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ΘΕΜΑ: SHIPS'S CANALS

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Ο ΔΙΕΥΘΥΝΤΗΣ ΤΗΣ ΣΧΟΛΗΣ:

Contents

Definition of ship’s canals **CHAPTER 1**

Canals are waterways channels, or artificial waterways, for water conveyance, or to service water transport vehicles. They may also help with irrigation. It can be thought of as an artificial version of a river.

In most cases, the engineered works will have a series of dams and locks that create reservoirs of low speed current flow. These reservoirs are referred to as slack water levels, often just called levels.

A canal is also known as a navigation when it parallels a river and shares part of its waters and drainage basin, and leverages its resources by building dams and locks to increase and lengthen its stretches of slack water levels while staying in its valley.

In contrast, a canal cuts across a drainage divide atop a ridge, generally requiring an external water source above the highest elevation.

Many canals have been built at elevations towering over valleys and other water ways crossing far below.

Canals with sources of water at a higher level can deliver water to a destination such as a city where water is needed. The Roman Empire's aqueducts were such water supply canals.

Construction **CHAPTER 2**

Canals are built in one of three ways, or a combination of the three, depending on available water and available path:

Human made streams **Chapter 2.1.**

A canal can be created where no stream presently exists. Either the body of the canal is dug or the sides of the canal are created by making dykes or levees by piling dirt, stone, concrete or other building materials. The finished shape of the canal as seen in cross section is known as the canal prism. The water for the canal must be provided from an external source, like streams or reservoirs. Where the new waterway must change elevation engineering works like locks, lifts or elevators are constructed to raise and lower vessels. Examples include canals that connect valleys over a higher body of land, like Canal du Midi, Canal de Briare and the Panama Canal.

A canal can be constructed by dredging a channel in the bottom of an existing lake. When the channel is complete, the lake is drained and the channel becomes a new canal, serving both drainage of the surrounding polder and providing transport there. Examples include the Lage Vaart . One can also build two parallel dikes in an existing lake, forming the new canal in between, and then drain the remaining parts of the lake. The eastern and central parts of the North Sea Canal were constructed in this way. In both cases pumping stations are required to keep the land surrounding the canal dry, either pumping water from the canal into surrounding waters, or pumping it from the land into the canal.

Canalization and navigations Chapter 2.2.

A stream can be canalized to make its navigable path more predictable and easier to maneuver. Canalization modifies the stream to carry traffic more safely by controlling the flow of the stream by dredging, damming and modifying its path. This frequently includes the incorporation of locks and spillways, that make the river a navigation. Examples include the Lehigh Canal in Northeastern Pennsylvania's coal Region, Basse Saône, Canal de Mines de Fer de la Moselle, and Aisne River. Riparian zone restoration may be required.

Lateral canals Chapter 2.3.

When a stream is too difficult to modify with canalization, a second stream can be created next to or at least near the existing stream. This is called a lateral canal, and may meander in a large horseshoe bend or series of curves some distance from the source waters stream bed lengthening the effective length in order to lower the ratio of rise over run (slope or pitch). The existing stream usually acts as the water source and the landscape around its banks provide a path for the new body. Examples include the Chesapeake and Ohio Canal, Canal latéral à la Loire, Garonne Lateral Canal, Welland Canal and Juliana Canal. Smaller transportation canals can carry barges or narrowboats, while ship canals allow seagoing ships to travel to an inland port (e.g., Manchester Ship Canal), or from one sea or ocean to another (e.g., Caledonian Canal, Panama Canal).

History CHAPTER 3

Early canals were connected with natural rivers, either as short extensions or improvements to them.

One of the first canals built was the Grand Canal of China, which was developed over a long period starting in the 5th century BCE.

In the modern era, canals in the United Kingdom are typically associated with the Duke of Bridgewater, who hired the engineer James Brindley and had the first canal (the Bridgewater Canal) built that ran over a flowing river.

In the United States, the canal that brought about an age of canal building was the Erie Canal. It was a long-sought-after canal and connected the Great Lakes to the Hudson River. This canal initiated a half-century-long boom of canal building and brought about many new features that allowed canals to be used in different areas previously inaccessible to canals. These features include locks, which allow a ship to move between different altitudes, and puddling, which waterproofed the canal.

Ancient canals Chapter 3.1.

The oldest known canals were irrigation canals, built in Mesopotamia circa 4000 BC, in what is now Iraq and Iran. The Indus Valley Civilization, Ancient India, (circa 2600 BC) had sophisticated irrigation and storage systems developed, including the reservoirs built at Girnar in 3000 BC. In Egypt, canals date back at least to the time of Pepi I Meryre (reigned 2332–2283 BC), who ordered a canal built to bypass the cataract on the Nile near Aswan.

In ancient China, large canals for river transport were established as far back as the Spring and Autumn Period (8th–5th centuries BC), the longest one of that period being the Hong Gou (Canal of the Wild Geese), which according to the ancient historian Sima Qian connected the old states of Song, Zhang, Chen, Cai, Cao, and Wei. The Caoyun System of canals was essential for imperial taxation, which was largely assessed in kind and involved enormous shipments of rice and other grains. By far the longest canal was the Grand Canal of China, still the longest canal in the world today and the oldest extant one. It is 1,794 kilometres (1,115 mi) long and was built to carry the Emperor Yang Guang between Zhuodu (Beijing) and Yuhang (Hangzhou). The project began in 605 and was completed in 609, although much of the work combined older canals, the oldest section of the canal existing since at least 486 BC. Even in its narrowest urban sections it is rarely less than 30 metres (98 ft) wide.

Greek engineers were also among the first to use canal locks, by which they regulated the water flow in the Ancient Suez Canal as early as the 3rd century BC.

"There was little experience moving bulk loads by carts, while a pack-horse would [i.e. 'could'] carry only an eighth of a ton. On a soft road a horse might be able to draw 5/8ths of a ton. But if the load were carried by a barge on a waterway, then up to 30 tons could be drawn by the same horse."

— technology historian Ronald W. Clark referring to transport realities before the industrial revolution and the Canal age.

Middle Ages Chapter 3.2.

In the Middle Ages, water transport was several times cheaper and faster than transport overland. Overland transport by animal drawn conveyances was used around settled areas, but unimproved roads required pack animal trains, usually of mules to carry any degree of mass, and while a mule could carry an eighth ton, it also needed teamsters to tend it and one man could only tend perhaps five mules, meaning overland bulk transport was also expensive, as men expect compensation in the form of wages, room and board. This was because long-haul roads were unpaved, more often than not too narrow for carts, much less wagons, and in poor condition, wending their way through forests, marshy or muddy quagmires as often as unimproved but dry footing. In that era, as today, greater cargoes, especially bulk goods and raw materials, could be transported by ship far more economically than by land; in the pre-railroad days of the industrial revolution, water transport was the gold standard of fast transportation. The first artificial canal in Western Europe was the Fossa Carolina built at the end of the 8th century under personal supervision of Charlemagne.

In Britain, the Glastonbury Canal is believed to be the first post-Roman canal and was built in the middle of the 10th century to link the River Brue at Northoverwith Glastonbury Abbey, a distance of about 1.75 kilometres (1,900 yd). Its initial purpose is believed to be the transport of building stone for the abbey, but later it was used for delivering produce, including grain, wine, and fish, from the abbey's outlying properties. It remained in use until at least the 14th century, but possibly as late as the mid-16th century.

More lasting and of more economic impact were canals like the Naviglio Grande built between 1127 and 1257 to connect Milan with the Ticino River. The Naviglio Grande is the most important of the lombard "navigli" and the oldest functioning canal in Europe.

Later, canals were built in the Netherlands and Flanders to drain the polders and assist transportation of goods and people.

Canal building was revived in this age because of commercial expansion from the 12th century. River navigations were improved progressively by the use of single, or flash locks. Taking boats through these used large amounts of water leading to conflicts with watermill owners and to correct this, the pound or chamber lock first appeared, in the 10th century in China and in Europe in 1373 in Vreeswijk, Netherlands. Another important development was the mitre gate, which was, it is presumed, introduced in Italy by Bertola da Novate in the 16th century. This allowed wider gates and also removed the height restriction of guillotine locks.

To break out of the limitations caused by river valleys, the first summit level canals were developed with the Grand Canal of China in 581–617 AD whilst in Europe the first, also using single locks, was the Stecknitz Canal in Germany in 1398.

Africa Chapter 3.3.

In the Songhai Empire of West Africa, several canals were constructed under Sunni Ali and Askia Muhammad between Kabara and Timbuktu in the 15th century. These were used primarily for irrigation and transport. Sunni Ali also attempted to construct a canal from the Niger River to Walata to facilitate conquest of the city, but his progress was halted when he went to war with the Mossi Kingdoms.

Early modern period Chapter 3.4.

Around 1500–1800 the first summit level canal to use pound locks in Europe was the Briare Canal connecting the Loire and Seine (1642), followed by the more ambitious Canal du Midi (1683) connecting the Atlantic to the Mediterranean. This included a staircase of 8 locks at Béziers, 157 metres (515 ft) tunnel, and three major aqueducts.

Canal building progressed steadily in Germany in the 17th and 18th centuries with three great rivers, the Elbe, Oder and Weser being linked by canals. In post-Roman Britain, the first early modern period canal built appears to have been the Exeter Canal, which was surveyed in 1563, and open in 1566.

The oldest canal in North America, technically a mill race built for industrial purposes, is Mother Brook between the Boston, Massachusetts neighbourhoods of Dedham and Hyde Park connecting the higher waters of the Charles River and the mouth of the Neponset River and the sea. It was constructed in 1639 to provide waterpower for mills.

In Russia, the Volga–Baltic Waterway, a nationwide canal system connecting the Baltic Sea and Caspian Sea via the Neva and Volga rivers, was opened in 1718.

The modern canal system was mainly a product of the 18th century and early 19th century. It came into being because the Industrial Revolution (which began in Britain during the mid-18th century) demanded an economic and reliable way to transport goods and commodities in large quantities.

By the early 18th century, river navigations such as the Aire and Calder Navigation were becoming quite sophisticated, with pound locks and longer and longer "cuts" (some with intermediate locks) to avoid circuitous or difficult stretches of river. Eventually, the experience of building long multi-level cuts with their own locks gave rise to the idea of building a "pure" canal, a waterway designed on the basis of where goods needed to go, not where a river happened to be.

The claim for the first pure canal in Great Britain is debated between "Sankey" and "Bridgewater" supporters. The first true canal in what is now the United Kingdom was the Newry Canal in Northern Ireland constructed by Thomas Steers in 1741.

The Sankey Brook Navigation, which connected St Helens with the River Mersey, is often claimed as the first modern "purely artificial" canal because although originally a scheme to make the Sankey Brook navigable, it included an entirely new artificial channel that was effectively a canal along the Sankey Brook valley. However, "Bridgewater" supporters point out that the last quarter-mile of the navigation is indeed a canalized stretch of the Brook, and that it was the Bridgewater Canal (less obviously associated with an existing river) that captured the popular imagination and inspired further canals.

In the mid-eighteenth century the 3rd Duke of Bridgewater, who owned a number of coal mines in northern England, wanted a reliable way to transport his coal to the rapidly industrializing city of Manchester. He commissioned the engineer James Brindley to build a canal for that purpose. Brindley's design included an aqueduct carrying the canal over the River Irwell. This was an engineering wonder which immediately attracted tourists. The construction of this canal was funded entirely by the Duke and was called the Bridgewater Canal. It opened in 1761 and was the first major British canal.

The new canals proved highly successful. The boats on the canal were horse-drawn with a towpath alongside the canal for the horse to walk along. This horse-drawn system proved to be highly economical and became standard across the British canal network. Commercial horse-drawn canal boats could be seen on the UK's canals until as late as the 1950s, although by then diesel-powered boats, often towing a second unpowered boat, had become standard.

The canal boats could carry thirty tons at a time with only one horse pulling – more than ten times the amount of cargo per horse that was possible with a cart. Because of this huge increase in supply, the Bridgewater canal reduced the price of coal in Manchester by nearly two-thirds within just a year of its opening. The Bridgewater was also a huge financial success, with it earning what had been spent on its construction within just a few years.

This success proved the viability of canal transport, and soon industrialists in many other parts of the country wanted canals. After the Bridgewater canal, early canals were built by groups of private individuals with an interest in improving communications. In Staffordshire, the famous potter Josiah Wedgwood saw an opportunity to bring bulky cargoes of clay to his factory doors and to transport his fragile finished goods to market in Manchester, Birmingham or further away, by water, minimizing breakages. Within just a few years of the Bridgewater's opening, an embryonic national canal network came into being, with the construction of canals such as the Oxford Canal and the Trent & Mersey Canal.

The new canal system was both cause and effect of the rapid industrialization of The Midlands and the north. The period between the 1770s and the 1830s is often referred to as the "Golden Age" of British canals.

For each canal, an Act of Parliament was necessary to authorize construction, and as people saw the high incomes achieved from canal tolls, canal proposals came to be put forward by investors interested in profiting from dividends, at least as much as by people whose businesses would profit from cheaper transport of raw materials and finished goods.

In a further development, there was often out-and-out speculation, where people would try to buy shares in a newly floated company simply to sell them on for an immediate profit, regardless of whether the canal was ever profitable, or even built. During this period of "canal mania", huge sums were invested in canal building, and although many schemes came to nothing, the canal system rapidly expanded to nearly 4,000 miles (over 6,400 kilometres) in length.

Many rival canal companies were formed, and competition was rampant. Perhaps the best example was Worcester Bar in Birmingham, a point where the Worcester and Birmingham Canal and the Birmingham Canal Navigations Main Line were only seven feet apart. For many years, a dispute about tolls meant that goods travelling through Birmingham had to be portaged from boats in one canal to boats in the other.

Aqueduct over the Mohawk River at Rexford, New York, one of 32 navigable aqueducts on the Erie Canal.

Canal companies were initially chartered by individual states in the United States. These early canals were constructed, owned, and operated by private joint-stock companies. Four were completed when the War of 1812 broke out; these were the South Hadley Canal (opened 1795) in Massachusetts, Santee Canal (opened 1800) in South Carolina, the Middlesex Canal (opened 1802) also in Massachusetts, and the Dismal Swamp Canal (opened 1805) in Virginia. The Erie Canal (opened 1825) was chartered and owned by the state of New York and financed by bonds bought by private investors.

The Erie canal runs about 363 miles (584 km) from Albany, New York, on the Hudson River to Buffalo, New York, at Lake Erie. The Hudson River connects Albany to the Atlantic port of New York City and the Erie Canal completed a navigable water route from the Atlantic Ocean to the Great Lakes. The canal contains 36 locks and encompasses a total elevation differential of around 565 ft. (169 m). The Erie Canal with its easy connections to most of the U.S. mid-west and New York City soon quickly paid back all its invested capital (US$7 million) and started turning a profit. By cutting transportation costs in half or more it became a large profit center for Albany and New York City as it allowed the cheap transportation of many of the agricultural products grown in the mid west of the United States to the rest of the world. From New York City these agricultural products could easily be shipped to other U.S. states or overseas. Assured of a market for their farm products the settlement of the U.S. mid-west was greatly accelerated by the Erie Canal. The profits generated by the Erie Canal project started a canal building boom in the United States that lasted until about 1850 when railroads started becoming seriously competitive in price and convenience. The Blackstone Canal (finished in 1828) in Massachusetts and Rhode Island fulfilled a similar role in the early industrial revolution between 1828 and 1848. The Blackstone Valley was a major contributor of the American Industrial Revolution where Samuel Slater built his first textile mill.

Power canals Chapter 3.6.

A power canal refers to a canal used for hydraulic power generation, rather than for transport. Nowadays power canals are built almost exclusively as parts of hydroelectric power stations. Parts of the United States, particularly in the Northeast, had enough fast-flowing rivers that waterpower was the primary means of powering factories (usually textile mills) until after the American Civil War. For example, Lowell, Massachusetts, considered to be "The Cradle of the American Industrial Revolution," has 6 miles (9.7 km) of canals, built from around 1790 to 1850, that provided water power and a means of transportation for the city. The output of the system is estimated at 10,000 horsepower. Other cities with extensive power canal systems include Lawrence, Massachusetts, Holyoke, Massachusetts, Manchester, New Hampshire, and Augusta, Georgia. The most notable power canal was built in 1862 for the Niagara Falls Hydraulic Power and Manufacturing Company.

19th century Chapter 3.7.

Competition, from railways from the 1830s and roads in the 20th century, made the smaller canals obsolete for most commercial transport, and many of the British canals fell into decay. Only the Manchester Ship Canal and the Aire and Calder Canal bucked this trend. Yet in other countries canals grew in size as construction techniques improved. During the 19th century in the US, the length of canals grew from 100 miles (161 km) to over 4,000, with a complex network making the Great Lakes navigable, in conjunction with Canada, although some canals were later drained and used as railroad rights-of-way.

In the United States, navigable canals reached into isolated areas and brought them in touch with the world beyond. By 1825 the Erie Canal, 363 miles (584 km) long with 36 locks, opened up a connection from the populated Northeast to the Great Lakes. Settlers flooded into regions serviced by such canals, since access to markets was available. The Erie Canal (as well as other canals) was instrumental in lowering the differences in commodity prices between these various markets across America. The canals caused price convergence between different regions because of their reduction in transportation costs, which allowed Americans to ship and buy goods from farther distances much cheaper. Ohio built many miles of canal, Indiana had working canals for a few decades, and the Illinois and Michigan Canal connected the Great Lakes to the Mississippi River system until replaced by a channelized river waterway.

Three major canals with very different purposes were built in what is now Canada. The first Welland Canal, which opened in 1829 between Lake Ontario and Lake Erie, bypassing Niagara Falls and the Lachine Canal (1825), which allowed ships to skirt the nearly impassable rapids on the St. Lawrence River at Montreal, were built for commerce. The Rideau Canal, completed in 1832, connects Ottawa on the Ottawa River to Kingston, Ontario on Lake Ontario. The Rideau Canal was built as a result of the War of 1812 to provide military transportation between the British colonies of Upper Canada and Lower Canada as an alternative to part of the St. Lawrence River, which was susceptible to blockade by the United States.

In France, a steady linking of all the river systems – Rhine, Rhône, Saône and Seine – and the North Sea was boosted in 1879 by the establishment of the Freycinet gauge, which specified the minimum size of locks. Canal traffic doubled in the first decades of the 20th century.

Many notable sea canals were completed in this period, starting with the Suez Canal (1869) – which carries tonnage many times that of most other canals – and the Kiel Canal (1897), though the Panama Canal was not opened until 1914.

In the 19th century, a number of canals were built in Japan including the Biwako canal and the Tone canal. These canals were partially built with the help of engineers from the Netherlands and other countries.

A major question was how to connect the Atlantic and the Pacific with a canal through narrow Central America. (The Panama Railroad opened in 1855.) The original proposal was for a sea-level canal through what is today Nicaragua, taking advantage of the relatively large Lake Nicaragua. This canal has never been built in part because of political instability, which scared off potential investors. It remains an active project (the geography hasn't changed), and in the 2010s Chinese involvement was developing.

The second choice for a Central American canal was a Panama Canal. The De Lessups company, which ran the Suez Canal, first attempted to build a Panama Canal in the 1880s. The difficulty of the terrain and weather (rain) encountered caused the company to go bankrupt. High worker mortality from disease also discouraged further investment in the project. DeLessup's abandoned excavating equipment sits, isolated decaying machines, today tourist attractions.

Twenty years later, an expansionist United States, that just acquired colonies after defeating Spain in the 1898 Spanish - American War, and whose Navy became more important, decided to reactivate the project. The United States and Colombia did not reach agreement on the terms of a canal treaty (see Hay–Herrán Treaty). Panama, which did not have (and still does not have) a land connection with the rest of Colombia, was already thinking of independence. In 1903 the United States, with support from Panamanians who expected the canal to provide substantial wages, revenues, and markets for local goods and services. transform the country, took Panama province away from Colombia, and set up a puppet republic (Panama). Its currency, the Balboa – a name that suggests the country began as a way to get fom one hemisphere to the other – was a replica of the US dollar. The US dollar was and remains legal tender (used as currency). A U.S. military zone, the Canal Zone, 10 miles (16 km) wide, with U.S. military stationed there (bases, 2 TV stations, channels 8 and 10, Ps, a U.S.-style high school), split Panama in half. The Canal – a major engineering project – was built. The U.S. did not feel that conditions were stable enough to withdraw until 1979. The withdrawal fron Panama contributed to President Jimmy Carter's defeat in 1980.

Modern uses Chapter 3.8.

Canals can disrupt water circulation in marsh systems.

Large-scale ship canals such as the Panama Canal and Suez Canal continue to operate for cargo transportation, as do European barge canals. Due to globalization, they are becoming increasingly important, resulting in expansion projects such as the Panama Canal expansion project. The expanded canal began commercial operation on 26 June 2016. The new set of locks allow transit of larger, Post-Panamax and New Panamax ships.

The narrow early industrial canals, however, have ceased to carry significant amounts of trade and many have been abandoned to navigation, but may still be used as a system for transportation of untreated water. In some cases, railways have been built along the canal route, an example being the Croydon Canal.

A movement that began in Britain and France to use the early industrial canals for pleasure boats, such as hotel barges, has spurred rehabilitation of stretches of historic canals. In some cases, abandoned canals such as the Kennet and Avon Canal have been restored and are now used by pleasure boaters. In Britain, canal side housing has also proven popular in recent years.

The Seine–Nord Europe Canal is being developed into a major transportation waterway, linking France with Belgium, Germany, and the Netherlands.

Canals have found another use in the 21st century, as easements for the installation of fibre optic telecommunications network cabling, avoiding having them buried in roadways while facilitating access and reducing the hazard of being damaged from digging equipment.

Canals are still used to provide water for agriculture. An extensive canal system exists within the Imperial Valley in the Southern California desert to provide irrigation to agriculture within the area.

Navigability Chapter 4

The standard used in the European Union for classifying the navigability of inland waterways is the European Agreement on Main Inland Waterways of International Importance (AGN) of 1996, adopted by The Inland Transport Committee of the United Nations Economic Commission for Europe (ECE), which defines the following classes:

Class	Tonnage (t)	Draught (m)	Length (m)	Width (m)	Air draught (m)	Description
Class III	1000					
Class IV	1,000–1,500	2.5	80–85	9.5	5.2–7.0	Johann Welker
Class Va	1,500–3,000	2.5–2.8	95–110	11.4	5.2–7.0–9.1	Large Rhine
Class VIb	6,400–12,000	3.9	140	15	9.1	
Class VII	14,500–27,000	2.5–4.5	275–285	33.0–34.2	9.1	

Notable ship canals Chapter 5

Year Opened	Canal Name	Length	Maximum Boat Length	Start Point	End Point
1869	Suez Canal	193.3 km (120.1 mi)	Unlimited x 78 x 20	Egypt: Port Said	Port Tewfik
1894	Manchester Ship Canal	58 km (36 mi)	183 x 20 x 9	United Kingdom: Eastham Locks	Salford Quays
1895	Kiel Canal	98 km (61 mi)	310 x 42 x 14	Germany: Brunsbüttel	Kiel
1914	Panama Canal	77 km (48 mi)	366 x 49 x 15	Panama: Caribbean Sea	Pacific Ocean
1914	Houston Ship Channel	80 km (50 mi)	80 x 161 x 14	United States: Houston	Gulf of Mexico
1932	Welland Canal	43.4 km (27.0 mi)	226 x 24 x 8	Canada: Lake Ontario at Port Weller	Lake Erie at Port Colborne
1933	White Sea–Baltic Canal	227 km (141 mi)	443 x 47 x 4	Russia: Lake Onega	Baltic Sea in Saint Petersburg
1952	Volga-Don Canal	101 km (63 mi)	141 x 17 x 4	Russia: Volgograd	Tsimlyansk Reservoir
1959	Saint Lawrence Seaway	600 km (370 mi)	226 x 24 x 8	United States: Port Colborne	Canada: Montreal
1984	Danube-Black Sea Canal	64.4 km (40.0 mi)	138 x 17 x 6	Romania: Danube at Cernavodă	Black Sea at Agigea
1992	Rhine-Main-Danube Canal	171 km (106 mi)	190 x 11 x 4	Germany: Main at Bamberg	Danube at Kelheim

Suez Canal Chapter 5.1.

Suez Canal, Arabic Qanāt al-Suways, sea-level waterway running north-south across the Isthmus of Suez in Egypt to connect the Mediterranean and the Red seas. The canal separates the African continent from Asia, and it provides the shortest maritime route between Europe and the lands lying around the Indian and western Pacific oceans. It is one of the world's most heavily used shipping lanes. The canal extends 120 miles (193 km) between Port Said (Būr Saʿīd) in the north and Suez in the south, with dredged approach channels north of Port Said, into the Mediterranean, and south of Suez. The canal does not take the shortest route across the isthmus, which is only 75 miles (121 km). Instead, it utilizes several lakes: from north to south, Lake Manzala (Buḥayrat al-Manzilah), Lake Timsah (Buḥayrat al-Timsāḥ), and the Bitter Lakes—Great Bitter Lake (Al-Buḥayrah al-Murrah al-Kubrā) and Little Bitter Lake (Al-Buḥayrah al-Murrah al-Ṣughrā). The Suez Canal is an open cut, without locks, and, though extensive straight lengths occur, there are eight major bends. To the west of the canal is the low-lying delta of the Nile River, and to the east is the higher, rugged, and arid Sinai Peninsula. Prior to construction of the canal (completed in 1869), the only important settlement was Suez, which in 1859 had 3,000 to 4,000 inhabitants. The rest of the towns along its banks have grown up since, with the possible exception of Al-Qanṭarah.

Manchester Ship Canal Chapter 5.2.

The need for the Manchester Ship Canal arose in the 19 century when Manchester established itself as a world leader in industry. It was a huge project that cost 15 million pounds (1.9 billion by today's standards) and employed 1600 people to build it.

Construction of the Manchester Ship Canal was overseen by contracting engineer Thomas Walker. He divided the 36-mile (58km) route into 8 sections, putting an engineer in charge of work on each.
Up to 17,000 labourers (also known as navvies) worked on digging the canal. The project took 6 years to complete – with 54m yards³ (41m³) of earth removed during construction.
Navvies were paid the equivalent of around £19 for a 10-hour working day. Walker also provided living accommodation, meeting halls and hospital facilities for the workforce.
Engineers laid more than 200 miles (320km) of temporary rail track and used 180 locomotives and over 6,000 trucks and wagons to transport building materials along the canal route.
Other equipment included 124 steam powered cranes and 97 steam excavators.
Construction firsts along the route included the Barton Swing Aqueduct near Barton-on-Irwell in Greater Manchester.
The aqueduct was the first of its kind in the world. Designed by Edward Leader Williams, it's a kind of swing bridge that rotates on a pivot to let big ships pass along the canal.
The company building the canal ran out of money after 4 years and had to borrow £3m (about £354m today) from Manchester corporation (now Manchester city council) to finish the project.
The canal was officially opened by Queen Victoria in May 1894.

Kiel Canal Chapter 5.3.

A new bypass for one of the world ‘s most important shipping lanes: a fifth lock chamber is being built – right between the two already existing locks at the western end of the Kiel Canal. The job calls for high precision and the right concrete mix.
The Kiel Canal is one of the most travelled man-made shipping lanes worldwide. At Brunsbüttel, two dual-chambered locks serve to raise and lower ships on the water between the river Elbe and the Baltic Sea. But these aging locks are in urgent need of maintenance and repair – a project that will take years to complete. And any slowdown or stoppage at this key junction point is simply unthinkable. Thus, a bypass is being built at the site, in the form of a fifth lock chamber. The project is taking place on the island between the "small" and "big" lock. The job calls for precision work, as to avoid any disruptions or, worse, damage to the existing locks on either side. Any shocks or tremors must be avoided.
Consequently, preparation of the new site did not begin as usual, with sinking of sheet piling with vibro machines or pile drivers. Instead, diaphragm walls were constructed using a special method for the building of locks and waterside walls that keeps ground shocks to a minimum. Prior to installation, a special digger was used to clear a 1.20 m x 8 m trench (in three shovel loads) to a depth of up to 40 m. At the same time an argillaceous suspension, the clay mineral (bentonite), was pumped for stability into the resulting shaft. This prevented cave-ins while the diaphragm slats were inserted. Highly precise work was a must to ensure that the overlapping slats created a perfectly plumb, gap-free wall.
When the shaft had been dug to the desired depth, a special cement was added to the suspension for concreting the bottom. 40-tonne pilings were lowered. Through progressive introduction of more cement into the suspension, a mix was created in the shaft, which, when hardened, provided strong support for the piling wall. Special measurement equipment and continuous monitoring of impacts on the neighbouring locks ensured maximum safety at the site.
An innovative approach has also been used for anchoring of the lock basin to the bed of the waterway – in order to keep shocks to an absolute minimum: concrete expansion anchors are being installed diagonally using high pressure injection (HPI) drilling to first create a 244 millimetre hole 30 to 40 metres deep in the ground. Then, the HPI drill injects a cement suspension at a pressure of nearly 400 bar into the surrounding earth. This erodes away soil and replaces it with cement – all precisely controlled by computer. The high pressure injection valves cut through the overburden, so that the suspension is mixed in with the native soil – which in Brunsbüttel consists mostly of sand and gravel – creating a concrete anchor roughly seven meters long with a diameter of 1.10 metres. Prior to hardening, ribbed steel reinforcement rods are inserted and the drill hole filled with a special cement suspension.

As many as 1,690 such anchors are planned for the lock basin. And because it is meant to last for at least the next 100 years, the Federal Waterways Engineering and Research Institute (Bundesanstalt für Wasserbau – BAW) has imposed high geometric and material standards on the project. To ensure that these requirements would be met, the construction consortium thoroughly tested the anchor making process prior to the start of building. Site manager Sebastian Grote explains: "There is no standard solution for a project like this. Throughout the testing, we adjusted parameters such as pump pressure, pumped volume, drilling and transport speeds in close coordination with BAW and the maritime affairs office, in order to ensure that the necessary standards of quality and stability are met."
The bypass is to be ready, the fifth lock chamber completed, within five years. And, at a length of 350 m, it will be a full 20 m longer than the current "big" lock. This will make it possible for even larger ships to take advantage of the well-travelled shortcut through the canal.
Heidelberg Cement supplies several CEM III cement types, in total about 35,000 tonnes, and about 15,000 tonnes diaphragm wall suspension for this project.

Panama Canal Chapter 5.4.

Panama Canal, Spanish Canal de Panamá, lock-type canal, owned and administered by the Republic of Panama, that connects the Atlantic and Pacific oceans through the narrow Isthmus of Panama. The length of the Panama Canal from shoreline to shoreline is about 40 miles (65 km) and from deep water in the Atlantic (more specifically, the Caribbean Sea) to deep water in the Pacific about 50 miles (82 km). The canal, which was completed in August 1914, is one of the two most strategic artificial waterways in the world, the other being the Suez Canal. Ships sailing between the east and west coasts of the United States, which otherwise would be obliged to round Cape Horn in South America, shorten their voyage by about 8,000 nautical miles (15,000 km) by using the canal. Savings of up to 3,500 nautical miles (6,500 km) are also made on voyages between one coast of North America and ports on the other side of South America. Ships sailing between Europe and East Asia or Australia can save as much as 2,000 nautical miles (3,700 km) by using the canal.

Houston Ship Channel Chapter 5.5.

The channel is a widened and deepened natural watercourse created by dredging Buffalo Bayou and Galveston Bay. The channel's upstream terminus lies about four miles east of downtown Houston, at the Turning Basin, with its downstream terminus at a gateway to the Gulf of Mexico, between Galveston Island and the Bolivar Peninsula. Major products, such as petrochemicals and Midwestern grain, are transported in bulk together with general cargo. The original watercourse for the channel, Buffalo Bayou, has its headwaters 30 miles (48 km) to the west of the city of Houston. The navigational head of the channel, the most upstream point to which general cargo ships can travel, is at Turning Basin in east Houston.
The channel has numerous terminals and berthing locations along Buffalo Bayou and Galveston Bay. The major public terminals include Turning Basin, Barbours Cut, and Bayport. Many private docks are there, as well, including the ExxonMobil Baytown Complex and the Deer Park Complex.
The channel, occasionally widened and deepened to accommodate ever-larger ships, is 530 feet (160 m) wide by 45 feet (14 m) deep by 50 miles (80 km) long. The islands in the ship channel are part of the ongoing widening and deepening project. The islands are formed from soil pulled up by dredging, and the salt marshes and bird islands are part of the Houston Port Authority's beneficial use and environmental mitigation responsibilities.
The channel has five vehicle crossings: Washburn Tunnel, Sidney Sherman Bridge, Sam Houston Ship Channel Bridge, popularly known as the Beltway 8 Bridge; Fred Hartman Bridge connecting La Porte and Baytown, Texas; and Lynchburg Ferry.

Welland Canal Chapter 5.6.

The Welland Canal, one of the amazing man-made wonders of the world, which was originally constructed in 1829 to link Lake Erie with Lake Ontario and offer ships a safe detour around Niagara Falls.
The Welland canal is simply amazing. The first impression of a modern lake-faring freighter is of its overwhelming size. It doesn't seem possible that something of such immense proportions could even be built, much less be able to dock, load, and sail the lakes. Yet dozens of lakers and "salties" (sea going ships) ply up and down the Welland Canal every day, casting enormous shadows as they cruise incongruously past lush orchards and vineyards.

Longer than two football fields and weighing more than 30,000 tonnes, how is it possible to lift these behemoths up and over the cliff face of the Niagara Escarpment? Not only is this done on a routine basis, but the technology is so simple that ships have been routinely hoisted up and down the escarpment for over 150 years.
The Welland Canal has a long and colourful history. Engineers discovered the trick long ago - let gravity and water do the work. The locks are filled and emptied by water flowing downhill from Lake Erie toward Lake Ontario. Many fascinating hours can be spent watching how the gates are opened and shut to control the water flow, allowing ponderous monsters from all corners of the world to sail into the middle of the North American continent.

White Sea–Baltic Canal Chapter 5.7.

On August 2, 1933 was opened the White Sea-Baltic waterway which was named the Stalin White Sea–Baltic Canal.
The construction of the White Sea–Baltic Canal, which connected the White Sea with Lake Onega, was commenced by Joseph Stalin’s initiative in 1931. The canal was built by the forced labor of the White Sea – Baltic corrective labor camp operating on the basis of the Solovki camp.

The construction was conducted in secrecy and was directed by the heads of People’s Commissariat of Internal Affairs of the USSR. Due to ruthless exploitation of

approximately 280 thousand of GULAG prisoners, mainly kulaks (relatively affluent peasants), who only used hand tools, practically no machines, it became possible to meet record-breaking canal construction deadline. For instance, the Panama Canal's construction (length 80 km) was completed within 28 years, the Suez Canal (160 km) — within 10 years, and it took only 1 year and 9 months to finish the White Sea - Baltic Canal, 227 km long.
On October 16 1931 simultaneously along the whole length of the future waterway, from Povenets settlement on Lake Onega, to the Soroka settlement (Belomorsk) on the White Sea, were launched rock and earthworks.
From 1931 to 1933 the construction was directed by N. A. Frenkel. It was this man who is considered to come up with an idea of using cheap convicts' workforce on major national economic construction projects. According to different sources, from 50 to 200 thousand people perished of privations and hard labor.
On August 2 1933 the construction of the White Sea - Baltic waterway was finished, and already in May 1933 first steamships were launched through the new canal, whereas an official inauguration ceremony of the first shipping navigation kicked off on August 30 1933.
Creation of a strong transport route with a complex of sophisticated hydro-engineering constructions (locks, dykes, floodgates, dams and artificial canals) guaranteed an establishment of direct water communication between the Baltic Sea and the North, what enabled to eliminate the need of delivering natural resources of the Kola Peninsula and Karelia to the processing sites via circuitous routes bypassing the Scandinavian Peninsula and provided an opportunity to exploit wood, minerals, ore, fish and other natural wealth of that land.
During the years of the Great Patriotic War the canal being of great strategic importance underwent destruction, its southern part was completely destroyed. After the war the damaged units were restored, and in July 1946 the canal was brought into operation again. In '50s the work on electrification of its structures and mechanisms was launched.
Today there is a historical and cultural complex "The White Sea – Baltic Canal" operating on the basis of the canal, which represents a system of hydro-engineering structures, houses and administrative buildings, memorial places of forced labor and burial places of perished canal's builders.

Volga-Don Canal — Chapter 5.8.

International Marine Consultancy has extensive experience transporting equipment (tugs, barges, dredgers, etc.) through the Volga-Don Canal. Local partners provide the neccessary supporting services (tug assistance, pilotage, custom formalities, etc.). Have you got cargo that needs to go to the Caspian? Contact us today for a free quote!
The Volga-Don Canal, a canal, which connects the Volga River and the Don River at their closest points. The length of the waterway is 101 km (45 km through rivers and reservoirs).
The problem of connecting the two rivers goes back a long way in history. First canal work was done by the Ottoman Turks in 1569. Peter the Great made an unsuccessful attempt to build a canal in the late 17th century. Later on, they would come up with several more projects for connecting these rivers, however, they would never be carried out.

The actual construction of the Volga-Don Canal began prior to the Great Patriotic War of 1941-1945, which would interrupt the process. In 1948-1952 the construction was completed. During this period, the canal and its facilities were predominantly built by prisoners, who were detained in several specially organized corrective labor camps. By 1952, the number of forced laborers occupied on the site topped 100,000.

Upon completion, the Volga-Don Canal became an important link of the unified deep-water transportation system of the European part of the USSR. It starts at the Sareptsky backwater on the Volga River (south of Volgograd) and ends in the Tsimlyansk Reservoir of the Don River at the town of Kalach-na-Donu. The canal has nine one-chamber canal locks on the Volga slope, which can raise ships 88 m, and four canal locks of the same kind on the Don slope, which can lower ships 44 m. The overall dimensions of the canal locks are smaller than of those on the Volga River, however, they can make way for ships with up to 5,000-tonne cargo capacity. The plan dimensions of locks on the lower Don and the Volga-Don canal are 145 m x 17-18 m and, on the Volga, 290 m x 30 m. There are depth limitations on the lower Don between the town of Kalach and the town of Azov, because of the reduced depth at the sill of Kochetov lock (3.60 metres), and also on the Volga, over the sector Gorodets-Nizhny Novgorod, because of the insufficient depth (3.50 metres) in the lower pond of Gorodets lock.

Saint Lawrence Seaway Chapter 5.9.

The St Lawrence Seaway (Great Lakes Waterway) is the system of locks, canals and channels linking the Great Lakes and the St Lawrence River with the Atlantic Ocean.

St Lawrence Seaway

The Saint Lawrence Seaway (Great Lakes Waterway) is the system of locks, canals and channels linking the Great Lakes and the St Lawrence River with the Atlantic Ocean. The construction of progressively larger canals along the St Lawrence River began as early as 1783. By 1900, a complete network of shallow draft canals allowed uninterrupted navigation from Lake Superior to Montréal.

The waterway, some 3,700 km long from Île d'Anticosti to the head of Lake Superior, permits vessels of up to 225.5 m long, 23.8 m wide and a maximum draft (i.e., the distance between the top of the water and the bottom of the ship) of 8.1 m to sail from Montréal to Duluth, Minnesota, on Lake Superior. The majority of the cargo moving through the Seaway is iron ore, coal and other mine products, followed by agricultural goods, other bulk cargo (e.g., petroleum products and cement) and finished goods (e.g., iron and steel). Approximately 44 million tonnes of cargo moves through the Seaway annually, in contrast with the annual average of about 11 million tonnes in the 1950s.

Between 1913 and 1932, the Welland Canal (between Lakes Erie and Ontario) was rebuilt, but the United States was reluctant to enter a larger scheme, that is, to rebuild the Montréal–Lake Ontario channels. A threat by the Canadian government in 1951 to build a seaway entirely within Canadian territory resulted in a final agreement in 1954. Construction on the St Lawrence Seaway and Power Project began on 10 August 1954. In addition to the building of seven locks and deepening navigation channels to a depth of 8.2 m, the project also included the construction of the 2,090 megawatt Moses-Saunders Powerhouse near Cornwall, Ontario. The Seaway was opened to commercial traffic 25 April 1959. The official opening on 26 June 1959 was attended by Prime Minister John Diefenbaker, President Dwight D. Eisenhower and Queen Elizabeth II.

Italian labourers constructing the Welland Canal in Ontario. April 17th, 1914. \r\nImage: John Boyd/Library and Archives Canada/PA-061139.\r\n
Construction of the Seaway was a monumental engineering and construction feat. In addition to the primary works required to create the Seaway, ancillary works, such as major bridge and tunnel construction, were carried out in Montréal, Beauharnois, Cornwall and Massena. Moreover, the creation of Lake St Lawrence resulted in the flooding of 15,400 hectares and necessitated the relocation of highways, nine small communities, and parts of the towns of Iroquois and Morrisburg, Ontario. In all over 525 dwellings and 6,500 people, 64 km of railway track and 56 km of highway were relocated, and two new communities in Ontario, Ingleside and Long Sault, were created. (See also The Lost Villages.)

The St Lawrence Seaway Authority, a federal crown corporation, was established by Act of Parliament in 1954 to construct, operate and maintain the Canadian portion of the waterway between Montréal and Lake Ontario, including the locks in Canadian territory (five of the seven) and also the Welland Canal. In 1998, an Act of Parliament allowed for the Canadian part of the Seaway to be operated by Seaway users and other stakeholders as a not-for-profit corporation (St Lawrence Seaway Management Corp) under contract to the Canadian government.
The US government formed the St Lawrence Seaway Development Corp to operate the two locks near Massena, New York. The four US locks on the St Mary’s River are operated by the US Corps of Engineers.
Sections
The Montréal–Lake Ontario section, which is often thought of as the whole Seaway, naturally divides into four parts: the Lachine, Soulanges, Lake St Francis and International Rapids sections. The Lachine section includes the 33 km South Shore Canal, with the St Lambert and Côte Ste Catherine locks bypassing the Lachine Rapids. The two locks provide a total lift of 13.7 m to the level of Lake St Louis.

Danube-Black Sea Canal — Chapter 5.10.

I have always had the feeling that talking about communism is rather taboo in Romania. The academic year would always end before we reached 1947 in history class. As such, I am reluctant to dive into such a sensitive subject. But here I stand, after reading an interview from a dear family friend that was a political prisoner in the early 1950s,

understanding that such things must be shared so that they do not happen again. By no means do I claim to understand or ever be able to understand what happened in my country before I was born, but I am able to take further the memory of those who do.
The Danube is the biggest river in Europe. If flows from Germany to the Black Sea which makes it a rather important route for maritime transport between the Black Sea and the North Sea. The river forms a delta in Romania which was considered historically hard to navigate. With the general geographic idea settled, it is time to introduce the grand project of constructing the Danube-Black Sea canal.
Serious talks about the construction of the canal started in 1829, initiated by the DDSG (Donau-Dampfschiffahrts-Gesellschaft), which argued that it would be prosperous for the development of maritime transportation on the last 100km of the Danube. The idea of economic prosperity brought around by the canal was kept alive in the heart of Central Europe until finally being materialized in 1949.
Communism was installed in Romania in 1947 with more reluctance that it is usually believed. Gheorghe Gheorghiu-Dej, General Secretary of the Romanian Communist Party, believed that the best way to ensure its success was to stop anybody who even remotely opposed it. The mentorship relationship with Stalin was a determinant in his policy, and it is believed that Stalin himself suggested the start of the construction of the Canal by drawing a red line between Cernavodă and Năvodari. Combining the two, Gheorghiu-Dej named the construction of the canal "the grave of Romanian bourgeoise".

Finding the middle ground between imprisonment and economic prosperity through maritime transport, labor camps were created in the site of the canal. Filled with Romanian intellectuals, peasants who were not willing to give out their land, and numerous members of the clergy, the number of political prisoners as a percentage of the workers for the canal rose from 19.7% to over 80% in just three years.
Little food, the harsh Romanian winter, and the miserable working conditions brought around the death of thousands. Numbers vary with sources, but regardless, it created much pain and suffering. In a period of post-war famine and poverty, Romania was not prepared technologically and economically for taking on such an ambitious project. The

techniques used to dig the canal were plain rudimentary. With shovels, axes, and any other materials that the Soviet Union handed in, the construction of the canal was in effect, what Dej planned from the start: a communal grave.
The February of 1953 brought around the death of Stalin and a complete shift in the Romanian-Soviet relationships. Thus, the work was suspended for 23 years, and Gheorghiu Dej started following a semi-autonomous policy. Unfortunately, this was not the end of labor camps and unjust imprisonment, strict supervision of the population being the instrument of choice for regime stability until Dej's death in 1965.
A sequence of reforms and political tumult followed in the Romanian Communist Party (Partidul Comunist Român/PCR), which ultimately resulted in the instauration of the Ceausescu dictatorship. A situation which was at first seen as a small step forward ended up being two backwards. The oppression slowly escalated until the fall of communism in December 1989.
During 1973, a proposed plan from PCR to finish the construction of the canal was accepted. The canal became fully functioning in May 1984. Its cost was 2.2 billion dollars and a spot of blood in Romanian history.
"Dupa cum veti vedea, nu este vorba de un simplu canal, unde curge apa si pe unde se fac transporturi ieftine, ci este vorba de un complex de lucrari menite sa transforme total aceasta regiune care va fi scaldata de acest canal" ("As you will see, it is not just a canal that will bring cheap transportation. It is a complex work with the intent of fully transforming the region in which this water flows")-Gheorghe Gheorghiu-Dej, in ministry meeting, 25.09.2018-
The canal not only changed the region of Southern Dobrogea, but it changed the whole country. It was a weapon in a relentless war against free thinking and opposition. Instead of only the flow of shifting the flow of the Danube, it changed the flow of the downward spiral in which Romania was to enter for 42 years. Today, the 100km canal is in need of further restoration that has an estimated cost of another 1.5billion dollars, and no projects seem to have been initiated for any reparations. In 2015, it reported a considerable profit and was expected to experience further growth. Maritime transportation is still one of the cheapest ways of shipping goods, but at the rate of technological advancements, it is hard to say it is still sustainable in the long term.
An idea that could have been so economically beneficial during XXth century Europe managed to become a terror instrument in an unwanted regime. Like many instances throughout economic history, human sacrifice seemed to have defined the image of what could have been an ambitious project. As such, the Danube-Black Sea canal did not deliver as promised. The region was not flooded by economic prosperity and industrialization but flooded with the blood of those who had the courage to oppose. Like all the other communist projects in Romania, the walls of the canal are a ruin and a scar of a forced industrialization era.

Rhine-Main-Danube Canal Chapter 5.11.

The Rhine–Main–Danube Canal (German: Rhein-Main-Donau-Kanal; also called Main-Danube Canal, RMD Canal or Europa Canal), in Bavaria, Germany, connects the Main and the Danube rivers across the European Watershed, running from Bamberg via Nuremberg to Kelheim. The canal connects the North Sea and Atlantic Ocean to the Black Sea, providing a navigable artery between the Rhine delta (at Rotterdam in the Netherlands), and the Danube Delta in south-eastern Romania and south-western Ukraine (or Constanța, through the Danube–Black

Sea Canal). The present canal was completed in 1992 and is 171 kilometres (106 mi) long.

The first concrete plans for the new waterway emerged in 1938, for the so-called Mindorfer Linie south of Nuremberg. As early as 1939 the first preparatory work began at Thalmässing in Landkreis Roth. However, after the war this route was dropped. By 1962, the Main's channel had been expanded as far upstream as Bamberg. In 1966, the Duisburger Vertrag, an agreement between Bavaria and the Federal Republic of Germany, was reached for financing the completion of the project. The contract was signed on 16 September of that year in Duisburg by Federal Transport Minister Hans-Christoph Seebohm, Federal Finance Minister Rolf Dahlgrün, Bavarian Prime Minister Alfons Goppel and the Bavarian Finance Minister Konrad Pöhner.

The last section to be built, between Nuremberg and Kelheim, became politically controversial in the 1970s and 1980s, mainly because of the 34-kilometre (21 mi) long section through the Altmühl valley. On 25 September 1992, the canal was completed. The equivalent of some 2.3 billion euros were invested in the construction from 1960 to 1992. Almost 20 percent of that went for environmental protection projects.

The cross-section of the waterway is normally trapezoidal, with 31 metres (102 ft) width at the bottom, 55 metres (180 ft) width at the water surface, 4 metres (13 ft) of water depth, and a side grade of 1:3 (i.e., 4x3x2=24 which is just the difference between top and bottom widths). The channel is a Waterway Class Vb; the largest authorised vessel is 190 metres (620 ft) long and 11.45 metres (37.6 ft) wide. The channel in the Kelheim-bound Bamberg lock has a depth of 2.70 metres (8.9 ft). In the few sections with a rectangular profile, the width is usually 43 metres (141 ft) (i.e., the mean between top and bottom widths).
The length of the canal is 171 kilometres (106 mi); the summit elevation (between the Hilpoltstein and Bachhausen locks) is 406 metres (1,332 ft) above sea level. This is

the highest point on Earth that is currently reached by commercial watercraft from the sea.
The height difference along the north ramp of the canal—from the Main at Bamberg to the crest elevation—is 175 metres (574 ft), with 11 locks. From the crest elevation down to the Altmühl at Dietfurt is a drop of 51 metres (167 ft) through three locks. The further difference in elevation of 17 metres (56 ft) along the Altmühl, with two more locks, makes a total of 68 metres (223 ft) for the south ramp. This means that the Danube end of the canal is 107.3 metres (352 ft) above the level of the Main end.

Maritime transport CHAPTER 6

Maritime/Ocean transport, fluvial transport, or more generally waterborne transport is the transport of people (passengers) or goods (cargo) via waterways. Freight transport by sea has been widely used throughout recorded history. The advent of aviation has diminished the importance of sea travel for passengers, though it is still popular for short trips and pleasure cruises. Transport by water is cheaper than transport by air, despite fluctuating exchange rates and a fee placed on top of freighting charges for carrier companies known as the currency adjustment factor (CAF).

Maritime transport can be realized over any distance by boat, ship, sailboat or barge, over oceans and lakes, through canals or along rivers. Shipping may be for commerce, recreation, or for military purposes. While extensive inland shipping is less critical today, the major waterways of the world including many canals are still very important and are integral parts of worldwide economies. Virtually any material can be moved by water; however, water transport becomes impractical when material delivery is time-critical such as various types of perishable produce. Still, water transport is highly cost effective with regular schedulable cargoes, such as trans-oceanic shipping of consumer products – and especially for heavy loads or bulk cargos, such as coal, coke, ores, or grains. Arguably, the industrial revolution took place best where cheap water transport by canal, navigations, or shipping by all types of watercraft on natural waterways supported cost effective bulk transport.

Containerization revolutionized maritime transport starting in the 1970s. "General cargo" includes goods packaged in boxes, cases, pallets, and barrels. When a cargo is carried in more than one mode, it is intermodal or co-modal.

Merchant shipping: A nation's shipping fleet (merchant navy, merchant marine, merchant fleet) consists of the ships operated by civilian crews to transport passengers or cargo from one place to another. Merchant shipping also includes water transport over the river and canal systems connecting inland destinations, large and small. For example, during the early modern era, cities in the Hanseatic League began taming Northern Europe's rivers and harbors. And, for instance, the Saint Lawrence Seaway connects the port cities on the Great Lakes in Canada and the United States with the Atlantic Ocean shipping routes; while the various Illinois Canals connect the Great Lakes and Canada with New Orleans. Ores, Coal, and grains can travel along the rivers of the American mid-west to Pittsburgh, or Birmingham. Professional mariners are merchant seaman, merchant sailor, and merchant mariner, or simply seaman, sailor, or mariners. The terms "seaman" or "sailor" may refer to a member of a country's navy.

According to the 2005 CIA World Factbook, the total number of merchant ships of at least 1,000 gross register tons in the world was 30,936. In 2010, it was 38,988, an increase of 26%. As of December 2018, a quarter of all merchant mariners were born in the Philippines.[4] Statistics for individual countries are available at the list of merchant navy capacity by country.

Importance CHAPTER 7

Canal de Castilla in Castile and León, Spain, has 207 kilometers, crossing 38 municipalities, initially to transport wheat, now it is used for irrigation.

Historically canals were of immense importance to commerce and the development, growth and vitality of a civilization. In 1855 the Lehigh Canal carried over 1.2 million tons of anthracite coal; by the 1930s the company which built and operated it over a century pulled the plug. The few canals still in operation in our modern age are a fraction of the numbers that once fueled and enabled economic growth, indeed were practically a prerequisite to further urbanization and industrialization. For the movement of bulk raw materials such as coal and ores are difficult and marginally affordable without water transport. Such raw materials fueled the industrial developments and new metallurgy resulting of the spiral of increasing mechanization during 17th–20th century, leading to new research disciplines, new industries and economies of scale, raising the standard of living for any industrialized society.

The surviving canals including most ship canals, today primarily service mostly bulk cargo and large ship transportation industries, whereas the once critical smaller inland waterways conceived and engineered as boat and barge canals have largely been supplanted and filled in, abandoned and left to deteriorate, or kept in service and staffed by state employees, where dams and locks are maintained for flood control or pleasure boating. Their replacement was gradual, beginning first in the United States in the mid-1850s where canal shipping was first augmented by, then began being replaced by using much faster, less geographically constrained & limited, and generally cheaper to maintain railways.

By the early 1880s, canals which had little ability to economically compete with rail transport, were off the map. In the next couple of decades, coal was increasingly diminished as the heating fuel of choice by oil, and growth of coal shipments leveled off. Later, after World War I when motor-trucks came into their own, the last small U.S. barge canals saw a steady decline in cargo ton-miles alongside many railways, the flexibility and steep slope climbing capability of lorries taking over cargo hauling increasingly as road networks were improved, and which also had the freedom to make deliveries well away from rail lined road beds or ditches in the dirt which couldn't operate in the winter.

At their simplest, canals consist of a trench filled with water. Depending on the stratum the canal passes through, it may be necessary to line the cut with some form of watertight material such as clay or concrete. When this is done with clay, it is known as puddling. The Corinth Canal seen from the air.

Canals need to be level, and while small irregularities in the lie of the land can be dealt with through cuttings and embankments, for larger deviations other approaches have been adopted. The most common is the pound lock, which consists of a chamber within which the water level can be raised or lowered connecting either two pieces of canal at a different level or the canal with a river or the sea. When there is a hill to be climbed, flights of many locks in short succession may be used.

Prior to the development of the pound lock in 984 AD in China by Chhaio Wei-Yo and later in Europe in the 15th century, either flash locks consisting of a single gate were used or ramps, sometimes equipped with rollers, were used to change the level. Flash locks were only practical where there was plenty of water available.

Locks use a lot of water, so builders have adopted other approaches for situations where little water is available. These include boat lifts, such as the Falkirk Wheel, which use a caisson of water in which boats float while being moved between two levels; and inclined planes where a caisson is hauled up a steep railway.

To cross a stream, road or valley (where the delay caused by a flight of locks at either side would be unacceptable) the valley can be spanned by a navigable aqueduct – a famous example in Wales is the Pontcysyllte Aqueduct (now a UNESCO World Heritage Site) across the valley of the River Dee.

Another option for dealing with hills is to tunnel through them. An example of this approach is the Harecastle Tunnel on the Trent and Mersey Canal. Tunnels are only practical for smaller canals.

Some canals attempted to keep changes in level down to a minimum. These canals known as contour canals would take longer, winding routes, along which the land was a uniform altitude. Other, generally later, canals took more direct routes requiring the use of various methods to deal with the change in level.

Canals have various features to tackle the problem of water supply. In cases, like the Suez Canal, the canal is simply open to the sea. Where the canal is not at sea level, a number of approaches have been adopted. Taking water from existing rivers or springs was an option in some cases, sometimes supplemented by other methods to deal with seasonal variations in flow. Where such sources were unavailable, reservoirs – either separate from the canal or built into its course – and back pumping were used to provide the required water. In other cases, water pumped from mines was used to feed the canal. In certain cases, extensive "feeder canals" were built to bring water from sources located far from the canal.

Where large amounts of goods are loaded or unloaded such as at the end of a canal, a canal basin may be built. This would normally be a section of water wider than the general canal. In some cases, the canal basins contain wharfs and cranes to assist with movement of goods.

When a section of the canal needs to be sealed off so it can be drained for maintenance stop planks are frequently used. These consist of planks of wood placed across the canal to form a dam. They are generally placed in pre-existing grooves in the canal bank. On more modern canals, "guard locks" or gates were sometimes placed to allow a section of the canal to be quickly closed off, either for maintenance, or to prevent a major loss of water due to a canal breach.

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