THE WORLD'S FIRST INDUSTRIAL GAS TURBINE SET – GT NEUCHÂTEL

A Historic Mechanical Engineering Landmark

POWER SERVICE

SETTING THE STANDARD

Bridging the gap between pioneering spirit and modernity

The GT Neuchâtel is a tribute to the pioneering spirit of the past century. As the world's first commercially used industrial gas turbine plant, it was built by BBC in 1938 and stayed in operation for 63 years. On August 18, 2002 it was finally shut-down due to a damaged generator.

In 1988 the ASME International (American Society of Mechanical Engineers) designated the GT Neuchâtel a Historic Mechanical Engineering Landmark status reserved for milestones of outstanding technical development.

This inspired the Power Service of ALSTOM (Switzerland) Ltd to restore the GT Neuchâtel after its closure, reconstruct it and put it on public display in Birr. Now its stands as a symbol of the top-class technology produced by Alstom and its predecessor companies (BBC /ABB Power Generation Ltd) for more than 100 years.

A brief review (from 1988)

1988 The GT Neuchâtel is honored by the American Society of Mechanical Engineers (ASME) as a Historic Mechanical Engineering Landmark (see attached the reprint of the ASME GT Neuchâtel brochure of September 2, 1988).

1995 The GT Neuchâtel is found to be in "excellent condition" during a service inspection.

2002 After 63 years and 1908 starts, damage occurs to the generator and the plant is permanently closed down.

2005 Alstom takes over the plant from Service Industriels de la Ville de Neuchâtel.

2006 Following comprehensive restoration work, it is reconstructed and put on display at the production site in Birr, Switzerland.

Re-designation of the ASME Landmark award for the GT Neuchâtel

After the GT Neuchâtel was shut down, Alstom recognized the importance of preserving this landmark for the benefit of engineers and the general public. Therefore, rather than discard and dispose of this pioneering unit, Alstom decided to relocate, restore and display the machine at Alstom's development and production facility in Birr, where the latest gas turbine technology is being developed. The ASME, in appreciation and acknowledgement of this preservation of a vital part of mechanical engineering history, re-designated this landmark in its new location on June 4, 2007.

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 Information at ASME, Three Park Avenue, New York, NY 10016-5990, 1-212-591-8614 and http://www.asme.org/communities/history

Designation

Since the History and Heritage Program began in 1971, 242 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.

The 120,000-member ASME is a worldwide engineering society focused on technical, educational and research issues. ASME conducts one of the world's largest publishing operations, holds some 30 technical conferences and 200 professional development courses each year, and sets many industrial and manufacturing standards

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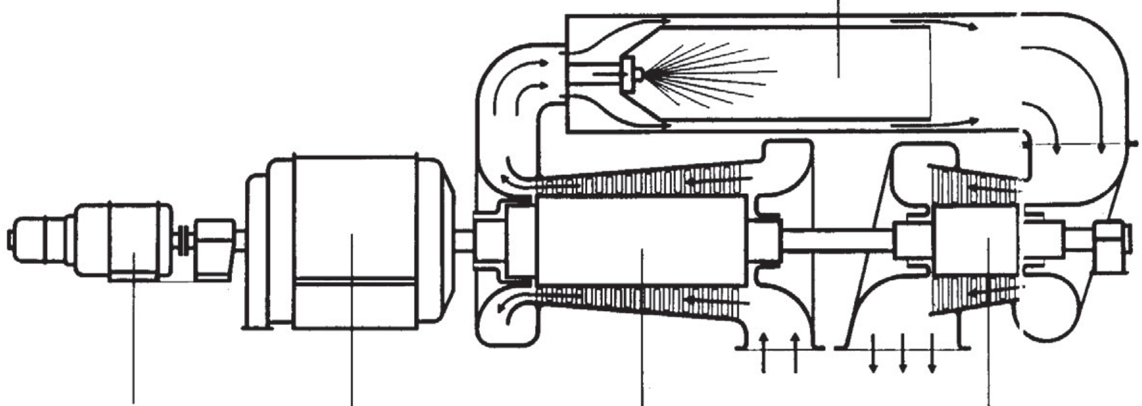
The World's First Industrial Gas Turbine Set at Neuchâtel (1939)



Layout of the single-stage gas turbine set without recuperator

An International Historic Mechanical Engineering Landmark

September 2, 1988

Neuchâtel, Switzerland

Schweizerischer
Ingenieur- und Architekten-Verein
Société suisse
des ingénieurs et des architectes
Società svizzera
degli ingegneri e degli architetti

Neuchâtel (1939)

The World's First Industrial Gas Turbine Set

Historical Significance of Landmark

The economic use of the simple cycle gas turbine for the generation of electricity in a public power station was first realized in 1939, the design of this machine as illustrated. This set was ordered by the Municipal Power Station in Neuchatel, Switzerland.

The introduction of the gas turbine in the field of power generation is the realization of a long cherished dream of engineers. Two thoughts can be suggested. First, the simplification of equipment and the desire to eliminate the steam plant consisting of steam boilers, steam engines, and condensing plant. Second, to drive directly from the rotary movement of the turbine, the generator for producing electricity, and to do away with the crank and connecting rod mechanism of the steam engine.

The first step in this direction of simplification was, of course, the advent of the steam turbine, that did away with the reciprocating steam engine, with the gas turbine as a further step. Indeed the steam turbine simplified welded rotor design, introduced in 1926, was adapted to the gas turbine to eliminate separate discs or wheels, and remains a feature for both steam and gas turbines of BBC design.

The Neuchatel Gas Turbine was the first successful electric power generating machine, which went into commercial operation as a standby unit and is presently still used almost 50 years after commissioning. It has a power output of 4 MW at generator terminals, and an efficiency of 17.4%. Rotating at 3000 rpm, the turbine, with inlet temp. 550°C (1022°F), provides 15,400 KW, of which 11,400 is absorbed by the compressor with an air inlet temp. of 20°C (68°F). The acceptance tests were supervised by the "Grand Old Man" in the field of thermal machines, Prof. Aurel Stodola.

Persons involved in conception, design, etc., were Claude Seippel, Head of Engineering Dept., Kurt Niehus, Deputy of Mr. Seippel, Hans Pfenninger, Thermodynamic process aerodynamics, Willy Burger, Mechanical design. Earlier work on axial compressors of high efficiency, an absolute necessity for gas turbines was performed by Claude Seippel, Georges Darrieus, and Jean von Freudenreich.

Special Features and Characteristics

The compressor, the turbine, and the generator were arranged in line and directly coupled, a concept very similar to that of modern large gas turbines. The gas turbine power station in Neuchatel is installed in a bomb proof cavern as seen in *Fig. 1*. This new gas turbine (Neuchatel) was based on the "Houdry" groups, it used an improved turbine blading, with outlet angles constant over the height, and tapered rotor blades to reduce the centrifugal stress. The combustion chamber was derived from the Velox boilers and start-up combustion of the "Houdry" groups.

There were numerous forerunners and attempts prior to this successful installation. Brown Boveri had, in the 1930's, built many similar machines before which were used as supercharging groups for the "Houdry" catalytic cracking process*, and for the supercharged "Velox" boilers. They used highly efficient axial compressors, which had been developed before using aerodynamics of wings.

* Such a unit installed at Sun Oil Marcus Hook Refinery, PA, USA, demonstrated 2½ years of constant service already by 1939.

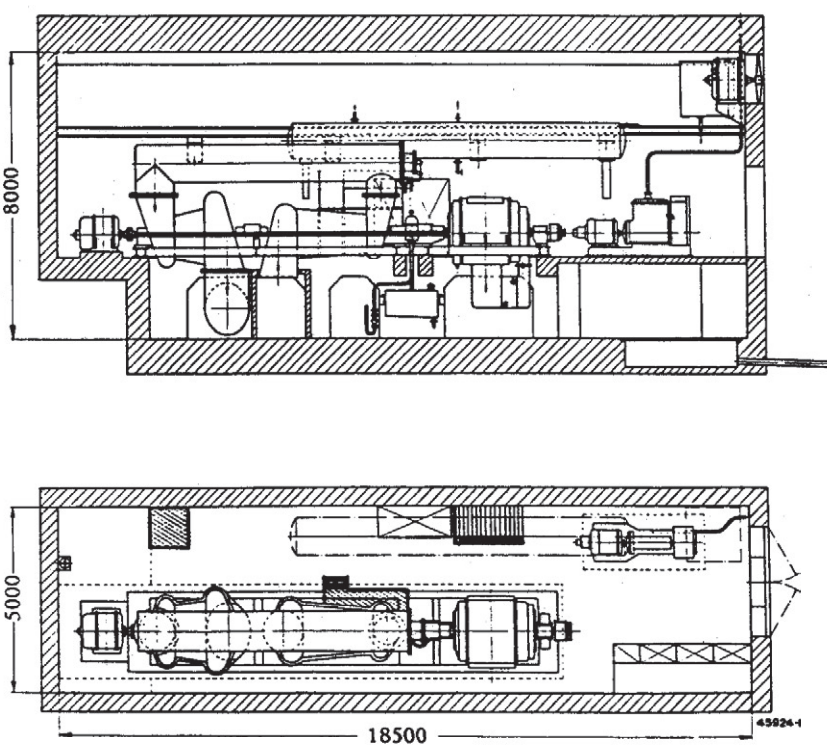


Fig. 1. Bomb-proof gas-turbine-driven 4000 kW standby plant. City of Neuchatel (Switzerland).

Landmark Contribution to Development of New World Wide Industry

In Switzerland, two companies, Brown Boveri and Sulzer, continue to build gas turbines, mainly for export, such units number over 500, about 50 to the USA, and in the 70's more than 40 large machines were built under license to BBC in the USA.

In the US, several companies, like General Electric, Solar, Westinghouse, and others, have built thousands of gas turbines. The utility industry alone boasts of 62.5 GW of gas turbine electric generating capacity to be operational in 1988. This represents 1275.5 MW per year since 1939 or the equivalent installation of 318 Neuchatel sized gas turbines per year.

Proposed new fields of gas turbine applications, envisioned in 1939, were locomotives, ship propulsion, as well as the combination of the combustion turbine with the utilization of the heat of the exhaust gases for production of steam in exhaust gas boilers, which in combination of a steam turbine would be more economical than a high pressure steam turbine plant.

Further development in the future of combined cycles, using gas and steam turbines are expected to play an important role for electric power generation, as demonstrated by the present installed capacity, as well as co-generation facilities with large plant capacities to 1280 MW, to be operational in 1990 in the USA.

Historical Development

In February, 1939, Dr. Adolf Meyer, former Director of BBC Brown Boveri, presented a paper at a meeting of the Institution of Mechanical Engineers in London, titled "The Combustion Gas Turbine: Its History, Development and Prospects."

Dr. Meyer concluded that the subject of combustion turbines "is a promising one, full of interesting possibilities." These prospects the author believed were based on raising the turbine inlet temperature in the near future to 648°C (1200°F) from 538°C (1000°F), raising the cycle efficiency (of the Neuchatel machine) from 18% to 23% representing an improvement of 28%. This possibility was not only realized in further combustion turbine development, but far exceeded. Increasing to turbine inlet temperature of 1010°C - 1121°C (1850°F - 2050°F) common in modern utility sized units, and prototype advanced gas turbines with 1260°C (2300°F) firing temp.

Historical Events

1791	First Gas Turbine Patent, John Barber, England
1900/1904	First trials of Stolze Hot Air Turbine
1905	Holzwarth Explosion Turbine Concept
1906/1908	First "Explosion" Type built by BBC for Dr. Holzwarth
1928	BBC again takes up manufacture of improved cycle Holzwarth turbine
1933	First BBC Holzwarth turbine goes into operation with blast furnace gas fuel
1934	Turbo-Charged (Gas Turbine) Velox boilers developed about 80 compressor sets/gas turbines installed by 1939
1937	First "Houdry" Gas Turbine compressor set and generating 2000 KW goes into operation at Marcus Hook Refinery, PA, USA.
1937	First simple cycle gas turbine generating set ordered
1939	First 4000 KW Neuchatel simple cycle gas turbine goes into operation
1939	First Gas turbine electro locomotive 2500 HP ordered from BBC by Swiss Federal Railways

To differentiate the "modern" developments from earlier "explosion" turbines, the term "constant pressure gas turbine" was generally employed, but later considered preferable as "continuous combustion gas turbine", or briefly "combustion turbine."

Patent office records of different countries indicate that the first patent for a gas turbine was granted in 1791 in England to John Barber, *Fig. 2.* Since then the number of patents has steadily increased in the endeavor of engineers to produce a substitute for the reciprocating steam engine.

That the design simplification has been achieved in replacing steam plant, can be seen in *Fig. 3,* which represents the combustion turbine in its simplest form. The heater is replaced by the combustion chamber, and the forced draft and induced draft fans by the larger more expensive axial compressor.

In the efforts to improve the efficiency of the steam process in about 1850, Redtenbacher wrote to Zeuner. "The Fundamental Principle of the Generation and Use of Steam is Wrong. It is hoped that steam engines will disappear in a not far distant future, as soon as we know more about the nature and effects of heat."

In 1928, Brown Boveri again took up the manufacture of a Holzwarth gas turbine and proposed a cycle, which might be called the two-chamber, two-stroke cycle. The first unit went into operation in 1933, at a German steel plant with blast furnace gas as fuel.

This prophesy came true, but at a much later date due to the invention of the steam turbine which relegated the gas turbine to the background.

As far as is known, the first gas turbine to be built and tried, was the hot air turbine developed and built by Stolze (designed in 1892), with first trials made between 1900 and 1904. This set was of particular interest because of a multistage reaction gas turbine and multistage axial compressor were used (probably first of its kind).

The cycle thermal efficiency of this machine was too low to be successful for compressor and turbine efficiency attainable at that time. Holzwarth, in 1905, resorted to the explosion or constant volume turbine to overcome the then thought of insurmountable difficulty. The first unit of this type was built between 1906 and 1908, and based on the experimental results obtained, Brown Boveri built and tested to the order of Dr. Holzwarth, a second unit of 1000 HP, which however produced only 200 HP.

The BBC work done in connection with the Holzwarth gas turbine resulted in the development of the Velox boiler and because of this experience it led back to the combustion turbine. The pressurized boiler required the development of a high efficiency compressor set to enable the exhaust gas turbine to develop sufficient power driving it. This development resulted in 10 to 12 stage axial compressors and 4 to 5 stage reaction turbines.

The attainment of cycle efficiencies of 70% and more, suggested the possibilities of the combustion turbine cycle as a prime mover without the use of steam with overall efficiencies of 70-75%, gas turbine cycle efficiencies would be as follows:

Turbine Inlet Temp. °F	Cycle Efficiencies Percent
1000	15 - 18%
1200	19 - 23%
1800	22 - 26%

Experience gained from a large number of Velox boilers and exhaust-gas turbines for diesel engines, a temp. of 538°C (1000°F) was considered absolutely safe for uncooled heat resisting steel turbine blades. This would result in obtainable outputs of 2000-8000 KW with compressor turbine efficiencies of 73-75%, and an overall cycle efficiency of 17-18%

Before the advent of high pressure and temperature steam turbine with regenerative heating of the condensate and air pre-heating, resulting in coupling efficiencies of approx. 25 percent, the gas turbine would have been considered competitive with steam turbine plant of 18% which was considered quite satisfactory. This hard reality required consideration of a different application for the gas turbine, which now was unable to compete with "modern" base load steam turbines of 25% efficiency.

Dr. Meyer in his address to the Institution of Mechanical Engineering in London, foresaw further cycle developments and improvements which would open up new fields for the gas turbine. Alternatives to steam locomotives, ship propulsion, wind tunnel drives, blast furnace plants, and finally a challenge to conventional steam power plants. Here the combustion turbine would be utilized with the recovery of exhaust heat to produce steam for the steam turbine in a combined gas turbine steam plant that would be more economical due to higher efficiencies and lower cost per kilowatt installed.

IT MUST BE CONCLUDED HERE THAT THE NEUCHATEL GAS TURBINE HISTORICAL SIGNIFICANCE TODAY IS FURTHER ENHANCED BY VISIONARIES SUCH AS ADOLF MEYER AND OTHERS OF BBC AT THE TIME, WHO SAW A DOMINANT ROLE FOR THE COMBUSTION TURBINE WITH FURTHER DEVELOPMENT OF COOLING TECHNOLOGY - HIGH TEMPERATURE MATERIALS, COMPRESSOR, AND TURBINE AERODYNAMICS.

The ASME History and Heritage Program

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The 4 MW Gas Turbine, Municipal Power Station at Neuchatel, Switzerland, is the 26th International Historic Mechanical Engineering Landmark to be designated, and the 8th to be designated outside of the United States; others are in England (3), France, West Germany, Australia and China.

In addition, 90 National and 11 Regional Landmarks, 5 heritage sites and 1 collection have been recognized. Each reflects its influence on society, either in its immediate locale, nationwide, or throughout the world.

An ASME landmark represents a step in the evolution of mechanical engineering. Site designations note an event or development of clear historical importance to mechanical engineers. Collections mark the contributions of a number of objects with special signficance to the historical development of mechanical engineering.

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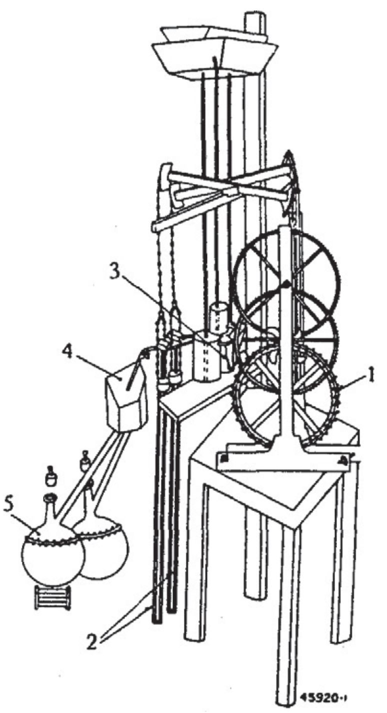

Fig. 2. Drawing of first patent for a gas turbine (John Barber, 1791).
1. Turbine
2. Gas and air compressor
3. Combustion chamber
4. Receiver
5. Gas producer

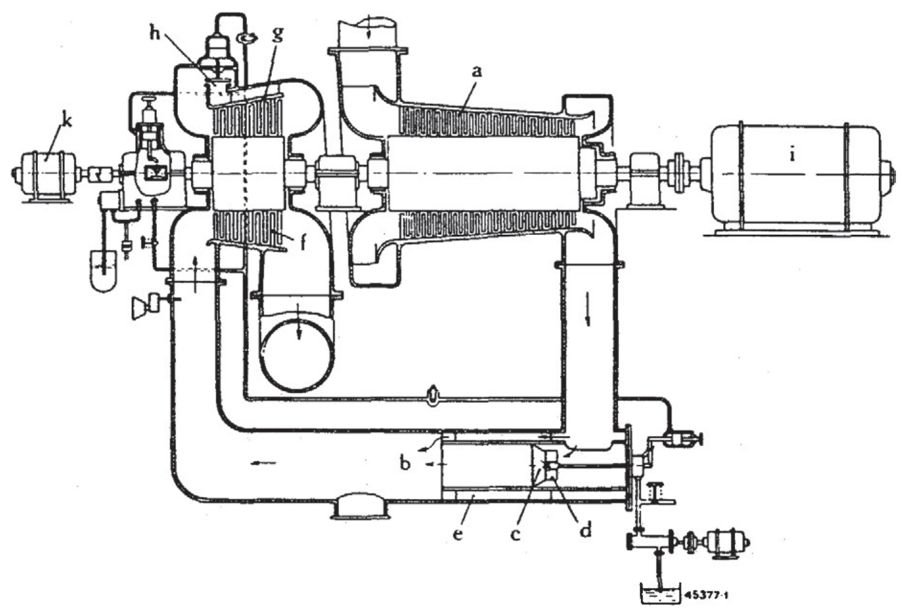

Fig. 3. Diagram of the simplest form of combustion turbine plant. With reaction type gas turbine and axial compressor for oil fuel, and with excess air cooling.

a. Axial compressor
b. Combustion chamber
c. Combustion nozzle
d. Burner
e. Cooling-air jacket
f. Gas-turbine blading
g. Gas turbine
h. Safety valve
i. Generator
j. Starting motor

Acknowledgements

The American Society of Mechanical Engineers is grateful to all those who contributed to the designation of the 4 MW Gas Turbine as an International Historic Mechanical Engineering Landmark. Special thanks go to R. Foster-Pegg for preparing the nomination material, to Septimus van der Linden, ABB Energy Services, Inc., for writing the commemorative brochure, to Peter Escher, Secretary, SIA, Swiss Engineers and Architects Association and to Asea Brown Boveri Ltd., Lausanne, for coordinating ceremony details.

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International Historic Mechanical Engineering Landmark
4MW Gas Turbine, Municipal Power Station
Neuchatel, Switzerland

This gas turbine was the first successful electric power generating machine to go into commercial operation. It was designed and constructed by A.G. Brown Boveri, Baden Switzerland, and installed in 1939. It has since served continuously as a stand-by unit.

The American Society of Mechanical Engineers
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1988

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