OSCILLATING STEAM ENGINE BY JOHN PENN & SONS

IN THE STEAMBOAT *DIESBAR*

Photo: Olivier Bachmann

Designated a

Historic Mechanical Engineering Landmark

July 2nd, 2008

Dresden, Germany

ASME
SETTING THE STANDARD

A history of the Fleet

Paddle steamers have been plying the waters of the River Elbe in Saxony since 1836. In March of that year local merchants in Dresden first pursued the idea of using the river for the transportation of both material goods and passenger traffic. In July of 1836 a royal Saxon decree permitted the merchants the privilege of steam navigation on the river, and the "Elbdampfschiffahrts-Gesellschaft" was founded shortly afterward.

The maiden voyage of the passenger steamer *Königin Maria* took place the following year. In 1867 the company changed its name to "Sächsisch-Böhmische Dampfschiffahrts-Gesellschaft", to reflect its expanded regional reach, which included neighboring Bohemia as well as Saxony. In the prime of its development and at the zenith of its growth around 1900, the company featured a fleet of 37 steamers and carried up to 3.6 million passengers annually. These numbers have never been matched!

The official poster from 1936 to commemorate 100 years of steamboating on the Elbe. Image: Sächsische Dampfschiffahrt

Two World Wars and significant geographical and political changes in Europe took their toll on the nature and structure of steam navigation on the Elbe. After World War II, the majority of the fleet of steamers was either destroyed or confiscated to contribute to wartime reparations. Following the establishment of the Soviet-controlled German Democratic Republic (GDR), the company was nationalized and in 1948 took the name of "Elbschiffahrt Sachsen". During the GDR years, the steamers later operated under banner of the "VEB Fahrgastschiffahrt Weisse Flotte" and were commonly known as the "White Fleet".

A lack of financing to comprehensively modernize the fleet and replace many of the old ships is one of the primary reasons why so many paddle steamers survived in the second half of the 20th century in Dresden and in Saxony, while in most other Western European regions and countries they were being scrapped by the hundreds. This irony of history is one of the reasons why Dresden in the 21st century can proudly feature the largest fleet of genuine paddle steamers in the world.

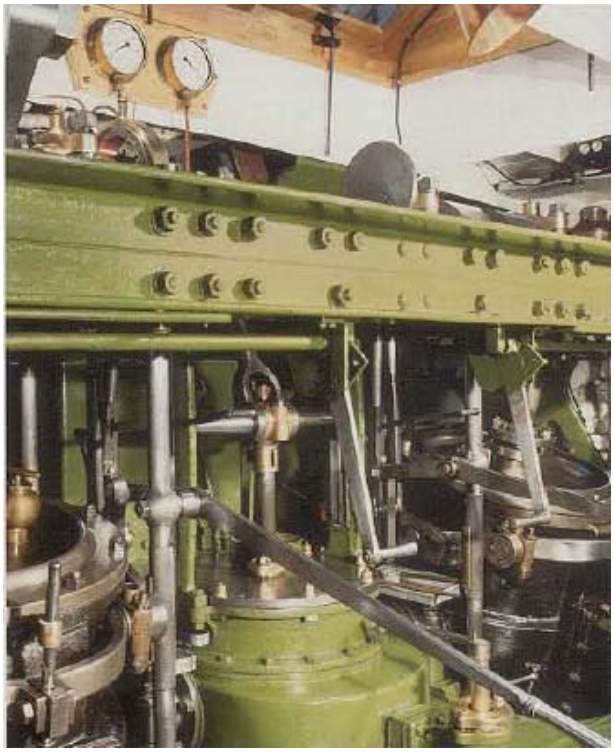
Today's fleet and fleet structure came into place in 1993 and 1994, when private German investors founded the "Sächsische Dampfschiffahrts GmbH & Co. Conti Elbschiffahrts KG" and invested more than 26-million Deutsche Marks into the complete overhaul and stylish reconstruction of eight of the historic paddle steamers. This investment not only saved the old steamers from an uncertain fate, but also would turn out to be an excellent business decision. Since the mid-1990s, the "Sächsische Dampfschiffahrts GmbH" has become one of most commercially profitable navigation companies in all of Europe, turning the old-time charm and unique experience of the genuine paddle steamers into financial profit and proving the formidable economic viability of the old-fashioned paddle steamers even in the 21st century.

The economic success of the initial eight overhauled paddle steamers led the company to acquire a ninth steamer in 2000, bringing back the original Elbe steamer *Krippen* from its most recent home in Frankfurt, to its historically appropriate operating territory in Saxony.

The vessel in front of the famous Baroque Dresden skyline. Photo: Olivier Bachmann

The John Penn Engine

In the fleet of nine operational paddle steamers, the *Diesbar* is unique.
Built in 1884, it is the second-oldest ship in the fleet, being predated by only the *Stadt Wehlen* of 1879. It is (together with the *Krippen*) one of only two flat-deck, single-deck steamers in Dresden and, as such, is smaller than the other seven steamers, all of which feature more or less expansive upper decks. The *Diesbar* is also the only Dresden paddle-steamer fired by coal and the only vessel that retains its original steam assisted rudder, installed in 1928.



View of engine frame, with portions of the two cylinders and air pump visible below. The long handle is for valve adjustment. Photo: Sächsische Dampfschiffahrt

The *Diesbar's* principal unique feature is its original two-cylinder oscillating steam engine, built in 1841 by the famed English manufacturer John Penn & Sons of Greenwich, England. Today, the *Diesbar* is one of the very few surviving examples of a John Penn engine, and in that regard is a crucial piece of living history from the early era of steam engineering and manufacturing. Indeed, the *Diesbar* has the distinction of being driven by the world's oldest operational marine steam engine; it is also the world's oldest operational oscillating steam engine. The fact that this machine has survived in operating condition for over 165 years is testimony to the quality of its original craftsmanship and proof of the technical timelessness of steam.

Early steamboats used a variety of engine designs, but most had a single vertical cylinder, with the piston rod acting on a large overhead crosshead and walking beam. A connecting rod down from the walking beam converted the reciprocating piston motion into rotation of the paddle-wheel shaft. A later arrangement, called a side-lever engine, relocated the walking beam (lever) below the shaft, and two-cylinder versions became common, but all of these engines were large and heavy for the power they produced. With space at a premium aboard vessels, a smaller, lighter engine was needed.

Eliminating most of the rods and levers would make a smaller engine, and one way of doing this was to allow the engine's cylinders to oscillate. This permitted the piston rod to be directly connected to the crankshaft. Each of two vertical cylinders pivoted on horizontal trunnions so that the piston rod could follow the motion of its crank. The trunnions were hollow so that steam could be admitted to the cylinders on one side and exhausted on the other. These were double-acting engines with steam pushing alternately on both sides of the pistons, and valves built into the trunnions used the oscillating motion to direct steam into and out of each cylinder. The two cylinders were "quartered," with the two cranks positioned at right angles on the crankshaft. This gave four overlapping power strokes per revolution of the shaft and allowed the engine to be started from any stopped position.

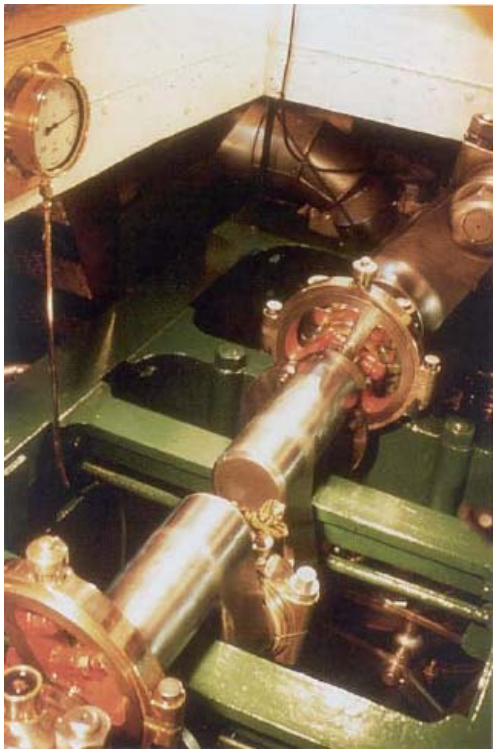
By 1840 oscillating cylinder engines had become a specialty of John Penn & Sons, and the *Diesbar*'s engine is an excellent example of the type. Steam from the boiler enters the cylinders through the outboard trunnions and exhausts to a condenser through the inboard ones. This engine includes Penn's refinement of adjustable valves, enabling the operator to set the desired cut-off for greater efficiency. A third, fixed cylinder in the center, called an air pump, maintains a partial vacuum in the condenser and helps pump condensate back to the boiler. It is driven by the crankshaft.

The crankshaft turns two paddle wheels with feathering blades, or buckets. Linkages on the wheels keep each bucket essentially perpendicular to the water's surface for its entire passage through the water. A wheel with feathering blades is about half the diameter of one with fixed, radial blades, and it can efficiently turn about twice as fast. This made it a good match for direct-acting, oscillating engines.

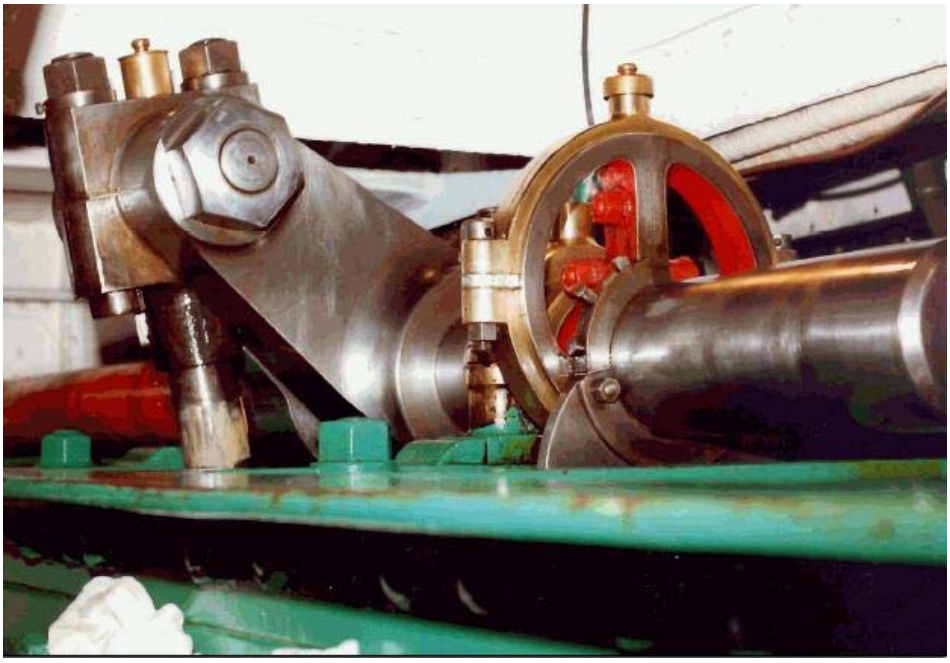
Oscillating engines remained popular, especially in Europe, for much of the 19th century. Almost forty years after Penn built this engine, ASME's first president, Robert H. Thurston, noted in his *A History of the Growth of the Steam Engine* that, "It [the oscillating engine] is very compact, light, and moderately economical, and excels in simplicity." (p. 381) These virtues kept it a favorite for river and lake steamboats until better boilers and higher steam pressures made other engine designs more desirable by the turn of the century. The trunnion seals could not handle pressures much over 2.75 bar (40 pounds per square inch) without significant leakage, so fixed-cylinder engines of various designs gradually replaced most oscillating engines, and few of this important type remain in service today.

Interestingly, the engine predates the vessel by almost 43 years and the present-day *Diesbar* is the third ship in which this John Penn engine has been installed. Originally, the engine was built for the wooden paddler *Bohemia* (1841) and served in that ship for several years. In 1853, the engine was fitted with a new crankshaft, supplied by the steel and forge works of Krupp in Essen. The lettering emblazoned on the replacement crankshaft reads:

"Cast Steel 10 Years Guarantee – Krupp Essen 1853"



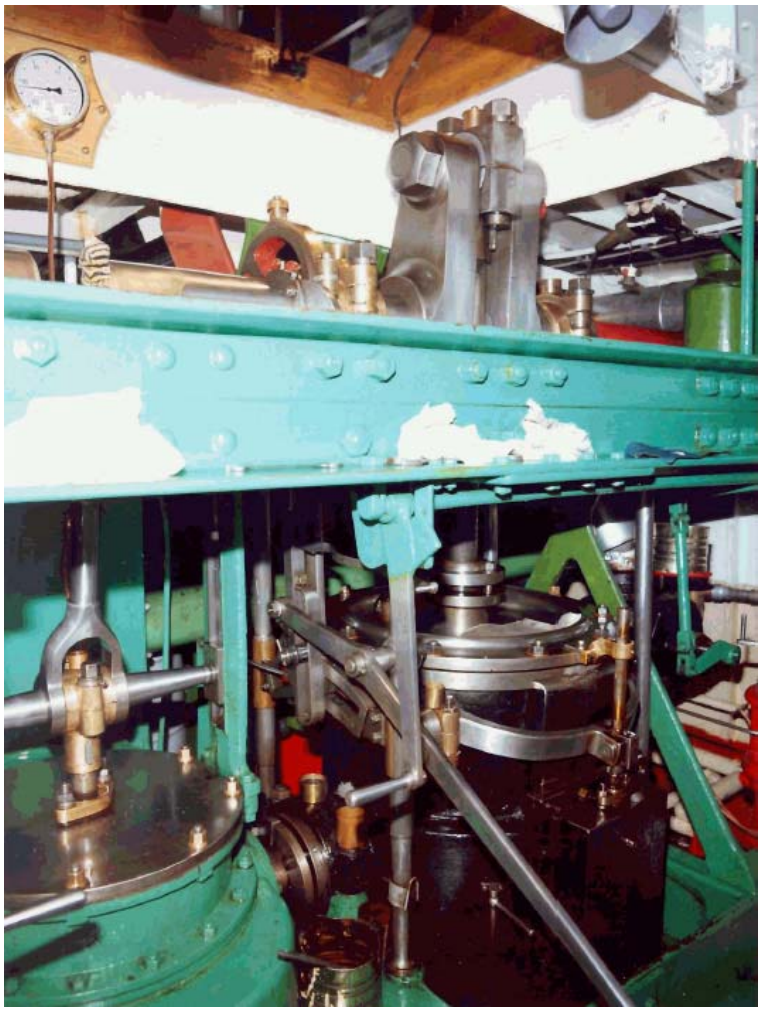
Looking down on the engine from the main deck, showing the top of the frame, Krupp crankshaft, valve eccentrics, and air-pump crank. Photo: Sächsische Dampfschiffahrt



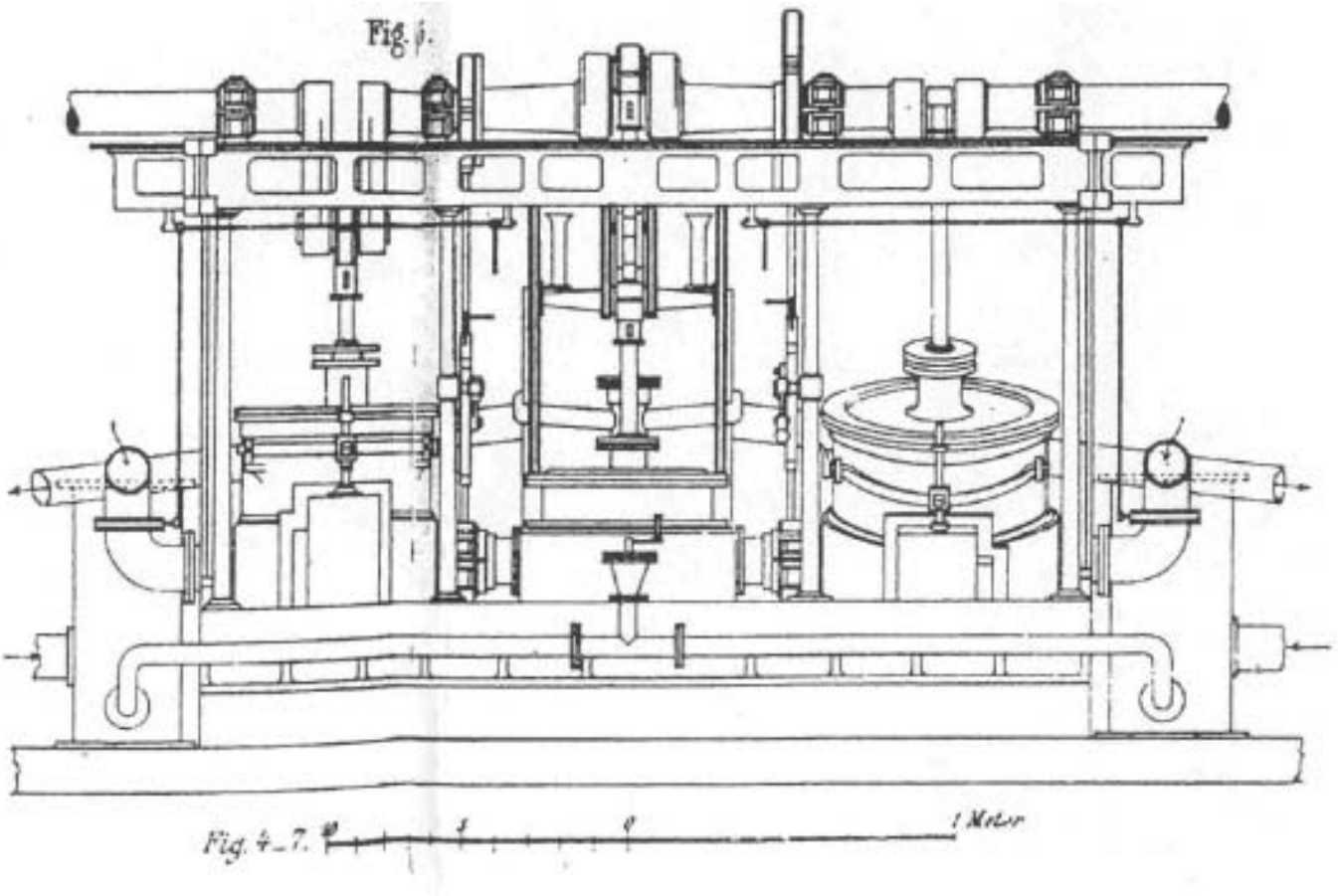
A detailed view of one of the piston rod crank bearings and a valve eccentrics. Note the brass lubrication cups on top of each. Photo: Robert Horlacher

Because of the added value of the replacement crankshaft and the general quality of it's other components, the engine was re-used in 1857 for the newly built steamer *Stadt Meissen*, after the wooden-hulled *Bohemia* had been dismantled in 1856. The engine remained installed in the *Stadt Meissen*, later re-named *Pillnitz*, until the scrapping of that ship, shortly before 1884. Since 1884 the engine has been installed in the *Diesbar*.

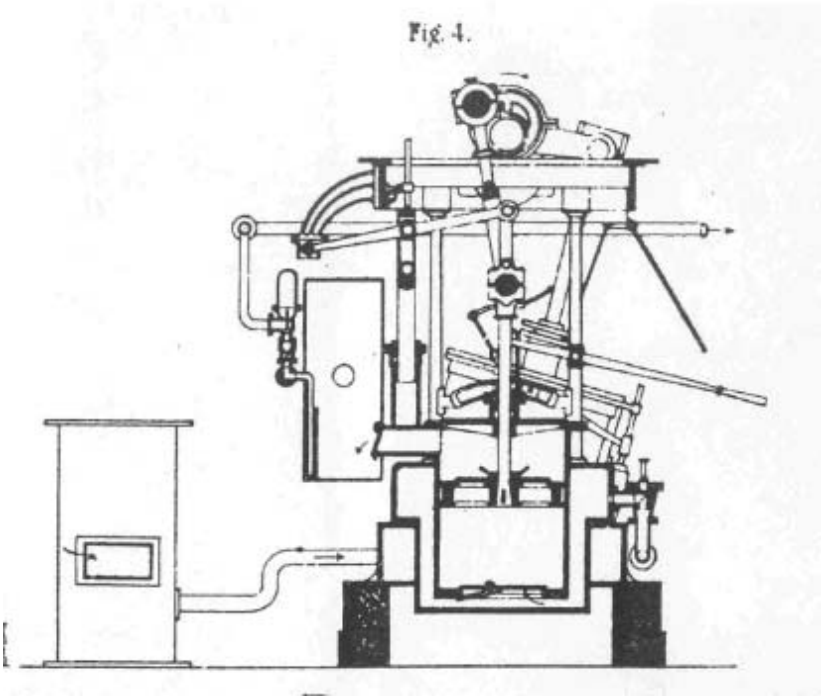
Driving the two side wheels of 3.80 meters (12.5 feet) diameter, at a maximum speed of 38 rpm, the engine is capable of developing up to 110 horsepower, while achieving a speed of about 14 km/h (7.6 knots).



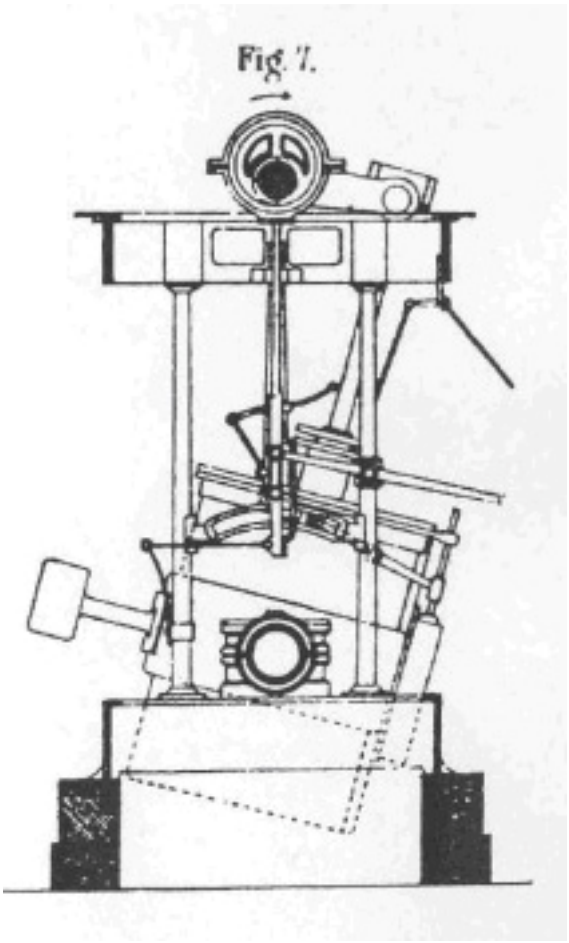
A detailed view of one cylinder with its piston rod fully extended (R) and a portion of the air pump (L). Photo: Robert Horlacher



Side view of engine showing crankshaft at top and air pump between the two oscillating cylinders.



Cross section view of engine through air pump.



Cross section view of engine showing the hollow trunnion, valve gear, and a cylinder at mid-stroke, fully pivoted to one side.

All of these drawings show the technical layout of the oscillating John Penn steam engine built for the paddler *Königin Maria* of 1840/41, virtually identical to that aboard the present-day *Diesbar*.

Plan taken from:
H. Fischer, Dampfschifffahrt auf der Sächsischen Elbe im "Civilingenieur",
Jahrgang 1890, Tafel XVI

Technical Specifications of the Engine:

Maximum power: 110 horsepower @ 38 revolutions per minute
Steam pressure: 250 kilopascal (36 pounds per square inch)
Bore and stroke: 622 x 686 mm (24.5 x 27.0 inches)

Documented Engine Maintenance in the 19th century

1853: Crankshaft replacement
1869/70: Replacement of one steam cylinder
1874/75: New upper frame
1878/79: Substantial engine maintenance and parts upgrade
1880/81: Substantial engine repairs

Source:
"*Bohemia I in Böhmen, Diesbar II in Sachsen – Zwei Schiffe mit derselben Dampfmaschine*"
by Johannes Hirsch, Michael Bor, Werner Mar, Dampferzeitung 1/1994

Technical Specifications of the Ship:

Overall length	53.5 meters (175.5 feet)
Beam over hull	5.07 meters (16.6 feet)
Beam over paddle wheel boxes	10.2 meters (33.5 feet)
Draft (light or empty)	0.79 meters (2.6 feet)
Passenger capacity	160
Steam boiler:	double-flue wagon-head type

Photo: Olivier Bachmann

The Life and Work of John Penn Sr. and John Penn Jr.

John Penn Sr. (1770-1843) was born near Taunton England and as a youth was apprenticed to a millwright. Penn moved to London in 1793, and set up shop as a millwright and machinist at Greenwich. In 1799 he established his own company, originally manufacturing agricultural machinery. By 1820 he had branched out into other machinery and by 1825 had started making marine engines and boilers. By 1838 the firm was regularly supplying engines for river steamers. By the late 1850s the firm was world famous in its field; indeed several ships were named the *John Penn*.

John Penn, Jr. (1805-1878) succeeded his father in running firm after Penn Sr. died in 1843. The company made engineering improvements to existing marine engine designs and in the 1840s and 1850s was a major engineering works, regularly supplying engines for mail steamers and to the British Admiralty for battleships. One notable advance was the development of the oscillating steam engine, the type on the *Diesbar.* In association with Francis Petit Smith, in 1858 Penn solved the problem of excessive wear of propeller-shaft bearings by making them of lignum vitae, an exceptionally hard and dense wood.

As well as supplying English ships, there was a healthy export market to European countries that lacked the expertise to build their own engines and boilers, and hence John Penn & Sons also had a strong market position in Central Europe during the 1830s and 1840s. They received many orders for marine steam engines for ships plying the Elbe.

John Penn Jr. served twice as president of the Institution of Mechanical Engineers (IMechE)—in 1859 and 1867, served on the Council of the Institution of Civil Engineers and was the first president of the West Kent Microscopial Society in 1861.

In Penn's honor, in 1873 a street near the original factory was renamed John Penn Street.

By the time Penn Jr. died, in 1878, the company had supplied 735 ships with marine engines. After his death his four sons continued the business under the same name until 1899 when they merged with Thames Ironworks and Shipbuilding. As shipbuilding declined in the area, the firm branched into manufacturing such items as motor vehicles, electric cranes and electrical equipment. With further business decline, Thames Ironworks went out of business in 1914.

Source:
Peter Trigg and Richard Cheffins—Greenwich Industrial History Society (http://gihs.gold.ac.uk)
Philip Branbury "*Shipbuilders of the Thames & Medway"* 1971

Overall Technical and Historical Value

More than a floating museum, the *Diesbar* and its engine are fine examples of living history and showpieces of timeless technology in reliable, live operation! As such, ship and engine both are time-less ambassadors of the 19th century and the way of life and pattern of mechanical engineering back then. The engine is testimony to both the pioneering technical and entrepreneurial spirit of John Penn & Sons and impressively documents the level of cross-border European technical cooperation and collaboration already in place in the 1830s and 1840s.

Photo: Olivier Bachmann

HISTORIC MECHANICAL ENGINEERING LANDMARK

JOHN PENN & SONS
OSCILLATING STEAM ENGINE

JOHN PENN & SONS
OSZILLIERENDE SCHIFFSDAMPFMASCHINE

1841

WIDELY ADOPTED AFTER 1815, STEAMBOATS WERE THE WORLD'S FIRST FORM OF MECHANIZED TRANSPORT. JOHN PENN & SONS, OF GREENWICH, ENGLAND, WAS AMONG THE EARLIEST AND MOST SUCCESSFUL BUILDERS OF MARINE STEAM ENGINES. PENN BUILT THIS TWO-CYLINDER OSCILLATING ENGINE IN 1841 FOR THE WOODEN-HULLED *BOHEMIA*. SINCE 1884 THIS ENGINE HAS POWERED THE *DIESBAR*. COMPARED TO ALTERNATIVE DESIGNS OF EARLY MARINE ENGINES, ITS COMPACT SIZE, LOW CENTER OF GRAVITY, AND DIRECT MECHANICAL LINKAGES MADE THE PENN ENGINE WELL SUITED FOR A PADDLEWHEEL STEAMER. ITS RELIABILITY AND SIMPLICITY HAVE FURTHER CONTRIBUTED TO THE SURVIVAL OF THIS PIONEERING TECHNOLOGY IN MECHANICAL ENGINEERING.

DAMPFSCHIFFE WAREN WELTWEIT DIE ERSTE FORM DER MECHANISCHEN FORTBEWEGUNG, UND SETZTEN SICH NACH 1815 IM GROSSEN STILE DURCH. JOHN PENN & SONS AUS GREENWICH, ENGLAND WAR EINER DER ERSTEN UND AUCH ERFOLGREICHSTEN ERBAUER VON SCHIFFSDAMPFMASCHINEN. JOHN PENN BAUTE DIESE OSZILLIERENDE 2-ZYLINDER DAMPFMASCHINE 1841 FÜR DEN DAMPFER *BOHEMIA*. SEIT 1884 HAT DIESE MASCHINE DAS JETZIGE SCHIFF *DIESBAR* ANGETRIEBEN. VERGLICHEN MIT ANDEREN MASCHINENTYPEN AUS DERSELBEN EPOCHE, MACHTEN DIE KOMPAKTE GRÖSSE, DER TIEFLIEGENDE SCHWERPUNKT UND DIE DIREKTE, MECHANISCHE KUPPLUNG DIESE JOHN PENN MASCHINE BESONDERS GEEIGNET FÜR EINEN SEITENRADDAMPFER. DIE BETRIEBLICHE ZUVERLÄSSIGKEIT UND TECHNISCHE UNKOMPLIZIERTHEIT HABEN DIREKT ZUM ERHALT DIESER MECHANISCHEN PIONIERTECHNOLOGIE BEIGETRAGEN.

ASME THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS-2008

The commemorative plaque presented by ASME, July 2nd 2008

The History and Heritage Program of ASME

The History and Heritage Landmarks Program of ASME (the American Society of Mechanical Engineers) began in 1971. To implement and achieve its goals, ASME formed a History and Heritage Committee initially composed of mechanical engineers, historians of technology and the curator of mechanical engineering at the Smithsonian Institution, Washington, D.C. The History and Heritage Committee provides a public service by examining, noting, recording and acknowledging mechanical engineering achievements of particular significance. This Committee is part of ASME's Center for Public Awareness. For further information, please contact Public Awareness at ASME, Three Park Avenue, New York, NY 10016-5990, 1-212-591-7020 and http://www.asme.org/history.

Designation

Since the History and Heritage Program began in 1971, nearly 250 landmarks have been designated as historic mechanical engineering landmarks, heritage collections or heritage sites. Each represents a progressive step in the evolution of mechanical engineering and its significance to society in general. Site designations note an event or development of clear historic importance to mechanical engineers. Collections mark the contributions of a number of objects with special significance to the historical development of mechanical engineering.

The Landmarks Program illuminates our technological heritage and encourages the preservation of the physical remains of historically important works. It provides an annotated roster for engineers, students, educators, historians and travelers. It helps establish persistent reminders of where we have been and where we are going along the divergent paths of discovery.

Founded in 1880 as the American Society of Mechanical Engineers, ASME is a not-for-profit professional organization promoting the art, science and practice of mechanical and multidisciplinary engineering and allied sciences. With more than 127,000 members worldwide, ASME is a global engineering society focused on technical, educational and research issues. ASME develops codes and standards that enhance public safety, and provides lifelong learning and technical exchange opportunities benefiting the engineering and technology community.

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Valentin Stingelin, ASME Switzerland Chapter: Original landmark nominator

Michael Lohnherr, CEO Sächsische Dampfschiffahrt: Landmark owner, ceremony host

Andrew Thompson, ETH Zurich: Nomination initiator, general project coordinator and author of the commemorative brochure

Hans Quack, TU Dresden and VDI: Local Dresden project coordinator

For further reading consult:

"Die älteste und grösste Raddampferflotte der Welt"
(*The Oldest and Biggest Paddle Steamer Fleet in the World*)
by Wolfgang Quinger & Wolfgang Zimmerman, © 2002

Robert H. Thurston *A History of the Growth of the Steam Engine* Appleton & Co., New York 1878

Richard Sennett and Henry J. Oram, *The Marine Steam Engine* Longmans, Green & Co., London 1898