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EUROPEAN INDUSTRIAL HERITAGE: THE INTERNATIONAL STORY

Co-funded by the
Creative Europe Programme
of the European Union





Imprint

European Industrial Heritage: The International Story

This brochure is published by ERIH,
the tourism information network of industrial heritage in Europe

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With the support of the Creative Europe Programme of the European Union

3rd edition 2021

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ERIH Anchor Point





European Industrial Heritage: The International Story

Introduction

From its very beginning, industrialisation has crossed borders - it was never a purely national phenomenon. Since the mid-18th century new technologies and methods of production spread rapidly across Europe. Manufacturers built their factories in different countries and generated massive profits, and thousands of workers migrated to the emerging industrial areas. Trade unions fought successfully for workers rights which became embedded in the European welfare state of today. It was on these foundations that modern Europe was established, characterised by its great economic prosperity and its high standards of social and medical care.

Every town, every industrial monument, and every workers' estate was, and still is, part of this process that started in Europe and subsequently spread across the world. But most visitors are still unaware of this. The closely connected network of European industrial regions that continue to inspire and strengthen each other is something that is rarely presented today at most industrial monuments and attractions.

This must change! The ERIH network uncovers the European dimension of industrialisation, offering a hands-on experience of our collective European history. On the ERIH website more than 2.000 sites in 47 European countries invite visitors to discover the variety of themes and stories that together make up our industrial heritage. Over 100 Anchor Points, 20 Regional Routes and 16 Theme Routes currently present the legacy of industrialisation as a mosaic. The aim is that every ERIH site will in future present their part of this mosaic and give visitors an insight into the various European links and interconnections. ERIH is supported in this by the European Commission's framework programme 'Creative Europe' which acknowledges the network's contribution to the conservation and presentation of European industrial heritage and is funding its activities since the year 2014.

This funding has enabled the production of this brochure which aims to encourage ERIH sites to present the European dimension of industrialisation to their visitors. Like the ERIH theme routes, the brochure outlines the history of the various industrial sectors, thus creating an exciting European narrative. Of course this is not intended to be exhaustive. Rather, it seeks to encourage its readers to focus particularly on the transnational aspects of European industrial heritage and provide ideas for including the international story in the sites' presentations.

This brochure is a first step in presenting this complex subject and we look forward to receiving amendments and ideas to continue telling this exciting story.

European industrial heritage: the international story. awareness.



New destinations for family outings and educational visits have appeared over the past half-century. Princely palaces with their accumulations of old masters and fine furniture, elegant parks, and waterfalls cascading from mountains have been joined by show mines, steam railways, trip boats on canals, water- and wind-mills that still grind flour, and former textile mills adapted to accommodate concerts or exhibitions. The industrial heritage is no longer a minority interest, but has taken its place with aristocratic mansions and captivating scenery as

something that many people wish to experience.

Industrial buildings have been conserved and museums of industry established by varied agencies; by groups of former workers, by national and local government bodies of all political shades, by companies respectful of their traditions and, above all, by voluntary groups determined that the histories of their communities should not be lost.

It is ironic that the popularity of industrial heritage has increased as Europe's relative standing in the global pattern of

mining and manufacturing has diminished. Industry has ancient origins but it grew to dominate the economies of most European countries from the eighteenth century. In the early twenty first century we are witnessing the closure of the last deep coal mines in Western Europe, and the colossal machines recently used to extract brown coal have quickly become redundant. Huge plants that seemed eternal, ironworks, oil refineries, car plants, are coming to the ends of their days. Even sites and machines that seemed characteristic of the late twentieth century are become part of the heritage. In Hungary there is a museum of nuclear power generation, while Concorde supersonic airliners are displayed in museums in France and Great Britain. As industrial communities seek different directions they are aware that new growth may derive benefits from roots in the past. The European Route of Industrial Heritage exists to enable Europeans to share their past experiences of mining and manufacturing, and to show how we made things and how we moved them in recent centuries.

The ERIH website offers practical assistance for travellers. It also enables its readers to venture in imagination to the most distant parts of Europe. Those who study the website follow in the footsteps of travellers whose writings open up our understanding of the industrial past. The Swede Reinhold Rücker Angerstein 1718–60, who visited England in 1753–55 provides a fascinating description of a country on the verge of industrial revolution. Arthur Young (1741–1820) the English agriculturalist, observed changes in culture as he passed from Lorraine into Alsace in 1789 (when he reached Stras-



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burg he learned of the storming of the Bastille), and provided a motto for every archaeologist, *'so much more powerful are things than words'*. Karl Friedrich Schinkel (1781–1841), the great Prussian architect, was excited to see the Menai Suspension Bridge and the Pontcysyllte Aqueduct in North Wales in 1826. In 1844 Carl Gustaf Carus (1789–1869), physician to King Friedrich Augustus II of Saxony, went out at night in the company of his royal master to see the pyrotechnics provided by ironworks at Merthyr in South Wales. Friedrich Engels (1820–95)

and Alexis de Tocqueville (1805–59) wrote the classic accounts of 'Little Ireland' the worst slums in Manchester, and Thomas C Banfield in 1848 described in detail the agriculture and manufactures along the River Rhine. ■



Essen (D)
Zollverein Cooking Plant.
Illumination. WHS

Le Bourget (F)
Air and Space Museum.
Condoré



Petite Rosselle (F)
Parc Explor Wendel



Ostrava (CZ)
Vitkovice Ironworks.
Gasholder. Reconversion
in Multi-Purpose Hall

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Europe before factories.



We Europeans live in a world where most of the domestic gadgets that we use, the electronic devices that provide us with entertainment and means to contact our friends, the clothes we wear, the books we read even much of the food we eat is made in factories and is carried long distances to reach us. It is difficult to imagine a world in which this was not so.

Even in prehistoric times some places specialised in the production of certain goods that were traded over long distances. The trading links of the Roman Empire are exemplified in the

Samian ware from southern France and the Rhineland found in Great Britain, and the amphora that brought to northern Europe wine and olive oil from the Mediterranean lands. Metals have been mined, smelted and made into useful objects in the Erzgebirge, the Harz Mountains and at Falun over many centuries. Woollen cloth and salt were traded over long distances in the middle ages, and the consequence of the voyages of discovery of the fifteenth and sixteenth centuries was the flow into Europe of such things as silk, coffee, potatoes, porcelain and spices that in the long term were to make great changes in the lives of Europeans. Nevertheless it is in the Industrial Revolution of the eighteenth century that we can see the beginnings of moves towards globalisation, as innovations made it possible to increase the output of iron, as the scale of coal-mining grew and the steam engine provided a new source of energy, as the production of textiles was concentrated in factories and as improved roads, canals and subsequently railways provided faster means of travelling for people and greater capacity for carrying goods.

We can best experience the nature of life before the Industrial Revolution in the open air museums of northern Europe. The great farmhouses from Westphalia displayed at Detmold, those from Flanders at Bokrijk, from the Netherlands at Arnhem, from Galicia at Sanok, or those in the Norwegian Folk Museum at Oslo or at Maihaugen at Lillehammer, were occupied by families who were to a large extent self-sufficient. Many such houses were occupied at one end by humans and by animals



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at the other. Families made cheese and butter from the milk given by their cows, they brewed beer from malt made from the barley they prepared and spun yarn from the wool sheared from their sheep or from flax and hemp grown around their farmsteads. They were dependent on some specialist craftsmen within their communities, on weavers who produced fabrics from their yarn, on woodworkers who made their furniture and smiths who forged their tools. Their grain was ground to flour by millers using water- or wind-power. Even in

prosperous areas some families did not enjoy the comforts of great farmhouses. They lived in ramshackle huts and may have starved in times of scarcity. Ways of living in southern Europe where families extracted oil from olives rather than making butter, and made wine rather than beer, were rather different, but they similarly lived lives that were in part self-sufficient. ■

Arnhem (NL)
Open Air Museum

Lillehammer (N)
Malhaugen Open Air Museum

Detmold (D)
LWL Open Air Museum (LWL)

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Long journeys in small ships: international trade.



Harlingen is a small port on the eastern side of the IJsselmeer (Zuyder Zee NL), now the ferry port for the West Friesian islands, which is rich in evidence of international trade in the seventeenth and eighteenth centuries. The harbour was then surrounded by shipyards, lime kilns, potteries and salt boiling pans, as well as the ships and drying sheds of the town's fishermen. The most telling evidence of international trade is warehouses that bear inscriptions showing that they served merchants trading to Russia, Poland, Java and Sumatra. The

links between Europe and distant parts of the world can also be experienced in the Netherlands at Enkhuizen, where a collection of historic vessels is displayed in the Peperhuis, a seventeenth-century East India Company warehouse, and at Zaanse Schans at Zaandam, where abundant wind power was employed to process many of the commodities brought in by local ships after voyages to the East. In Gothenburg (S) visitors can see the ship that takes its name from the city, a replica built in 1993 of a vessel belonging to the Swedish East India

Company that sank as it approached the harbour in 1745. The city museum is in the offices and warehouses built for the company between 1747 and 1762. Several western European countries established companies that traded or attempted to trade with China and other countries in the Far East, France, from the port of Brest, the Habsburg Empire from Antwerp, and Great Britain from London.

Many ports and trading cities in Europe had links with the Hanseatic League, an association of merchant guilds, chiefly from cities in Germany, which flourished between the thirteenth and fifteenth centuries, although it declined with the rise of Dutch naval power in the seventeenth century, and its governing body met for the last time in 1669. The League established a depot at Bergen (Norway) where smoked and dried fish, cod liver (or train) oil, and fish roes were collected in warehouses on the Tyskebryggen (German Quay) before being shipped to southern Europe in exchange for salt. A Hanseatic museum occupies one of the warehouses on the quay. The League provided markets for manufacturers in Germany, such as those who worked with wire in Altena in the Sauerland to make fastenings which were exported on a large scale to Scandinavia.

Many long-distance trading routes were established long before the Industrial Revolution of the eighteenth century, the carriage of grain and soft-woods to Western Europe from such Baltic ports as Gdansk, Riga and Memel (Klaipėda). There were also established patterns of trading that took wine and olive oil from the Mediterranean countries to the north. The notorious triangu-



lar trade that carried textiles and metal products to West Africa, black slaves to the Americas and sugar, cotton and other colonial produce back to Europe, is commemorated in the Museum of Slavery in Liverpool (GB).

Trading with distant parts of the world provided raw materials for manufacturers in Europe. By the beginning of the eighteenth century sugar, tea, coffee, tobacco, spices and dyestuffs were being processed around all the ports that were involved in long-distance trade. They changed many aspects of people's daily lives. ■

Bergen (N)
German Quay WHS



Zaandam (NL)
Zaanse Schans



The treasures of our earth.

The visitor approaching the great copper mine at Falun (Sweden) sees first a vast hole in the ground the result of a collapse in 1687. When he enters the building housing the company museum he sees a charter sealed on 16 June 1288, and artefacts relating to mining that are even older. These are salutary reminders that industry did not begin in the eighteenth century. Like other ancient sources of metallic ores Falun continued to be important through the Industrial Revolution and afterwards, and retains many buildings and struc-

tures from the eighteenth and nineteenth centuries, although the extraction of copper ceased in the last quarter of the twentieth century.

Non-ferrous metals served many purposes. Lead and tin were alloyed to make pewter, the material from which plates, dishes and tankards were made all over Europe. Brass, made from copper and zinc, was also found in the households of all but the poorest families. Gold and silver were, of course, used for coinage, as well as for luxury utensils.

Many minerals, ores of lead, silver, iron, zinc, tin, nickel, cobalt and uranium, have been mined in the Erzgebirge (the Ore Mountains) in Saxony, Germany, extending across the border of what is now the Czech Republic. Miners from the Harz Mountains began mining iron and silver ores in the Erzgebirge in 1168. Mining in the Erzgebirge reached a peak in the fifteenth and sixteenth centuries when it was illustrated by the Chemnitz physician Georgius Agricola (1494–1555) in his *De Re Metallica*. The principal museum of mining in the region is at Freiberg, where one of the oldest academies of mining was founded in 1765. Public ceremonies associated with mining continue to be observed, and traditional miners' uniforms are still worn on special occasions. The Abrahamschacht (Abraham pit) at Freiberg is a large complex of surface buildings dating from 1839, which includes sheds for ore dressing. The Alte Elisabeth mine is an inclined adit, sunk in the 1840s, where winding was carried out by a steam engine built by Constantin Pfaff of Chemnitz, installed in 1848–49. At Altenberg a museum of mining is located in a dressing plant for ore (*Pochwerk*) first mentioned in a document of 1577 which worked until 1952. It is the starting point for tours of the *Grosse Pinge*, a crater that resulted from mining, 12 ha in extent, 450m in diameter and 150m deep.

The history of mining in the Harz Mountains is illustrated in the twin towns of Clausthal and Zellerfeld, where there are extensive remains of sixteenth-century water power systems, and some surviving surface buildings including those of the Dorothee Mine of





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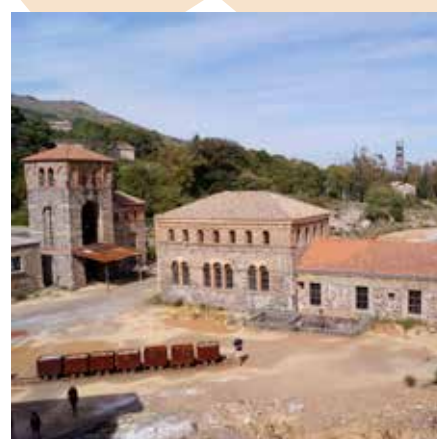
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1713, as well as the Upper Harz Mining Museum. At Goslar's Rammelsberg, visitors can see remarkably early mines, including the Rathstiefsten Drift of c. 1140 and the Feuerzäher Vault of c. 1360, as well as architecturally ornamented entrances to later adits, and an ore-dressing plant of 1936–38. The whole industry is interpreted in the museum and visitor mine at Rammelsberg.

Banská Štiavnica, in present-day Slovakia, has a similar history. The town was already renowned in the thirteenth century for producing silver, lead and iron ore. Part of the museum of mining is located in the *Kammerhof*, where ores were once assayed, and an open air museum displays headstocks, a reconstructed miner's cottage and locomotives, and offers extensive guided tours of a show mine.

The silver mines at Tarnowskie Góry near Katowice (Poland) also have medieval origins. Extraction ceased early in the twentieth century but the workings were opened for visitors from the 1950s. Visitors can now travel 1700m through underground workings, where

they can venture on a 270 m journey in a boat along a navigable level, one of the most outstanding experiences offered in any mining museum.

The *Erzberg* (Iron Mountain) in Austria, sometimes called the *Steirischen Brotlaib* (Styrian loaf of bread) was one of Europe's principal sources of ore from the twelfth century if not from the traditional date of its discovery in 712 AD. The long history of ore mining and smelting in the area is interpreted in the museum at Eisenerz and on the Styrian Iron Trail which guides visitors to industrial monuments along a 40 km route from Leoben to Hiefiau. ■



Eisenerz (A)
Ore Mountain



Falun (S)
Falun Mine WHS



Goslar (D)
Rammelsberg Museum
and Visitor Mine WHS



Tarnowski Góry (PL)
Historic Silver Mine WHS



Guspini (I)
Mines of Montevecchio

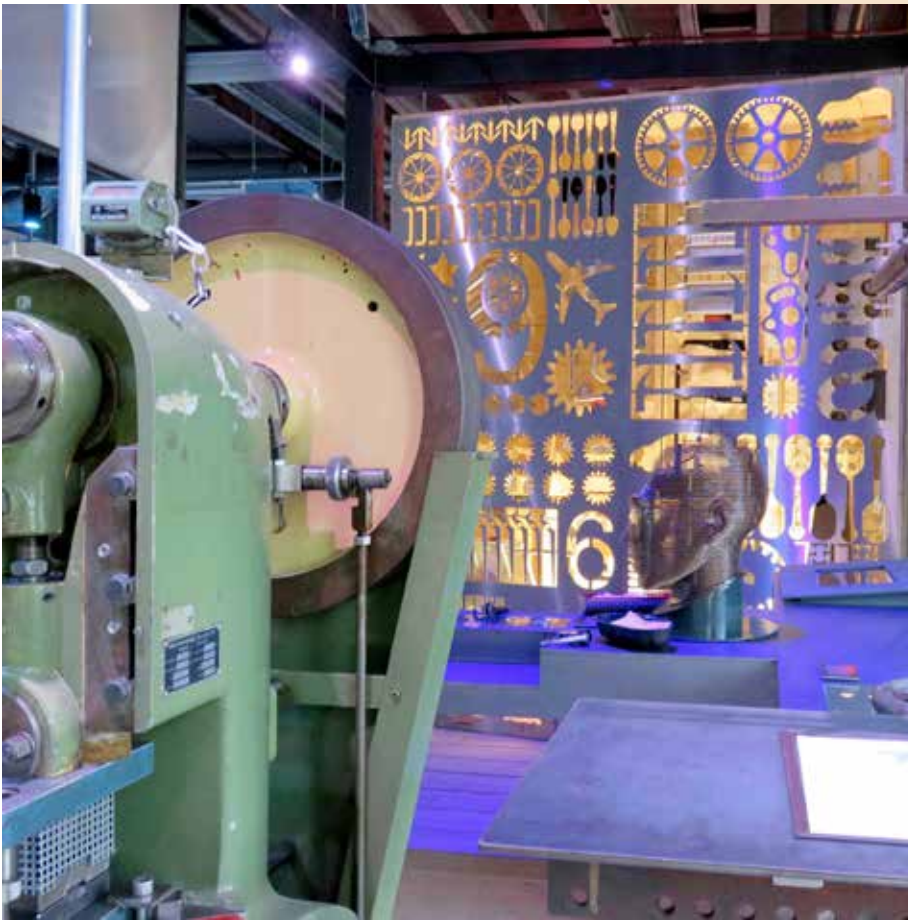


Rumelange (L)
National Mining Museum

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Long-lived manufactures.



Travel writers in England in the eighteenth century usually identified the 'manufactures' of towns they were describing, by which they meant goods made there that were traded in distant parts of the country or even exported, those items that were traded beyond 'the reciprocal dealings of the inhabitants'. Most substantial towns in eighteenth-century Europe produced some goods that were traded at a distance, and some had and have associations with particular trades that extend back many centuries.

Many towns specialised in the production of textiles, whether fabrics with particular characteristics, or such finished items as hosiery, carpets or lace. Others produced leather goods, gloves or whips, but the longest associations with particular manufactures relate to the forging of tools and similar items.

The German city of Solingen was celebrated in the middle ages for the making of weapons and cutlery. The industry was re-organised on a factory basis in the nineteenth century, and the landscape is dominated by large factories, but most

manufacturing was and is carried out in small workshops. Solingen was the world's largest producers of scissors which were the principal product at Hendrich's Drop Forge, a factory with 33 drop hammers, which worked between 1886 and 1986, and is now presented to the public. The Museum of Blades, located in a former Augustinian monastery, displays the whole range of items produced over many centuries by Solingen's metal workers, swords, daggers, medical instruments, domestic cutlery and knives for fairground knife throwers. The museum includes a pewter workshop, and one of its iconic exhibits is a pewter teapot.

The city of Steyr in Austria was the principal commercial centre for the Styrian iron trade. Edge tools, cutlery and nails were made there from the Middle Ages, and merchants' houses in the Gothic, Baroque and Classical styles witness to the prosperity of the town's trades. Metal working traditions were extended by the establishment of factories making bearings, bicycles and motor vehicles.

The English city of Sheffield has a similar history. It had abundant water-power and coal, and could readily import steel from Sweden. Many factories were established in the cutlery trade in the nineteenth century, but small workshops continued, and the trade of the 'little mesters' (small masters) who specialised in the making of particular kinds of knives, is demonstrated in the Kelham Island Museum. The process of making crucible steel, invented in Sheffield by Benjamin Huntsman (1704–76) can be studied at the Abbeydale Industrial Hamlet,

which also includes a scythe-making shop, while the Shepherd Wheel is a water-powered grinding shop typical of those used by 'little mesters'.

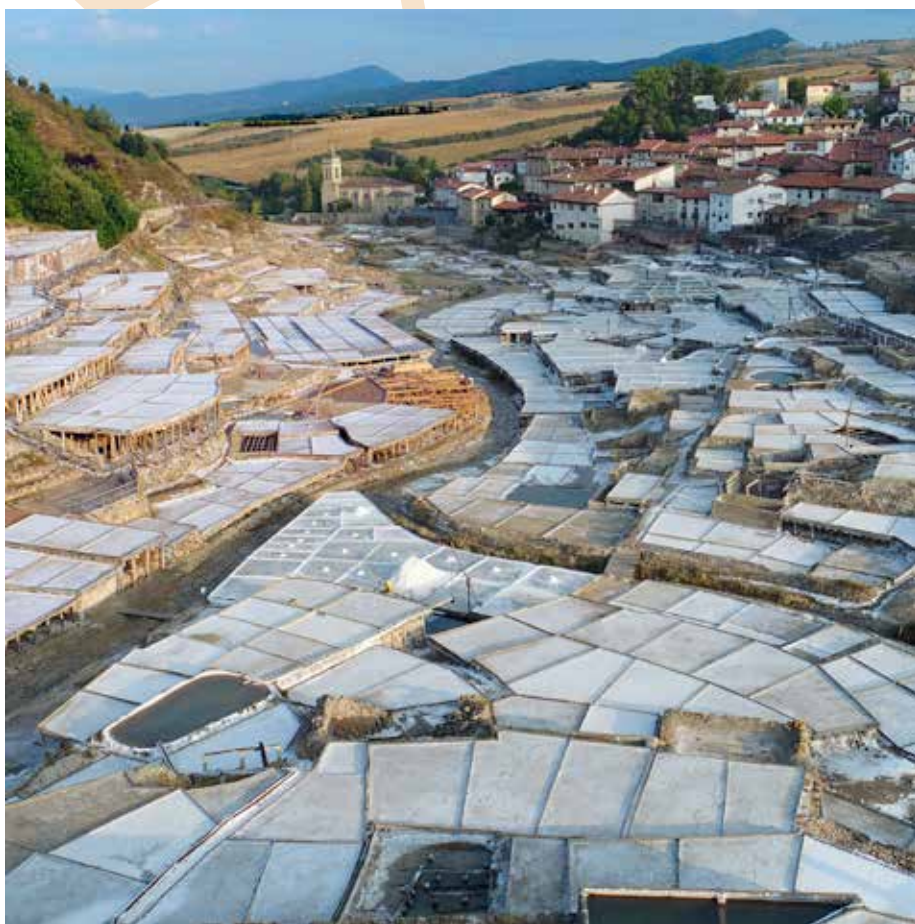
The manufacture of metal goods in Birmingham (GB) and the nearby Black Country was well-established by 1700. The towns and heathland communities of the Black Country produced nails, chains, locks and metal wares for saddlers, while craftsmen in Birmingham specialised in 'toys', assorted metal goods of higher value. The atmosphere of long-established, small-scale production can be experienced in the restored Jewellery Quarter in Birmingham, at the Black Country Living Museum in Dudley and at the industrial hamlet of Mushroom Green in Brierley Hill.

The origins of the long-lived industries of the Sheffield and Birmingham areas, and of the Styria and the Bergisches Land are lost in the distant past. The beginnings of some similar industries that also proved long-lived can be precisely identified. One such successful plantation was the new town at Eskilstuna in Sweden, founded by Reinhold Rademacher (1609–68) at the instigation of King Carl Gustaf in 1658–59. The architect Jean de la Vallée (1624–96) originally built twenty wooden smithy buildings arranged on a grid plan. Within a few years more buildings had been added and 72 craftsmen, some of them from Germany, were working there making locks, nails and cutlery. Six surviving buildings make up the museum complex known as Rademacher's Smithies, but the legacy of the seventeenth century community can also be seen in the modern engineering companies that still flourish in Eskilstuna. ■



-  **Uft (NL)**
CIVON Innovation Centre
-  **Birmingham (GB)**
Museum of the Jewellery Quarter
-  **Sheffield (GB)**
Kelham Island Museum
-  **Solingen (D)**
Hendrichs Drop Forge
LVR Industrial Museum
-  **Dudley (GB)**
Black Country Living Museum

White gold: salt.



Salt is essential to life and has been used as a preservative for food and for seasoning since prehistoric times. It was a source of taxation revenue for governments, and easily applied glaze for ceramics, and in some societies a form of currency. In seventeenth-century Europe salt was readily produced in the Catholic south and formed a convenient item of exchange with the fishermen of the Protestant north. *Bacalao* (the Spanish term for salt cod), *Bacalhau* (the Portuguese term) or *Klippfisch* is still sold in the markets

of Valencia in Spain, Oporto in Portugal and Piraeus in Greece. Salt was used in the preservation of beef, pork and butter, and gave savour to the farinaceous gruels on which many subsisted. In several countries its manufacture became a royal monopoly.

Salt is produced by four principal methods. In countries where the climate is warm sea water can be channelled into lagoons where over time it evaporates leaving deposits of salt. The remains, or in some cases the working installations of lagoons can be seen at

Figueira da Foz in Portugal, Las Salinas de Imón in Spain, Margherita de Savoia, on the Adriatic coast of Italy, where large-scale production continues, at the Saline Ettone e Enferosa, at Marsala, Sicily, at Mytilene on the Greek island of Lesbos, at Piram on the Adriatic coast of Slovenia, and at Pomorie in Bulgaria. Deposits of rock salt can be mined, and some sources such as those at Hallstatt (A) have been worked since prehistoric times. Brine can be pumped to the surface from inland sources and then boiled to leave salt, as on the Danish island of Laeso, or at the Lion Salt Works near Northwich in England. The German city of Halle became part of Prussia in 1680 and in 1719 King Frederick William I ordered the construction of a salt works on an island in the River Saala. Brown coal (lignite) was used as the fuel for boiling pans, a steam pumping engine was installed in 1865, and the works continued in production until 1964, after which it became the city's Museum of Salt and Saltworkers. Brine can also be passed through graduation towers as at Bad Dürrenberg in Saxony (D) or Ciechocinek in Poland which are filled with bundles of blackthorn twigs on which the liquid, when pumped through, leaves deposits of salt which can be collected.

Many place where the waters are infused with salts have become spas or resorts, and many have believed that the atmosphere of salt mines aids recovery from illness. The iodine-rich atmosphere at Ciechocinek, for example, still attracts convalescent patients. The role of salt working in aiding recovery and scale of some underground workings, has led to the creation of sculptures,



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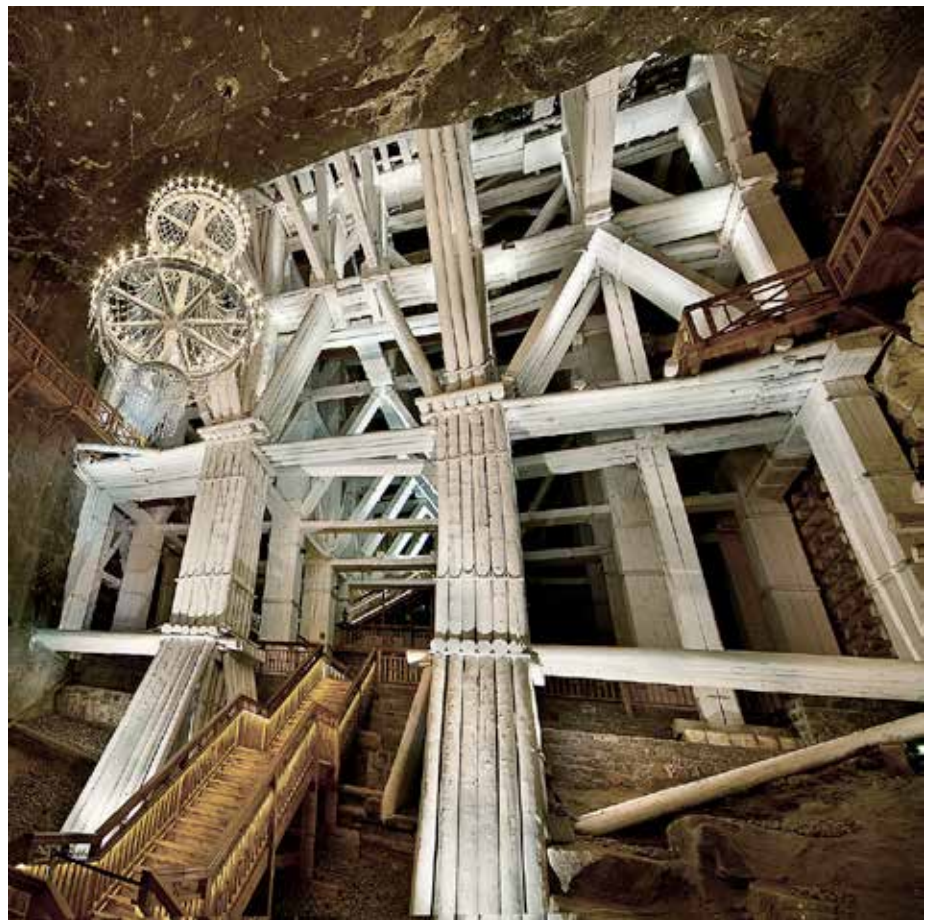


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reliefs and even of churches underground. At Wieliczka near Kraków (PL), one of the largest salt mines in Europe where a thousand people were employed in the sixteenth century, the St Antonio chapel of 1689 and the Blessed Kings' Chapel are both richly decorated with salt reliefs of biblical scenes. The significance of salt extraction is also illustrated by the works at Arc-et-Senans in the French *département* of Jura, built between 1775 and 1779 to the design of Claude-Nicolas Ledoux (1736–1806). The two boiling houses, a monumental entrance porch and 24 dwellings for workers in two curved wings make it one of Europe's most spectacular industrial complexes.

In the course of the Industrial Revolution salt became a raw material that was essential for the manufacture of key substances, particularly of hydrochloric acid and sodium carbonate (or alkali) used in making glass and in other chemical processes. Huge chemical plants, using the process for producing alkali devised by Ernest Solvay (1838–1922) were constructed in the late nineteenth century around sources of salt and of potash (potassium chloride), at Couillet near Charleroi (B) in 1865, at Dombasle near Nancy (F) in 1873, at Bad Friedrichshall (D) in the Neckar Valley in the 1890s and at Northwich in Cheshire (GB) in 1874. The museum at Solikamsk in Russia, where 11,000 people are still employed producing potash, has one of the most comprehensive collections of structures and artefacts relating to salt working, including wooden brine-pumping towers, boiling pans, salt chests and bath houses. ■



Salinas de Añana (E)
Salinas de Añana

Halle/Saale (D)
Saltworks



Wieliczka (PL)
Cracow Salt-Works Museum in Wieliczka

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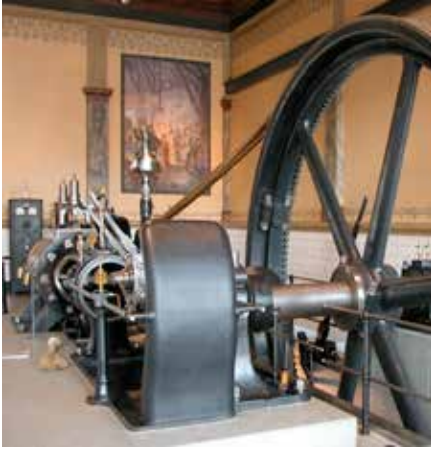
Coal & steam: the Industrial Revolution of the 18th century.



Most historians would agree that mining and manufacturing in Europe took new directions in the eighteenth century, and that the changes began in Great Britain. These changes affected the whole spectrum of industry. The first and most basic development was the large-scale use of coal as fuel. Coal had been used as a means of domestic heating and for some manufacturing processes long before the eighteenth century, but in the course of that century production in Great Britain steadily increased, and accelerated rapidly from the 1780s. The

greater availability of coal made possible the expansion of iron-making, of the smelting of non-ferrous metals, and of brick, lime, pottery and glass manufacturing.

Coal also enabled the use of new prime movers. While many of the textile factories and ironworks of the eighteenth century relied on water-power, and the leading engineers of the period devoted much energy to improving the efficiency of water wheels, the large-scale expansion of manufacturing, particularly after 1800, depended on steam engines. The first effective steam engine appears to have been that built by Thomas Newcomen (1663–1729) to drain a coal mine at Coneygre near Dudley in the English Midlands in 1712. Newcomen's engine could only be used for pumping, but it proved valuable to the owners of both coal mines and those extracting non-ferrous metals. About 100 had been installed in England by 1733, and some examples had been built in other European countries. Martin Triewald (1691–1747), for example, installed a steam engine to drain the famous iron ore mines at Dannemora in Sweden in 1727. It was not successful, but the engine house still stands. From 1769 James Watt improved the efficiency of steam engines by, amongst other developments, using separate condensers. He also, with others in the 1780s, devised means of using engines to develop rotative motion – that is enabling them to turn machines. Thereafter it was possible to use steam power to work rolling mills for metals or the machinery in textile factories. The proliferation of cheap, simple winding engines for mines from



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the 1790s, many of them Newcomen engines adapted for rotative motion, greatly increased the production of coal.

Another change of the Industrial Revolution was the development of the factory, a place where production was concentrated and where powered machinery was operated. The factory originated in textile production. The silk mill built by the brothers Lombe (John 1693–1722, Thomas 1685–1739) at Derby (GB) using technology copied from mills in Bologna (I), probably set the pattern for Richard Arkwright's cotton spinning mills at Cromford and for many more constructed in Great Britain, and, within a few years in many parts of continental Europe. The late eighteenth century saw the same principles applied in other industries. Manufacturing establishments, such as glass works and potteries, became larger, and the tasks of many of their workers were simplified and specialised. Nevertheless in most European countries such everyday items as clothing, furniture, footwear and food continued for some decades to be supplied by individual local craftsmen.

The Industrial Revolution was also characterised by a growth in the speed of transport and greater capacity for moving freight. Canals, serving the same purposes of those constructed in England from the 1760s, were built in Belgium, Germany, France and elsewhere, and every European country imported the technology of the main line railway, demonstrated by the opening of the line from Liverpool to Manchester in 1830. Another of the perceived characteristics of the Industrial Revolution was the growth of great cities, the largest of them commercial centres, 'towns of passage' for both people and goods, rather than simply centres of manufacturing. ■

Telford (GB)
Blists Hill Victorian Town.
Mine Shaft WHS



Chemnitz (D)
Industrial Museum



Cromford (GB)
Cromford Mills WHS

Manchester (GB)
Museum of Science and Industry.
Station Building

Co-funded by the
Creative Europe Programme
of the European Union



Changes after 1870.



Industrial development in Europe took new directions from the 1870s. In part this was due to the introduction of new materials. First amongst them was mild steel, originally produced in 1856 by Henry Bessemer (1813–98), then from the 1860s made by an alternative process, the open hearth furnace developed by Sir William Siemens (1823–83). In Britain mild steel was officially recognised as a suitable material for bridges in 1877, and its potential was demonstrated in 1890 by the completion of the Forth railway bridge in Scotland, with two huge 521 m

long cantilevered spans. During the following decade steel became the norm for the construction of such buildings as textile mills, hotels and department stores. Bessemer converters are displayed in several museums. A whole Bessemer plant remains at Hagfors and a complete open hearth plant of 1877 is preserved at Munkfors in Sweden. At the same time the Frenchman François Hennebique (1842–1921) successfully marketed his methods of concrete construction across Europe, and by 1917 his agents had completed some 17,692 contracts.

Different kinds of steel for specialist purposes were also developed. In 1882 Sir Robert Hadfield (1858–1940) invented manganese steel, an alloy that increased that elasticity of the metal, which made it suitable for use in railway track work and in crushing machines. In 1913 another Sheffield steel maker Harry Brearley (1871–1948) introduced stainless steel, originally with 12.5 per cent chromium content, which, in its many forms became one of the characteristic materials of the twentieth century.

Another new material was aluminium. The Frenchman Paul Héroult (1863–1914) and the American Charles Hall (1863–1914) both discovered around 1886 means of producing the metal by electrolysis, using cryolite, whose chief source was in Greenland, around the year 1886. The process requires large amounts of electricity, and most aluminium smelting plants were set up near sources of hydro-electric power such as the Dauphine region of the French Alps where its history is portrayed at Vaujany.

The properties of electric power were demonstrated by such scientists as Alessandro Volta (1745–1817) and Michael Faraday (1791–1867), and from the 1870s when a power station began operations in Paris it began to be applied to practical purposes, to the lighting of streets and large buildings from the 1870s and tramways from 1883. Subsequently it powered machinery in factories, rolling mills and hammers in metal works, and locomotives on railways. From the 1890s larger ‘central’ (which meant for public use) power stations were opened, and

electric power became one of the essentials of twentieth-century civilisation.

There were also profound changes in the chemical industry. The ammonium soda process for making alkali (sodium carbonate) was introduced by the Belgian Ernest Solvay (1838–1922). Large plants were set up in several parts of Europe where supplies of salt were available, and became centres for the production of numerous industrial raw materials and household products. A whole chain of materials, including explosives, medicines and plastics, arose from experiments by Sir William Perkin (1838–1907) which produced aniline dyestuffs, and were the basis of large chemical plants based on the destructive distillation of coal and later of oil. Plastics, characteristic twentieth century materials, were developed gradually in the late nineteenth century and a significant innovation was the patenting of thermosetting phenol-methanal resins by Leo Baekeland (1863–1944) in 1907, and his establishment of a factory near Berlin two years later. The Bakelite Museum at Williton, Somerset (GB), displays a wide range of plastics, while the wider significance of the chemical industry can be studied in the German Chemical Museum at Merseburg and at Catalyst at Widnes (GB).

Other changes of the late nineteenth century were characterised by a machine, the sewing machine, the first of which was invented in France in 1830 by Bartholémy Thimonniere (1793–1857) and used for the production of military uniforms. In most European countries the first sewing machines to be used on a large scale were produced by the company established by Isaac Merit



Singer (1811–75) in the United States. Together with the availability of more compact prime movers, gas engines then electric motors, they enabled the establishment of factories such as those at Colchester, Leeds and Northampton (all GB); where clothing and footwear could be manufactured on a large scale. ■

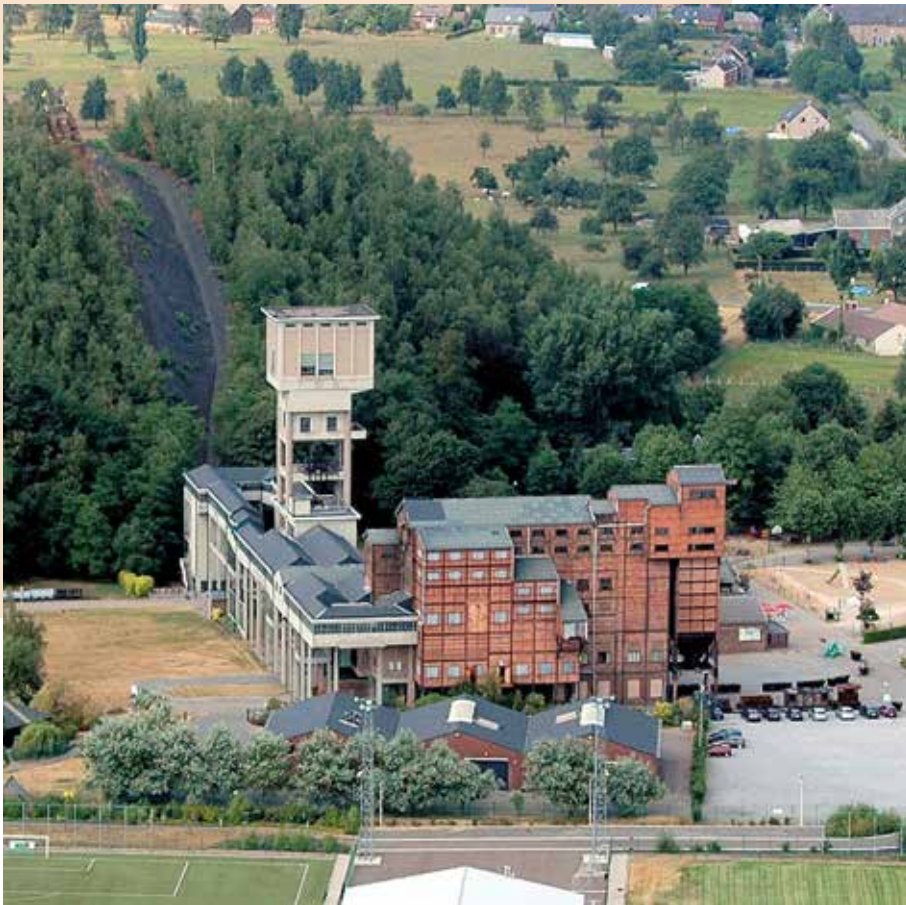
South Queensferry (GB)
Forth Rail Bridge WHS



Bitterfeld-Wolfen (D)
Industry and Filmmuseum

Merseburg (D)
German Chemical Museum

Black gold: the rise of coal-mining.



Coal was the driving force of the Industrial Revolution. Two impressively large lumps of Welsh coal are displayed at Bedwellty Park, Tredegar. One, of 15 tonnes, proved too large to be taken to the Great Exhibition of 1851 in the Crystal Palace at London; the other, of two tons, was displayed at the Festival of Britain in 1951. The earliest forms of mining coal were from adits – horizontal passageways driven into the sides of hills to reach the seams of coal within, or from bell pits, shafts sunk to a depth of about 10m at the bottom of which coal was dug out

in every direction, creating the shape of a bell. When the roof began to fall in the shaft would be abandoned, and another dug nearby, and as the original collapsed it would leave a saucer-shaped depression. The remnants of bell pits were discovered during many open cast mining projects in the twentieth century, and a notable mining landscape, covered with bell pits survives on the Cleve Hills near Ludlow (GB). Several mining museums provide access to adits that were formerly used for extracting coal, at Apedale, for example, where working only ceased in

the 1980s, and others, such as Beamish (both GB), have adits that replicate such workings. Some of the most difficult coal mining conditions are illustrated in the workings in the narrow seams at Arigna in Co Roscommon in Ireland.

The day-to-day operations of early mining are best appreciated at the larger museums of technology, such as the German Mining Museum in Bochum. Here can be seen early miners' tools, forged from wrought iron, drainage pipes shaped and bored from tree trunks, the safety lamps used from the early nineteenth century which gave light without igniting methane gas, the ventilation doors, often tended by children, the ladders by which miners gained entry to the workings, and the vehicles and rails used to convey coal from working faces to pit bottoms. Early winding equipment, whether worked by hand or by horses, has rarely survived and is best illustrated by models.

At the characteristic coal mine of the mid-nineteenth century water was pumped from the workings, and coal was raised up the shafts by steam engines. The pit at Elsecar (GB) retains its Newcomen Engine of the 1780s. Big Pit at Blaenavon and Caphouse Colliery near Wakefield are both of a size characteristic of mid-nineteenth century pits but both worked well into the twentieth century, and include structures of later date. The mine at Blégné in Belgium closed in 1980, and was the last to work in the Liège region, but while many of its surviving structures are of twentieth century date it worked for no less than 200 years and retains evidence of earlier times.

In some parts of Europe peat was of greater importance than coal. In the



marshlands along the River Ems near the border between German and the Netherlands the ways of extracting peat are illustrated in the Veenpark at Baarger-Compasum (NL) and the Elisabethfehn Marshland Museum in Barßel (D).

The properties of coal gas were demonstrated in 1792 by William Murdock (1754–1839), whose employers, the engineering company Boulton & Watt proceeded from 1805 to manufacture plant to supply gas for lighting streets, factories and in due course private housing. By 1850 most substantial towns in Western Europe had gas supply systems, and in large cities gasworks grew to be substantial concerns, producing by-products which served as feedstocks for the chemical industry. The making of coal gas diminished from the 1960s with discoveries of natural gas. The role of the gas industry is illustrated in conserved small plants at Biggar, Fakenham and Carrickfergus (GB), Hobro (DK), Neustadt/Dosse (D) and Paczków (PL), while larger works have been adapted to new uses at Piraeus (GR), Augsburg (D), Budapest (H) and Warsaw (PL). ■



-  **Blegny (B)**
Blegny Mine WHS
-  **Wakefield (GB)**
National Coal Mining Museum for England
-  **Barnsley (GB)**
Elsecar Heritage Centre
-  **Blaenavon (GB)**
Big Pit National Coal Museum WHS
-  **Carbonia (I)**
Italian Centre for Coal Mining Culture
-  **San Martín del Rey Aurelio (E)**
Pozo Sotón Mine

Coal triumphant.



The scale of coal mining changed from the late nineteenth century. Deeper pits were sunk and some collieries employed several thousand miners. Coal was raised to the surface, and miners travelled to and from their work in cages hauled from lofty headstocks of steel or concrete, wound by compound steam engines and later by electric winding machines. Mechanised screens separated grades of coal by size, and loaded them directly into railway wagons, although in some collieries sorting by hand continued after 1950. From the 1880s larger collieries used compressed air from compressor houses on the surface to power tools. Machines were increasingly used for cutting and carrying coal underground, particularly after 1950, and they were powered by electricity, often from collieries' own power stations. Pithead baths were introduced in Germany in the 1880s and became obligatory in larger pits from 1900, and soon afterwards in Belgium and the Netherlands. It was not until the 1930s that the Miners' Welfare Committee in Great Britain began to erect baths.

Museums that reflect coal mining in recent times include those at Ostrava in the Czech Republic, Bexbach in the Saarland, Carbonia in Sardinia, Cercs in Catalonia and El Entrego in Asturias. The Limburg coalfield on the borders of Belgium and the Netherlands was exploited from the closing years of the nineteenth century. Activities were concentrated in a small number of very large pits, including that at Beringen in Belgium, now the Flemish Mining Museum, and the Winter-slag pit near Genk, otherwise C-Mine 10.

The most spectacular monuments to twentieth-century coal mining are in the Ruhrgebiet. The winding engine room of the Zollern 2/4 mine in Dortmund dating from 1904, is a light and airy tent-like building in the Jugendstil. Zollverein Colliery Shaft XII in Essen, a shaft which opened in 1932, once employed 5000 men, and closed in 1986. It is a superb example of Expressionist architecture. Another aspect of the coal industry in the Ruhrgebiet is illustrated by the monumental buildings of the Hansa Coke Plant in Dortmund, opened in 1927 and closed in 1992.



Few coal workings remain accessible but there are some places where visitors can explore coal workings deep underground. At Zabrze (PL) visitors to the Guido Colliery, which takes its name from Guido Henckel von Donnersmarck (1830–1910), can see workings 320 m underground. The Sotón mine between Sotrondo and El Entrego in Asturias (E) was developed from 1845 by the Englishman William Partington. The workings were deepened in 1917–22 when two 33 m high headstocks were built. The



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Itinéraire culturel
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has been extracted, and a briquette plant at Hoyerswerda. The outstanding monument is the F60 overburden conveyor bridge at Lichterfeld, completed in 1991 and scarcely used. It incorporates 11,000 tonnes of steel, extends 80 m above the ground and could move 29,000 cubic metres of spoil per hour.

Two other aspects of coal mining are commemorated on the European Route of Industrial Heritage. Mines have always attracted migrant workers, and the museum established at Ronchamp in Alsace by Marcel Maulini (1913–83), born in the Vosges of Italian parents, commemorates the role of Polish migrants in local mines. Safety in mines was much improved in the twentieth century but the increased scale of operations meant that when disasters occurred they involved terrifying loss of life. At Senghenydd in South Wales is a memorial to 83 men who died in an accident in 1907 and 493 lost in an underground explosion on 14 Oct 1913, while at the Grube Anna II at Alsdorf (D) some 271 victims of an accident on 21 October 1930 are remembered. ■

colliery closed in 2014, and visitors who are physically fit can now be taken on four-hour tours which venture into workings 556 m below the surface.

A feature of the twentieth-century coal industry in Germany and Poland was the exploitation of brown coal or lignite. The industry is commemorated by a power station built in 1922–23 to burn brown coal at Borken in Hesse, by a visitor centre at Grossräschen in Lusatia which by 2018 will overlook a lake occupying a vast area from which lignite

-  **Hoyerswerda (D)**
Knappenrode
Energy Factory
-  **Beringen (B)**
beMine Flamish
Mining Museum
-  **Lichterfeld (D)**
F60 Overburden
Conveyer Bridge
-  **Essen (D)**
Zollverein Colliery.
Shaft XII. WHS
-  **Marcinelle (B)**
Bois du Cazier WHS
-  **Zabrze (PL)**
Guido Mine
-  **Gräfenhainichen (D)**
Ferropolis-Town of Iron
-  **Grossouvre (F)**
Charcoal Hall
-  **Ostrava (CZ)**
Michal Mine
-  **Dortmund (D)**
Zollern II/IV Colliery
LWL Industrial Museum



Metallic wealth.

Some mines of metallic ores of ancient origin continued to be important in the eighteenth century and afterwards. Others sources of ore were discovered during the Industrial Revolution. Our understanding of the location of coal, metallic ores and clays was increased by the work of geologists. The most notable was William Smith (1769–1839) who, from humble origins, became a surveyor and used the knowledge he gained from fossils while building canals to develop an understanding of stratification, which was displayed in the Geological Map of

Britain published in 1815. Smith was responsible in 1829 for arranging the Rotunda Museum at Scarborough for the Philosophical Society whose aim was ‘to give energy, concentration and effort to native talents to examine the great laboratory of the earth’.

The demand for copper increased greatly. One new use was for sheathing the hulls of ships which enabled them to undertake longer voyages in tropical waters. Rolled copper could also be used to construct larger vats for brewers and distillers, and from the mid-nineteenth

century copper was used in cables for telecommunications systems and later for the transmission of electric power.

Age-old mines were transformed by innovations, by steam pumping and winding engines, by the use of cages in shafts, by the safety lamp, and subsequently by the application of high explosives, compressed air and electric power. Cornwall, important for tin ores since ancient times, became an important source of copper in the eighteenth century. The expansion of mining owed much to steam engines, initially to Thomas Newcomen’s atmospheric engines, then to engines supplied by Boulton & Watt, and from 1812 by the Cornish engine, a condensing, single-cylinder, high pressure beam engine designed by Richard Trevithick (1771–1833). About 300 engine houses still stand in Devon and Cornwall, of which seven retain their engines, including those at East Pool and Levant. The mining landscape of the area around Redruth and Camborne is unique, and is interpreted at numerous sites and by means of several trails.

Parys Mountain on the island of Anglesey in North Wales forms one of the most dramatic mining landscapes in Europe, and produced ores that transformed the copper industry. Ore was discovered there in 1761, and it was exploited from two adjacent and largely open-cast mines, both of which from the 1780s were controlled by Thomas Williams (1737–1802), the ‘Copper King’, who for a time commanded the world copper market. From the beginning of the nineteenth century the scale of activity diminished as deposits were exhausted and by 1881 only





about 250 men were working on the mountain. The colourful soils, impregnated with copper, lead and sulphur, have little vegetation. There are remains of dressing floors and calcining kilns, and green pools where copper was once precipitated from water pumped out of the workings.

The principal expansion of copper ore output in the late nineteenth century came in the Rio Tinto mines in southern Spain. They too had origins in ancient times, but activity on a large scale began in 1873 with the established, with capital from Britain, of the Rio Tinto Company. The huge Bessemer Smelter, constructed in 1904, stands in a landscape as arid as that of Parys Mountain. There are also remains of crushing plants, precipitation pits, calcining kilns, smelters, and a sulphuric acid plant, and of a metre gauge railway that linked Rio Tinto with the port of Huelva between 1876 and 1974.

Less common metals have also been mined in Europe. Abies Alba in Italy, Amaden in Spain and Idrija in Slovenia have been sources of cinnabar, the ore from which mercury is extracted. Cobalt, the source of blue dyes, was mined at Modum in Norway, and tungsten at Fundao in Portugal. The area near Aachen (D) known as Kelmis or La Calamine, was for centuries Europe's principal source of calamine or zinc carbonate, used in making brass, and between 1816 and 1919 was a neutral region, independent of the Netherlands (later Belgium) and Prussia (later the German Empire). ■



Almadén (E)
Almadén Mining Park
WHS

Amlwch (GB)
Parys Mountain
(Jens Klein)



Minas de Riotinto (E)
Riotinto Mining Area
(Edgar Bergstein)

Trewellard, Pendeen,
near St Just (GB)
Cornwall Mining Area WHS
(Jens Klein)

The glow of furnaces & forges: ironworking.



The making and shaping of iron was a key element in the transformation of Europe in the eighteenth and nineteenth centuries. Excavations in Sweden and Germany have suggested that blast furnaces were used in some parts of Europe as early as the fourteenth century, but it was in the fifteenth century that the indirect process for producing wrought iron, by smelting iron ore in a blast furnace to produce what is usually called pig iron (a form of cast-iron) and then refining it to wrought iron in a finery-and-chafery forge, was used in Italy, then in the Liège region (B), northern France and then to southern England.

Furnaces and forges of that period used charcoal for fuel and water-power for operating their bellows and hammers, a pattern that scarcely changed until the second half of the eighteenth century, while a few ironworks operated in that way into the twentieth century. The blast furnace at Sauvignac-Lédrier in the Dordogne (F) for example, originated in the 1530s, and its blast furnace continued to operate until 1930. Other furnaces remain in isolated rural settings in most European countries. One of the most evocative is the Fourneau St-Michel, an essentially complete blast furnace of 1771, which worked until 1842, and is preserved amongst the forests of the Belgian Ardennes. The forge at Osterby Bruk near Dannemora in Sweden provides perhaps the best impression of a forge of this period, but la Grosse Forge d'Aube in Normandy, is a well-preserved example of a Walloon forge of the early sixteenth century from which the finery-and-chafery forge was derived. The preserved ironworks village (or bruk) at Engelsberg, also in Sweden, includes a blast furnace



of the 1770s. The community is clustered around the owners' chateau of the 1740s. A forge, rebuilt in the 1840s, also makes use of the water-power system, and workers' houses from the eighteenth century still stand along with two summer houses constructed from blocks of slag. One of the most complete works of this period is La Grande Forge at Buffon near Montbard in France, built in 1768–70 by the famous naturalist Georges-Louis Leclerc de Buffon, which worked until 1866 and includes a blast furnace, a finery-and-chafery forge and slitting mills.

The nature of ironmaking changed when it became possible to use coke as fuel and to employ steam engines to power bellows, hammers and rolling mills. Coke was used in the blast furnace at Coalbrookdale (GB) by Abraham Darby I (1668–1717) in 1709, and in the time of his son Abraham Darby II (1711–63) in the 1750s it was employed in several newly-built furnaces in the region, soon spreading to other parts of Britain, and then to the Ruhrgebiet, Belgium, Saxony and Silesia. Darby's furnace can still be seen, and the pud-



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dling process for making wrought iron, developed by Henry Cort (1740–1800) in the late eighteenth century is sometimes demonstrated at the nearby Blists Hill Museum. Several ironworks from the Industrial Revolution period survive in South Wales, the most complete of them within the Blaenavon industrial landscape.

Different traditions were used in southern Europe. From the Italian Alps through Provence to Spain some blast furnaces were of the Bergamasque type, with flat fronts held in by wrought iron bars extending between two towers. Furnaces and forges were blown by streams of air created by water pouring down 'trumpets', as at Pescia Fiorentina near Capalbio in Tuscany (I).


There were further changes in scale in the late nineteenth century. The most important was the development from 1856 by Henry Bessemer of mild steel, which for most purposes could be substituted for wrought iron, but which could be readily produced in greater quantities. The principles on which blast furnaces operated remained the


same, but their size increased, there were new means of powering bellows, lifts were used to charge raw materials, and tops were closed in and the hot gases used in hot blast stoves, the invention in 1828 of James Neilson (1792–1865), to heat the air being charged from bellows, and to reclaim by-products. Blast furnaces grew in size through the twentieth century and several awe-inspiring works have been conserved for visitors to explore, most notably those at Völklingen in the Saarland, Hattigen and Duisburg-Meiderich in the Ruhrgebiet, Uckange in Lorraine, Esch-sur-Alzette in Luxembourg, and the Vitkovice Ironworks at Ostrava in the Czech Republic.


Most of the processes that shaped iron into useful forms are demonstrated in various parts of Europe. Scythe making at Nans-sous-Sainte-Anne (F), at Leverkusen and at the Tobias Hammer at Ohrdruf (D), needles at Iserlohn (D) and Redditch (GB), wire at Altena in the Sauerland (D), tinplate at Kidwelly (GB), and the Mannesmann process for making seamless tubes at Remscheid (D). ■


Blaenavon (GB)
Model of the Ironworks WHS

 Dommartin-le-Franc (F)
Metallurgic Park

 Duisburg (D)
North Landscape Park.
Blast Furnaces

 Hattigen (D)
Henrichshütte Ironworks
LWL Industrial Museum

 Völklingen (D)
Völklingen Ironworks
WHS

 Sabero (E)
Museum of Iron and Steel Industry
and Mining of Castilla and Leon



Textiles: the processes.



The most appropriate place to begin the examination of textile manufactures in Europe is in the small town of Monschau that lines the banks of the River Laufenbach in the Eifel, 30 km south of Aachen (D). The Rotes Haus (red house) was built in 1756 by Johann B Scheibler (1705–65) as the focus of a system of domestic production of woollen cloth. A spectacular stairwell is ornamented by late Baroque carvings that depict every stage of textile manufacture, the preparation of the raw materials, the spinning of yarn, the weaving of cloth

and its finishing by tentering, shearing, fulling and dyeing.

Woollen fabrics and various kinds of linen, made from hemp or flax, were made all over Europe by the sixteenth century, and the tools and implements used in their manufacture can be seen displayed in context at Bokrijk (B), Detmold (D), Maihaugen (N) or other open air museums, as well as in collections specifically devoted to textiles. Most self-sufficient peasant families had hand cards for treating wool, heckles for combing flax, and two kinds of spinning

wheel, great wheels for spinning wood and short wheels for hemp and flax.

The first practical multiple-spindle spinning machine was the spinning jenny invented and patented in England in 1770 by James Hargreaves (1721–78). Workshops in which hand-operated jennies were concentrated multiplied in the following decades and proved one route to the development of the textile factory. The water frame, patented by Richard Arkwright (1732–92) in 1769 drew out yarn between sets of rollers turning at different speeds, and would it by means of a flying onto a rotating spindle. As its name implies, it was initially operated by water-power, and formed part of a sequence of operations, including water-powered carding machines, that made it possible for Richard Arkwright to open the integrated spinning mill at Cromford (GB) in 1771. The spinning mule, invented by Samuel Crompton (1753–1827) in the 1770s, combined the rollers of the water frame with the moving carriage of the spinning jenny, and proved itself capable of producing uniform yarns in a wide range of sizes. The fully-mechanised self-acting mule was developed by Richard Roberts (1789–1864) and was widely used in spinning mills across Europe. The ring spinning frame was patented in the United States by John Thorp (1784–1848) in 1828 and came into widespread use in the late nineteenth century.

Weaving in peasant societies was often a specialised activity. A weaver's loom is essentially a frame in which longitudinal warp yard is wound between a pair of rolls or 'beams' making a 'shed' or opening through which the weft yards are carried by a shuttle or shuttles passed



from side to side. The speed of working was increased by the 'flying shuttle', the invention of John Kay (d 1764), introduced in 1773. The first powered loom was patented in 1784–87 by Edmund Cartwright (1743–1853) but it was many years before the power loom was successfully applied to every type of fabric.

The finishing of woollen cloth, by pounding it with hammers with fuller's earth in a water-powered fulling mill was the first textile process to be mechanised in the middle ages. Fabrics were traditionally bleached by exposing them to the sun on bleaching greens. This stage of production was transformed by the use of bleaching powder containing chlorine, patented in 1800 by Charles Tennant (1768–1838). Dyeing used such natural materials as indigo, woad and logwood, some of which were imported to Europe from the Far East or the Americas, but was transformed by the introduction in the second half of the nineteenth century of aniline dyes, discovered in Great Britain in 1856 by Sir William Perkin (1838–1907) but chiefly developed in Germany.

Many textile products and processes are illustrated in museums, calico printing at Mulhouse (F), Česká Skalice (CS) and Budapest (H), carpet making at Kidderminster (GB) and in the colourful Templeton's Mill at Glasgow, hosiery manufacture at Ruddington (GB), Salhus (N) and Herning (DK), heavy canvas for line shafting belts at Gothenburg (S), lace at Calais, Caudry (F) and Nottingham (GB), ribbons and tapes at Gross-Siegharts (A), Killinkoski, (FI) and Coventry (GB), leonine wares (fine gold, silver and copper brocades) at Roth (D), and heavy woollen fabrics dyed scarlet for military uniforms at Bramsche (D). ■



Calais (F)
The International City for
Lace and Fashion (Kleinefenn)



Salhus (N)
Norwegian Knitting
Industry Museum



Perth (GB)
Stanley Mills



Euskirchen (D)
Müller Cloth Factory
LVR Industrial Museum

‘There’s magic in the web of it’: silk.



Silk was brought to Europe from China along the Silk Roads through Central Asia in the middle ages. Silk manufacturing became established in northern Italy, particularly around Lake Como and in Bologna where multi-storey buildings that could accommodate tall silk throwing machines were constructed in the sixteenth century, and silk manufacturers were drawing power from 400 waterwheels in the region by 1700. A half-scale silk throwing machine is demonstrated in the Museo del Patrimonio Industriale in the city. Lyon in France also became a major centre for working silk and the city's Musée des Tissus, dating from 1864 and housed in the mansion of the Villeroy family, has displays concerning silk in ancient civilisations as well as the development of the industry across Europe.

The Englishman John Lombe (1693–1722) learned many of the secrets of working silk in northern Italy, and in 1721 built a five-storey silk mill in which throwing machines occupied the two lower floors and twisting machines the upper storeys, that was powered by the waters of the River Derwent at Derby (GB). The mill, rebuilt after an early twentieth-century fire, now houses Derby's Museum of Making. The building doubtless influenced Richard Arkwright when he designed his cotton spinning mill at Cromford which opened in 1771.

Silk manufacturing prospered in London amongst Huguenot immigrants in the early eighteenth century. Some of the fine houses they built with weaving rooms on the upper floors can still be seen in the Spitalfields area. The industry moved in the first half of the

nineteenth century into Essex where the Warner Silk Archives at Braintree has a collection of more than 80,000 silk items, most of which were made in the nearby silk mill opened in 1818 by Samuel Courtauld (1793–1881). The principal concentration of silk factories in England was on the borders of Cheshire and Staffordshire in the towns of Macclesfield, Congleton and Leek. A silk mill 74m long was built at Congleton in 1753, although only fragments remain. The industry is commemorated at Macclesfield by a museum in the School of Art building of 1877, by the Paradise Mill where 26 restored Jacquard looms are demonstrated, and by numerous houses with weavers' attics of the early nineteenth century.

In southern Italy the royal palace, the Casino Reale de Belvedere, in the former kingdom of Naples was built in 1774, but, after the king was distressed by the death of his son in 1778, it was adapted as a silk factory. Further silk-working buildings were added in the nineteenth century, and the complex is now a training centre for silk workers and designers, and has been designated a UNESCO World Heritage Site.

There are also museums of the silk industry at Stockholm (S), and at Soufli in Greece, while the Silk Exchange still stands in Valencia (E). The most complete collections of artefacts relating silk making are in the Museo didattico della Seta at Como (I), which remains the principal centre in Europe for research into silk, and the museum at Garlate in the neighbouring province of Lecco, founded in 1953 by the Abegg family who established another centre for research at Riggisberg in Switzerland. ■

Stockholm (S)
Silk Weaving Museum

Como (I)
Silk Museum



Bologna (I)
Museum of Industrial Heritage



Fabrics in variety.



The manufacture of cotton, like that of silk, depended on raw materials imported to Europe from distant countries, chiefly from the southern states of the United States and from Egypt. Cotton nevertheless became the pace setter, or, in the term used by economists, the 'leading sector' of several national economies. The technologies introduced at Cromford by Richard Arkwright, and the subsequent development of the spinning mule and the power loom, were spreading before the end of the eighteenth century to continental Europe. An Arkwright-style cotton-spinning factory was built in 1784 by Johann Gottfried Brügelmann (1756–1802) in a community at Ratigen southwest of the Ruhrgebiet, appropriately named Cromford. Similar mills proliferated in Flanders, in Switzerland around Zurich and Winterthur, in Saxony and in Bohemia.

Woollen manufacturing technology developed more slowly than cotton production, but similar machines could be applied to spinning, and gradually in the first half of the nineteenth century the power loom was used to weave various



types of woollen cloth. In England the industry's prosperity in the mid-nineteenth century was epitomised by such ostentatious buildings as Manningham Mill and Saltaire Mill in Bradford, West Yorkshire.

The flax industry was transformed by the Yorkshire entrepreneur John Marshall (1765–1845) who worked his first mill in Leeds from 1785, utilising machines made by the engineer Matthew Murray (1765–1826). Marshall and his partners built the first wholly iron-framed 'fireproof' textile mill at Ditherington, Shrewsbury, in 1795–96. Leeds became



the principal centre of flax spinning in Britain, but the industry also flourished in Scotland, particularly around Dundee where several iron-framed mills were built with iron roofs in the Gothic style. From the 1850s flax spinning at Dundee was largely displaced by the manufacture of jute fabrics, using raw materials imported from India.

John Marshall's company was closed by his descendants in the mid-1880s, symbolising the decline of the flax industry in Yorkshire. Meanwhile it flourished elsewhere. Flax production had long



been important in Ireland but from the 1830s spinning factories proliferated around Belfast and by 1900 Irish mills were exporting all over the world. The Benur Valley Heritage Centre in Co Armagh occupies a flax mill of the 1850s and the machines used in the industry are displayed in the Ulster Museum of Technology. Flax manufacturing also prospered in the late nineteenth century in Flanders, where its history is portrayed in the National Flax Museum at Kortrijk. The prospects of wealth realised from textile manufacturing led some entrepreneurs to build mills in places where they were never likely to be viable. The village of Prosperous, established in the bogs of central Ireland in 1780, never matched its name, and the ruin of the mill of 1792–94 at Spinningdale in the Scottish Highlands is one of the Europe's most poignant industrial monuments. Gayle Mill near Hawes (GB), built to house Arkwright's processes in 1784, was soon adapted to other uses, and housed a saw mill before it was adapted in 2008 to the needs of the twenty-first century.

The twentieth century saw the growth of synthetic textile manufacturing. Rayon or artificial silk, introduced in 1892, was derived from wood pulp, and nylon, first manufactured on a large scale in 1940, from petroleum derivatives. One of the few heritage sites devoted to this aspect of the textile industry is the former viscose plant at Échirolles near Grenoble (F), but the processes are illustrated in several major museums of technology.

Manchester became the symbol of the cotton trade, and in the 1840s of the growing industrialisation of Europe. Its mills and its slum housing were described in the 1840s by many overseas visitors, most notably by Friedrich Engels (1820–95) and Alexis de Tocqueville (1805–59). It was then still dominated by cotton spinning mills, the most notable examples of which still stand in the Ancoats area, but from the mid-nineteenth century Manchester's economy diversified. Mechanical engineering whose growth had been stimulated from the 1790s by demands for textile machinery and steam engines to power mills, assumed a greater importance, as did factories producing consumer goods. Cotton manufacturing ceased to expand, but the city became the global centre of cotton trading, a role reflected in the Exchange and in the lofty warehouse buildings that still line Whitworth Street. Manchester's significance as the symbol of industrialisation is shown by the way in which its name was applied to other textile manufacturing cities, to Ghent, the 'Manchester of Belgium', Łódź, the 'Manchester of Poland', Bielsko-Biala, the 'Manchester of Silesia', and Gabrovo, the 'Manchester of Bulgaria'. ■

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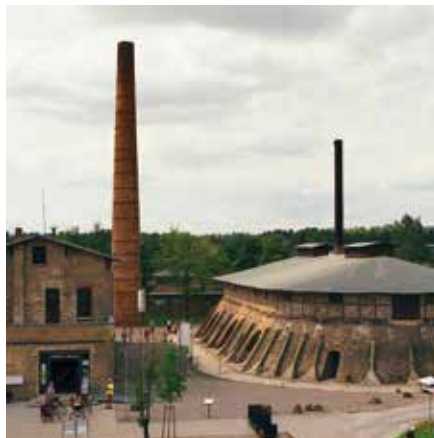
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-  **Augsburg (D)**
Textile and Industrial Museum
-  **Delmenhorst (D)**
Nordwolle Industrial Museum
-  **Bocholt (D)**
TextileWorks LWL Industrial Museum
-  **Łódź (PL)**
Manufaktura – Factory Museum
-  **Terrassa (E)**
mNACTEC Catalanian Museum
of Science and Industry
-  **Pratovecchio Stia (I)**
Museum of the Art of Woolmaking
-  **Prato (I)**
Museo del Tessuto
-  **Balmaseda (E)**
'La Encartada' Factory Museum
-  **Dundee (GB)**
Verdant Works



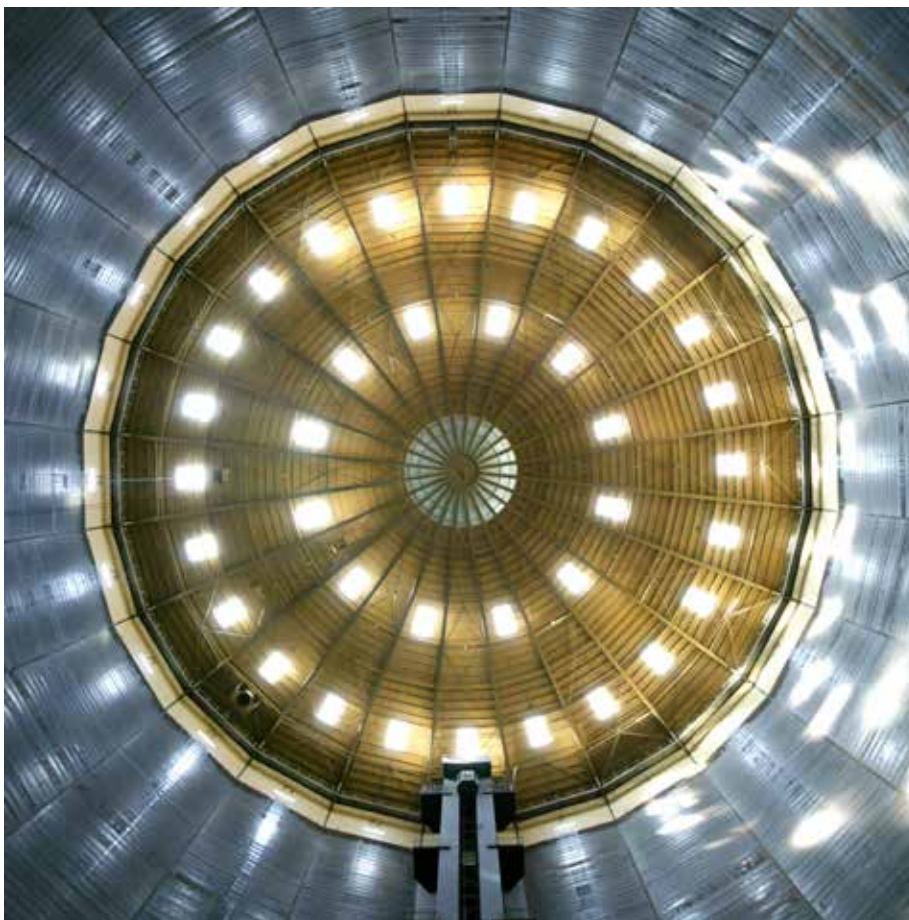




-  **Norrköping (S)**
Museum of Labour
(Arild Vågen)
-  **Lage (D)**
Lage Brick Works
LWL Industrial Museum
-  **Zehdenick (D)**
Mildenberg Brick
Works Park
-  **Gent (B)**
Industrial Museum
-  **Peenemünde (D)**
Historical Technical
Museum
-  **Llanberies (GB)**
Welsh Slate Museum
-  **Geeste (D)**
Emsland Moormuseum
-  **Grimeton (S)**
Grimeton Radio
Station WHS
-  **Waltham Abbey (GB)**
Royal Gunpowder Mills







Istanbul (T)
santralistanbul

Cedegolo (I)
Museum of
Hydroelectric Energy

Rjukan (N)
Norwegian Industrial
Workers Museum WHS

Bydgoszcz (PL)
Exploseum
DAG Fabrik Bromberg

Tyssedal (N)
Norwegian Museum of
Hydro Power and Industry

Oberhausen (D)
Gasholder (Wolfgang Volz)

Narvik (N)
Museum Nord

Malnisio di Montereale Valcellina (I)
Power Plant Museum & Science Centre



Workshops of the world: engineering

The principal makers of machines in mid-eighteenth-century Europe were clockmakers, together with millwrights whose 'machines' used buildings as frames. It was from clockmakers, along with blacksmiths, that the textile entrepreneur Richard Arkwright looked for help in the 1760s and 70s when he sought to make water frames for spinning cotton. A mine owner at that time seeking to install pumping machinery would purchase a cylinder and pump barrels from an iron foundry, forgings from a smith and expertise from an engine

erecator. The pioneering steam engine makers Boulton (Matthew 1728–1809) & Watt (James 1736–1819) worked in this way until 1796 when they established their own foundry which remained in production for almost a century. At the same time similar companies were established in other British cities, in Leeds, Manchester and London, and the ability to create machines from iron parts spread to other European cities, and in the course of the next 50 years to many much smaller towns. The techniques of making castings, using cupola furnaces

for re-melting pig iron or scrap, of making forgings using the techniques of the blacksmith, aided by steam- or water-powered hammers, and of finishing, using lathes and machines for planing, drilling and slotting. The coming of main line railways from the 1830s created a demand for steam locomotives. The first purpose-built factory for assembling locomotives remains in Forth Street, Newcastle-upon-Tyne (GB), and similar works were erected all over Europe. Most have been demolished but some of the first generation of steam locomotives remain to be studied in museums.

The blast furnaces and engineering works at Seraing (B) that extends along the banks of the River Meuse 8 km west of Liège were established in 1816 by John Cockerill (1790–1840) in a former palace of the Bishops of Liège.

In Vienna (A) the locomotive works of the Nordbahn (North Railway) was built in the suburb of Floridsdorf by John Baillie (1806–59) in 1839, after which he worked in Karlsruhe (D) with Emil Kessler (1813–67) on the Badenia, the first locomotive to run on the state railway of Baden, and subsequently worked in Hungary. Kessler was subsequently involved with the establishment of locomotive works in Karlsruhe and in Esslingen in Württemberg. The works of the Südbahn (Southern Railway) in Vienna was established by John Haswell (1812–97) in 1839. The Scottish-born Haswell made the rest of his career in the Habsburg Empire, where he designed an 8-coupled locomotive in 1855 that set the pattern for heavy freight locomotives for several generations, built the first four-cylinder locomotive in 1861, and devised a hydraulic press that could





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produce heavy forgings in 1862. The locomotive works opened in Munich (D) in 1836–37 by Joseph Anton Ritter von Maffei (1790–1870) produced 500 locomotives by 1864. Public demonstrations when one of the company's S3/6 type pacifics was lodged in the Deutsches Museum in 1958 were testimony to the affection in which the steam locomotive was held. The Swiss Abraham Ganz (1814–67) opened the foundry that was to become the foundation of Budapest's (H) engineering industry in 1845. The company employed more than 6000

men by 1895. Other hubs of mechanical engineering developed in Pilsen (CZ), Winterthur (CH), Turin (I) and Berlin (D).

Mechanical engineering skills also spread to smaller towns where companies chiefly making agricultural machines developed from the businesses of millwrights, ironmongers and blacksmiths. In the course of time some companies came to supply specialised products to global markets. The scale of such concerns can readily be appreciated in the Long Shop at Leiston in eastern Suffolk, or in the museum in the paint shop of the St Nicholas works at Thetford in Norfolk, England.

A different kind of engineering enterprise was established in 1776 at Beaucourt in the Pays de Monbéliard (F) by Frédéric Japy (1749–1812). Originally he produced parts for watches, using machine tools that could be operated by unskilled workers. Under Japy's descendants the company produced a wide range of metal goods in the mid-nineteenth century, including machine tools, coffee grinder, pumps and later typewriters, electric motors and bicycle parts. In 1895 the Japy company declined to embark on building motor cars and was eclipsed in the Pays de Monbéliard by the company established by Armand Peugeot (1849–1915). ■



Furtwangen (D)
German Clock Museum

Paris (F)
Museum of Arts and Crafts

Sochaux (F)
The Peugeot Experience Museum

Leiston (GB)
Long Shop Museum

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Ships for the world's trade.

Until the 1860s most seagoing ships were made in small yards on river banks or on the shores of sheltered harbours. The most significant innovations did not involve changes in methods of construction. Copper sheathing and bolts were applied to deter maritime pests, enabling ships to make longer voyages to distant waters. Sir Marc Brunel's (1769–1849) block-making machines, installed at Portsmouth (GB) from 1801, accelerated the production of essential components. Increasing quantities of wrought iron became available for

anchors and small fastenings. The ironmaster Alexander Brodie (1732–1811) who had works near the Iron Bridge and in London, manufactured cast-iron stoves that could heat cabins safely in rough weather. Estuary shipyards were dependent on supplies of timber brought down Europe's rivers, sometimes in ships sometimes as massive rafts. Shipbuilding also depended on 'naval stores', the collective name given to the softwoods used for masts, spars and yard arms, the various derivatives of pine resin used as preservatives,



and the hemp and flax necessary for cordage and sail making. Significant numbers of European and particularly of British ships were built elsewhere, in India, where shipbuilders used teak which was more resistant than oak to decay, or on the shores of the maritime provinces of Canada. The processes involved in building wooden ships can best be appreciated in former naval dockyards such as those at Chatham (GB), Karlskrona (S), the Holmen base in Copenhagen (DK), the former Royal Navy yard at Vittoriosa, Malta, or the Arsenal at Venice (I).

The first practical iron vessel was probably the *Trial*, a barge on the River Severn launched by the ironmaster John Wilkinson (1728–1808) in 1787. The development of steam propulsion was pioneered in Scotland by William Symington (1763–1831), whose paddle steamer *Charlotte Dundas* was launched in 1803. Steam boats became important on the rivers of continental Europe. The potential for building steam-powered ships of iron was demonstrated by Isambard Kingdom Brunel's (1806–59) 3270-ton SS *Great Britain*, launched in 1843. She was the first oceangoing, iron hulled, screw driven ship, and made her maiden voyage to New York in 1845. On a subsequent voyage, in 1846, she went aground at Dundrum in Northern Ireland. Between 1852 and 1876 the SS *Great Britain* took migrants to Australia, and was then employed carrying coal. She went aground in the Falkland Islands in 1886, but was returned in 1970 to the dock at Bristol, England, where she was built, one of the most spectacular examples of the conservation of the industrial heritage.





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Nevertheless most of Europe's seagoing trade in 1860 remained in wooden sailing ships. The construction of iron steamships depended on the availability of wrought-iron (later steel) plates rolled to appropriate sizes, and on workshops that could supply engines. Iron ships could not be constructed on beaches, but required slipways or docks, and, as their size increased, investments in cranes and workshops where rivets could be manufactured and plates prepared for fitting. They also required deep water for launching, and in Britain these requirements dictated the removal of shipbuilding from London to the mouths of the Clyde, the Tyne and the Wear, to Merseyside, and Belfast. The Scottish shipbuilding industry is commemorated by the Titan Crane of 1905 at Clydebank.

In 1914 most steel ships were fitted together by riveting, but in 1885 Nikolai Benardos (1842–1905) obtained a patent in Russia for electric welding, and subsequently the technique was widely used for repairing vessels. The first all-welded ship was the 389-ton *Fullargar*,

built at Birkenhead (GB) on the banks of the River Mersey opposite Liverpool and after the Second World War riveting was almost entirely displaced by welding.

The history of shipbuilding is illustrated by notable preserved ships, such as the *Cutty Sark*, at Greenwich (GB), HMS *Warrior* at Portsmouth (GB), and the *Soldek*, conserved at Gdansk, the first ocean-going ship built in Poland after the Second World War. The NDSM yard at Amsterdam (NL) includes concrete slips of 1919 where many ships were constructed and at the Meyer company's yard at Papenburg (D) visitors can view the construction of cruise liners and other large seagoing ships. The ways in which craft for inland waterways and the coastal trade were constructed is depicted in the yard at Dendermonde (B). ■

Bristol (GB)
SS Britain

Chatham (GB)
Historic Dockyard

Copenhagen (DK)
Holmen

Clydebank (GB)
Titan Crane

 Papenburg (D)
Meyer Shipyard

Venice (I)
Arsenal

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Oil and motor vehicles.



The motor car, the characteristic artefact of twentieth-century civilisation, was made possible by the availability of fuels derived from petroleum. The oil industry is often said to have originated in the United States in 1859 when Edwin Drake (1819–80) drilled a well from which petroleum was extracted at Titusville, Pennsylvania, but it had earlier origins in Europe. During the twentieth century the industry expanded from a producer of oil for lamps to providing the universal fuel for transport, and feed-

stocks for numerous chemical manufactures.

The oil refinery established at Lucăcești-Bacău in Romania in 1840 is recognised as the first of its kind, although it operated on a small scale using equipment originally intended to distil plum brandy. Drilling for oil began at Bóbrka in Poland in 1854 and the industry's history is displayed in an open air museum. Jan Józef Ignacy Łukasiewicz (1822–82) demonstrated the first kerosene lamp in his pharmacy at L'viv

(UA) in March 1853, and established the first refinery in Poland in 1856 at Ulaszowice. The refinery at Rîfov near Ploiești in Romania opened in 1857. Pehr August Alund set up a refinery at Anglesberg on an island in Lake Amnängen (S) in 1875–76. His eight retorts produced a thousand barrels of fuel per year, but production of fuel ceased in 1902 and the establishment closed completely in 1927. The refinery, now part of the Bergslagen Ecomuseum provides a picture of the beginnings of an industry whose huge present day establishments, with mysterious stills and crackers, many hectares of tank farms, and innumerable kilometres of pipes, are not readily understood. A new industry began in the 1960s with discoveries of oil off the coasts of Great Britain and Norway and gas in the Netherlands. The museum at Stavanger (N) shows the growth of the industry from 1971.

The origins of the modern motor car can be discovered in Germany. Karl Benz (1844–1929) patented his first practical engine in 1879 and in 1883 set up a works in Mannheim, from which he patented a three-wheel motor car, now in the Deutsches Museum in Munich, in 1886, and a four-wheel car in 1893. Gottlieb Daimler (1834–1900) established a works at Stuttgart in the early 1880s where he applied the oil engine developed by Nikolaus Otto (1832–91) to drive moving vehicles, a motor cycle in 1885, a four-wheel carriage in the following year, and his first purpose-built motor car in 1889. The following year he built 350 cars and began to issue licenses for production in other countries.



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The first motor cars were built in small workshops, but from 1900 more ambitious factories were constructed, either extended series of single-storey shops, or multi-storey buildings which allowed more logical flows of components. Some were stylish buildings where wealthy owners could be entertained when buying or taking in their vehicles for services. An outstanding example is the Argyll Motor Works, at Alexandria, near Glasgow (GB), built in 1905, with red sandstone from Dumfriesshire, granite from Aberdeen and marble from Italy. It now accommodates the Loch Lomond Galleries shopping mall. All the major motor car manufacturers were influenced by the system of assembly line production introduced by Henry Ford (1863–1947) from 1911. Most present-day factories are rather confusing concentrations of largely inelegant buildings housing huge presses producing body panels, vast workshops making smaller parts, and largely-automated assembly lines. Europe's most spectacular motor car factory is the 507 m long, five-storey Fiat Lingotto works at Turin (I), designed by

Giacomo Matte-Trucco (1864–1934) and built in 1916–24, which has a test track on the roof.

No aspect of the industrial heritage is better illustrated in museums than the motor car. Numerous collections made by wealthy individuals, many of them primarily of high-performance sports cars, are displayed to the public. There are collections in most large museums of technology, and some manufacturers have museums that display their products, Skoda at Mlada Boleslav (CZ), Ferrari at Modena and Marandello (I), Peugeot at Sochaux (F) and Mercedes-Benz at Stuttgart (D), for example. There are also important collections of commercial vehicles, made by Tatra at Kopřivnice (CZ), by MAN at Augsburg (D), by DAF at Eindhoven (NL) and by Saurer at Arbon (CH). ■


Wietze (D)
German Petroleum Museum

Budapest (H)
Hungarian Railway Museum.
Railcar by Ganz (M.Uebel)

Angelsberg (S)
Oljeoen


Eindhoven (NL)
DAF Museum

Ladenburg (D)
Dr Carl Benz Museum

 Hoorn (NL)
Hoorn-Medemblik
Steam Tram Museum

Marinello (I)
Ferrari Museum

Turin (I)
Lingotto Factory

 Zwickau (D)
August-Horch-Museum

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From the depths of dark forests.

The ability to use wood – to build ships that could transport traders to Asia and colonists to America, to devise machines that could spin yarn or pump water from mines, and to create commodities such as clocks or toys that could be traded from regions with sparse agriculture resources was one of the foundations of European industrialization. Baltic softwoods (or deals) for example were being taken up the River Severn into the English Midlands by the early eighteenth century and in the 1770s timber from Gdansk (PL) formed

the scaffolding for the erection of the Iron Bridge.

A forest can be felled and cleared as a prelude to agricultural use of the land on which it stands, but in recent centuries most woodlands have been managed. Mature trees may be used for building houses or ships. Some wood may be split into staves for barrels. Some trees may be coppiced, cut so that they grow with many trunks, for use as charcoal or pit props. Underwood can be sold as fuel or used to make baskets, chairs, clocks or toys while twigs and



cuttings can be bundled into faggots to heat baking ovens. Ashes from wood fires are a source of potash, and wood can be charged into kilns to produce tar. Some forests were sources of furs. Timber was floated down some rivers to customers or exporters. Forest industries are well illustrated in the Norsk Skogbruksmuseum at Elverum, and in the museums at Puntaharju in Finland and Sopron in Hungary, while a forest manufacture that was vital to another industry, can be appreciated at the Stott Park Mill in the English Lake District which made reels and bobbins for textile manufacturers.

In the past 150 years Europe's forests have become the continent's main source of paper. The manufacture of paper originated in China and spread to Western Europe by the eleventh century. Rags were the principal raw material, but with the invention of papermaking machines in the early nineteenth century, by the brothers Fourdrinier (Henry 1766–1854; Sealy 1773–1847) and others, demand increased. Paper was made from straw, and from Esparto grass, but the industry was transformed from the 1850s by the use of wood pulp, which also became an important material for the manufacture of artificial fibres.

The making of paper by hand is demonstrated in museums and restored mills all over Europe, in the Netherlands Open Air Museum at Arnhem, at Almalfi in Italy, Capellades in Spain, Düren in Germany and Dusniki Zdrój in Poland, for example. Paper making machines can be seen on the Paper Trail at Hemel Hempstead in England, and in the Galliciani Mill at Basel which worked





from 1453 until 1955 and houses the Swiss Museum of Paper.

Most paper mills using wood pulp are very large, and few historic plants have been preserved after they have ceased operating. The Brunnshaab cardboard factory at Viborg in Denmark, adapted from a textile mill in 1909, has been a museum since its closure in 1988, and retains most of its machines. The Klevfos Industrimuseum in Norway produced wood pulp used to make wrapping paper. Its machinery, dating from 1909 has been retained and illustrates the whole process from the mills that cut wood into chips and the boilers in which the chips were heated with caustic soda, to the guillotines that cut the paper before despatch. The richly-ornamented buildings of the 1890s at the Verla pump mill in Finland, together with the adjacent workers' village, now form a UNESCO World Heritage Site. The most distinguished of all mills of this kind is the Sunila Pulpmill at Kotka, Finland, built in 1937–38 to the design of Alvar Aalto (1888–1936), where visitors are welcomed to see the plant in operation. ■

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Bergisch Gladbach (D)
Old Dombach Paper Mill
LVR Industrial Museum



Laakirchen (A)
Austrian Museum of
Papermaking and Printing



Oslo (N)
Norwegian Museum of Science
and Technology

Verla (FIN)
Verla Ground Mill WHS

Duszniki Zdrój (PL)
Museum of Papermaking

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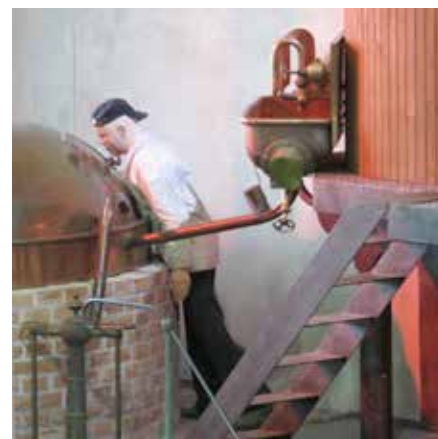
Our food & drink.



Bread made from wheat is the staple food over much of Europe, and until the late nineteenth century almost every community had a mill for grinding grain into flour. Many water-powered mills using millstones for grinding still operate on a small scale for visitors, and sell the flour they produce, as do a smaller number of windmills. The Mühlenroute based around the Westphalian city of Minden (D) provides guidance to 43 mills. The Big Mill at Gdansk (PL), built by the Teutonic Knights in the mid-sixteenth century, and rebuilt many times, remains

one of Europe's most imposing corn mills although it is no longer in use. The building's seven storeys are capped by a colossal pitched roof. Its stones were powered by eighteen overshot water wheels.

The production of flour was transformed in the second half of the nineteenth century by the adoption of rolling milling technology, demonstrated in 1834 by the Swiss Jacob Sulzberger (1802–55), and subsequently developed in Hungary by Abraham Ganz (1814–1867) and Andras Mechwart (1834–1907). Thir-



teen roller mills were built in Budapest in the 1860s, most of them in the Ferencváros area, and by 1870 Budapest was the largest flour-producing city in Europe. The five-storey *Concordia* mill of 1867 remains. The technology spread is demonstrated at Caudwells' Mill in Derbyshire, at the San Antonio mill of 1912 at Medina de Rioseco, Spain, and at a mill at Castelló d'Empúries in Catalonia, installed in 1860s. The scale of late nineteenth and early twentieth century roller mills built in ports to grind imported grain is illustrated by the Baltic Mill at Gateshead, England, now an arts centre.

Biscuits are a stable form of grain. Gingerbread, still sold at fairs and markets in northern Europe, was widely traded in the seventeenth and eighteenth centuries. Several towns were celebrated for their gingerbread including Deventer in the Netherlands, where the manufacture of Deventer Koeken is celebrated in the town museum and at the Hotel de Leeuw. The technology of biscuit making on a large scale was developed in the early nineteenth century at naval victualling depots such as that at Karlskrona in Sweden and the Royal William Yard at Plymouth, England, and was adopted by commercial manufacturers such as E G Verkade at Zaandam (NL) who supplied merchant ships embarking on voyages to the Far East. Biscuits were sold through imaginative marketing, which is illustrated by the astonishing collection of biscuit tins and other marketing artefacts at the museum at Reading (GB). The baking of bread is demonstrated in specialist museums at Seia (P), Radzionków (PL) and Me-





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demblik (NL), and in several open air museums.

Beer was already produced in large establishments in Europe's principal cities by 1700, in London, Edinburgh, and in some towns where the supply of water was favourable to brewing, such as Burton-on-Trent (GB) and Pilsen (CZ). Nevertheless much beer production was on a small scale, and malt houses, a typical example of which is conserved at Great Dunmow in England, were features of many towns. Most of Europe's large-scale brewing concerns, including Peroni in Rome (I), Stiegl in Salzburg (A), Guinness in Dublin (IRL), Heineken in Amsterdam (NL), Carlsberg in Copenhagen (DK) and the Union Brewery in Ljubljana (SLO), have facilities for visitors, and brewing on a smaller scale is demonstrated in several open air museums.

A feature of the late nineteenth century food industry was the growth of producer co-operatives to market their products. One of the first was a dairy co-operative at Hjedding near Olgod in Jutland (DK), opened in 1882, and now

the Meiermuseum. Also in Denmark is an open air museum of the co-operative movement at Holbæk. Dairy co-operatives were important elsewhere in Scandinavia and in the Netherlands and Ireland. In Spain about 50 buildings in the Art Nouveau style were built in the early twentieth century to accommodate wine co-operatives, and were known as Wine Cathedrals. A preserved example built in 1913 at L'Espluga de Framcoli, north of Tarragona, has the appearance of an imaginative Gothic railway terminus. The museum at Agia Paraskevi on the Greek island of Lesvos occupies a former communal olive oil mill.

Museums in various parts of Europe are devoted to particular types of food, to cheese at Nakkila-Seurra in Finland and Alkmaar in the Netherlands, to coffee in London and in Campo Maior in Portugal, to sugar at Halfweg in the Netherlands and Funchal on the Portuguese island of Madeira, to rice in Valencia in Spain and to pasta in Riesa in Saxony. ■

-  **Amsterdam (NL)**
Heineken Experience
-  **Vigo (E)**
Galician Museum of the Sea
-  **Pilsen (CZ)**
Pilsen Urquell Brewery
-  **Schiavon (I)**
Poli Distillery and Museum
-  **Saxmundham (GB)**
Snape Maltings
-  **Tychy (PL)**
Tyskie Brewery
-  **Żywiec (PL)**
Żywiec Brewery Museum



Luxury and utility: ceramics and glass.



The ceramics and glass industries had much in common. Both have their origins in the ancient civilisations. The products of each range from exquisitely beautiful objects collected by the wealthy to commonplace disposable containers. Glass and ceramic sherds found in archaeological excavations provide evidence of past manufactures and living conditions. Window glass, bricks and tiles are essential components of most buildings. Large production plants in both industries were concentrated on coalfields from the mid-eighteenth cen-

tury. The industries were even interdependent, for glassmaking depended on crucibles made from refractory clays.

Porcelains – clay wares with more or less translucent bodies – were brought to Europe from China by Portuguese and Dutch traders. Porcelain was probably first made in Europe by Johann Friedrich Böttger (1682–1719) at the pottery established in 1710 at Meissen near Dresden (D). In 1768 William Cookworthy (1705–80) patented a porcelain made with China Clay or Kaolin from Cornwall, where the extraction of clay subsequently

became a major industry. Kaolin was discovered in the same year near Limoges, which became the principal centre for pottery manufacture in France. More than 30 factories were in production there in 1850, and their products are displayed in a museum named after its founder Adrien Debouché (1818–81).

The most intensive concentration of ceramics works (or potbanks) was in the North Staffordshire Coalfield around Stoke-on-Trent (GB), where Josiah Wedgwood (1750–95) opened a rationally-planned pottery at Etruria in 1769 that became the pattern for subsequent large-scale ceramics works. The Gladstone works is a characteristic potbank of the mid-nineteenth century, and Middleport a model factory of the 1880s, while the Potteries Museum & Art Gallery has the country's best collection of North Staffordshire wares, Wedgwood products are displayed in a museum at the model factory built by the company at Barlaston in the 1930s, and the preparation of materials for pottery is demonstrated at the Etruria Industrial Museum and Cheddleton Flint Mill.



Several potteries had royal patronage. Perhaps the most celebrated is the works established in 1738 which moved to Sèvres near the palace of Madame de Pompadour on the outskirts of Paris in 1756, and was formally recognised as a royal factory three years later. Visitors can tour the present-day factory and view collections of historic wares. At Schloss Nymphenburg in the suburbs of Munich visitors can see the products made at the pottery originally established in 1747 by the Prince-Elector Max III Joseph (1727–77), which moved to Nymphenburg in 1754 and prospered due to the work of the Swiss modeller Franz Anton Bustelli (1723–63).

Other potteries were developed by talented entrepreneurs. Jean Francois Boch (1782–1858) established a pottery in a Benedictine abbey at Mettlach in the Saarland (D) which he purchased in 1794. In 1836 he merged his business with the porcelain company established by Nicolas Villeroy (1759–1843), and Villeroy & Boch became one of the most powerful brands in the industry in the twentieth century. The St Lambert

works near Liège (B) was also opened in a former monastery, in 1826. The company established at Selb in Bavaria (D) by Philip Rosenthal (1855–1937) also gained a strong brand image, but one of the main themes of the museum at Selb is technical ceramics such as heat shields for space shuttles

Glass is made by heating mixture of silica (sand) sodium carbonate (alkali) and lime at a very high temperature. It can be blown, moulded, pressed, drawn, rolled or spun, can be decorated by cutting, and engraving. Plate glass was made by casting in France from 1688. Traditions of making glass in some places in Europe extend back many centuries. The glassmakers of Venice (I) moved in 1291 to Murano, an island in the lagoon, where visitors can see Venetian glass made over many centuries in a museum, as well as visiting working glass works. Traditional Bohemian glass and glassmaking can be seen at Jablonec nad Kysou and Karlovy Vary (both CZ), and at Waldekraiburg in Bavaria where Sudeten Germans, expelled after 1945 from Czechoslovakia,

continued the traditions of Bohemian glassmaking in a village established in a former explosives factory. The centre for the study of the glass industry in Spain is at La Gránja de San Ildefonso near Segovia where manufacturing near the royal summer palace began in 1727–28, and moved to an imposing grey granite building in the 1770s. The royal works in France, La Crystallerie de la Reine (the queen's glassworks), a palace-like building that incorporates two glass cones, is the headquarters of the ecomuseum at Le Creusot. The manufacture of utilitarian glass wares, bottles, jars, lamps, carboys and lamps is illustrated at Petershagen on the River Weser in Germany, and at the Surte works in West Gotland in Sweden. ■

Baruth (D)
Baruth Glassmaking Village

Murano (I)
Glass Works

 Selb (D)
Porzellanikon

Mettlach (D)
Villeroy and Boch, Keravision

St Helens (GB)
The World of Glass

Seraing (B)
Christal Discovery
Val Saint Lambert

 Maastricht (NL)
former 'De Spinx'
Sanitary Ceramics Factory

Safe in harbour.



The sea has carried international trade throughout the industrial period and in 1950 remained the principal means of intercontinental passenger transport. Until after the middle of the nineteenth century many merchant ships were remarkably small. The warship *Victory*, launched in 1765 and preserved at Portsmouth, England, displaces 3,500 tonnes and is 70 m long and was vastly larger than most merchant ships of her time. Nevertheless the use of iron enabled the construction of larger vessels and port facilities expanded to accom-

modate them. Some of Europe's principal ports, such as Southampton (GB), were situated on natural harbours where ships could moor in deep waters. Others such as Hamburg (D), Rotterdam (NL) and Bristol (GB) took advantage of the sheltered estuaries of large rivers. Many needed to build docks, basins in which ships could float at all states of the tide while being loaded and unloaded.

A dock was built at Liverpool (GB) as early as 1715 but it was John Rennie (1761–1821) in the 1790s who devised the essential principles of subsequent

construction. His West India Docks in London of 1800–03 incorporated high boundary walls, designed to restrict pilfering, and multi-storey warehouses. This was the pattern for the future construction, including the Albert Dock at Liverpool designed by Jesse Hartley (1780–1860), and now home of the Liverpool Maritime Museum. While shipping has long ceased to use the range of wet docks in London built between 1800 and 1913, many of the docks themselves remain in water, surrounded by luxury apartments, and can be explored on foot.

As main line railways gained access to ports multi-storey warehouses were displaced by single-storey, open-sided transit sheds, the best examples of which remain at Antwerp in Belgium. The hydraulic crane was patented in 1846 by Sir William Armstrong (1810–1900), and cranes, pumping stations and accumulator towers providing the necessary heads of water for their operation became features of many ports. Multi-storey warehouses for particular purposes appeared in the late nineteenth century, for tobacco, tea, and frozen meat, while grain ships increasingly despatched their cargoes by suction into concrete silos. Ports exporting coal, some of it despatched to 'coaling stations' on the main sea routes throughout the world, were important, the most significant of them in Cardiff, Wales, where the Pierhead Building, once the centre of the global coal trade still stands.

The first train ferry in Britain took carriages across the Firth of Forth before the completion of the Forth railway bridge in 1890. Ferries crossed the English Channel from Southampton and



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Richborough to France during the First World War, and some of the equipment was redeployed to operate a ferry service for freight wagons between Harwich (GB) and Zeebrugge (B) in 1924. From 1936 there were direct sleeping car services between London and Paris via a ferry between Dover (GB) and Dunkirk (F). Train ferries were of most importance in Scandinavia, some of them providing links with Germany, and between Sicily and the Italian mainland. Similar installations could be used for loading cars and trucks on to ships, and, after some tentative experiments before the Second World War, 'roll-on: roll-off' services expanded rapidly in the 1950s, and all over Europe now form the main means of carrying freight over short sea crossings, although new bridges in recent decades over the Sound between Denmark and Sweden and the Great Belt between Funen and Zealand have reduced the number of vehicle ferries in Scandinavia. Vessels preserved at Maritiman in Gothenburg (S) include a car ferry of 1963.

From the late 1960s international sea traffic was transformed by the introduc-

tion of containers, which in a short time rendered most wet docks redundant.

Sir Samuel Cunard (1787–1865) established regular sailings between England and North America in 1830s and in 1839 gained a contract to carry mails which set the pattern for what became known as 'liner' services for more than a century. There was fierce competition between the shipping lines of the various European nations in the decades before the First World War, particularly on the route to North America. While luxury facilities for first-class passengers draw much attention, the liners also conveyed large numbers of emigrants from Europe to the United States. Liner services were restored after the Second World War but declined dramatically from 1957 after the first commercial jet flights across the Atlantic. Since that period large passenger vessels have been used for cruising rather than transport. The Stazione Marittima at Genoa in Italy, with a baggage hall of the 1930s decorated with images of ships, hotels and biplanes, is an outstanding memorial to liner travel. ■



Hamburg (D)
Museum of Work, Harbor Museum

Antwerp (B)
Old Port Cranes

Liverpool (GB)
Albert Dock WHS

Genova (I)
Stazione Marittima
(Wikimedia Commons.
Alessio Sbarbaro)

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Inland navigation.

Europe's principal rivers, the Rhine, the Rhone, the Elbe, the Severn, the Niemen, were used for commercial navigation from early times. Each had its own traditions, relating to the shapes of boats and the customary stretches over which boatmen worked. On some rivers logs were taken downstream lashed together as rafts, a custom that survived well into the nineteenth century. On the Rhine a raft assembled at Bingen (D), might be more than 200 m long, and have a crew of up to 500 people, and would take about eight days to reach

Dordrecht in the Netherlands where the logs would be sold.

Man-made waterways, canals, were used for navigation in ancient China, and by the fifteenth century artificial channels in the Netherlands were used both for drainage and navigation. The Canal du Midi in France, built by Pierre-Paul Rignet (1609–80) and opened shortly after his death, linking the River Garonne, and therefore France's Atlantic coast, with the Étang de Thau on the Mediterranean, was a summit waterway that included Europe's first canal tunnel,



demonstrated the possibilities for inland navigation. In the next 70 years ambitious projects were realised in Prussia, Russia and Ireland.

The British canals of the Industrial Revolution, the first of which were the Sankey Brook Navigation and the Bridgewater Canal, of 1757 and 1760, served different purposes. Originally they were built to supply coal to towns, but they evolved into a network that for 50 years distributed merchandise across much of Britain, and carried coal for much longer. The system included 58 km of tunnels, including that beneath the Pennines at Standedge, 4951 m long, and numerous aqueducts, including that at Pontcysyllte, which carries the Ellesmere Canal for 305 m at a height of 38 m above the River Dee.

The success of British canals led to the construction of waterways, most of them linked to river navigations or lakes, in most of the coalfields in Europe. In the course of the nineteenth century the scale of operations changed. The first major innovation was the steamship, invented in Britain but scarcely used on British waterways. The first steam boat on the Rhine, the British *Defiance*, reached Cologne in 1816, and the following year the *Caledonia* ventured as far as Koblenz (D). In 1834 the steamship *Argo* became the first to pass through the Iron Gates on the Danube. Several paddle steamers from the mid-nineteenth century are preserved, including the *Stadt Wehlen* of 1879 at Dresden in Saxon (D) and the *Skibladner* of 1856 which plies between Eidsvoll and Lillehammer on Lake Mjosa in Norway.





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Several forms of lift and inclined plane were built in Great Britain, but the inadequacy of building materials meant that only those in the Coalbrookdale area, such as the Great Hay Incline which carried boats of no more than eight tonnes, worked for long periods. By the 1880s hydraulic transmission could be used, steel was available for construction and wire rope for haulage, and soon afterwards it was possible to employ electric motors. The Anderton Lift in Cheshire, completed in 1875 to the design of Edwin Clark (1814–94) set a pattern copied at Fontinettes in northern France in 1888, and on the four lifts of 1885–1917 on the Canal du Centre near La Louvière in Belgium. The prosperity of inland navigation was also reflected in the improvement in the channel of the Rhine which enabled trains of barges to progress as far upstream as Basel (CH) by 1904, and the completion in 1899 of the Henrichenburg lift at Waltrop (D) at the Dortmund-Ems Canal.

The prosperity of inland navigation in the twentieth century was marked by the completion of spectacular engineering projects, some of them in Germany: At Niederfinow on the Oder-Havel Canal, a 36 m boat lift built in 1927–34 raises vessels of up to 1000 tonnes. A similar lift at Rothensee near Magdeburg was completed in 1939. A lift at Scharnebeck on the Elbe Seitenkanal raises Europa barges of 1350 tonnes 23 m, and opened in 1975. A steel aqueduct 918 m long has carried the Mittelland Canal over the Elbe near Magdeburg since 2003. The inclined plane on the Canal du Bruxelles à Charleroi at Ronquières in Belgium was completed in 1965. The lift at Strépy Thieu, which



raises Europa barges 73.15m, was completed in 2002, after which the four lifts near La Louvière were retained, and have been designated a UNESCO World Heritage Site. From the 1890s vessels were hauled upstream through the Iron Gates gorges on the Danube by steam railway locomotives, but a hydro-electric scheme completed in 1972 and associated works linked with the navigation have submerged the railway and the towing path cut in the time of the Emperor Trajan. The history of navigation through the Iron Gates is portrayed in the museum at Drobeta Turnu-Severin in Romania. ■



Waltrop (D)
LWL Industrial Museum
Henrichenburg Shiplift

Dudley (GB)
Dudley Canal Tunnel



Swansea (GB)
National Waterfront
Museum

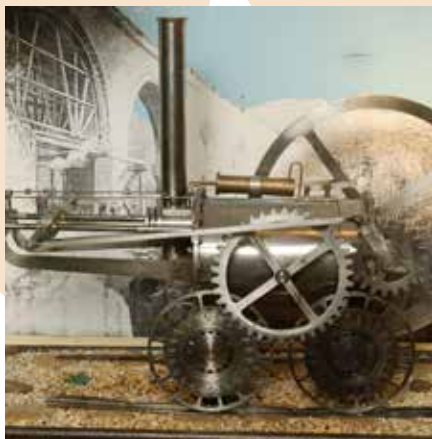
Wrexham (GB)
Pontcysyllte Aqueduct WHS

Magdeburg (D)
'Rothensee' Ship Lift

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Progress comes on iron rails.



The first known railways were wooden tracks serving metalliferous mines in central Europe, illustrated in the mid-sixteenth century by Georgius Agricola (1494–1555), and guide-wheel lines, on which vehicles called 'hunds' run on parallel timber baulks guided by a 'pin' that passed between them. Lines of this sort continued in the German-speaking world into the nineteenth century and examples are conserved at Lucerne in Switzerland and Eisenerz in Austria.

The main line railway evolved in the English coalfields, where by the early seventeenth century distinctive systems of wooden railway were developing in Northumberland and Durham and in Shropshire, where iron wheels were used on railway vehicles from 1729, and crude cast-iron rails were laid from 1767. In the North East railways were generally of wider gauges, and substantial bridges were built, such as the Causey Arch of 1727. In the early nineteenth century George Stephenson (1781–1848) and others began to develop steam locomotives, first suggested by Richard Trevithick (1771–1833), and from 1820 railway builders began to use the T-section wrought iron rails developed by John Birkinshaw. Many of these technological developments were brought together in the railway between Liverpool and Manchester built by George Stephenson and opened in 1830 using the terminus now incorporated in the Museum of Science and Industry in Manchester. Trains ran on specialised track, they were mechanically propelled, the line accommodated public traffic and conveyed passengers, and it operated under a measure of public control. These are the five accepted criteria for the mine line railways that



were built all over Europe in the decades after 1830

At first the growing railway system was something of a mystery to travellers, but publishers such as George Bradshaw (1801–53), John Murray III (1808–92) and Karl Baedeker (1801–55) began to explain its secrets, and by the 1850s patterns of rail-borne tourism were developing. Georges Nagelmackers (1846–1905) from the mid-1870s developed the Compagnie Internationale des Wagons-Lits et des Grands Express Européens which provided sleeping car and

restaurant services between the continent's principal cities. In 1879 Werner von Siemens (1816–92) demonstrated an electric locomotive in Berlin, and by 1902 electric locomotives were being built in Budapest (H) for main lines in Italy. The Swiss and Italian mountain routes through the Simplon and Lötschberg passes, completed in 1906 and 1910 were electrified from the beginning. The line from Berlin to Silesia was electrified by 1911, and that from Paris to Orléans in 1926, while Bavaria, Sweden and Switzerland, all well-endowed



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with hydro-electric power, had electrified most of their systems by 1939. Electrification continued in most countries after the Second World War.

The pattern of long-distance international trains established by 1914 was revived with modifications after the First World War, but after 1945 the division of Europe by the Iron Curtain made it impossible to restore some traditional routes. Nevertheless it was still possible in the 1970s for the British traveller arriving at Hoek van Holland on the overnight ferry from Harwich (GB) to board trains for Copenhagen, Moscow or Rome. The willingness of national railway companies to co-operate enabled the development from 1957 of the Trans-Europe Express (TEE) network of fast, first-class only trains, designed to meet the needs of businessmen. The system grew and by the late 1970s totalled 39 trains serving 31 routes. It declined with the building in France and Germany, and later in other countries, of high speed routes on which trains operated relatively frequent services, and also with the growth of low cost airlines.

The last TEE trains ran in 1995–96, but some rolling stock has been preserved, a German multiple unit in Nuremburg and Belgian-built locomotive-hauled carriages with corrugated aluminium sides at Schaerbeek. Few very long-distance trains with sleeping cars remain but high speed lines make it possible to cross Europe by train faster than at any time in the past.

Freight traffic has also been transformed in recent decades. Traditional railway freight depots have been closed in most countries, and typical freight trains are now made up of flat wagons carrying containers to and from ports, or large wagons carrying steel or motor cars, or bulk tankers containing coal, grain or oil. ■

Merthyr Tydfil (GB)
Cyfarthfa Castle Museum.
Trevithick's Pen-y-darren
Locomotive of 1804



Azpeitia (E)
Basque Railway Museum

Nuremberg (D)
DB Railwaymuseum



Gijón (E)
Asturian Railway Museum



Jaworzyna Śląska (PL)
Silesian Railway Museum



Entroncamento (P)
National Railway Museum



Vila Nova de Famalicão (P)
National Railway Museum at Lousado

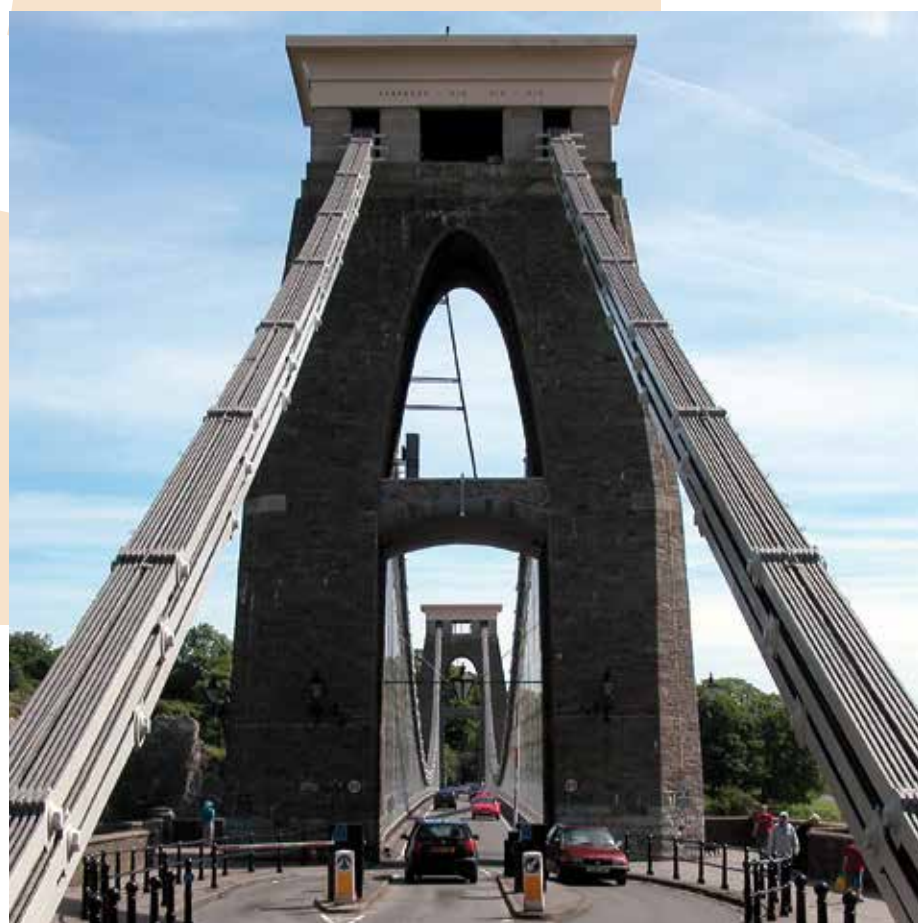
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High roads.

The development of roads along which coaches or wagons could travel long distances at reasonable speeds was an important pre-condition of industrialisation. By the mid-sixteenth century the road from Paris to Orleans, the nearest port on the River Loire was paved, and before 1700 there were timetabled coach services, if only in the summer months, from London to most of the principal towns in England. The extent of well-surfaced roads increased in the mid-eighteenth century, either by royal decrees enabling the speedier carriage of mails, or by the raising of revenue from tolls that could be devoted to road improvements. Toll houses and roadside posts measuring distances are displayed in most open air museums. Some roads were improved for political or strategic reasons. That from London to Holyhead, authorised by legislation of 1815, enabled members of parliament from Ireland to travel more easily to London, and also made it easier to send English troops to Ireland. Its improvement under the direction of Thomas Telford (1757–1834) included the construction of the cast-iron Waterloo Bridge at Bettws-y-Coed and the Menai Suspension Bridge, linking Anglesey Island and the mainland of Wales.

The nature of road transport facilities in various countries in the mid-nineteenth century is revealed in guide-books such as those published by John Murray III (1802–92) and Karl Baedeker (1801–59). In most countries there were coaches operating scheduled services, sometimes called ‘diligences’ and vehicles that plied for private hire. In most German states diligences belonged to the government and were called *Eilwa-*



gen. Vehicles, signs and models relating to in the pre-railway era in Bavaria are illustrated in the transport museum in Nuremberg (D). In Great Britain it has been estimated that in 1835 there were about four thousand mail and stage coaches, giving employment to about 35,000 people, and 150,000 horses. The inns where horses were changed and passengers refreshed could be impressively large establishments, with extensive yards and ranks of stables. In large towns many have been replaced by shopping centres. Only one of Lon-

don's great coaching inns remains, the George in Southwark. There are several notable collections of horse-drawn vehicles, including those of the Bavarian court displayed at Nymphenburg Castle at Munich, and those that belonged to the Marquesses of Bute, conserved by the National Trust at Arlington Court near Barnstaple in Devon.

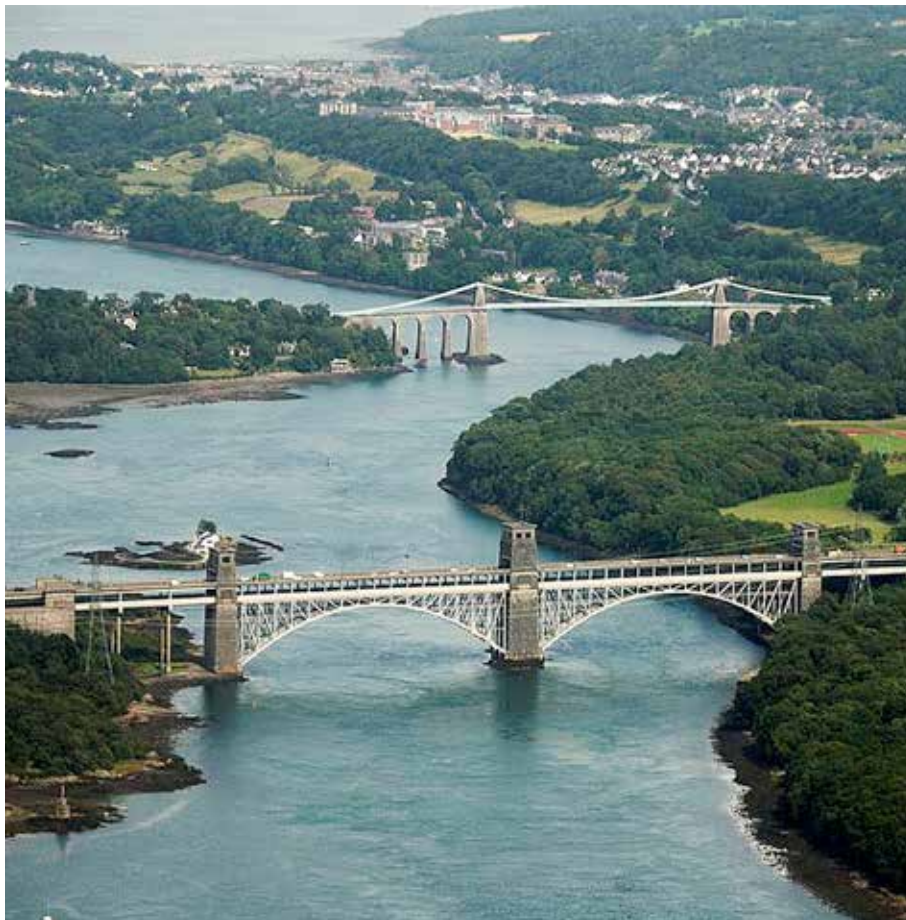
Most roads in Europe in 1850 had unbonded surfaces, although in the Netherlands some had surfaces of bricks called *klinker*, and in Belgium many were paved with cobbles. From



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the 1890s, initially due to the demands of cyclists, tar was increasingly used to create bonded surfaces, which became increasingly necessary as numbers of motor cars with pneumatic tyres increased. Concrete was also used to surface roads, and the race track at Brooklands in England of 1907 brought it to public attention. The pattern for road building in the second half of the twentieth century was set by the Italian *autostrada* and the German *autobahnen* of the 1930s the prototype for which was the 10 km long Auto-

bil-Verkehrs- und Übungstrasse (Automobile Traffic and Practice Road) or AVUS, built in the Grunewald district of Berlin between 1913 and 1921. It was the first road in Europe to be designed primarily for the motor car. ■

Bristol (GB)
Clifton Suspension Bridge

Oberhausen (D)
LVR Industrial Museum.
Road Construction Equipment.
Temporary Exhibiton 2006

Menai Bridges (GB)
Menai Bridges



Telford (GB)
Iron Bridge and Tollhouse WHS

Telford (GB)
Iron Bridge Tollhouse WHS
Table of Tolls

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Flying machines.

Aeroplanes, heavier-than-air craft deriving from the first successful powered flight made by the Wright Brothers (Wilbur 1867–1912, Orville 1871–1948) in the United States in 1903, were developed in Europe in the following decade, and a Bleriot XI of 1909 is preserved in Paris. Aircraft were mass-produced during the First World War after which the first experimental commercial flights took place. Some utilised adapted military aircraft, but as early as 1919 the four-seater Junkers F13, the first all-metal framed passenger aircraft, was

introduced. It remained in production for 13 years and some aircraft remained in service for 20 years. Examples remain in the Deutsches Museum in Munich, in Berlin, Budapest and Stockholm, and at Le Bourget, Paris.

The 1920s also saw the growth of airships. Count Ferdinand Zeppelin (1838–1917) built his first dirigible airship at Friedrichshafen on Lake Constance (D) in 1900, and the town remained the base for his operations in the inter-war years. The Zeppelin Museum contains many artefacts from airships, and shows films of



some of the epic inter-continental and round-the-world journeys made by Zeppelins in the 1920s and 30s, before the fire at Lakehurst, New Jersey, in 1937 brought an end to the use of airships filled with hydrogen. The crash of the experimental airship R101 in 1930 similarly ended British interests in airships, although two enormous airship hangars, one of them where the R101 was built, remain at Cardington near Bedford (GB).

The needs of European imperial powers to communicate with their colonies and dependences led to the encouragement of intercontinental air routes by subsidies. The French needed to maintain contacts with Indo-China and Central Africa, the British with India, the Cape and Australasia and the Dutch with Indonesia. Routes were built up with stops, where the small numbers of passengers carried on airliners of the time could sleep overnight. By the early 1930s low-wing, all-metal monoplanes, most of them carrying about 20 passengers were displacing earlier biplanes, and by 1939 four-engine aircraft such as the Armstrong Whitworth Ensign and the Fokker-Wulf Fw200 Kondor, were coming into operation, which potentially could have carried 40 passengers across the Atlantic or to Australia. The Second World War brought an end to such prospects, but similar aircraft in the form of bombers went into mass production, and transatlantic flights became commonplace.

There was a brief interlude in the history of commercial aviation in the late 1930s and 1940s when flying boats appeared the most viable means of crossing oceans since they did not need runways and their relatively large





size enabled the provision of luxurious accommodation. They were used on imperial mail routes, and on services linking the principal cities around the Baltic. Foynes, at the mouth of the River Shannon, Ireland, became the airport for flights to Botwood in Labrador, Canada, and remained so during the Second World War. Some flying boats remained in commercial service after 1945, but the building of long runways during the war rendered them redundant, and the last British services ceased flying in 1958. Visitors can explore a Short

Sandringham IV flying boat of 1946 in the museum at Southampton (GB).

Air travel grew steadily in the late 1940s and 1950s, at first dependent on airliners developed from wartime bombers. The first turbo-prop airliner, the Vickers Viscount, flew in Britain in 1948, and was used on many European routes. The first pure jet airliner, the de Havilland Comet was also made in England but its development was delayed after metal fatigue caused two examples to crash. It was eclipsed by the American Boeing 707 which could carry up to

180 passengers. It revolutionised intercontinental air transport after its first transatlantic flight in 1958, and effectively brought an end to traditional ocean liner passenger services in the next decade.

There are aircraft museums in most European countries, although many concentrate on military aircraft. Most airliners in the former USSR were made in factories in Ukraine, and the collection of the aviation museum at Kyiv includes eight Tupolov airliners and six Ilushins. ■



*Berlin (D)
German Technical
Museum*

*Dessau-Roßlau (D)
Hugo Junkers
Technical Museum.
Ju 52*

*Budapest (HU)
Hungarian Museum of Science,
Technology and Transport*



*Friedrichshafen (D)
Zeppelinmuseum*

Living in cities.



Housing for working people in every city and town had its own particular characteristics. In some places closely intertwined working and living quarters can still be seen, as in the faubourg Saint-Antoine in Paris, the centre of furniture-making in the French capital since the fifteenth century, or the *Gewerbehöfe* (industrial yards) in the Kreuzberg district of Berlin. In Ghent, the principal textile-manufacturing city in Belgium, houses were built in parallel ranges around courts known as *Begijncomplex* (inner blocks) and were approached

by passages through larger buildings fronting the main thoroughfares. In Scottish cities most working people lived in multi-storey tenement blocks. Some cities in England, including Leeds, Nottingham and Birmingham, had many back-to-back houses, terraced dwellings that shared common back walls. The first generations of houses built as cities began to expand in the eighteenth century were mostly demolished long ago because they could not be altered to conform with sanitary legislation, but in Manchester some early dwellings have

been investigated by archaeological excavations. In Birmingham some back-to-back houses in Hurst Street and Inge Street built between 1802 and 1831 have been restored and opened to visitors by the National Trust.

The Frenchman Léon Faucher (1804–54) and other travellers in England in the 1840s were appalled by living conditions in cities, but commended rural factory communities, many of which depended on water-power and were thus free of smoke. Textile manufacturers such as the Strutts at Belper or the Greggs at Quarry Bank aimed to attract and retain skilled workers, and to establish communities in which children would succeed their parents in factories. The factory and adjacent workers village of more than 800 dwellings at Saltaire, built in the 1850s by the worsted manufacturer Sir Titus Salt (1803–76) continued the tradition.

The owners of other isolated industrial communities had broader objectives. Robert Owen (1771–1858) from 1799 managed mills set up by his father-in-law David Dale (1739–1806) at New Lanark, and his ideas about co-operation and education became highly influential. Workers at New Lanark lived in tenement blocks, similar to those in Scottish cities but in the second decade of the nineteenth century Owen built a school, notable for its enlightened teaching methods, and the Institution for the Formation of Character, which can still be seen by visitors. The equally influential Familistère at Guise in the *département* of Aisne in France was established from 1859 by the iron founder Jean-Baptiste Godin (1817–88), who was inspired by the



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1920s and 30s was in Vienna (A) where numerous architecturally distinguished developments can still be seen, most notably the Karl Marx Hof, 1 km long, and comprising 1382 dwellings, constructed in 1927–30 to the design of Karl Ehn (1884–1957). ■

ideas of the socialist Charles Fourier (1771–1817). Most of the buildings remain and their history is explained in a museum. The Chartist movement in Great Britain in the 1830s and 40s aimed to gain the vote for working people, and also established the Chartist Land Company which reflected a widespread desire by industrial workers to return to the land. Five estates were acquired, three-bedroom cottages were built on each in plots of up to 1.2 ha. They were settled by more than 250 families, but the financial foundations of the scheme were insecure and the company was wound up in 1850. A cottage on the estate at Dodford is conserved by the National Trust. Colonies of a different kind, intended to provide houses and small holdings for very poor families were established at Frederiksoord and Willemsoord in the Netherlands in 1818–20.

Paternalistically-inspired factory communities abounded in the late nineteenth and early twentieth centuries. Examples include Noisiel-sur-Marne in France around the chocolate factory

of 1872 built by Émile-Justin Menier (1826–81), Crespie d'Adda and Collegno in Italy, Port Sunlight, Bournville and New Earswick in England, and the colonies established by the Krupp family around Essen, Altenhof I and II and Margarethenhöhe of 1906. The suburb of Nikiszowiec, part of Katowice in present-day Poland, is a self-sufficient community built for miners and their families with its own shops, bakeries, hospital, pharmacy, laundry, and public bath house which has been adapted as a museum.

Local government authorities in many cities came to take a responsibility for housing. The London County Council, set up in 1889, continued the practice of philanthropic bodies in building multi-storey blocks of apartments, one of the first of which, dating from 1849–50, remains in Streatham Street. *Het Schip* (the ship) in Amsterdam (NL); a block of 102 dwellings built in 1919–20 by a housing association with the support of government, proved influential. Perhaps the most impressive housing by city authorities in the

Birmingham (GB)
Back-to-Backs Worker
People's House



Lanark (GB)
New Lanark WHS



Port Sunlight (GB)
Port Sunlight Village (Paul Thompson)

Guisse (F)
Familistère

Capriate San Gervasio (I)
Villaggio Crespi d'Adda WHS



Berlin (D)
Nazi Forced Labour
Documentation Centre

Co-funded by the
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of the European Union



Blue gold: water – making cities habitable.



Water is essential to life, but it can also be a threat. It can be helpful to Man in powering water wheels of all shapes, sizes and configurations; it can be medicinally beneficial, as at Spa in Belgium, Mariánské Lázně (Marienbad) in the Czech Republic or Bath in England; it can be lifted from springs or rivers into reservoirs and led by aqueducts or pipelines to provide for the needs of great cities, or to fill navigable canals. It can also be man's enemy with its potential to flood lowlands or carry diseases. The significance of pure water is symbolised

by elaborate well head installations, some of which are preserved in open air museums.

The creation of effective water supply systems was one of the great achievements of the engineers of the Roman Empire, and the Pont du Gard, part of a 50 km system that supplied water to the city of Nîmes in France, and the 36-arch aqueduct at Segovia in Spain, both of the first century AD are monuments to a civilisation whose engineering achievements were not matched for many centuries. The water

towers near the Rotes Tor (red gate) in Augsburg (D), three of which in their present form date from 1599, 1672 and 1746. Nine more were added subsequently, and by 1850 Augsburg's water supply systems reached most houses in the city. The New River a contour canal that took water 38 km from springs near Hertford into London built by Sir Hugh Myddleton in 1613, is less spectacular but evidence of the importance of supplying water to great cities. In some cities there were networks of wooden pipes that took water to the homes of the wealthy, and made it available to the populace at large from conduits, like that at Carfax, the principal crossroads in Oxford (GB), which now stands in parkland at nearby Nuneham Courtenay. The outstanding water supply system constructed in the eighteenth century was the 58 km aqueduct of 1720, with its 109 stone arches, that took water into Lisbon, Portugal. Its history is explained in a museum in the Barbadinhos pumping station of 1880.

A steam engine was used to pump water for drinking at Chelsea, London, in 1720, and through the nineteenth century and into the twentieth century steam pumping stations were built in most towns and cities in Europe. Notable conserved examples include the London Museum of Water & Steam at Kew, in a pumping station of 1838, which displays a steam engine with a 90 inch (2.29 m) diameter cylinder, which can still be steamed, and another with a 100 inch (2.54 m) cylinder. The pumping station of 1884 at Papplewick near Nottingham is architecturally the most spectacular of British water





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pumping installations. The Finnish Museum of Technology is located in a waterworks of the 1870s on the island of Kuninkaankartano near Helsinki. The Zawada pumping station of 1895 at Karchowice (PL) holds a comprehensive collection of the equipment used in the purification and supply of drinking water. Other preserved pumping stations include one of 1904 in Riga, Latvia, and the Cornellà station of 1909 in Barcelona, Spain. In the second half of the nineteenth century civil engineers built dams to create reservoirs from which cities could be supplied with water. The Gileppe Dam in eastern Belgium of 1862–76 is a notable example, while the 118 km linking the Elan Valley reservoirs in mid-Wales with Birmingham, opened in 1904 is one of the longest of its kind. Similar pumping stations were built to remove sewage from great cities, according to the principles set out by the British engineer Sir Joseph Bazalgette (1819–91). Examples include that at Crossness in London and the Bukeneč pumping station of 1906 in Prague.

Man's efforts to reclaim land from the sea and to protect it against floods are, naturally, best appreciated in the Netherlands. At Kinderdijk south east of Rotterdam are two ranges of windmills on either side of drainage canals, one of eight brick-built tower mills built in 1738, the other of eight octagonal tower mills faced with reeds constructed two years later, together with two smaller mills. This amazing landscape can be explored along the *Molenkade* walkway. Equally astonishing is the Cruquius engine house one of three built in the 1840s to drain the Haarlemmermeer. The 144-inch (3.65 m) cylinder of the engine built by Harveys of Hayles in Cornwall operated eleven cast-iron beams balanced on the walls of the circular crenelated engine house tower.

While many water pumping installations are spectacular, perhaps none provides a better interpretation of the industry than Aquarius at Mulheim-an-der-Ruhr (D), a museum in a water tower of 1892–93, that makes dramatic use of multi-media systems. ■



Cornellà de Llobregat (E)
Agbar de les Aigües Museum



Haarlemmermeer (NL)
Cruquius Steam Pumping Station

Karchowice (PL)
Zawada Historical Water Station



Lemmer (NL)
Ir. D.F. Wouda Steam
Pumping Station WHS



London (GB)
London Museum of Water & Steam



Medemblik (NL)
Dutch Steam Machine Museum



Prague (CZ)
Stará Čistírna Old Waste
Water Treatment Plant



Industrial heritage.



Concern for the industrial past, its buildings, its machines, its products, the memories of workers and entrepreneurs, is not entirely a recent phenomenon. The term 'industrial archaeology', meaning the study of the physical remains of past systems of mining, manufacturing and transport, came to be used in Britain in the mid-1950s, and was taken up in other countries, but it was not a new expression. The Portuguese Francisco de Sousa Viterbo (1845–1910) used it in 1896, in a study that showed how people's memories of their work could be of relevant in the modern world. Concern for a fast-disappearing industrial heritage was expressed in Britain in the 1960s by the establishment within a few years of five open air museums concerned with the industrial past, by the re-opening by voluntary groups of railways on which steam locomotives could work, by a recognition that canals had a future as cruising waterways, and by the preservation of mills, mill engines, collections of artefacts by countless groups of concerned individuals. From the 1970s this concern for the industrial past was echoed across Europe.

The collection of aesthetically pleasing products of industry, of porcelain, glass, coins, shoes, and, in the twentieth century, of motor cars, has a long history. Visitors to Falun can see the beautifully-constructed models of hoists and other mining equipment made by Christopher Polhem (Polhammar) (1661–1851), the Swedish engineer who studied in Germany, Netherlands, England and France. Machines that were critical in the development of industry are displayed in Europe's principal mu-



seums of technology, the Conservatoire National des Arts et Métiers in Paris, established by a government decree of 1794, the Science Museum in London, which evolved after the Great Exhibition of 1851, the museums in Vienna and Stockholm, opened respectively in 1908 and 1936, and the Deutsches Museum in Munich, opened in 1925.

The open air museum, part of the Romantic Nationalism movement of the late nineteenth century, was born in Scandinavia. In 1891 Artur Hazelius (1833–1901) opened the collection of

historic buildings from all over Sweden that took the name Skansen (fortifications) because it was built on a fortified island in Stockholm harbour. Many such museums were established in Scandinavia, and subsequently in other countries, particularly after 1945, and the word 'Skansen' now means open air museum in several European languages. Hazelius and the founders of later museums were concerned to preserve the buildings and artefacts characteristic of rural life in particular regions. From the 1960s some open air

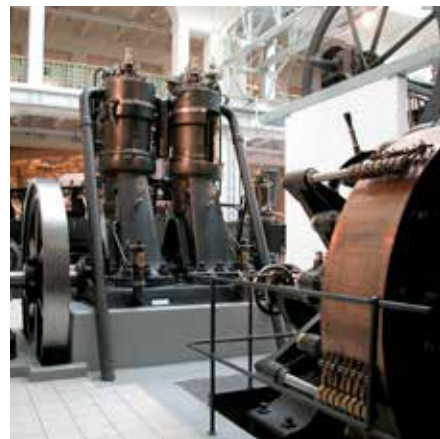


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museums, such as those at Hagen (D), Beamish (GB) and Zaanse Schans (NL), came to be concerned with the industrial past, although critics argued that buildings should not, where possible, be moved, but that they should remain in place and be interpreted.

An alternative approach was proposed from 1967 by the French ethnologists Georges Henri Rivière (1897–1985) and Marcel Evrard (1920–2009), founder of the Écomusée de la Communauté Le Creusot Montceau-les-Mines. Rivière argued that an ecomuseum should permit the people living in an area to discern their own identity, through their built environment, their ecology and geology, as well as through documentary and oral history, and that such topics should be studied as communal activities, and not be confined to experts. The project at Le Creusot proved influential, and the term 'écomusée' or its English equivalent 'ecomuseum' has since been applied to industrial conservation projects across Europe. The first international conference on ecomuseums was at Seixal, Portugal in 2012.

Initiatives to conserve and interpret the industrial heritage have multiplied across Europe in the past half century. Most have no great academic or social pretensions, but simply reflect the desire of communities to retain reminders of their past industrial activities and to tell their stories to visitors and to succeeding generations. ■

Beamish (GB)
Beamish Open Air Museum

Hagen (D)
LWL Open Air Museum

Munich (D)
German Museum

Paris (F)
Museum of Arts and Crafts

Le Creusot (F)
Creusot Montceau Ecomuseum

Vienna (A)
Technical Museum

Co-funded by the
Creative Europe Programme
of the European Union



Our place in history.



Encounters with the industrial heritage remind us first of our place in history. We may reflect on Europe in 1916, the year of Verdun and the Somme, when it was in the midst of a destructive war, on how our ways of life have changed in the past century, and how they may change again before 2116.

We can admire the beautiful objects produced by past generations of manufacturers, glass from Bohemia or Venice, or porcelain from Sèvres in France or Gustavsberg in Sweden. We can experience what an English poet called the 'keen unpassioned beauty of a great machine' when we see the Maffei S3/6 locomotive in the Deutsches Museum at Munich, Germany, or the 241P four-cylinder compound locomotive at Mulhouse, France, built by Schneider at Le Creusot, about 1950. We can wonder at the mathematical sophistication of James Watt's parallel motion or the intricacies of a Jacquard loom. We can also admire past generations of industrial buildings. Some manufacturers expressed their pride in what they were doing by commissioning fine architecture, such as the archway of 1836 in Fallonica, Tuscany, that was once the entrance to a foundry, the casting hall in the Gothic style of 1828 at the Sayner Hütte at Bendorf-Sayn, Germany, the Fagus shoe last factory designed by Walter Gropius (1788–1864) at Alfeld, Germany, or the extraordinary saltworks designed by Nicholas Ledoux (1736–1806) at Arc-et-Senans, France. We can marvel at seemingly miraculous feats of civil engineering, such as the aqueduct at Lisbon in Portugal, the canal lift at Strépy-Thieu in Belgium or the 574 m long and 78 m high Göltzschtalbrücke,

viaduct in Saxony, Germany. Visitors to some industrial heritage sites can see how skills, such as weaving, glass blowing, decorating pottery, building and repairing canal boats or replacing boiler tubes, are fostered and passed to future generations. We can come to appreciate some of the benefits of industrialisation, the improvements in personal hygiene that came with the availability of cheap cotton sheets, or the benefits to health of cheaper fuels for household heating. We can admire the resilience with which some groups of migrants developed manufactures in the countries that gave them refuge, the Huguenots in England, or the wartime refugees who settled at Hermoupolis on the Greek island of Syros in the 1820s.

Involvement with the industrial heritage also brings confrontations with aspects of our past that are causes for shame. The slave trade is remembered at Liverpool and forced labour under the Third Reich in Berlin. Hamburg in Germany, Caen in France and Coventry in England retain evidence of the saturation bombing of cities and at Sanok in Poland and Waldkraiburg in Germany we can learn about the forced movements of ethnic groups after the Second World War. We also have to confront the exploitation of workers, as well as the philanthropic activities of some employers. At Silkstone in Yorkshire (GB) is a memorial to the victims of an inrush of water into a local coal mine in 1838, who included eleven girls aged between 8 and 17 and fifteen boys aged between 7 and 16.

Industrial buildings, the machines that worked in them, the products that were made there, the memories of those

who laboured there, are keys to understanding many aspects of our past. All over Europe buildings whose architectural qualities may be unremarkable have been conserved by communal efforts because they have been judged to be worth keeping, they foster an appreciation of the industrial past and of wider aspects of a community's history, they can be homes to museum collections, and venues for meetings, concerts and exhibitions. Two of many French examples are at Bussièrès, a town of 1500 people in the Beaujolais region, where a collection of artefacts relating to silk working, carried on there from the 1830s until the 1960s, was begun in 1977, and displayed in an old silk mill from 1998. Textile manufactures at Cholet in Maine et Loire began in the seventeenth century and the town became famous for producing the 'mouchoir rouge (red handkerchief) de Cholet'. Here in 1982 a voluntary group prevented the demolition of a bleach-works of 1881 and has since developed the building as a museum and cultural centre. ■

Stepy Thieu (B)
Canal du Centre.
Ship Lift No 3



Alfeld (D)
Fagus Works WHS

Mylau (D)
Göltzsch Viaduct



S. João da Madeira (P)
Industrial Tourism



Reflections.

Coal mining in Western Europe has almost ended which gives rise to contemplation of its legacy. Its ending symbolises the changes of the early twenty-first century. At several former mines, such as Energeticon at Alsdorf, Germany, and C-Mine at Genk, Belgium, visitors are urged to contemplate future supplies of energy, while in several former coalfields trails show the effects of mining on the landscape. Aiseau-Presles near Charleroi, Belgium, is the starting point for a journey which takes in 43 towns and villages, and 340 large pit heaps in an area where 60 nationalities were involved in mining. The Durham Coast Heritage Trail in England extends 17 km south from Seaham to Crimdon, and includes the sites of four twentieth-century collieries whose workings extended under the sea, as well as former miners' villages and ports from which coal was exported. At Nordstern Park, Gelsenkirchen, in the Ruhr, where the coal mine closed in 1993, visitors can enjoy restaurants and bars in a garden landscape that incorporates the elegant pit head buildings of c 1930, and take trips on canal boats to the Henrichenburg boat lift or the gas holder at Oberhausen.

The industrialisation of Europe changed the face of the earth. Men's lives came to be determined by clocks, and their work measured by money. Machines replaced hand-operated spinning wheels and looms and later the sewing machine came to dominate the making of shoes and clothes. In the twentieth century robots took over from men and women many of the tasks along production lines for motor cars. Some manufacturing activities have been moved to the East, and Delhi and Beijing are now more severely polluted than Duisburg or Manchester. Europe is again experiencing radical change as old and not-so-old industries come to an end. New forms of economic activity aided by information technology are emerging, nanosciences, biotechnology, and the generation of electric power from wind and sun. Whole regions are looking for new identities and seeking to equip themselves for the future. What remains is a rich industrial and cultural legacy, a network of sites across Europe that conserve and interpret the continent's industrial past. ERIH brings them together and brings to life the industrial past so that it can animate our future. ■

ERIH, the EUROPEAN ROUTE OF INDUSTRIAL HERITAGE, is the tourist information network of industrial heritage in Europe.

Where was the world's first factory? Where was the largest steam engine built? And where can you find the most up-to-date colliery of its time? Industrialisation changed the face of Europe. Consequently it has left us a rich industrial heritage. A gigantic network of sites spread all over Europe. It only has to be brought back to life – which is what the European Route of Industrial Heritage is doing. It is the common link between them all. From disused production plants to industrial landscape parks and inter-active technology museums. Come with us on an exciting journey of discovery to the most important sites in Europe's industrial history.

ERIH's route system of Anchor Points, Regional Routes and European Theme Routes is your signpost to Europe's industrial heritage.

Anchor Points

Anchor Points form ERIH's virtual main route.



The name says it all. Many features are anchored here. Primarily the overall route framework. Anchor Points cover the complete range of European industrial history. After that, they tell tourists what they can see at a local level. Visitors of all ages can relive their industrial heritage through fascinating guided tours, exciting multi-media presentations and outstanding special events. Last not least, Anchor Points are simultaneously starting points for a variety of regional routes.

Regional Routes

Regional Routes open up the industrial history of a region.



Each region has its own specialisms and in this respect European industrial heritage is just like food. Its strength lies in the fact that it unites many different traditions within a single idea. The Regional Routes link landscapes and sites which have left their mark on European industrial history. Germany's Ruhrgebiet, for example. Or South Wales, a key region in the "world's first industrial nation". Both these areas comprise a number of less significant industrial monuments – the small cogs in the large machine.

European Theme Routes

Theme Routes illustrate the European connections.



Such as "The treasures of the Earth": what, where, when and how were they extracted from the ground? Or "Textile manufacturing": what were the milestones along the way from fibre to factory? Theme Routes focus on specific questions relating to European industrial history and reveal – often in connection with the **biographies** – potential links between radically different industrial monuments all over Europe. The result is a "circuit diagram" showing the connections between the main themes of European industrial heritage.