Steam at the Powerhouse

In this one to two hour tour of the fine collection of engines at the Sydney Powerhouse Museum, you can trace the history of the steam engine and the contributions it made to the development of New South Wales. Learn about the Ultimo Power House, built just over 100 years ago, the first large electric power station in Australia, whose buildings now house the museum.

Beam engines at Botany pumping station, installed in 1858

Self-guided visit to the steam exhibits at the Powerhouse Museum

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The tour

Before taking the tour, visit the Powerhouse website http://www.phm.gov.au/ for information on opening times, charges, access, parking and the times of special events.

When you arrive at the Powerhouse, pick up a map of the museum in the entrance lobby and then go to the Boulton and Watt engine on Level 4, the same level as the main entry to the museum.

The Boulton and Watt engine

James Watt was born in Greenock, near Glasgow, in 1736. He was trained as an instrument maker, and then worked for a time at the University of Glasgow. With some guidance from the distinguished professor of anatomy and chemistry, James Black, he experimented there with steam. The professor of physics, John Anderson, brought him a model of Newcomen's steam engine to repair, and this led him to make his first great invention in 1765, the separate condenser. Later in this tour you will see models that demonstrate the principles of Newcomen's engine and how Watt's condenser was able to provide a great improvement in its fuel consumption.

James Watt

Watt travelled to London to patent his invention, and on the way met for the first time his future partner, the Birmingham manufacturer Matthew Boulton. Boulton, an energetic, visionary extrovert with a thriving business, and owner of a factory capable of building the parts for steam engines, was the perfect foil for the diffident, diligent Watt.

Watt's first two commercial steam engines built in partnership with Boulton were operating by 1776. One was a pumping engine for the Bloomfield colliery, the other a blast furnace blowing engine for the iron maker John Wilkinson. Wilkinson, fortuitously, had just invented a machine that could bore true cylinders, and this solved one of Watt's major technical problems with the engines. A brisk business building pumping engines, mostly for Cornish mines, soon followed.

It was Boulton who in a 1781 letter drew Watt's attention to the potential market for a steam engine that could provide rotary motion to be used for driving a mill. Watt set to work, and had an experimental rotative engine working by March 1783. In March 1784 he delivered his first rotative engine to Wilkinson's Bradley Forge. Within a year he had installed five more rotative engines, one of them for Whitbread's Brewery in London, the engine now in the Powerhouse. It is the oldest remaining rotative engine in the world. When it was finally retired from the brewery in 1887 it was acquired for the Sydney Technological Museum by one of the trustees, Professor Liversidge, and brought to Sydney.

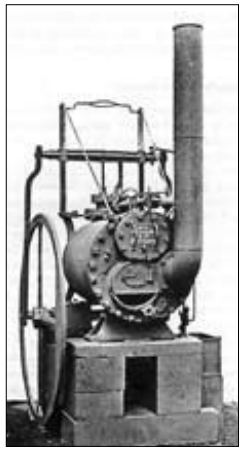
Matthew Boulton

The engine incorporates Watt's important inventions, the separate condenser, the parallel linkage, the double acting principle, the speed governor and the sun and planet gear motion. All these are explained in a series of exhibits located in the gallery behind the engine in the museum. There is more information about Boulton, Watt and the engine in a brochure that can be purchased in the Powerhouse shop.

Once the possibilities of rotative power from steam became recognised, new developments and applications followed. One was the steam locomotive. Move now to look at a fine example from the middle of the 19th century, Locomotive No 1 of the Sydney Railway Company.

Locomotive No 1

Newcomen's and Watt's engines used steam at a pressure little above atmospheric. Watt was opposed to the use of high-pressure steam in engines, because he considered it dangerous. Some of his contemporaries, notably Richard Trevithick (1771–1833) saw the possibilities for more compact, efficient and powerful engines using high-pressure steam. In 1891 Trevithick built a steam carriage for use on a road, and then in 1804, a railway locomotive. He also developed boilers for generating the high-pressure steam for his engines. Trevithick's engineering innovations were outstanding, and he overcame setbacks including a well-publicised accident involving his steam carriage, and a boiler explosion that killed four men. He became bankrupt, but continued to pursue the use of high-pressure



Trevithick high pressure steam engine, c. 1806, now in the Science Museum, London

steam.

Trevithick's invention of the locomotive led directly to the highly successful locomotive *Blücher* built by George Stephenson (1781–1848) for the Wylam colliery near Newcastle in the north of England. Stephenson went on to establish a company in Newcastle to manufacture locomotives, and to build the Liverpool and Manchester Railway. His son Robert (1803–1859) managed the locomotive works and developed a series of outstandingly successful locomotives, including the *Rocket*, famous for its performance in competitive trials at Rainhill near Manchester in 1829.

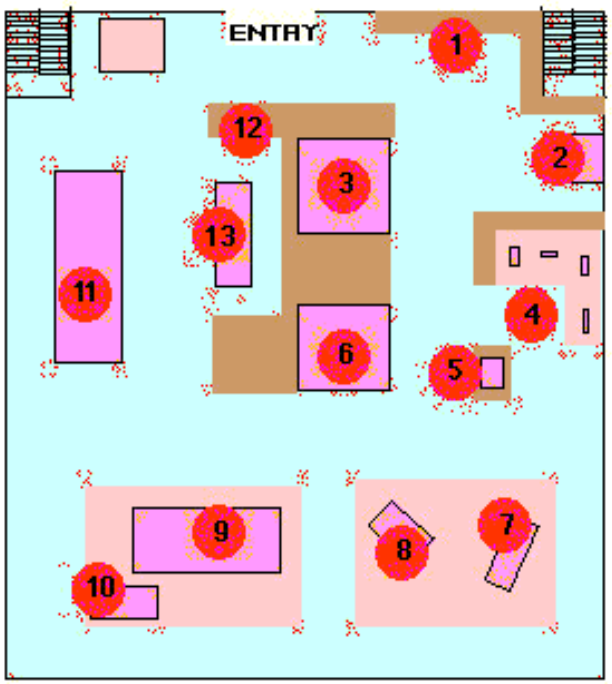
Locomotive No 1 is a typical product from the works of Robert Stephenson and Company. It is one of four purchased and shipped to New South Wales for the opening of its first railway in 1855. Looking at the locomotive, you can see that the ideas developed by Trevithick and the Stephensons, and incorporated in their locomotives, were the ones that dominated locomotive design for a hundred years. They include the horizontally mounted fire-tube boiler, the driving wheels coupled together and driven from the engine pistons through connecting rods guided by crossheads, the use of steam exhausted from the cylinders to provide a strong blast up the chimney, and the driver's position located behind the boiler and next to the tender which trails behind with a load of coal and water for the engine.

There is more information about Locomotive No 1 and Sydney's first railway in a brochure that can be purchased in the Powerhouse shop.

Now go downstairs to Level 3 and the area named 'The Steam Revolution'. There is a plan of this area in this brochure with the main exhibits numbered. Follow the numbers for the next part of the tour.

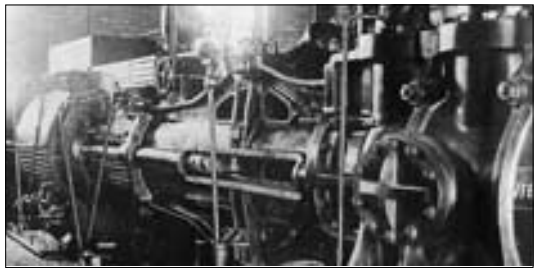
Newcomen's engine

Thomas Newcomen (1663–1729) a Devonshire blacksmith was the father of the steam engine. He experimented with steam for many years before his first pumping engine was installed in a colliery in 1712. The principle of his engine and its application in a beam engine are demonstrated in **exhibit (1)**. Steam is condensed in the engine cylinder by a spray of water, and the resulting vacuum drives the piston. Newcomen's massive beam engines driving mine pumps were very inefficient, but overcame the problem of removing water from mines. Before the end of the century, hundreds of them were installed, most in Cornish mines, but some as far away as Russia and Hungary. The exhibit also includes a working model of Watt's engine and an explanation of the principle of Watt's separate condenser.



The Botany pumping engines

Exhibit (2) is all that remains of the three large beam engines that for thirty years pumped all of Sydney's water supply from the Botany swamps south of the city. They were built in England by Thomas Perry and Sons and installed in 1858 in a pumping station located beside General Holmes Drive near Sydney Airport. They were taken out of service when the new water supply from the Upper Nepean scheme and Prospect reservoir was introduced in 1888. The Botany pumps were kept on standby until 1893 when they were scrapped. From 1876 steam pumping engines were used at Crown Street reservoir to lift water to the higher parts of the city. The two large Worthington-Simpson engines at Crown Street were installed in 1888 and ran until 1965. Steam engines and, later, steam turbines were in use at the Ryde water pumping station until the 1970s.



Worthington-Simpson engine and pump, Crown Street pumping station, installed 1888

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12. **Model of triple expansion marine engine**
13. **Parsons steam turbine**

Maudslay beam engine from the Goulburn brewery

This engine, **exhibit (3)** was removed from the Goulburn brewery when it closed in 1929. A typical beam engine, it was installed by the Bradley family when they opened their flour mill at Goulburn in 1837. It was built by Maudslay Sons and Field, the firm founded by a famous English engineer Henry Maudslay (1771–1831), who made many contributions to mechanical engineering, including the design of the table engine seen at **exhibit (5)** and the development of the lathe as a precision machine tool.

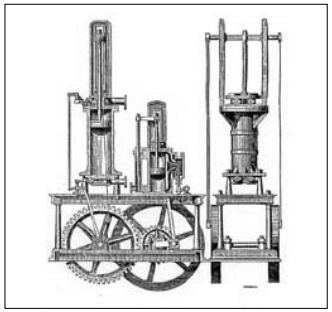
Australia's first steam engine was at Dickson's flour-mill at the western end of Goulburn Street in Sydney, opened by Governor Macquarie in 1815. The remains of an early steam boiler found near Day Street in Sydney, and on display in the museum, may have belonged to Dickson's mill. By 1840 there were 26 steam engines in New South Wales flour mills, and ten engines in other industries, mainly mining and saw-milling.

High pressure steam engines

At **exhibit (4)** are several working engines using high-pressure steam. They show some of the variety of engine designs that developed during the nineteenth and early twentieth centuries and the uses to which they were put.

Table engine built in Sydney?

This little engine, **exhibit (5),** is noteworthy because it was possibly built in Sydney around 1850. It illustrates the compact table engine design developed by Henry Maudslay in 1807. Steam engines of this type were being built in Sydney by P.N. Russell and Company by around 1860, and two of the firm's designs for steam engines driving refrigeration compressors were illustrated in the British journal *The Engineer* in 1861.



Steam engine driving refrigeration compressor by P.N Russell and Co., Sydney, as illustrated in 'The Engineer' 1861

Marshall engine

This engine, **exhibit (6)**, built at the beginning of the 20th century, is typical of the two cylinder horizontal engines made in very large numbers and used for driving machinery of many kinds. This one saw service in a saw-mill and a gold dredge. Similar ones were in flour-mills, breweries, manufacturing plants, ice works, dairy factories, mines and pumping stations throughout New South Wales at the time of Federation.

Merryweather fire engine

This fire engine, **exhibit (7)** saw service in Broken Hill from 1896. Sydney Fire Brigade imported its first large horse-drawn steam fire pump from England in 1891, when high pressure pumping was needed to reach the top of the new 10 and 12 storey buildings. It remained in service until 1929, and on stand-by until 1934, It is preserved in pristine condition at the Museum of Fire, Penrith.

Portable steam engine

Hundreds of engines like the one in **exhibit (8),** were in use throughout Australia in the late 19th century and the early 20th for driving saw mills and threshing machines, pumping water and operating small mines. Most were imported but some were made in Australia, usually to designs copied from British prototypes.

Engines similar to this one, but with a drive to large rear wheels, were used as traction engines for ploughing, pulling stumps, logging, and for heavy road haulage. Steam road rollers, similar in design, were still in use in Sydney after World War II.

Foden steam traction engine hauling a chaff-cutting plant and cook's galley, Wagga Wagga

Steam driven calliope

By the early twentieth century there were a small number of steam driven calliopes like the one at **exhibit (9),** doing the rounds of country shows or located in more permanent amusement parks. The engine of this one started life driving the electric generator on the Newcastle ferry *Wattle*. The barrel organ next to the calliope is driven by another small steam engine.

Steam driven ice cream machine

Steam driven ice cream machines like **exhibit (10)** were made in America for about twenty years from the late 19th century. This one was in a milk bar at Manly.

Bellis and Morcom steam engine

Many engines like **exhibit (11)** were imported into Australia during the 20th century, and used for driving machinery and generating electricity. This compact high-speed engine could generate around 50 times the power of the huge Boulton and Watt engine.

Model of triple expansion marine engine

Exhibit (12) is a model of a triple expansion marine engine, of the kind used to drive steam ships in the first part of the 20th century. Some of the last ships with engines of this kind were the Liberty ships built during World War II, which each had a single engine producing around 2000 horse power.

The idea of compounding, allowing the steam to expand at reducing pressure in two or more stages in separate cylinders, was first introduced in 1782 by Jonathon Hornblower, a contemporary of Boulton and Watt, who took legal action against him for alleged infringement of their patents. Watt himself had little interest in the idea of compounding as it was suited to the use of high-pressure steam, which he considered dangerous. But in the end, compounding won out because it could improve efficiency by up to 50 per cent. In 1845 John McNaught introduced a method for compounding existing beam engines by adding an extra high pressure cylinder, and this became quite popular.

The first large triple expansion steam engines in Australia were the 1000 horsepower engines designed by W. B. Chaffey and built by Tangye in England for the Chaffey brothers' irrigation project at Mildura on the River Murray in 1885. The engines were still in use in the 1950s, and one has been preserved in working order in its original location.

Steam engines built at Cockatoo Island for steamship 'Fordsdale', 1923

Parsons turbine

The machine at **exhibit (13),** radically different from all the piston driven steam engines in the museum, represents the most important development in steam power since the inventions of Newcomen and Watt.

Charles Parsons (1854–1931) patented his steam turbine in 1884 and exhibited it driving an electric generator in 1885. In 1888 steam turbine electric generating sets were installed in the Forth Banks electric generating station, near Parsons works in Newcastle on Tyne, England. By 1889 Parsons had produced 300 turbines. Machines similar to the one in the Powerhouse Museum, built in 1903, were installed on land and in ships to provide power for electric lighting.

Parsons' invention was perfectly timed to match the rapidly

growing use of electricity, first for lighting, and soon for driving trams, trains and all kinds of industrial machinery. By the time of World War I most of the world's electricity was being generated in power stations by steam turbines, and today they generate 90 per cent of electricity in New South Wales. The giant steam turbines in the power stations on the New South Wales coal fields each generate 5000 times as much power as the little machine on display in the museum. They work on exactly the same principle and are its direct descendants in design.

Less than ten years after Parsons built his first turbine, de Laval (1845–1915) in Sweden built a steam turbine operating on a slightly different principle, making use of the impulse of jets of steam. He built small turbines to drive cream separators for dairies, and some of these were imported into Australia from the early 1890s for use in dairy factories. Curtis, in America, soon improved on de Laval's original design, and incorporated the impulse turbine principle into large turbines for power stations.

A number of steam turbines for power stations were built in Australia under licence. In addition Cockatoo Island Dockyard built turbine machinery for 17 ships between 1920 and 1968.

This completes the tour of this part of the Powerhouse. There are a couple more steam exhibits on Level 2 in the transport area of the museum that you can visit when returning to the entrance.

New South Wales Locomotive 1243

This locomotive was built in Sydney by the Atlas Engineering Company in 1882, one of six that the company built for the New South Wales Government Railways. The prototype had been delivered by the British firm Beyer Peacock in 1877.

Up to the end of 1890, 54 locomotives had been built by local firms for the New South Wales Government Railways, and 395 locomotives had been imported. Several Sydney firms, including Atlas, Vale and Lacey, Mort and Hudson Brothers were very keen to build locomotives but lacked the capability to make many of the parts. Nor could they compete on price with British and American suppliers.

In the last years of its working life, this locomotive hauled the Vintage Train until 1974, when it was retired. The appearance of the locomotive is altered somewhat from the original as a result of modifications over the years including a new cab, new boiler with a Belpaire firebox and a longer smokebox.

Cut-away model of Beyer Garratt locomotive

This small model shows the internals of the most powerful locomotive to operate in New South Wales, the AD 60 class built in 1952. There were 42 of these locomotives built for the government railways by Beyer Peacock, mainly for coal haulage in the Hunter region. They were the last new steam locomotives to be delivered in New South Wales.

This type of locomotive was invented by an Australian, Herbert Garratt, in 1907. The concept was successfully developed and marketed world-wide by the British firm Beyer Peacock. Its distinctive feature was the two separate sets of cylinders and driving wheels, which allowed a wide firebox, good weight distribution and a large tractive effort.

Video of Sydney steam trams and ferries

Near the electric tram exhibit you can view a three minute video that shows some of Sydney's steam trams and ferries. At one time all the ferries on Sydney Harbour were driven by steam engines, but they were gradually replaced by more economical diesel engines. Most of the ferries on Sydney Harbour were locally built and many of their engines were designed and built in Sydney.

Steam tram in Elizabeth Street, around 1890

Sydney's first steam trams were imported from America in time to run from Redfern station to the 1879 International Exhibition being held on the site of today's Royal Botanic Gardens. By the end of the century there were over 100 steam tram 'motors', the little locomotives that hauled one or two single or double deck passenger cars, on Sydney streets. Only Paris had a steam tram fleet to rival Sydney's. After 1899 the system was electrified and the last steam trams ran on the main system in 1910. Several isolated steam tram lines survived in the suburbs until the 1930s, and the last line, in Parramatta, closed in 1943.

This completes the tour of the steam exhibits at the Powerhouse Museum. Before leaving, take a few minutes to look at the building, which was once the Ultimo Power House, opened in 1899 to provide electricity for the tram system.

The Ultimo Power House

Inside the building, near the transport exhibits, are the remaining parts of two brick chimneys. The building was once the boiler house for the power station, and housed sixty coal-fired boilers.

Next to the boiler house was the engine room, which now houses ''The Steam Revolution'. Initially there were four 1250 horsepower steam engines driving generators. They were built in America, carefully selected by the Chief Electrical Engineer of the Railways and Tramways, P. B. Elwell, as being the best available in the world for the purpose. Elwell, who supervised the design and construction of the Power House, died two months before it opened in 1899. The first engines were regularly overloaded, and in 1902 the engine room was extended to accommodate three 2500 horsepower engines, with space for three more.

Machinery at Ultimo Power House around 1905. Parsons steam turbine partly visible on the right

Elwell's successor, O. W. Brain, having visited England and America in 1902, decided to order a 3000 horsepower Parsons steam turbine instead of more reciprocating steam engines, and it was installed in 1905. In 1908 two more Parsons turbines, each of 5000 horsepower, the largest in the world at the time, were ordered. These two machines were retired in 1948. Over the years up to 1949 the capacity of the Power House was increased by retiring the engine driven generators and installing larger turbine generators. Two machines installed in 1923 were the first large turbine generators made in Australia.

The Power House finally closed in 1963, and by 1966 all the machinery had been removed for scrap. The building remained empty and derelict until 1979 when work began on converting it for reuse by the Powerhouse Museum. The museum opened on the site in 1988.