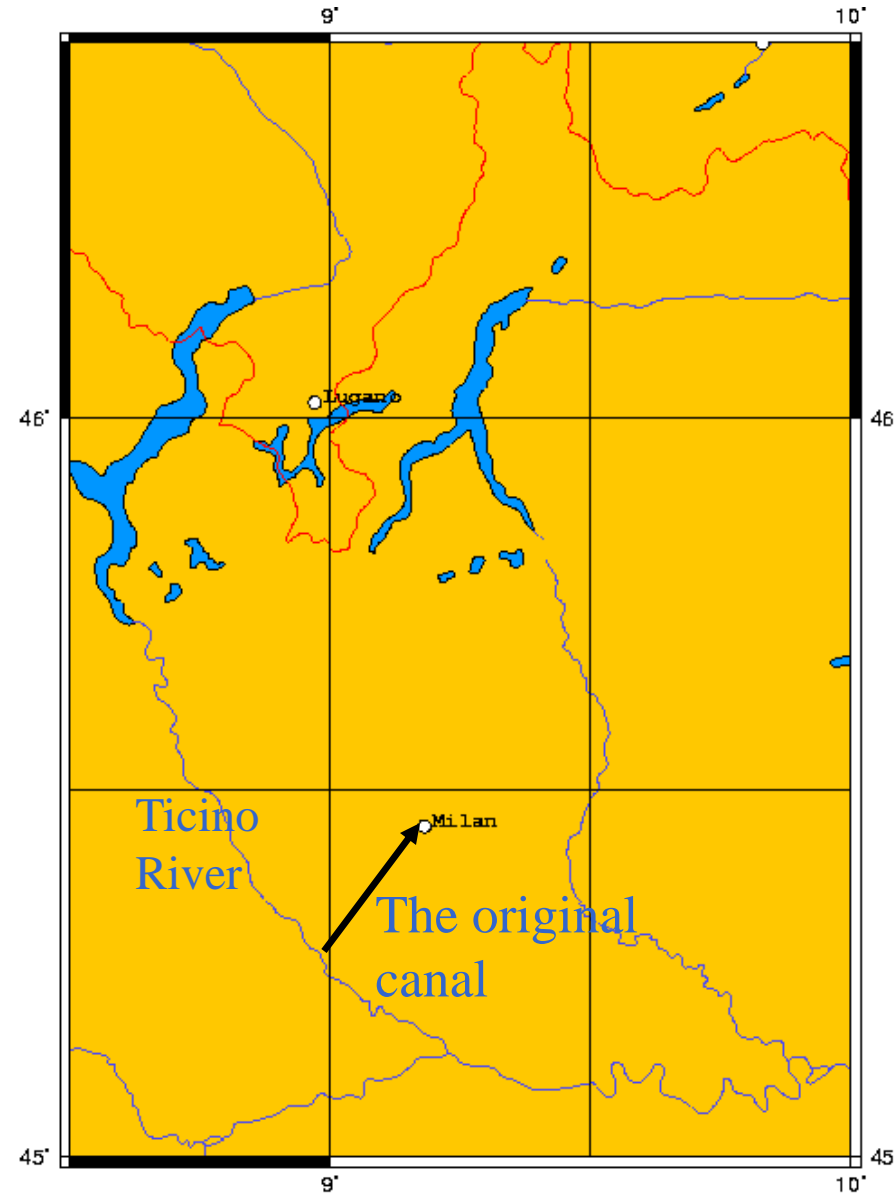
After a false start in 1177, the city-state of Milan began to dig in 1179 a canal for irrigation. By 1233, it spanned 30 km and was halted. As it became used for the transport of goods, further additions created an extensive network.



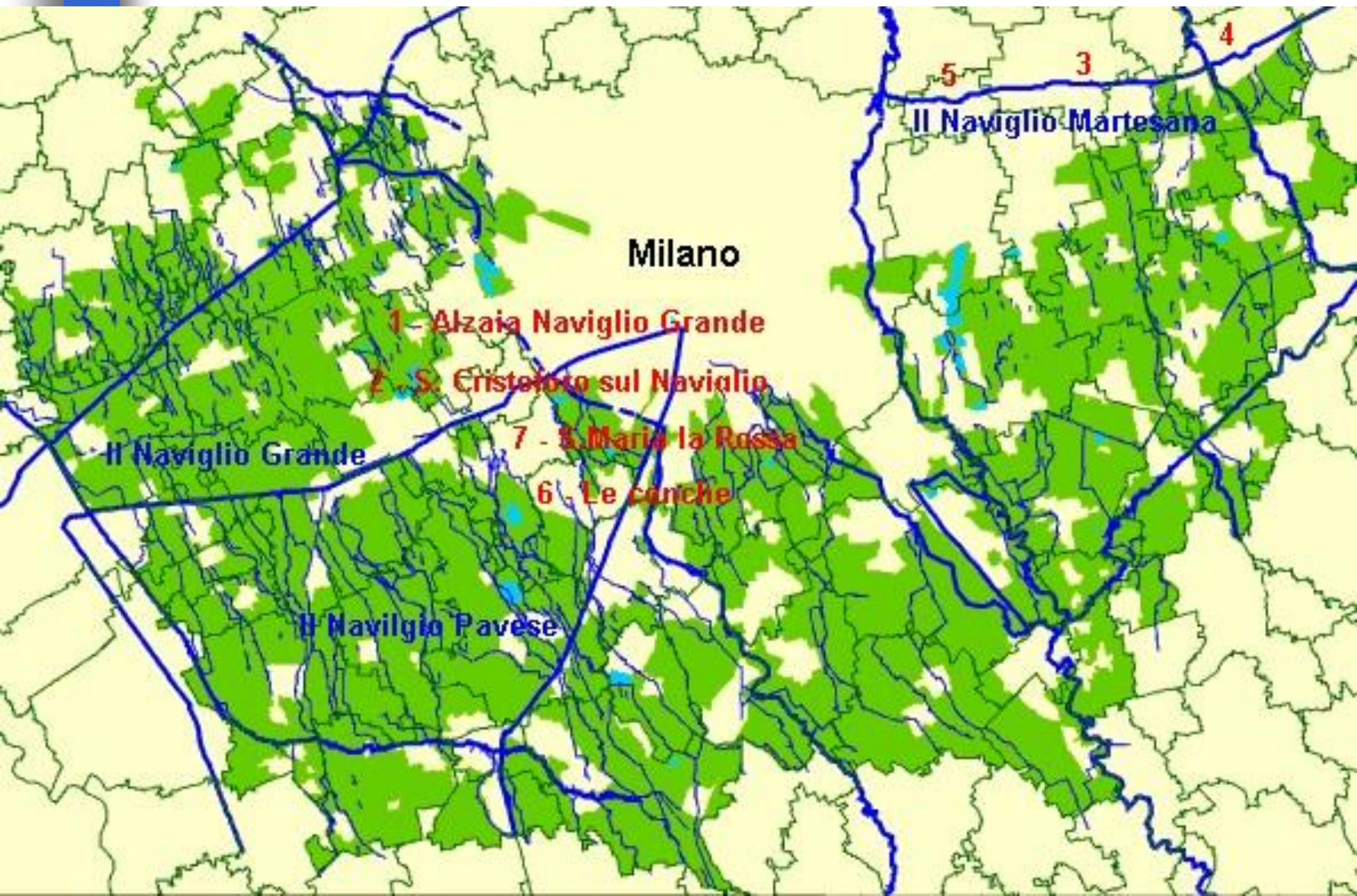
# Milan: The original Naviglio Grande



↑ The end of the Naviglio Grande in Milan today (the *Alzaia* bank is on the right)



# The Milanese Canal Network





# The French Canal de Craponne

In southern France, Adam de Craponne (1526-1576) built a major irrigation canal between 1554 and 1559. (The branch seen here, leading to Arles, was completed in 1581-1583.) It extended over 60 km. Unlike the Naviglio Grande, transportation was never important, but it fed an increasing number of watermills well into the 20th century.

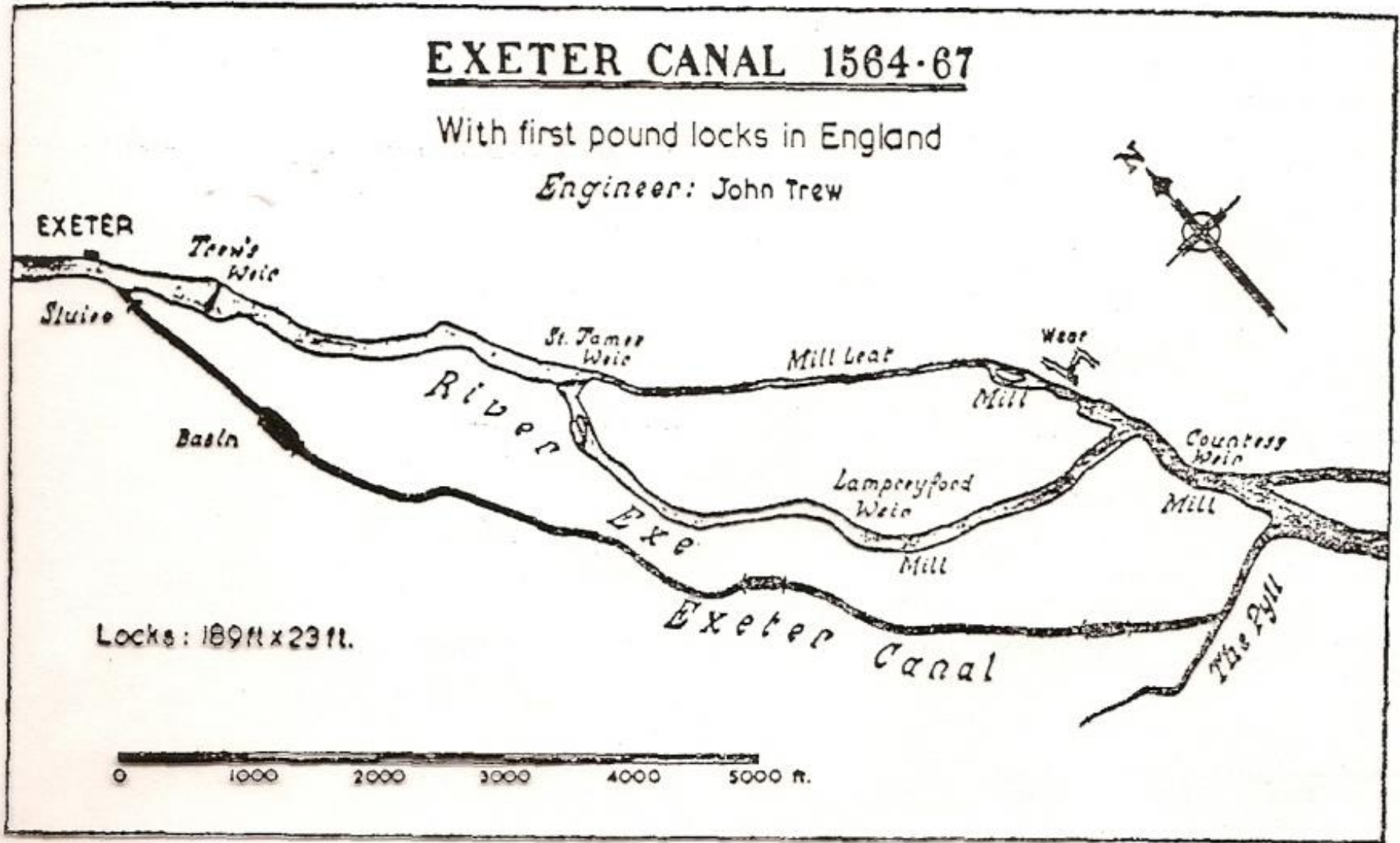


# The Exeter Lateral (Side) Canal

## EXETER CANAL 1564-67

With first pound locks in England

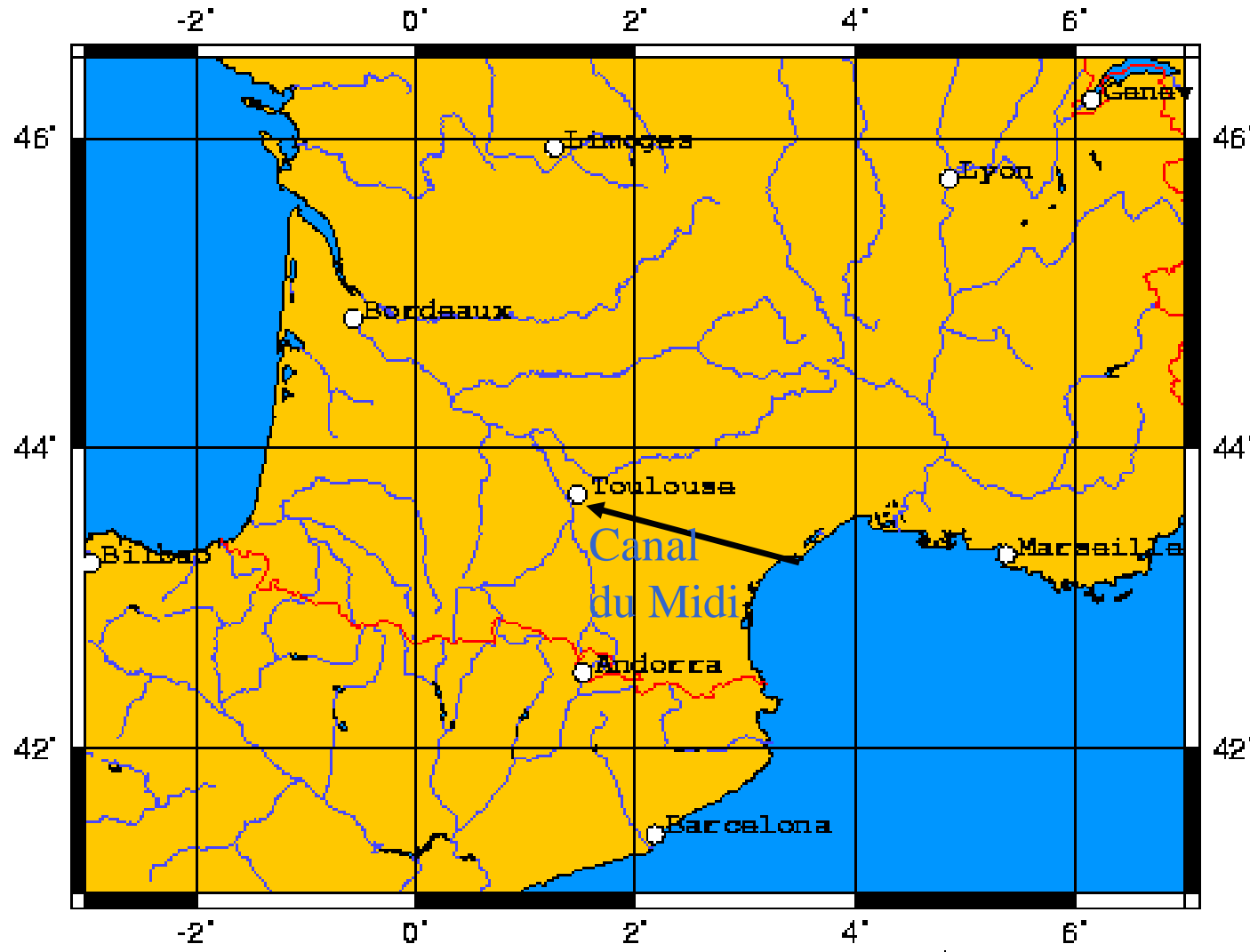
*Engineer: John Trew*



# France: The Canal du Midi

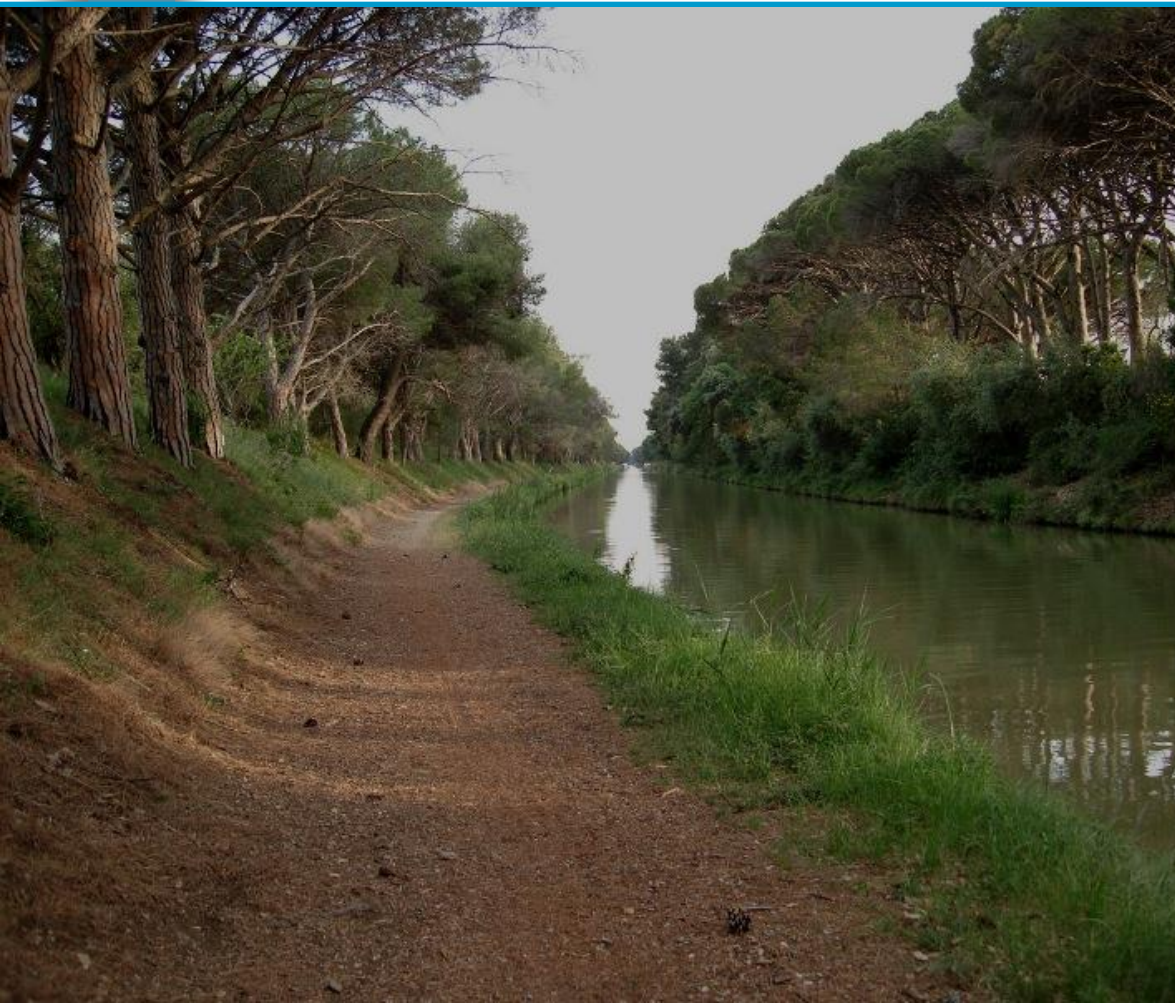
## The last of the great pre-modern canals

Major canals for navigation in France were built before 1700. The great Canal du Midi (1666-1681), a.k.a. the *Canal des Deux-Mers*, was designed by Pierre-Paul Riquet (1629-1680). One of the first summit canals, it spans 240 km from the Mediterranean to the city of Toulouse.



# The Canal du Midi

Unlike the locks of later canals, those of the Canal du Midi have rounded sides. →



The canal was lined with trees to hold the banks and provide shade. The original towpath was too narrow for horses, but it was later widened.

# Structures of the Canal du Midi



↑ The Béziers canal bridge, a later structure

The Malpas tunnel, dug with pickaxe and with gunpowder, an original part of the canal →



# The British Canal Revolution

- The Canal du Midi inspired the duke of Bridgewater to build a canal of his own between 1759 and 1765, to carry coal from the mines he owned to the city of Manchester
- Though only a few kilometres long, it was a great financial success
- Built on a single level, it included a canal bridge and an underground portion

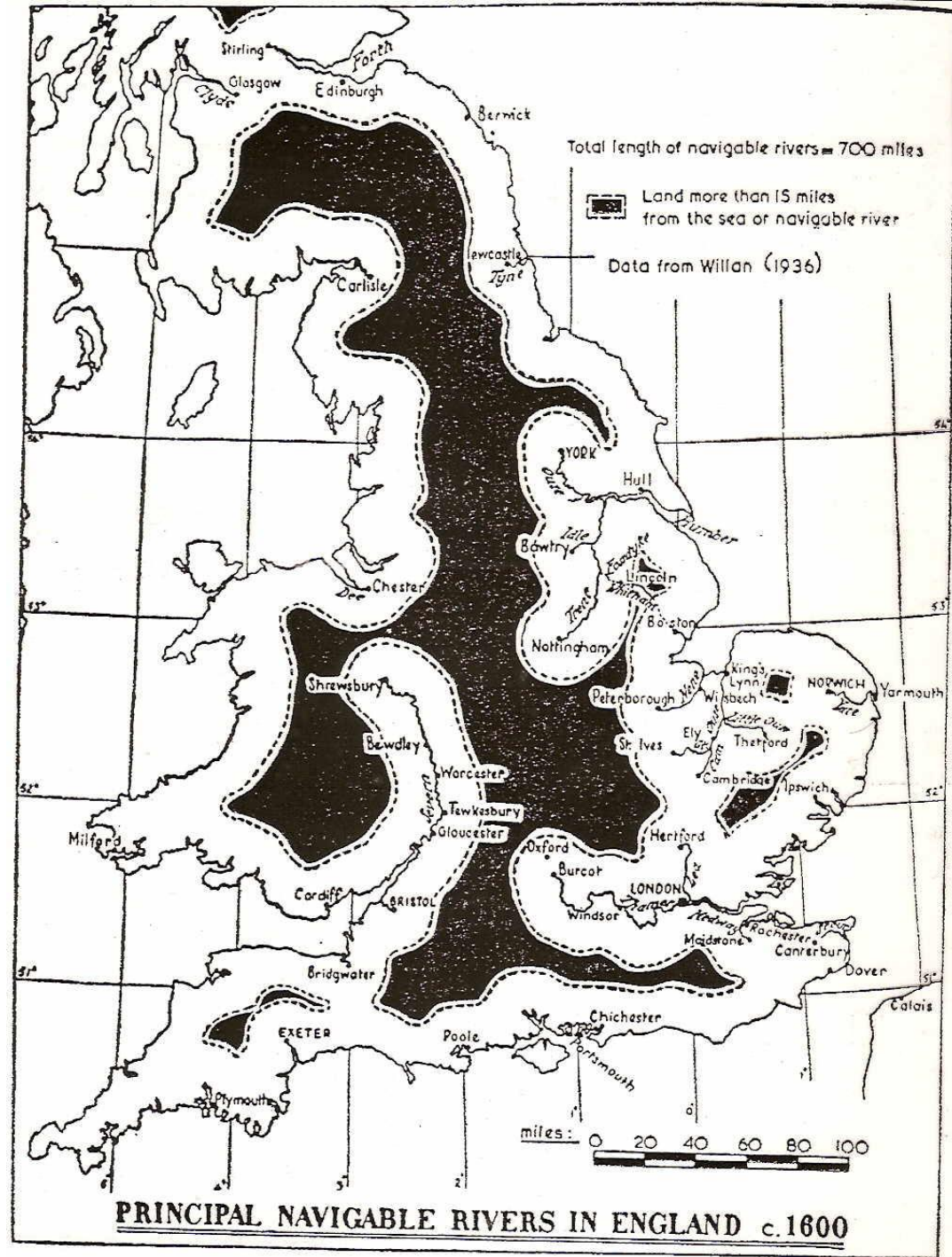
## The Canal Advantage:

Typical loads carried or drawn by a single horse around 1800

Pack horse	1/8 tonne
Stage waggon on "soft roads"	5/8 tonne
Stage waggon on macadam roads	2 tonnes
Waggon on iron rails	8 tonnes
Waggon on steel rails (in French mines, c. 1900)	13 tonnes
Barge on a river	25-30 tonnes
Barge on a canal	up to 45 tonnes

# In 1600..

- The British already knew the value of navigable rivers
- Between 1600 and 1760, they had already improved markedly on their island's network of rivers



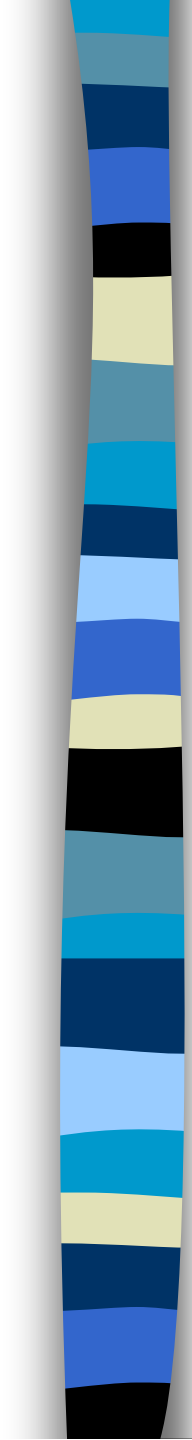




## To recapitulate (2)

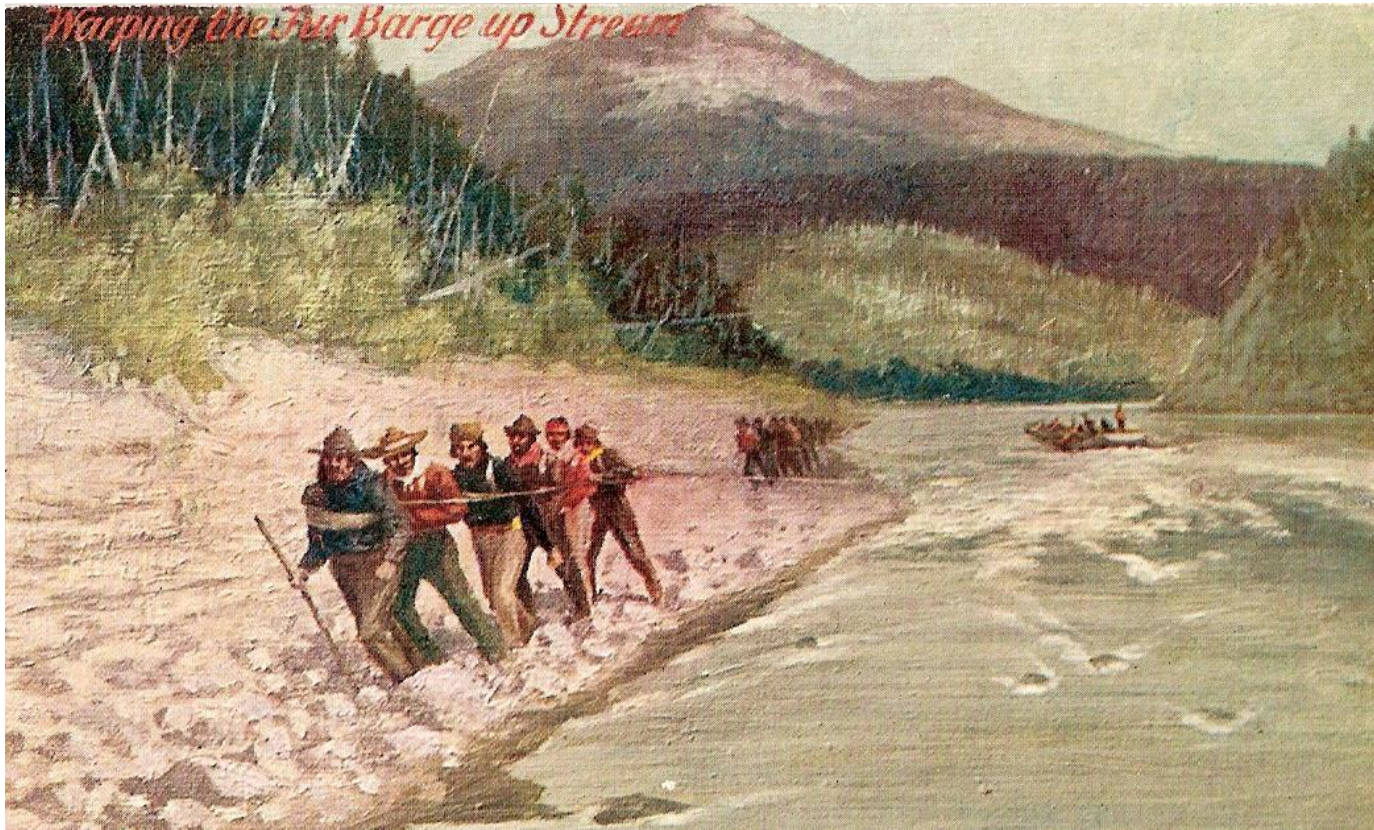
- What was the original purpose of the Milanese “Naviglio Grande”?
- Name one long-lasting use of the “canal de Craponne” in France?
- To what end was the Exeter Canal built in 16th-century England?
- What was the original intent of the “Canal des Deux-Mers” in France?
- Between 1600 and 1760, the length of navigable rivers in Great Britain increased by: (a) 500 miles, (b) 600 miles, (c) 700 miles?

# Going Uphill... (1)

- 
- In short:
  - Canals are expensive to build and maintenance is an ongoing chore
  - So, rivers remained the major means of inland navigation
  - Therefore, the toughest problem of river transportation remained: upstream haulage
  - Going downstream on a river is easy; even with no means of propulsion, a boat will be carried by the current, but something is needed to go upstream

# Going Uphill... (2)

- It was rarely possible to use sails, and it was exhausting to use oars or poles; often, horses or men ended up pulling barges upstream



Postcard

John Jones, c. 1905



# Improving on Canals

- Throughout the 18th century, countries such as England and France built canals that reduced the current to almost nothing, thus increasing the effectiveness of horses
- Yet, the high cost of canals, especially in less densely populated parts of the world, meant that rivers remained significant arteries of trade
- Therefore, authorities kept looking for alternatives applicable to rivers, either by improving equine performance or by substituting another source of power for upstream haulage



# The rise of mechanized navigation

- After centuries of fruitless projects and abortive initiatives, three forms of “mechanized” navigation were tried out between 1730 and 1830
- Though water-driven haulage, horseboats, and steamboats all contended to be the definitive answer to the problem of river commerce, only the steamboat succeeded and is remembered today, as it brought about a worldwide revolution in shipping after 1850
- Yet, the steamboat is part of a larger context, appearing at a time when it was only one possible solution among several

# Boats on North American waterways (1)

1869

The ageless canoe: on wild rivers, the Voyageurs used large canoes to carry freight and passengers

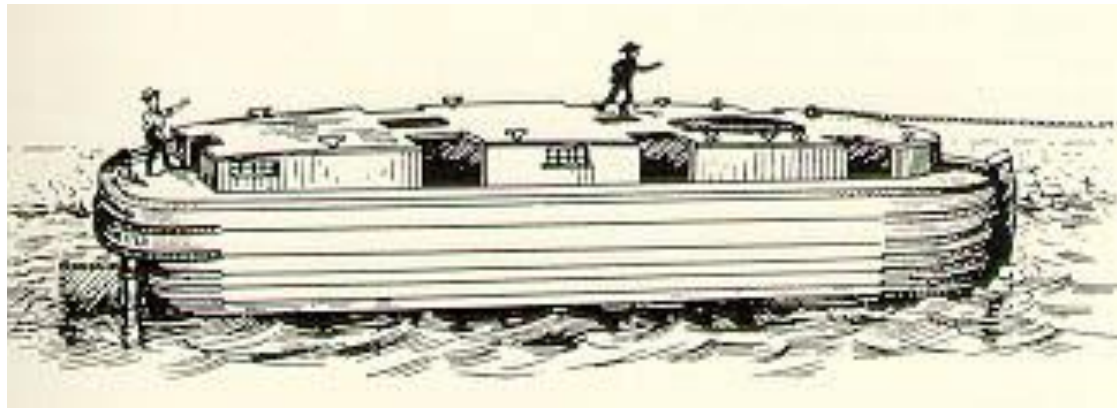
Frances Anne Hopkins (1838-1919), Archives Canada



Postcard  
John Jones, c. 1905

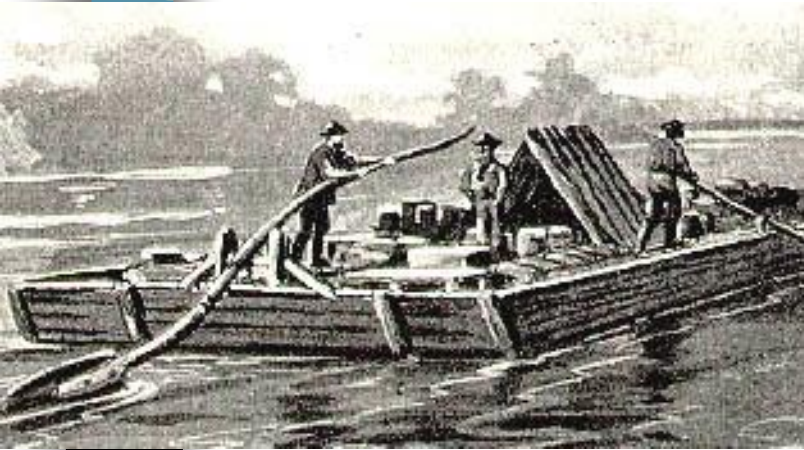
# Boats on North American waterways (2)

The keelboat: doing it the hard way (men either poled the boat upstream or pulled it themselves); the latter were known as bushwhackers in towpath-deprived North America



(In Canada, the famous York boat used from 1820 on was a species of keelboat.)

# Boats on North American waterways (3)



Keelless, flat-bottomed Canadian *batteau* and Chippewa canoe on Lake Superior near Thunder Bay (1901)

The flatboat: a one-way trip to disassembly...



William Armstrong (1822-1914),  
Library and Archives Canada

# Ottawa Raftsmen (1899)



# Boats on North American waterways (4)

The iceboat was of little practical importance for the transportation of people or goods, but it reminds us of the technological diversity already present in North America at the time. The willingness to experiment and innovate is far from new.



Philip John Bainbrigge (1817-1881),  
Archives Canada

Iceboat on Lake Huron near  
Penetanguishene, Ontario  
(c. 1845)



## To recapitulate (3)

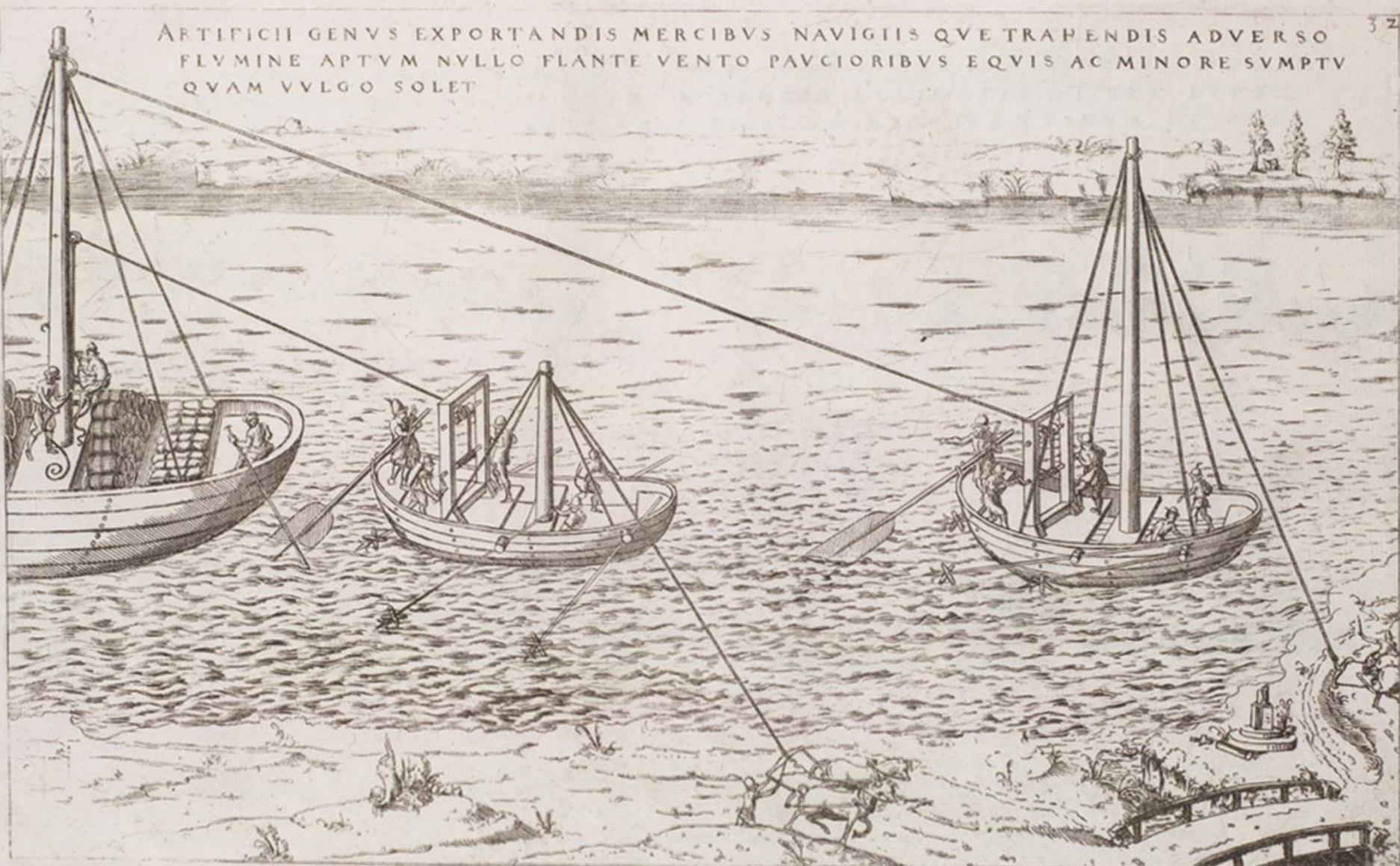
- In what way was a river a better navigation route than a canal?
- In what way was a canal a better navigation route than a river?
- What was one common feature of most existing boats on North American waterways before 1800?
- Why were canoes still used for river transportation in the 19th century?
- Name one limitation of the iceboat.

# To move upstream faster...

(In 1578, Jacques Besson proposes the use of winches)

ARTIFICII GENVS EXPORTANDIS MERCIBVS NAVIGIIS QVE TRAHENDIS ADVERSO  
FLVMINE APTVM NYLLO FLANTE VENTO PAVCIORIBVS EQVIS AC MINORE SVMP TV  
QVAM VVLGO SOLET

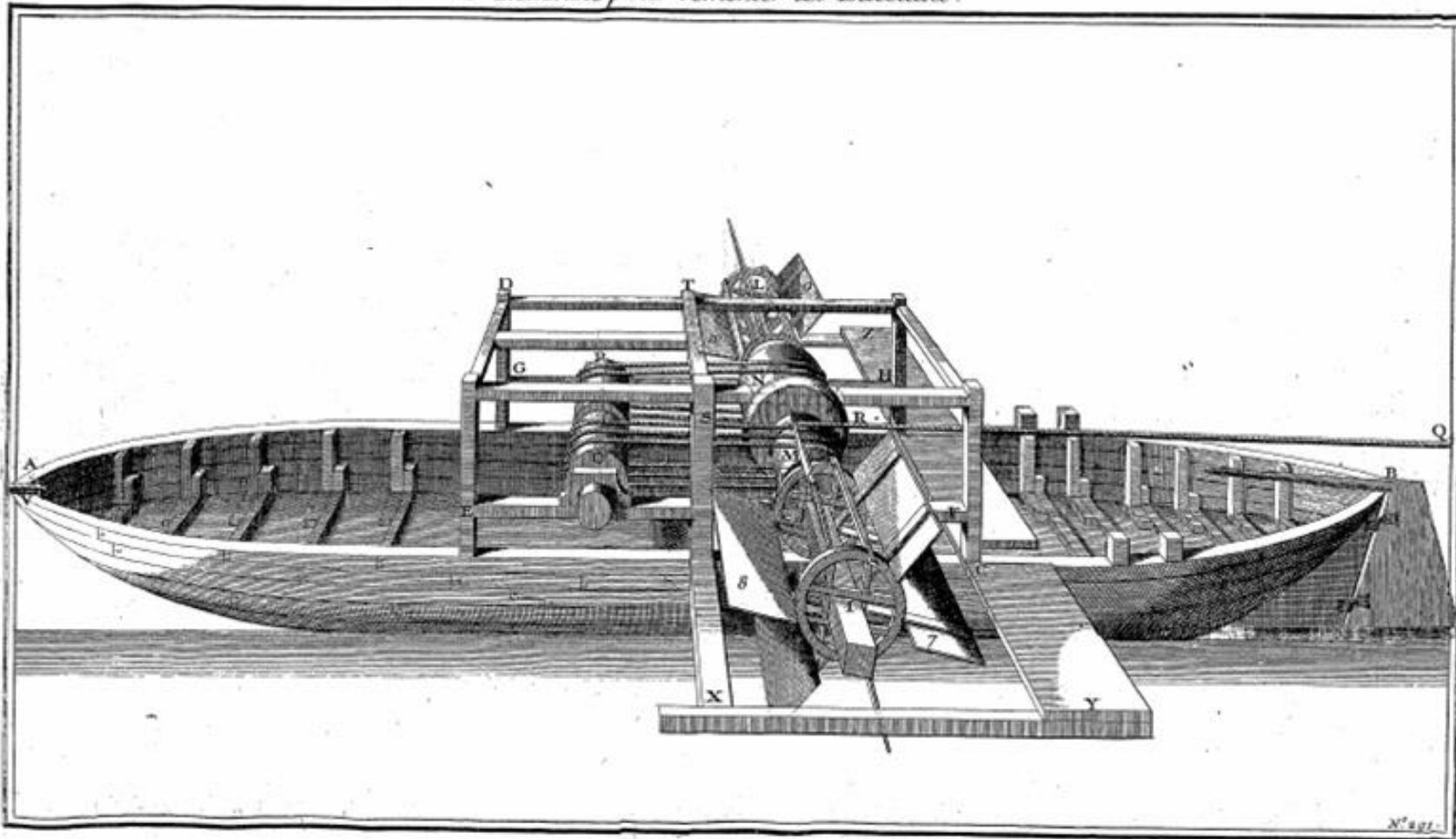
32



# A current-driven machine for pulling boats upstream (1729)

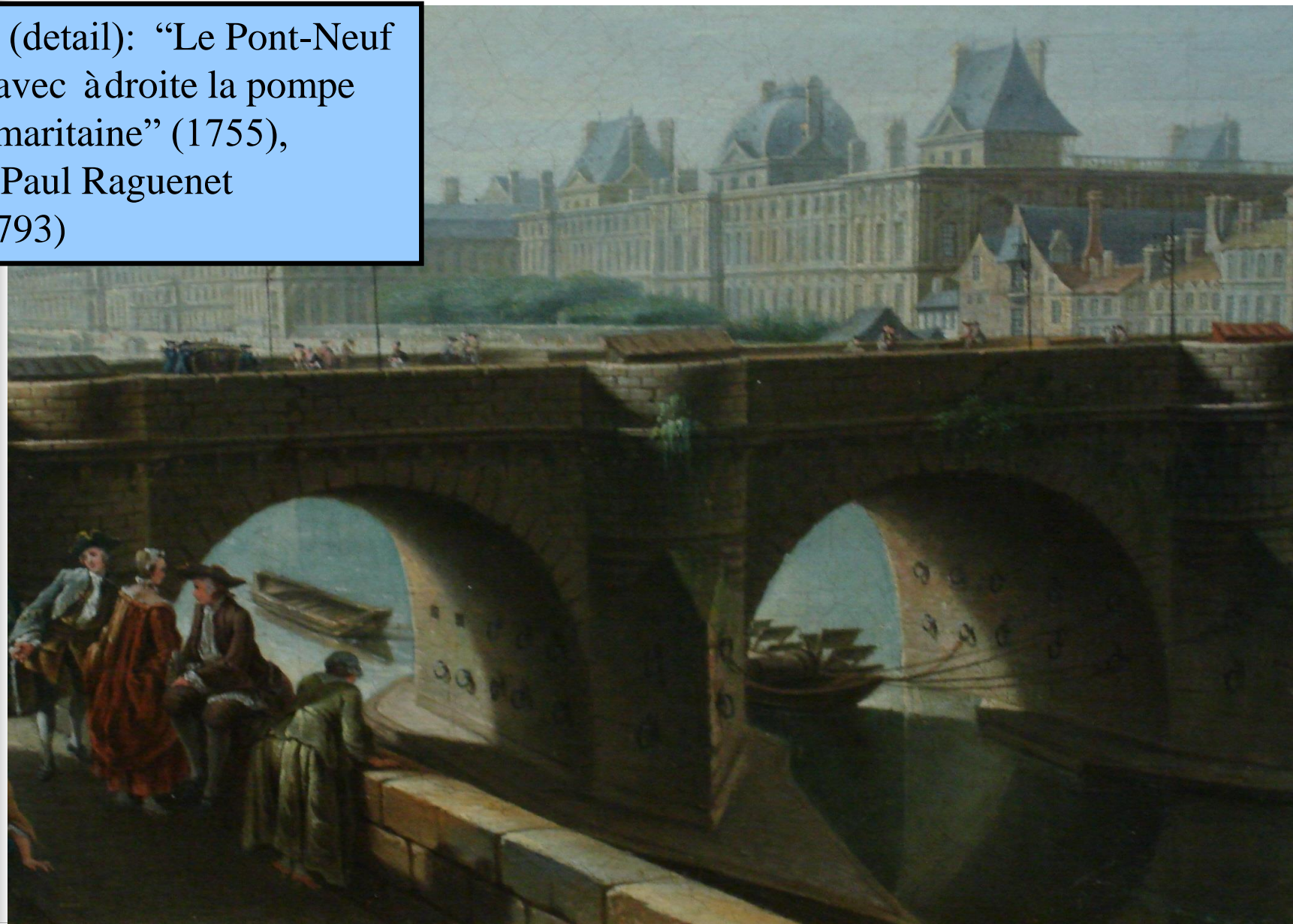
This machine designed by French inventor François Tavernier actually saw use in Paris between 1730 and 1760.

*2<sup>e</sup> Machine pour remonter les Bateaux.*



# A current-driven machine in Paris

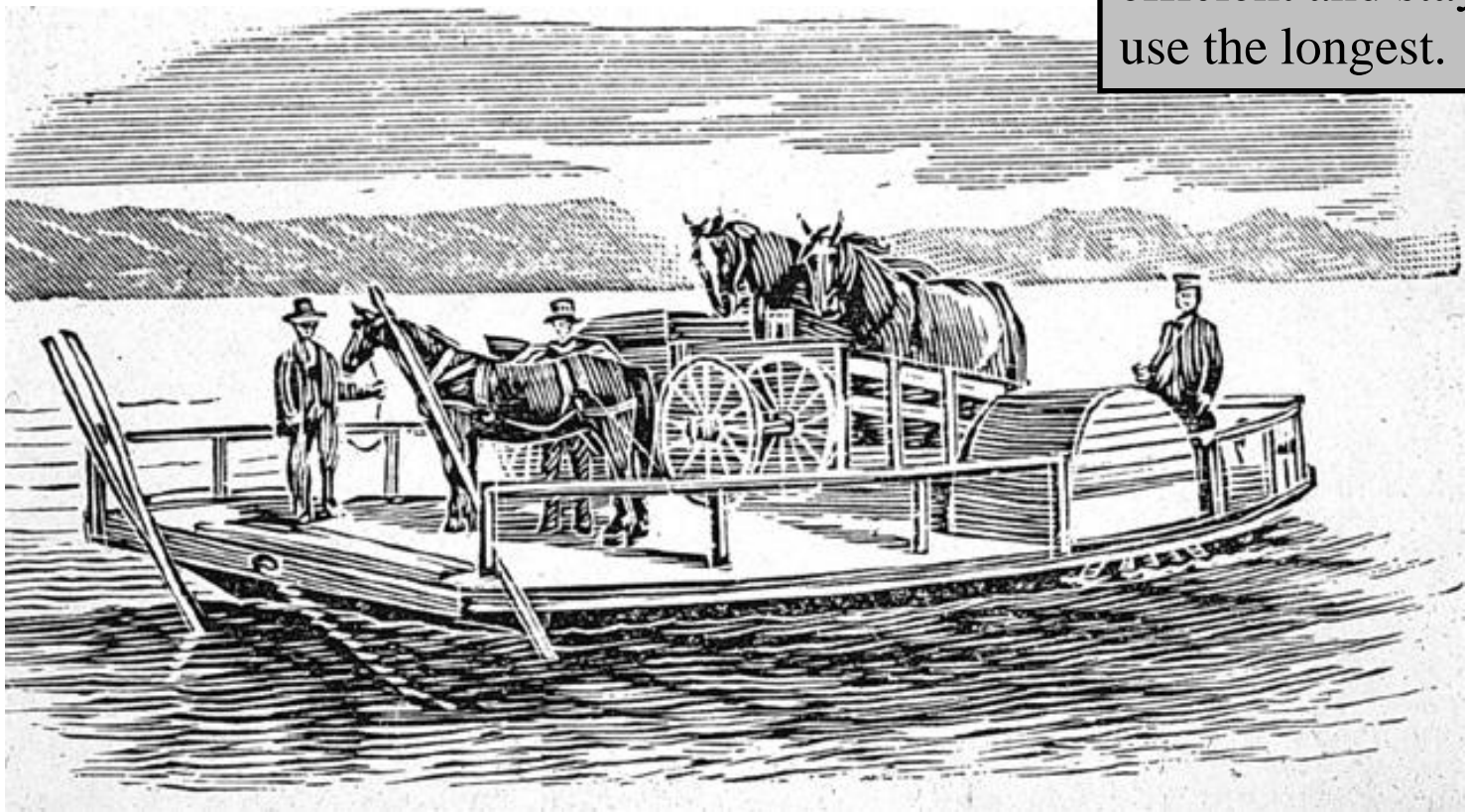
Painting (detail): “Le Pont-Neuf à Paris, avec à droite la pompe de la Samaritaine” (1755),  
by Jean-Paul Ragueneau  
(1715-1793)



# Boats on North American waterways: horseboats

## A Treadmill Horseboat

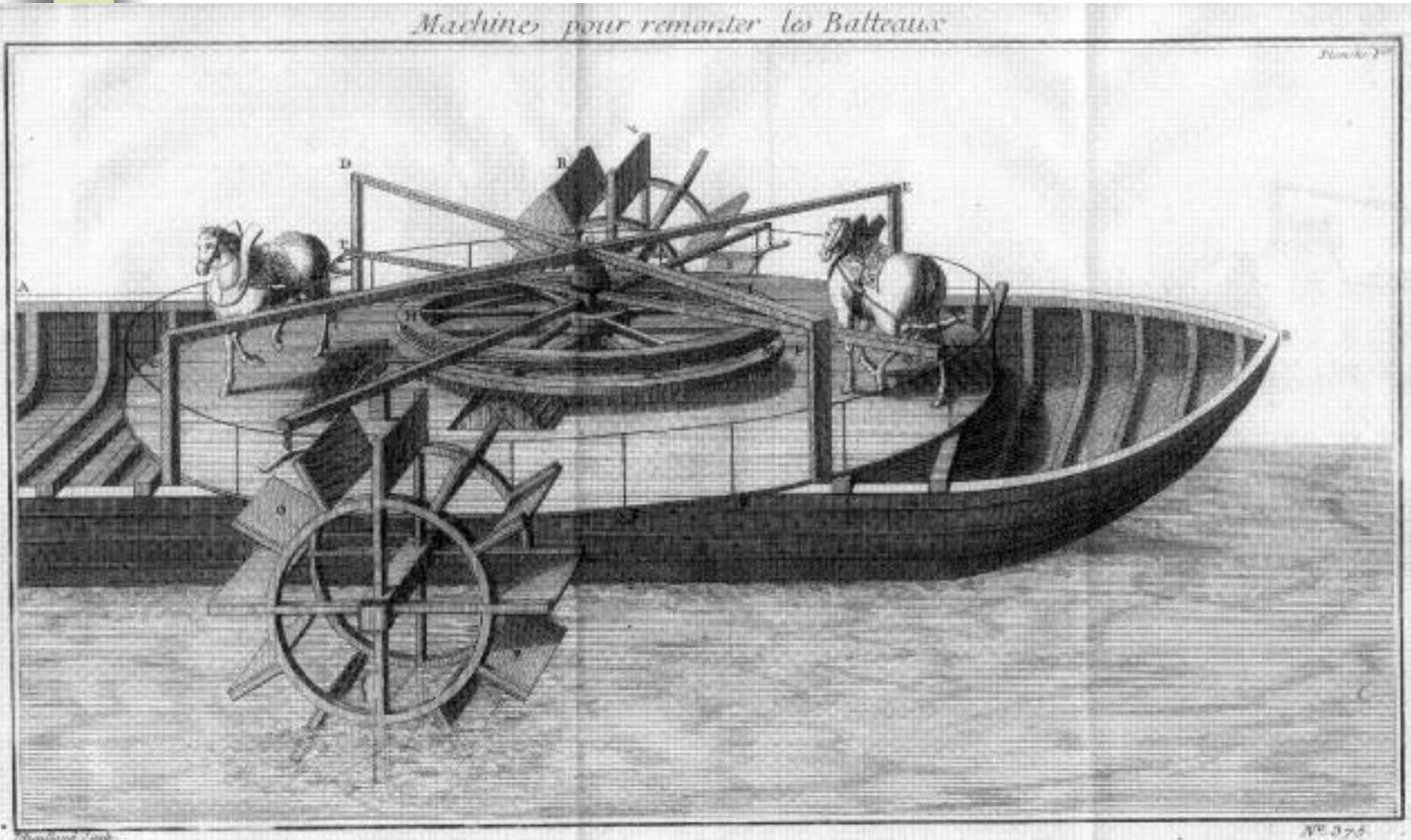
This type of horseboat, with one horse or two climbing a wooden treadmill, was most efficient and stayed in use the longest.



# Animal-driven propulsion using oxen... (*De rebus bellicis*, 4th c.)



# Animal-driven propulsion using horses (Maurice de Saxe, 1732)





# The Problem with Capstans

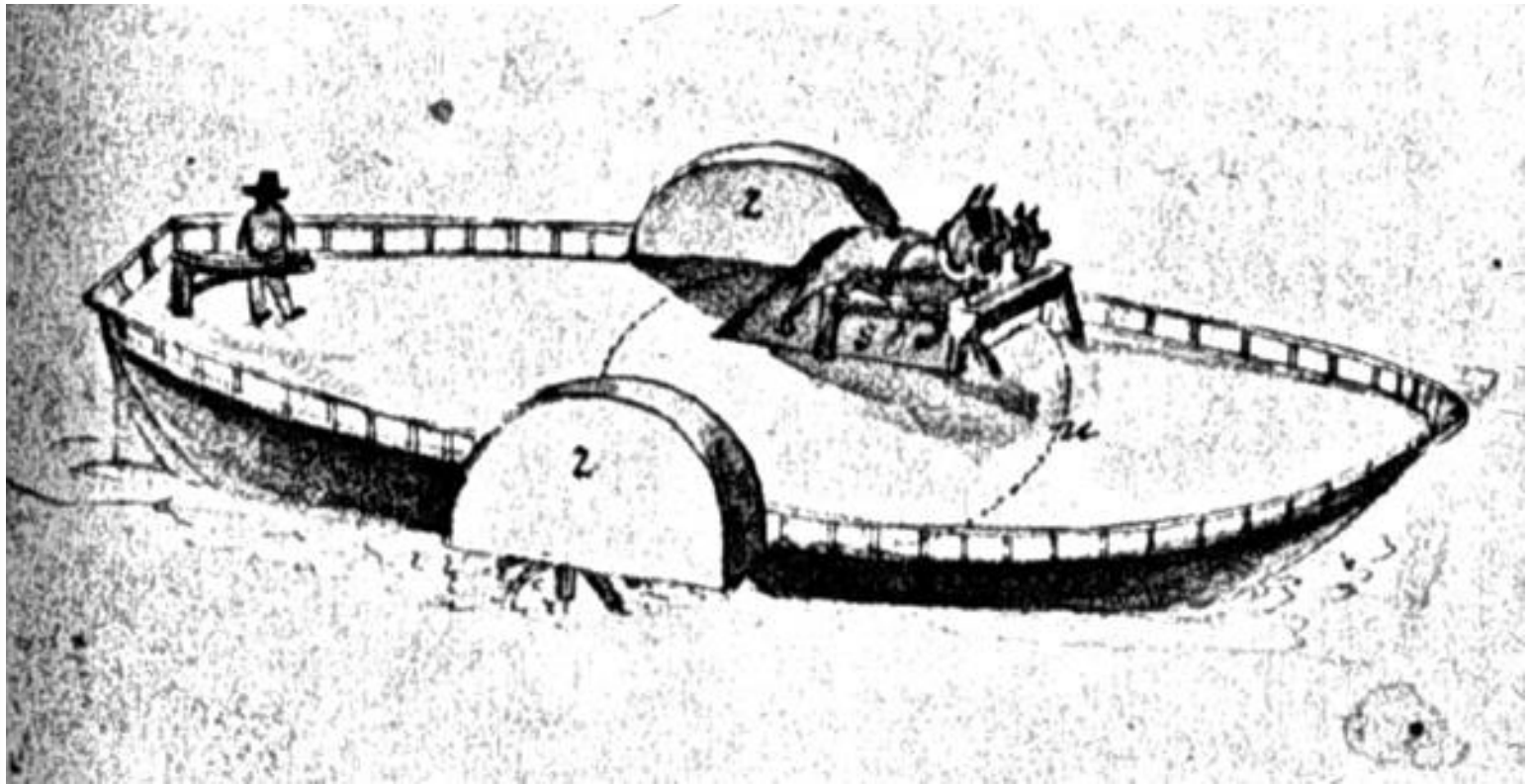
- Paddlewheelers powered by horse-driven capstans were tried in England during the late 17th century, but they weren't put into use until the late 18th century
- Even when such boats were used over short distances (as ferries, for instance), the horses soon suffered from a sort of vertigo as a result of walking in circles
- Therefore, animal-driven boats only flourished when capstans were replaced by treadwheels and then by treadmills

# The first recorded treadwheel in Europe (1556)

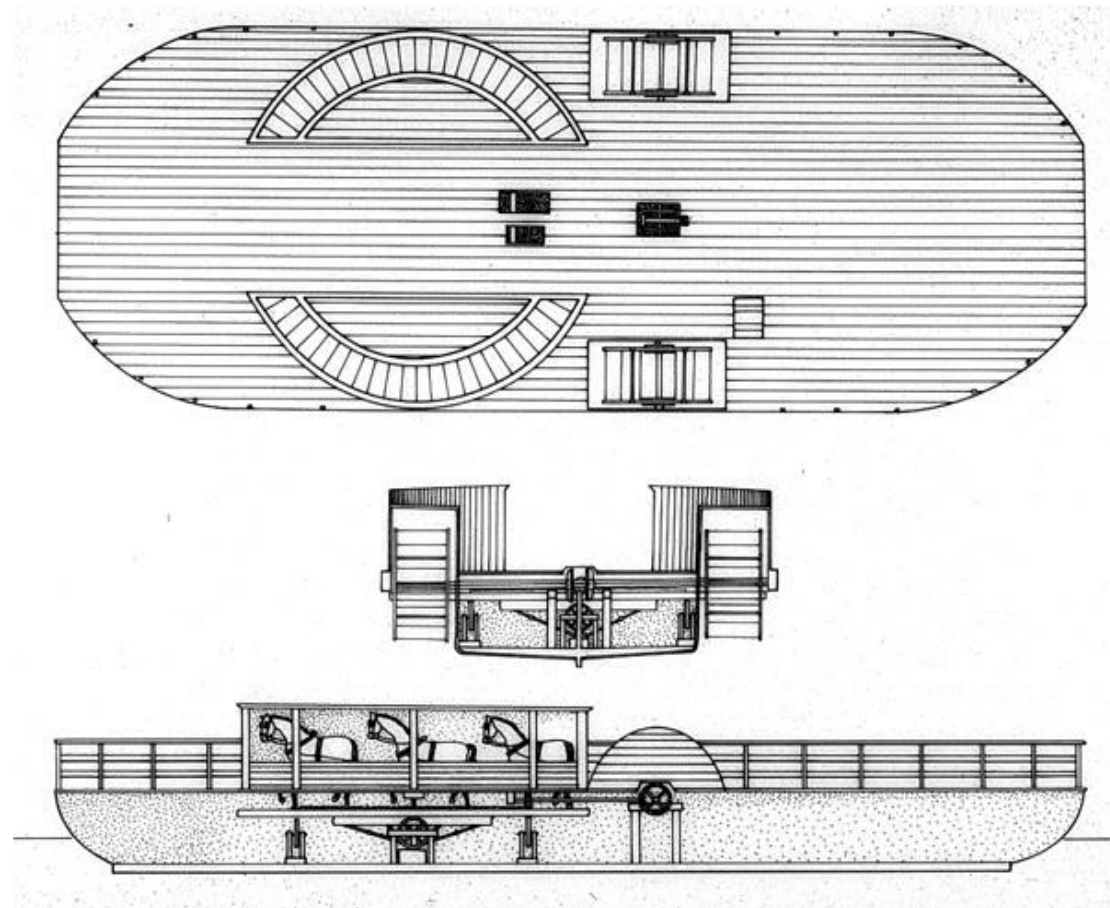
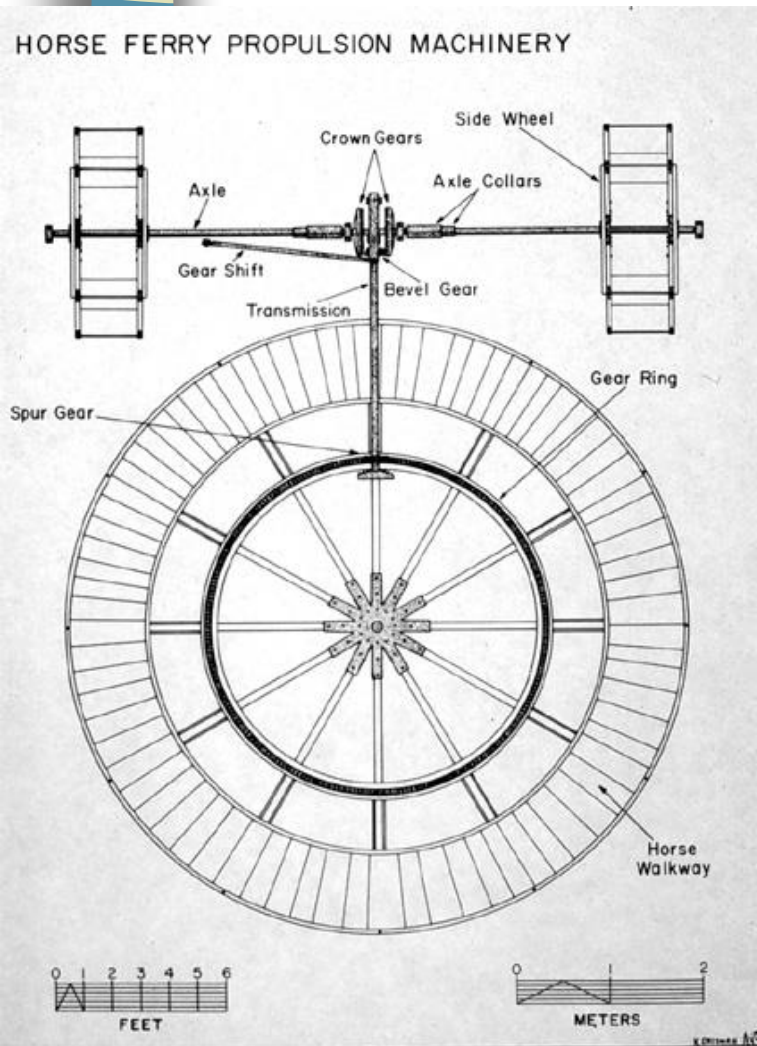
The first European treadwheel was illustrated by Georgius Agricola in *De Re metallica* (posthumously)



# Sketch of the Langdon horseboat (United States, 1819)

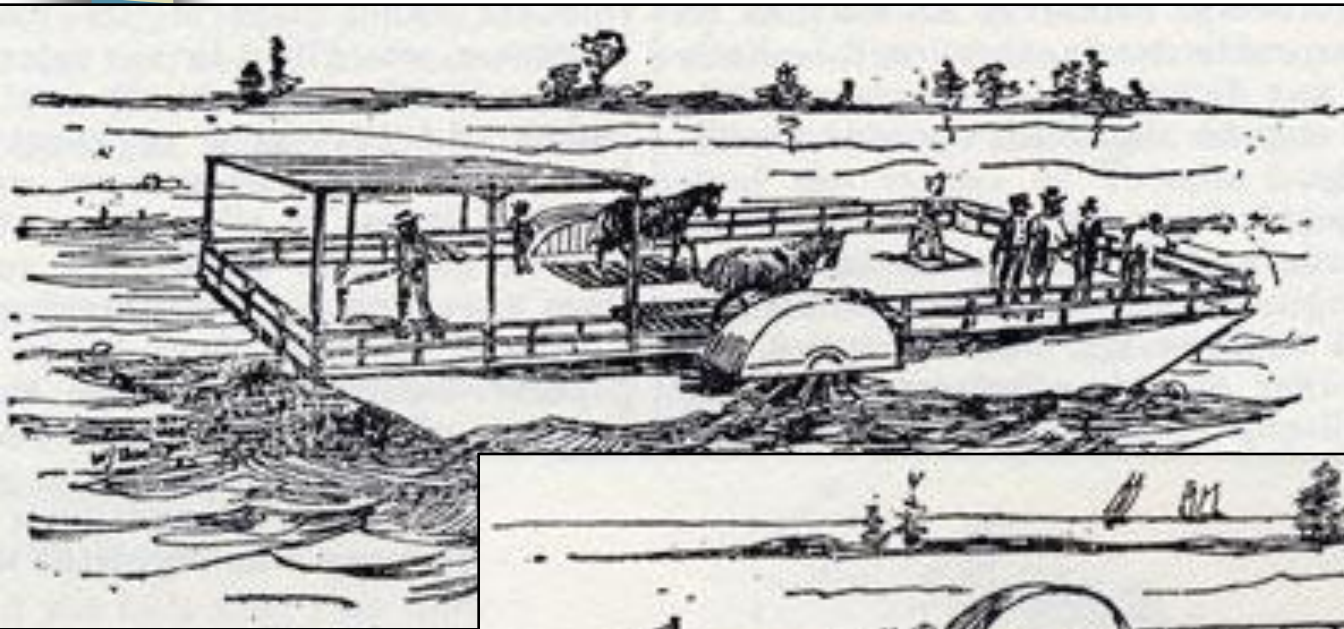


# Schematics of a Treadwheel-powered Horseboat



← The gearing

# Horse ferries using treadwheels



The first (left) and second (below) horse ferries commuting to the Toronto Islands



W. J. Thomson,  
1896

# The Treadmill: A New Source of Mechanical Power



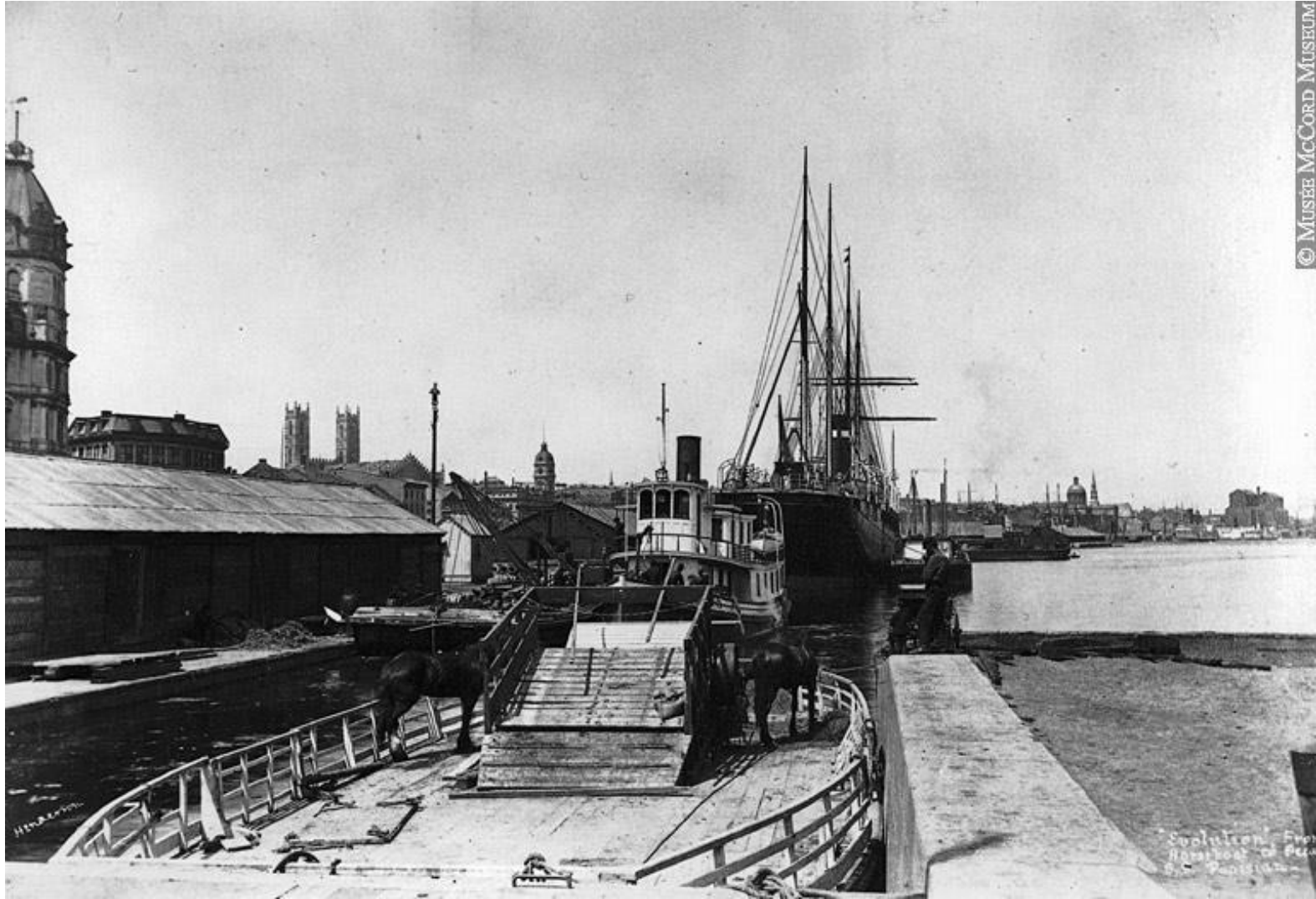
# Treadmill Horseboat (Bolton, Québec, 1867)



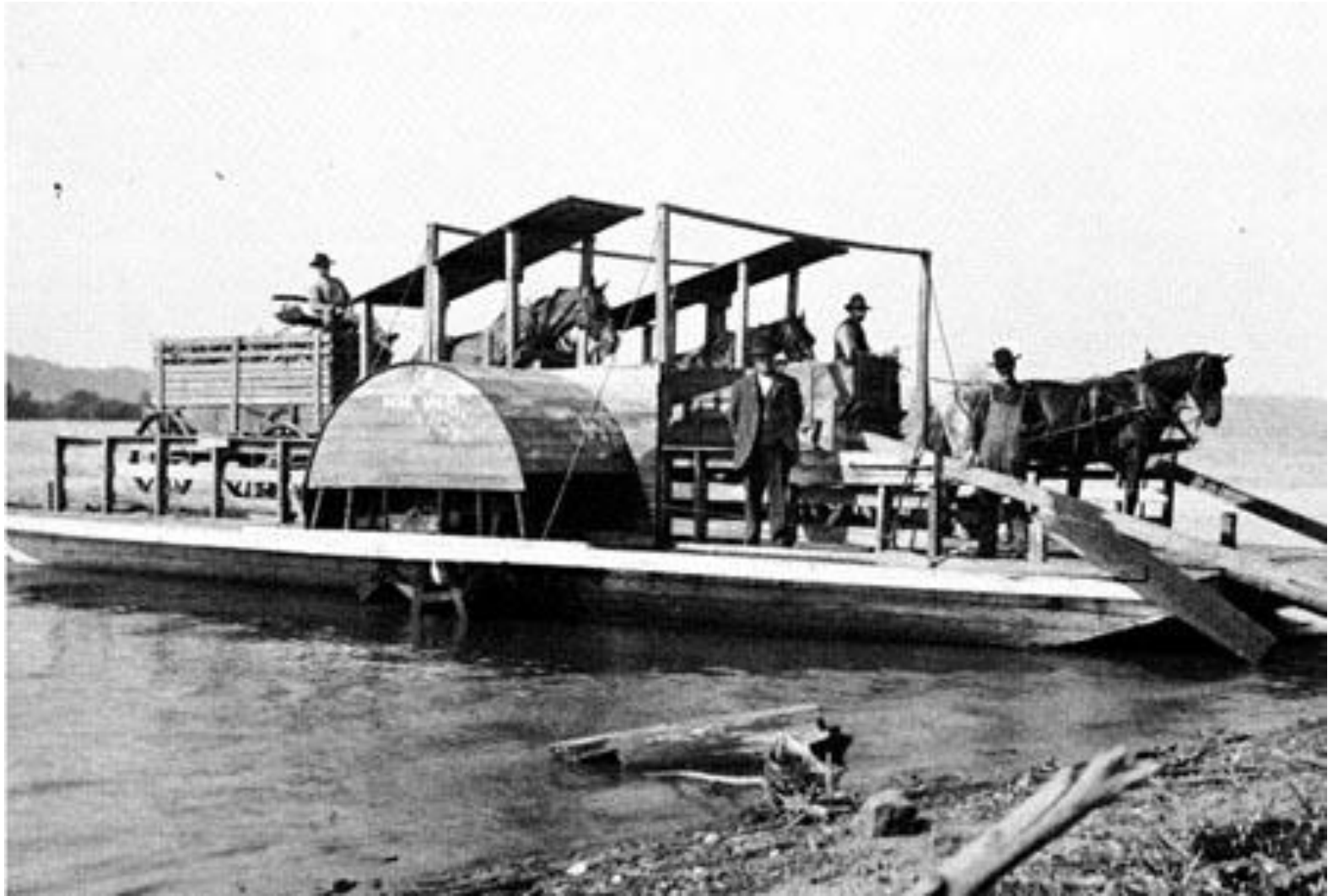
Huntington Copper Mine, William Notman, McCord Museum

# Treadmill Horseboat (Montr éal, c. 1870)

William Notman, McCord Museum



# Treadmill Horseboat (United States, c. 1900)





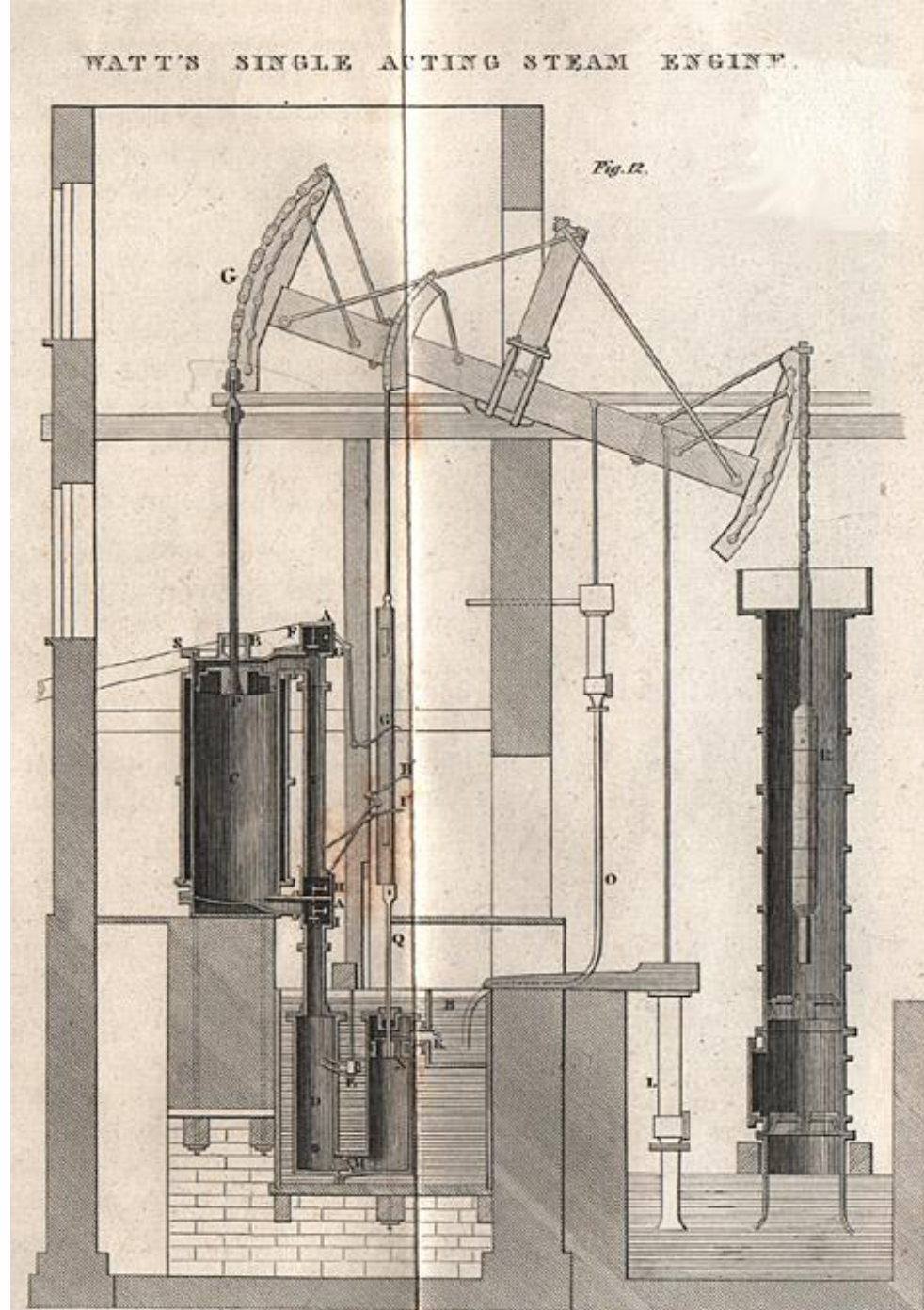
# To recapitulate (4)

- What was the main advantage of the current-driven machine in Paris?
- How old (at least) is the concept of the horseboat?
- What are the main advantages of horseboats?
- What are the main drawbacks of horseboats?
- How old (at least) is the treadwheel?
- If treadmills were so efficient, why did horseboats disappear?

# The Uses of Steam... (1)

By 1765, James Watt had identified one of the reasons for the inefficiency of the Newcomen engine: the need to cool and re-heat the cylinder every cycle. He determined that it was just as feasible to condense the steam in a separate vessel (the *condenser*) and he patented in 1769 a single-acting steam engine with condenser. By 1776, he was in business.

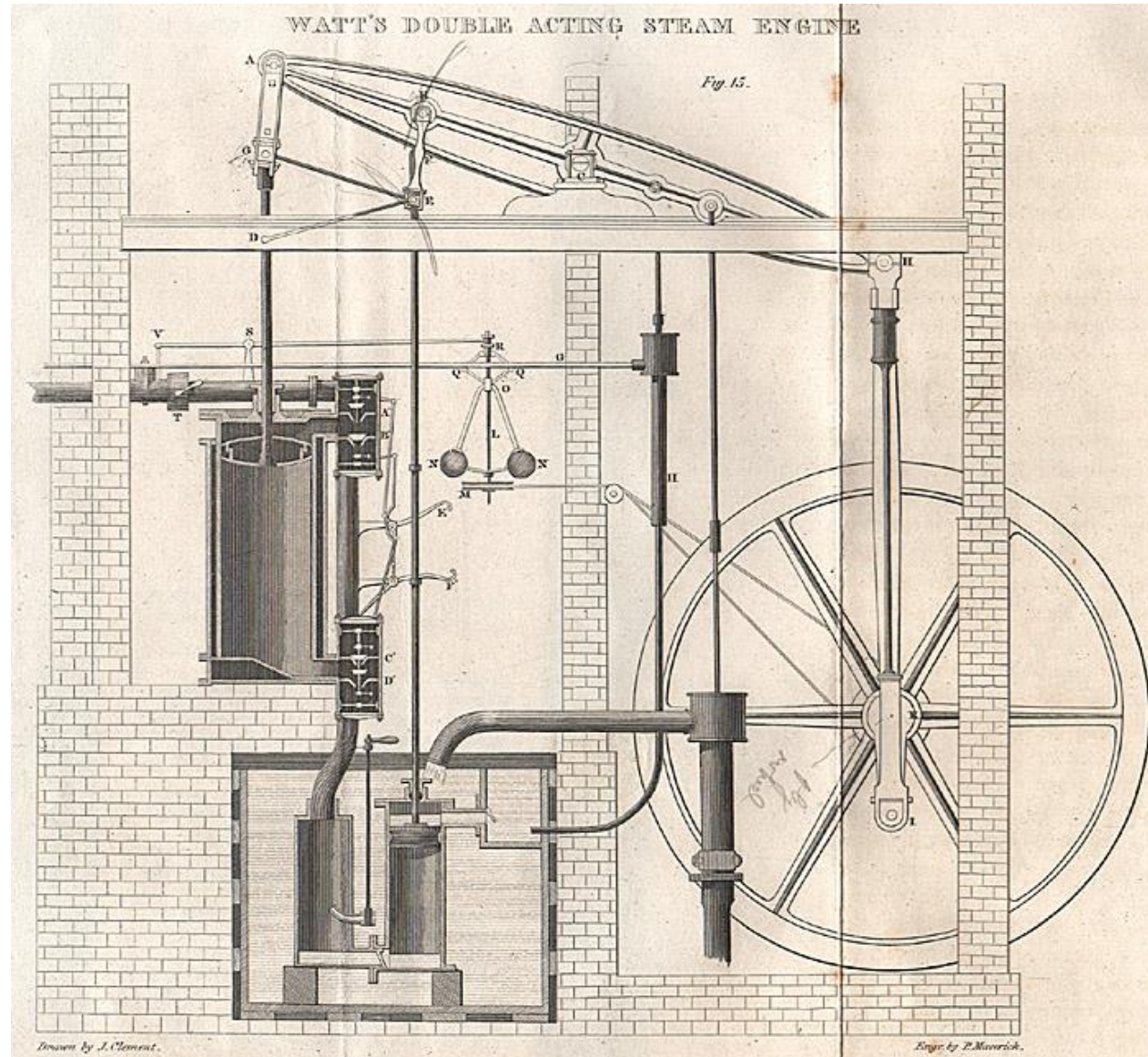
From Dionysius Lardner, *The Steam Engine Familiarly Explained and Illustrated* (1852)



# The Uses of Steam... (2)

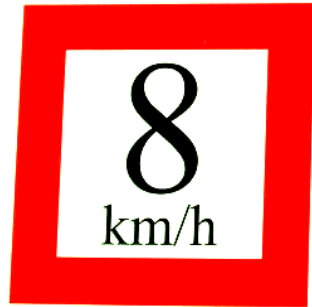
From Dionysius Lardner, *The Steam Engine Familiarly Explained and Illustrated* (1852)

In 1782, the partnership of Boulton and Watt patented the first double-acting steam engine, creating a vacuum both above and below the piston. This design also introduced a parallel motion linkage between the piston rod and balance beam to take full advantage of the double action.



## Vitesse modérée, berges préservées !

*Restrict your speed  
to preserve the canal banks !*



*Si vous avez mis moins de 10 minutes  
depuis le dernier panneau,  
**Ralentissez: votre vitesse est excessive.***

*If it took less than 10 minutes to cover  
the stretch since the last sign,  
Please slow down : you are exceeding  
the speed limit.*

← Speed limit on today's Canal du Midi

# Inventing the Steamboat (1775-1809)

- By 1775, various French inventors attempt to apply steam power to navigation; however, the steam engines available to them are still primitive, and the French Revolution in 1789 will curtail their efforts
- In Great Britain, the Boulton and Watt partnership prevents the use of its steam engine for navigation, while canal owners are hostile to steamboats
- So, it is in the United States and Canada that the first practical steamboats will be launched in 1807-1809

# From Fitch to Fulton and Molson

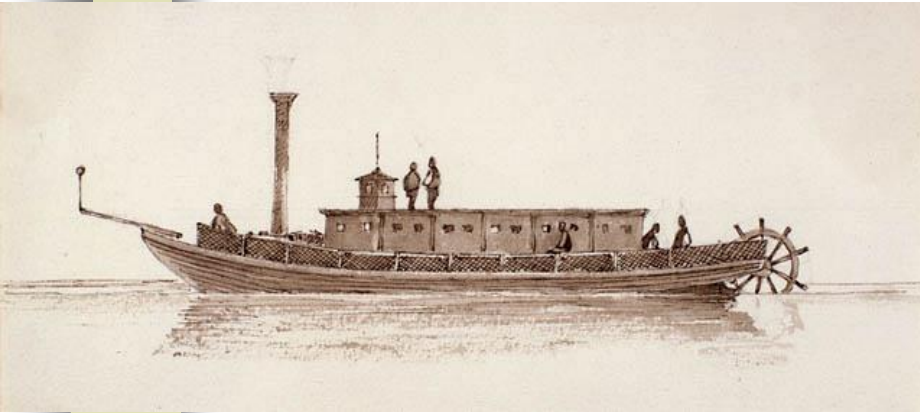
- **John Fitch** (1743-1798) developed the first practical steamboat, running one for the 1790 summer from Philadelphia to Trenton
- A competitor, **James Rumsey** (1741-1792), built a steamboat propelled by a water jet, but it was slow
- But the patent office decision in August 1791 did not choose among them

Sketch for an early 20<sup>th</sup>-c. fresco planned for Quebec City, illustrating famous inventors of the 18<sup>th</sup> and 19<sup>th</sup> centuries.



Robert Fulton →

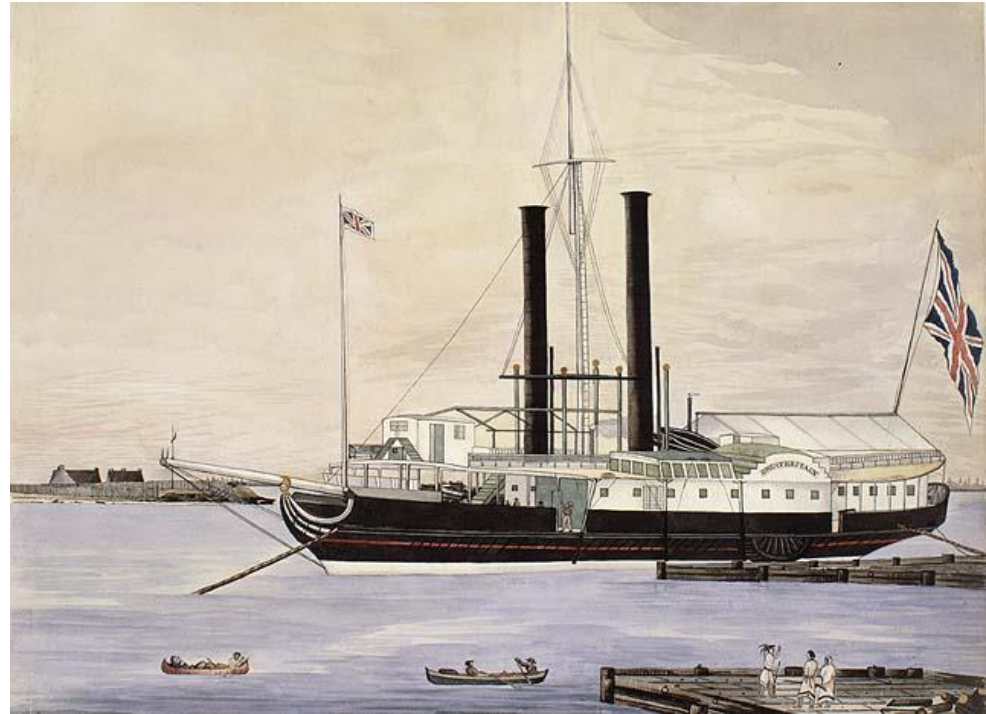
# Boats on North American waterways: steamboats



Henry Byam Martin (1804-1865),  
Archives Canada

Steamer *Iroquois* from Prescott  
on the St. Lawrence (1832)

In Canada, John Molson  
launched the first steamboat  
on the St. Lawrence in 1809,  
the *Accommodation*



Henry Francis Ainslie (1803-1879),  
Archives Canada

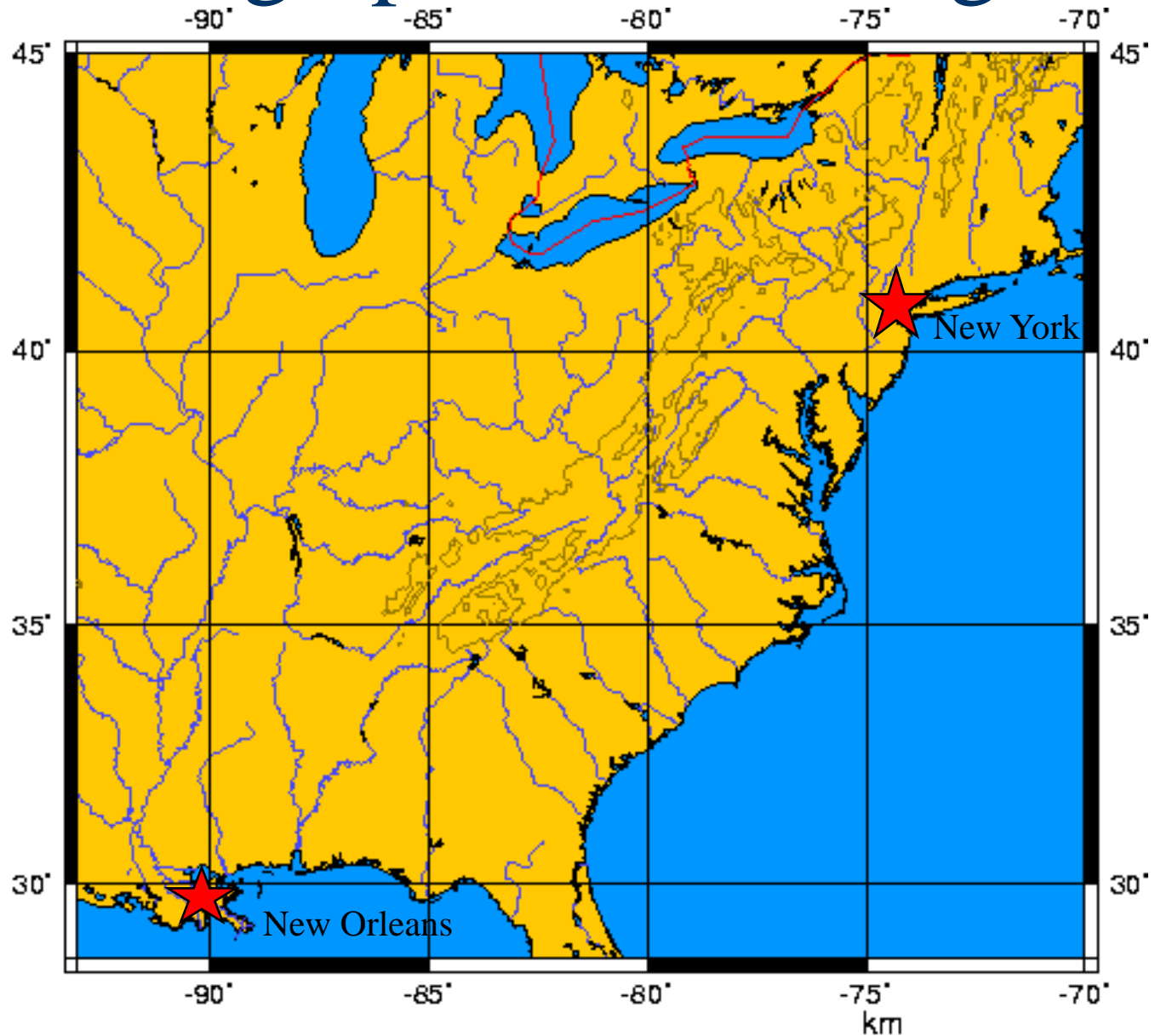
Steamer *Great Britain* on Lake  
Ontario (June 1839)



# Canals and Steamboats

- The development of the horseboat was a technological dead end, though it found niche uses up to the early 20th century
- In North America, the first half of the 19th century was dominated by two developments in water-borne transportation: new canals and the improvement of the steamboat, both made possible by an increasing population that resulted in more trade

# A Geographical Challenge







# The Gallatin Plan (1808)

- Gallatin's 1808 plan proposed various road and waterway improvements, especially along rivers like the Hudson, Potomac, Susquehanna, James, Santee, and Savannah, with canals extending to Lake Ontario and Lake Champlain
- Though Congress funded the 1809 Carondelet canal between the Mississippi at New Orleans and Lake Pontchartrain, monies set aside for further improvements were absorbed by the War of 1812
- The situation then changed with the success of the first Erie Canal (1817-1825)



# To recapitulate (5)

- What was new about the first Boulton and Watt steam engine?
- What was new about the second Boulton and Watt steam engine?
- In what country was the first practical steamboat launched?
- Name three (3) reasons why the U.S. Senate wished to improve transportation westward through the Appalachian range.
- What was the first real achievement foreseen by the Gallatin Plan?

# The Original Erie Canal

Remnants of the original  
Erie Canal lock and trench at  
the crossing of Schoharie Creek,  
in New York state



# The Impact of the Erie Canal (1)

- The success of the Erie Canal, already evident by 1823, spurred more canal construction
- U.S. canals built between **1815** and **1834** accounted for **half** of the total distance covered by canal works before the Civil War and 31% of all improvement investments
- Federal involvement was low, aside from land grants; 70% of these investments came from state and municipal governments, financing them with the sale of bonds to Eastern banks but also to the London market (Barings)



↑ Canal-bridge over Schoharie Creek (ruined)

# United States Canals (1825-1860)





# The Impact of the Erie Canal (2)

- By 1840, the U.S. network of canals extended over 5,000 km
- Besides the ambitious *interregional* canals designed to connect the Eastern seaboard states with the central states, several shorter *intraregional* canals were constructed to connect local centres or bring raw materials (Pennsylvania coal) to market
- Around **1834**, a canal boom was fueled by population growth, land speculation, and increasing bond sales to foreign markets, leading to a crash in 1839 that threw most canal projects into crisis until 1844



# U.S. Canals: From Boom to Bust

- After 1844, construction proceeded mostly on existing projects; few new canals were started, and the work that was done concentrated on completing old projects or improving new canals (broadening them, straightening them, adding laterals)
- The costs of construction and especially of upkeep had become clearer, and they required most canals to operate at near capacity to remain viable; indebtedness from the canal boom of 1837-1839 remained high; most of the best routes had been developed; and competition from railroads was proving hard to overcome since canals were exposed to freezing in winter, flooding in the spring, and low water in the summer



# U.S. Canals: After the Bust

- Still, many canals operated profitably until the Civil War; Erie Canal tonnage only peaked in 1880
- Waterway traffic remains commercially important even today
- In the 19th century, rivers and canals played a major role in helping early settlement while contributing to agricultural and industrial development

# Canada's First Lock Canal (1)

Coteau-du-Lac, Québec



Before the lock canal, a shore-hugging stone embankment protected a narrow channel known as a *rigolet*...

# Canada's First Lock Canal (2)

Coteau-du-Lac, Québec

This lock canal, arguably the first in North America, was built in 1779-1781 as the first of several efforts to improve upstream navigation along the St. Lawrence. It was fortified by the British because of its absolute importance to the supplying of Upper Canada in the face of the threat from the U.S. during the Revolutionary War. The British would later build the Rideau canal for similar reasons.



# Canadian Canals (1)

- In Montréal, the Lachine Canal goes back to ditches dug before 1700 to go around the Lachine rapids, though a navigable link was only completed in **1821-1825**
- The Rideau Canal was built between Kingston and the Ottawa River to provide a northern link between Upper Canada (Ontario) with Lower Canada (Québec), away from the St. Lawrence river bordered by the United States; it was opened in **1832**
- Bytown developed around the canal's entrance from the Ottawa River, later becoming the city of Ottawa and the country's capital



# To recapitulate (6)

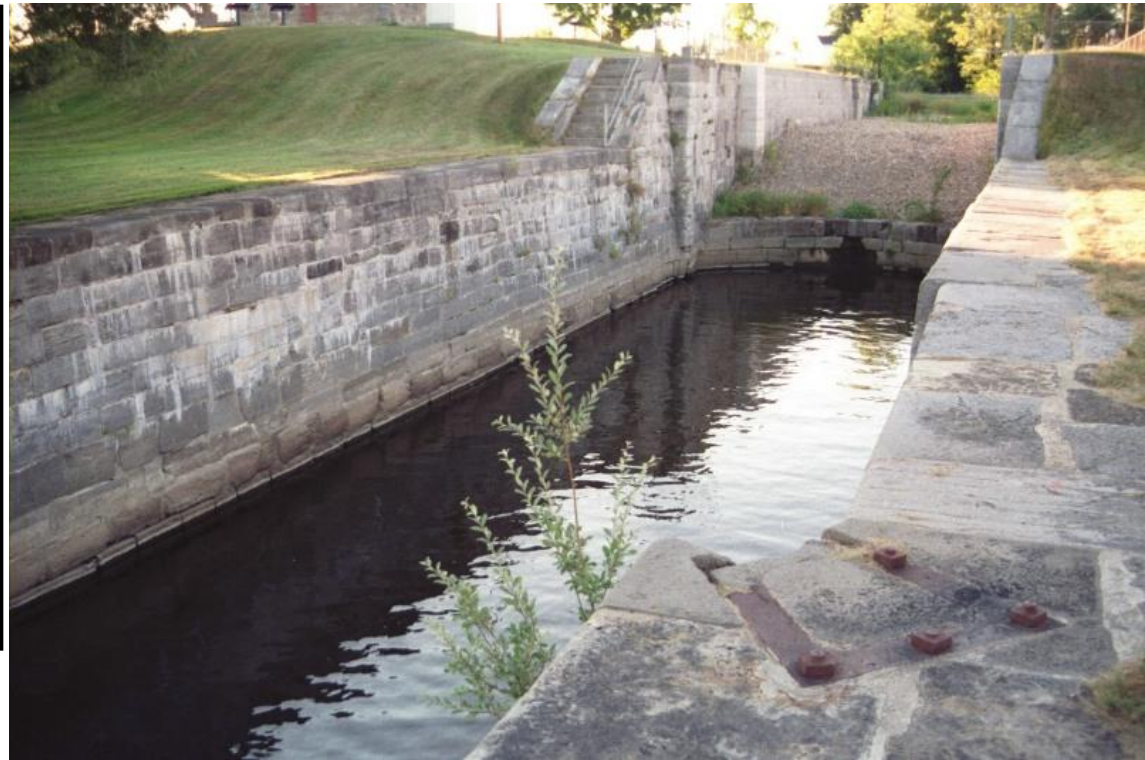
- What was the main source of financing for the U.S. canal age in the early 19th century?
- What area of the United States saw most of the construction of new canals?
- What kind of canal was the Erie Canal?
- Why did canal construction slow down after 1844 and the recovery from the 1839 crash?
- When did commercial traffic on the Erie Canal peak, measured in total tonnage?
- In what province is found Canada's first lock canal?



# The Road to Rideau: The Ottawa River Canals

- Replacing early French *rigolet* canals, the British built three canals with 11 locks from Carillon to Grenville along the Ottawa River between 1819 and 1833

Lock Number 1 in Carillon was built from 1830 to 1833; it is broadly similar to the Rideau Canal locks of the same vintage. (It is no longer in use.)



# Bytown's Rideau Canal Locks



Watercolour (ca. 1838)

Philip John Bainbrigg (1817-1881), Library and Archives Canada, Acc. No. 1983-47-76

# Rideau Canal Steamer (August 3, 1844)

The high-pressure steamer *Pilot* tows a barge and three canoes with “Indians”. Five or more canoes in company would have the lock opened for them. In the foreground, one dug-out and one birch-bark canoes.

George Seton (1819-1905), Library and Archives Canada, Acc. No. 1950-63-1.17R



# Rideau Canal: Hog's Back Dam (October 18, 1832)

The Hog's Back Falls were among the toughest natural obstacles overcome in the course of building the Rideau Canal.



Henry Byam Martin (1804-1865),  
Library and Archives Canada, Acc. No. 1981-42-5

# Rideau Canal: Hog's Back today





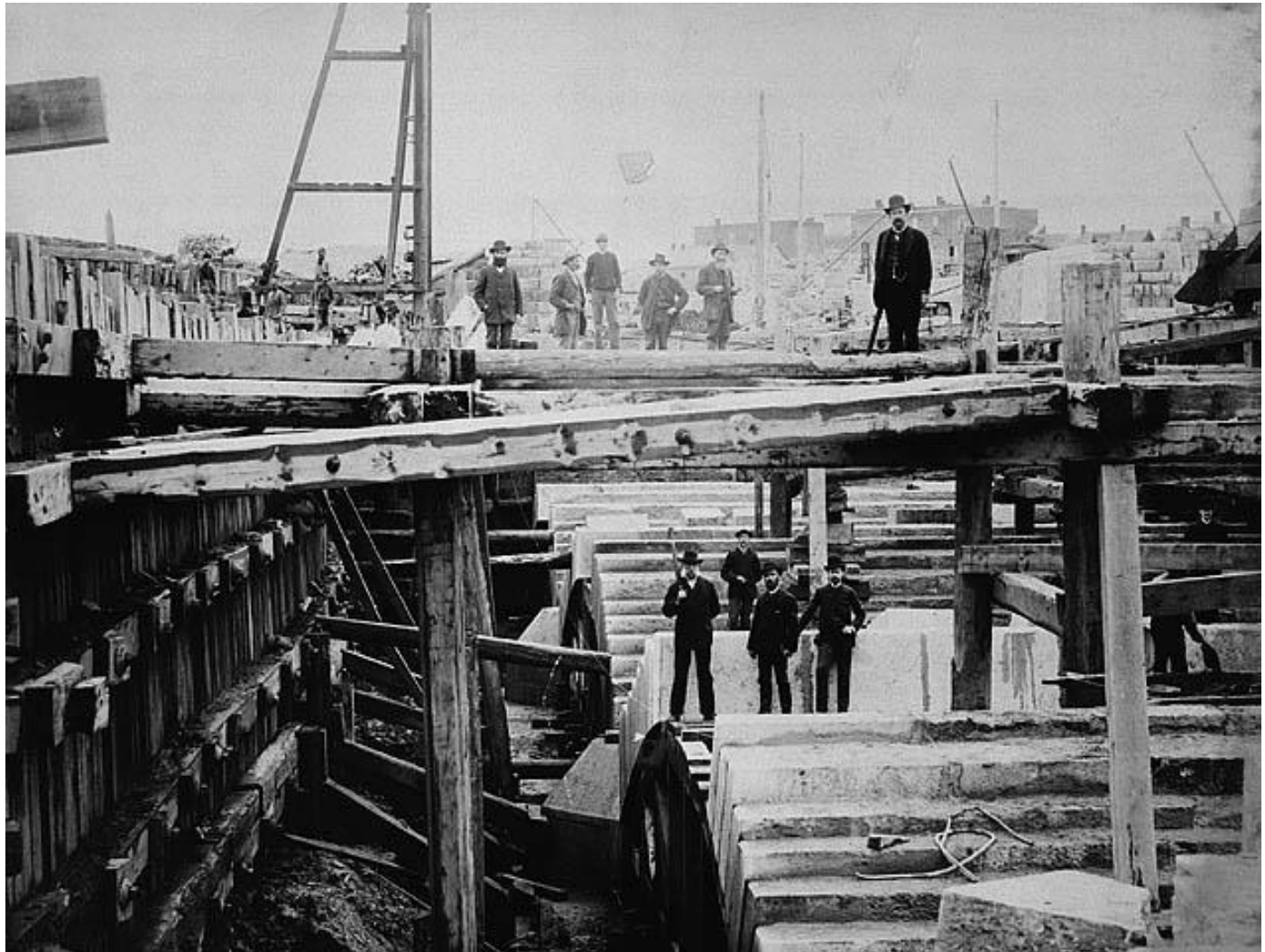
## Canadian Canals (2)

- In Montréal, the Lachine Canal was broadened and improved several times
- Foundries, mills, and factories were built along the Lachine Canal, contributing to the growing industrialization of Canada around 1850
- It was the last link in a chain of canals connecting ocean-going traffic on the St. Lawrence downstream of Montréal to shipping on the Great Lakes

# Plan of Lachine Canal in 1848



# Building Lachine Canal's Basin 4 (1877)

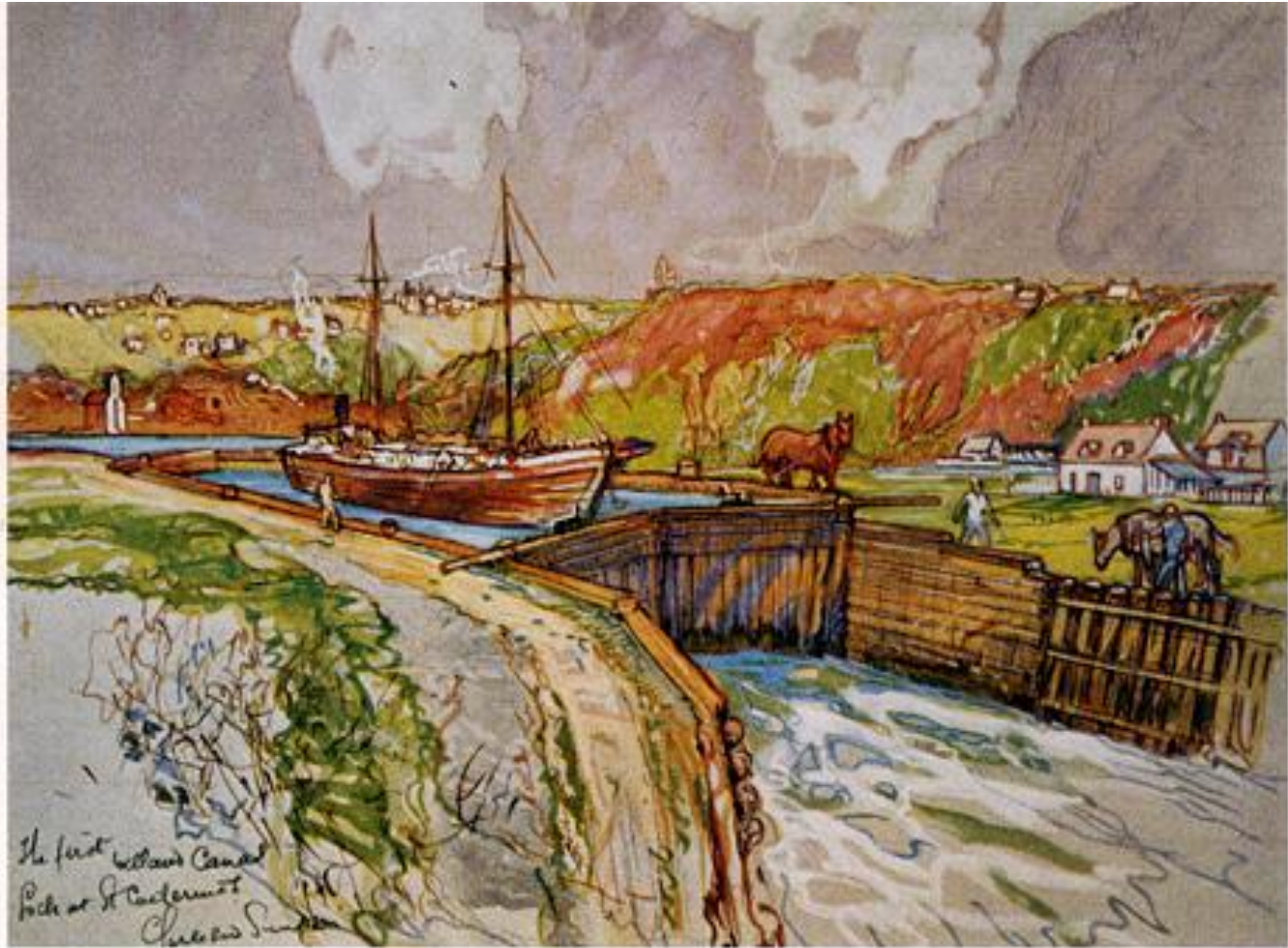




## Canadian Canals (3)

- The first Welland Canal, connecting Lake Ontario to Lake Erie over an elevation of 99 metres, was opened in **1829**
- The original 1824 plan had called for a canal to the foot of the escarpment, over which boats would be hauled on wooden rails, but it was finally to ascend the incline with a series of wooden locks
- The canal was rebuilt and improved in 1850, 1881, 1913, 1932, and 1972

# First Welland Canal in 1829 (recreation)

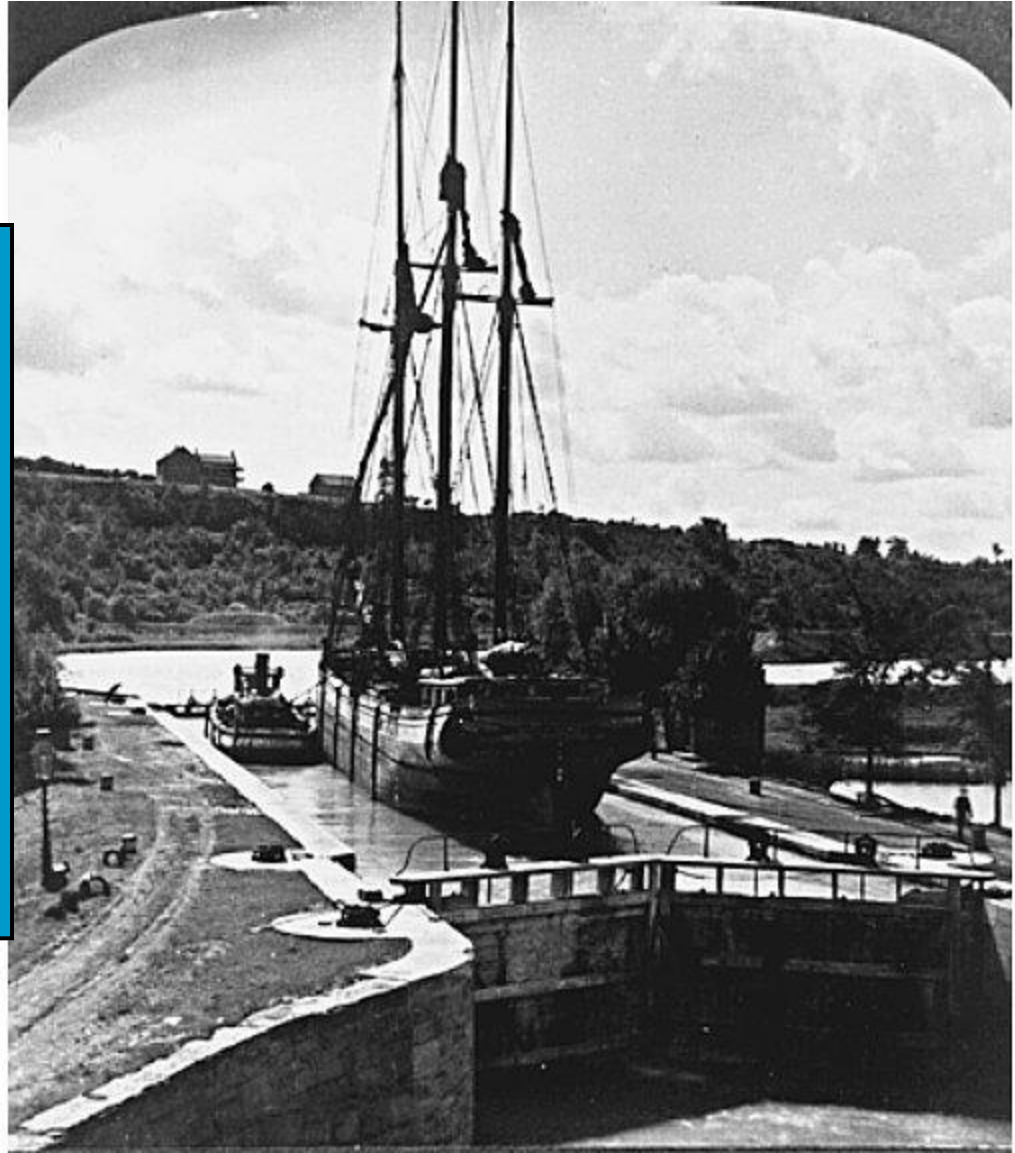


*First Welland Canal —  
Lock at St. Catharines*

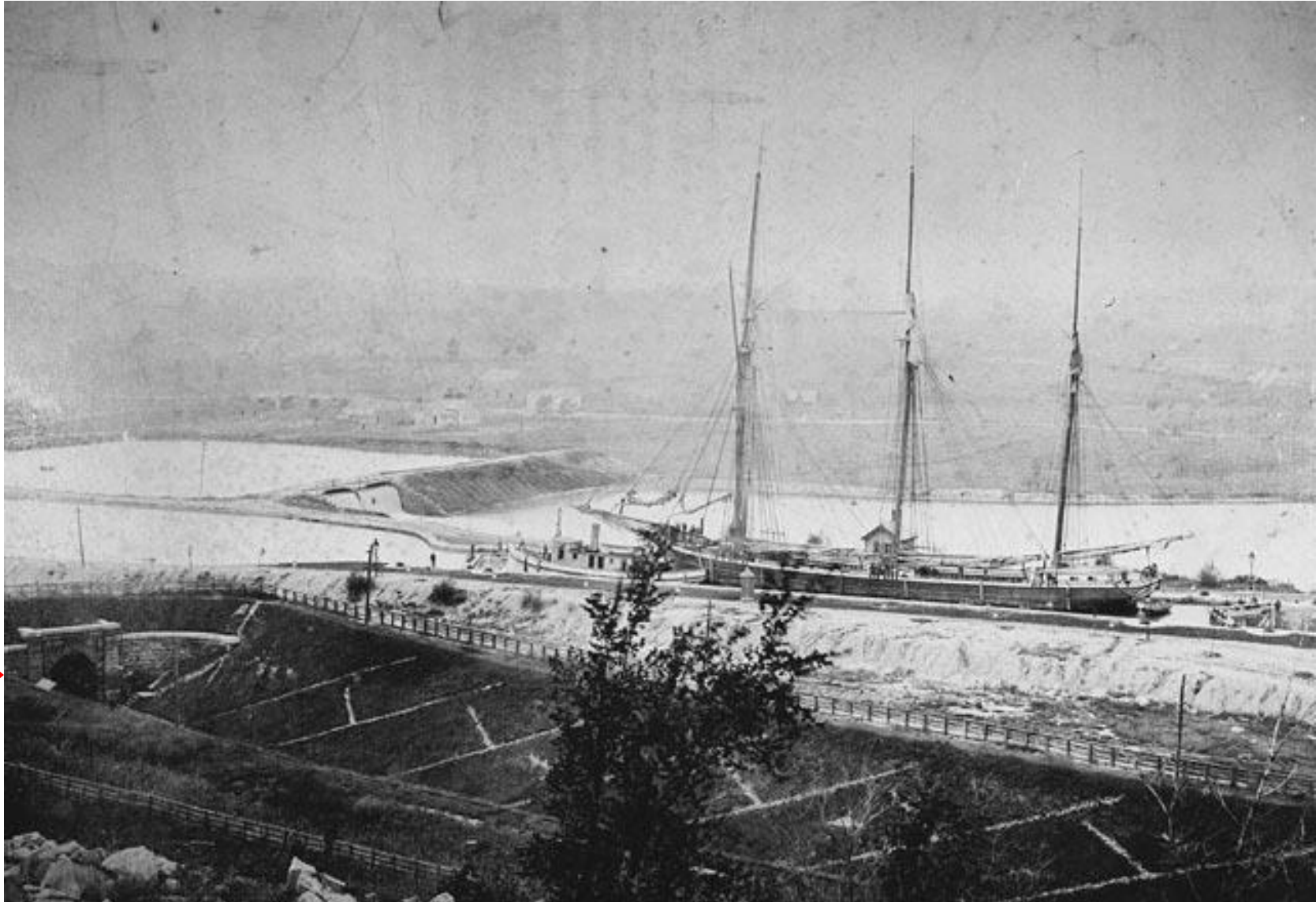
*Premier canal Welland —  
Ecluse à St. Catharines*

# Second Welland Canal (Sailing ship in lock near Thorold)

The second canal was completed by 1850. Masonry-lined locks replaced the old wooden locks of the first canal. Notice how much the locks resemble those of the Rideau canal in Ottawa.



# Third Welland Canal in 1885 (railway tunnel in foreground)



# The Welland Canal today (1)

Lock 3



© Courtney Scanlan, 2005

# The Welland Canal today (2)

## Lock 4



# The Welland Canal today (3)

Lock 6

© Courtney Scanlan, 2005





# Canadian Canals (4)

- While the Welland Canal was a vital link to the North American heartland, the Rideau Canal languished, reduced to a strictly regional role
- It served local markets between Ottawa and Kingston, often carrying raw materials, but it never became a thoroughfare for national or international shipping; it only fostered small-scale industrialization
- As a result, it was maintained in its original state and it is said to be the oldest Canadian canal so well preserved

# Lumber Barge on the Rideau Canal in Ottawa (1892)



# The Rideau Canal's Ottawa Locks today

- The entire Rideau Canal became a UNESCO World Heritage Site in 2007, recognized for its cultural and historical value
- It now caters mainly to pleasure boating

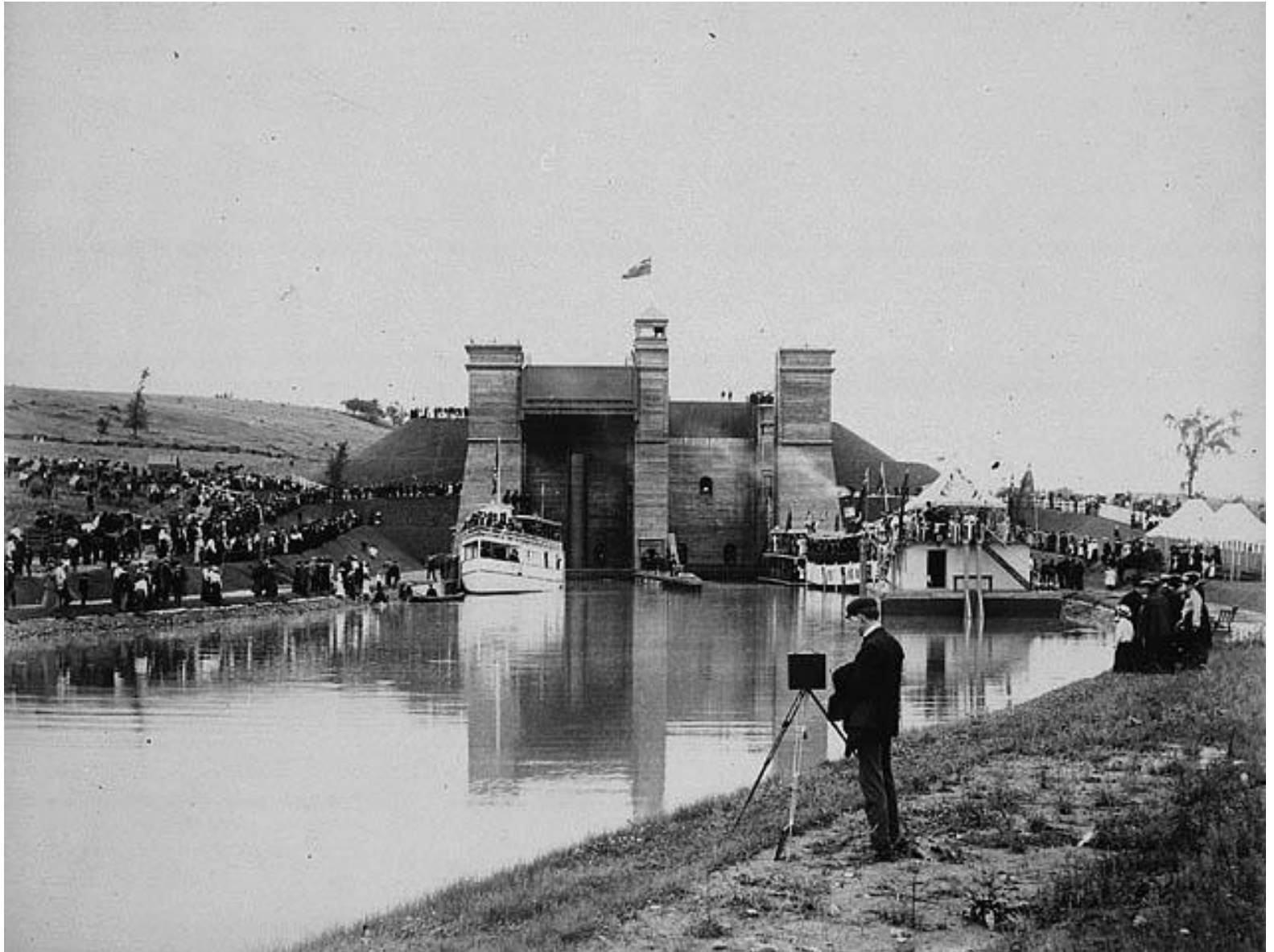




# Canadian Canals (5)

- Though railroads superseded the Rideau Canal, the new Dominion of Canada decided in 1878 to invest in a new link between Lake Ontario and Lake Huron's Georgian Bay
- Begun in 1833, the Trent-Severn waterway was only completed in **1920**, finally covering a distance of 386 km
- Its construction involved innovative engineering
- Besides the Big Chute Marine Railway (1917), Peterborough's hydraulic lift lock (19.8 m high) opened in 1904 as one of the world's most massive unreinforced concrete structure

# Opening the Trent Lift Locks (1904)



# The Peterborough Lift Locks today

