# A NATIONAL HISTORIC MECHANICAL ENGINEERING LANDMARK

# OXYGEN PROCESS
## STEEL-MAKING VESSEL

Trenton, Michigan
May 15, 1985

The American Society of Mechanical Engineers

# OXYGEN-PROCESS STEEL-MAKING VESSEL
## McLOUTH STEEL PRODUCTS CORP.
## TRENTON, MICHIGAN
## 1955

THIS IS ONE OF THE THREE ORIGINAL 60-TON VESSELS BY WHICH THE BASIC OXYGEN PROCESS OF STEEL MAKING WAS INTRODUCED INTO THIS COUNTRY FROM AUSTRIA WHERE IT WAS INVENTED. IT HERALDED THE FIRST NEW TECHNOLOGY IN FIFTY YEARS THAT BECAME THE BASIS OF A MAJOR PROCESS FOR STEEL PRODUCTION THROUGH-OUT THE WORLD. IN THIS PROCESS A WATER-COOLED LANCE INJECTS A JET OF HIGH-PURITY OXYGEN INTO THE BATH OF MOLTEN IRON. VARIOUS CHAMICAL REACTIONS TAKE PLACE TO PRODUCE A QUALITY LOW-NITROGEN STEEL AT A TON-PER-HOUR RATE NEARLY THREE TIMES THAT OF THE OPEN-HEARTH FURNACE.

**THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS**

**— 1985 —**

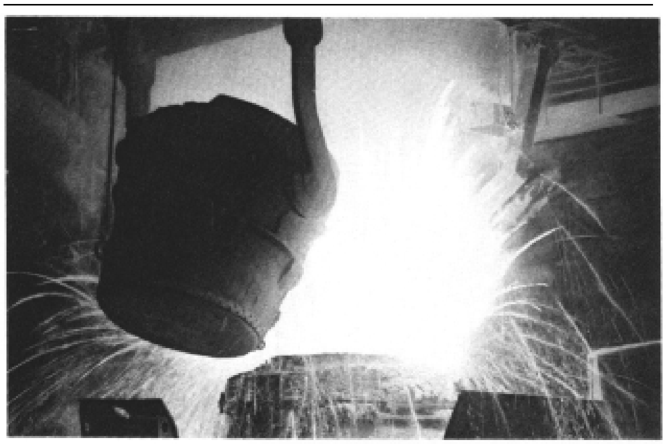
**This plaque commemorates the oxygen process vessel at McLouth Steel Product's Trenton, Michigan plant, designated a National Historic Mechanical Engineering landmark, by the American Society of Mechanical Engineers.**

This year, 1985, marks the 131st anniversary of the first commercial heat of steel made in the United States by the now extinct Bessemer Process. It was produced by a 2.5 ton Bessemer Converter in Wyandotte, Michigan just three miles north of this site. These are unique circumstances, when one considers that there were only four methods of making steel on a production basis and two of these methods were first introduced into the United States in Detroit's downriver area.

## NEWCOMER IN THE STEEL INDUSTRY

Donald B. McLouth started his business career by operating a small steel brokerage business. This developed and in 1934 he organized the McLouth Steel Corporation, which began operations in 1935. The Corporation continued to grow under his guidance and in 1954, at the time of his death, it had just completed an expansion program at the Trenton site which launched the company into major steel mill status as an integrated steel producer and which included the first basic oxygen steel process to operate in the United States.

The choice of this new steel making process was not an easy decision, though a natural one in retrospect. McLouth came out of the World War II period as a small rerolling mill and into a vastly expanding market. As a reroll mill they had to purchase their steel in a semi finished state from other domestic mills. The strong demand for steel naturally dictated that these mills use their own capacity rather than sell it to a competitor. McLouth had to grow or die.



MOLTEN IRON BEING CHARGED INTO AN OXYGEN PROCESS VESSEL

By 1949, McLouth owned four 60 ton electric furnaces, which it had purchased from the Government as war surplus. They were put into operation on the newly acquired Trenton site. For the first time, McLouth was making its own steel. The electric steel making process posed two factors, however, which tended to make operating costs difficult to control: 1) electricity requirements were very large in the electric furnace process, and the local power company considered it impossible to reduce power rates to a level requested by the company, and (2) the dependence of the electric furnace solely upon scrap steel meant that the operating cost fluctuated with the price of scrap. For example, scrap prices in Detroit increased from $19 per ton in 1949 to $31 per ton in 1950. It became evident that producing steel by this method placed McLouth at a competitive disadvantage with integrated mills which used molten pig iron rather than scrap.

It was for these reasons that McLouth was anxious to make further changes in its plant facilities in order to fit the electric furnaces into a more economical operating plan.

In 1952, company management conceived the idea of constructing an integrated steel mill in order to obtain the fullest advantage from all elements of equipment. Since the automobile industry took 75 percent of the company's output, McLouth decided to discuss the plan with executives of the leading automobile companies in Detroit. The automobile executives were receptive to the prospect of expanded steel capacity in the Detroit area. There were two major reasons why such a program might prove useful to them. First, production bottlenecks and assembly schedule revisions could be more easily handled by a local steel supplier who was totally committed to the automobile companies. Second, the existance of a strong independent mill in Detroit might induce other steel companies to be freight competitive with Detroit rather than the FOB Pittsburgh freight charges which existed at that time. (This eventually saved the auto companies millions of dollars per year.)

McLouth could not provide the huge capital resources that integrated steel operations typically require. At the end of 1952, the net worth of the company was $24.8 million and long term debt was $11.3 million. Cost of the newly proposed integrated mill was estimated at $105 million. McLouth set out in search of financing. The financial campaign was assured success when General Motors Corporation agreed to take $25 million of McLouth's non-voting preferred stock.

Initially, one of the key concepts of this new mill included the use of the old Bessemer converter system. McLouth executives believed that by using Bessemer converters they could reduce the cost of operating the electric furnaces. Although the quality of Bessemer steel was not adequate for the company's requirements, the steel could be "duplexed" or added to the scrap in the electric furnace and so shorten the time needed for a heat of steel, as well as reduce the amount of scrap required. As plans for construction proceeded, a serious problem developed in the use of the Bessemer converters. Ordinances of the town of Trenton forbade the discharge of large amounts of smoke and particles released into the atmosphere during the Bessemers blowing operation. Conferences with the city officials failed to effect any compromise whatever and McLouth was forced to look elsewhere.

## THE TIME WAS RIGHT

It was known that two steel mills in Austria had been making steel by a method called L-D or Linz-Donawitz process, which was a top-blown oxygen converter. These first European oxygen furnaces were too small to be of commercial value in this country. The timing was right, but it was a risky venture because oxygen converters had never been used in the western hemisphere. Although the process had been used in Austria, it had never been attempted on the scale required by McLouth to balance a 1,400 ton blast furnace. After a series of visits to Austria the company was convinced that the oxygen process offered a remarkable opportunity to reduce operating costs if it could be successfully operated on a large scale basis. The company, therefore, proceeded to invest in capacity for 500,000 tons of oxygen converter steel annually.

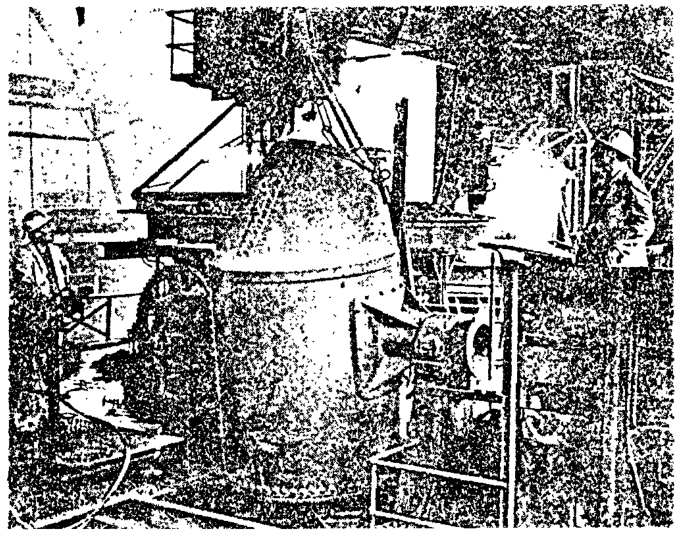
The entire basic oxygen process program, as it was called, proceeded on a tentative schedule, subject to many changes as obstacles presented themselves from time to time. In late 1954, three 60 ton oxygen vessels were in place along with a plant capable of turning out oxygen 99.5% pure at the rate of 3.5 million cubic feet per day.

## HISTORY

The idea of converting iron into steel with pure oxygen is over 130 years old and was expressed in some of the Bessemer patents. But little was done with the idea until about the 1930's when oxygen was beginning to be made available at an attractive enough cost to permit its commercial utilization in steelmaking.

The threads of the L-D story can be more directly traced to a professor of metallurgy in Berlin, named Robert Durrer. For many years he preached the doctrine of the utilization of pure oxygen rather than air in metallurgical processes, and particularly for the conversion of pig iron into steel. From 1933 until the outbreak of World War II, he conducted experiments on various steelmaking techniques making use of oxygen. Brief industrial application of some of his ideas came during wartime in Germany. Returning to his native Switzerland after World War II, he became associated with the largest of Switzerland's steel plants, the Gerlafingen works of the Gesellschaft der Ludw, Von Roll'schen Eisenwerke A.G. It was here that Robert Durrer proceeded to set up an experimental oxygen steelmaking shop.

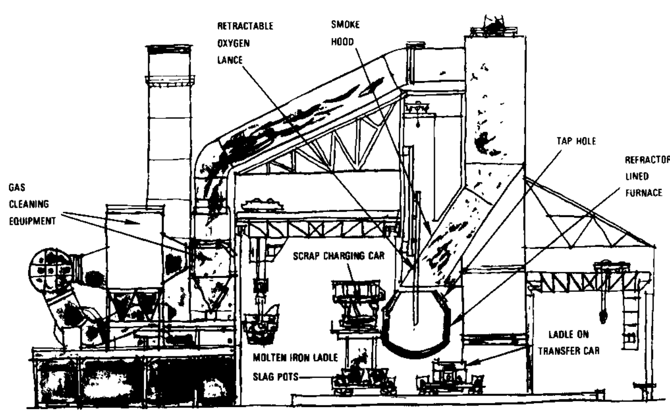
The dream of utilizing the top-blowing oxygen process to put Switzerland on the map as a major steel producer did not, unfortunately, succeed. But this development, starting at the Gerlafingen works of Von Roll, did start a chain of events moving, the full impact of which is still being felt today.



1948 — THE FIRST TOP-BLOWN OXYGEN CONVERTER AT GERLAFINGEN SWITZERLAND

To carry through our story, we must back track several years and recall the unbalanced state in which the Austrian steel industry was left at the close of World War II. The largest potential producing unit at Linz, which had been built by the German Hermann Goering Trust, had excess hot metal for its limited steelmaking capacity. Austria, desirous of rehabilitating her economy and becoming as self-sufficient as possible, was exceedingly anxious to expand steel producing facilities at Linz. However, the blast-furnace hot metal was unsuitable for Bessemer treatment, and the scarcity of capital precluded strong consideration of the erection of an open-hearth shop.

Looking for a way out of this situation, similar to McLouth's, Th. Suess, works manager of VOEST (United Austrian Iron & Steel Works), took up this new idea. After various experiments involving the position of the lance in relation to the bath, the distance between the nozzle and the bath, the oxygen supply, and the cross section of the nozzle, VOEST started with a series of




Schematic of a basic oxygen furnace shows the facilities needed to charge scrap and molten iron into the vessel and receive the steel after the oxygen blowing process is complete. Not shown are the chutes and bins which add fluxing materials to the vessel and alloying materials to the ladle of steel.

2-ton converter tests that reached a successful conclusion in June 1949. This operation, together with the improved technical information, prompted the managements of the two firms to build production plants. VOEST's L-D plant went into operation in November 1952, and Alpine's plant in May 1953.

## BASIC OXYGEN PROCESS

The oxygen process method of making steel was a sharp departure from the relatively slow cooking of the old way. This process uses as its principal raw material molten pig iron from a blast furnace. The other source of metal being scrap. Lime is the fluxing agent and the heat is provided by the use of oxygen and the chemical reaction; oxidation. The basic oxygen furnace is a steel shell lined with refactory materials. The body is slightly cylindrical, open at the top to receive raw materials and the oxygen lance which is then hooded to collect and guide the waste gases into extensive air-treatment facilities. The entire furnace is supported on horizontal trunnions, for tilting to either side.

The first step in making of a heat of steel in a basic oxygen furnace, is to charge it with steel scrap. Next an overhead crane transfers a ladle of molten iron from the blast furnace. The molton pig iron accounts for between 70 to 80 percent of the charge and is poured into the top of the furnace. The oxygen lance is lowered through a hole in the gas collection hood which has been moved over the top of the vessel prior to ignition and which carries the waste gases to cleaning facilities. The oxygen is turned on to a flow rate of about 4000 cubic feet per minute at a pressure of about 150 lbs. per square inch. The tip of the water-cooled lance is typically operated about five to six feet above the metal bath. Ignition takes place when the oxygen hits the molten iron. Iron oxide is produced in the area of oxygen contact. All of the lime charge is added before the blowing cycle reaches the one third point. The iron oxide immediately fluxes with the lime and it is this early formation of the slag that accomplishes most of the sulfur and phosphorus removal. The end point of the blowing cycle is determined by a visual drop in the flame action. Today, more sophisticated methods of measuring carbon level are in use.

When the approximate carbon level has been reached the oxygen is shut off, and both the hood and lance are removed. The furnace is then rotated toward the charging floor until the slag is even with the lip of the vessel. The slag is then decanted. At this point the temperature of the steel bath is taken with an immersion thermocouple and should be around 2930° F. The furnace is then rotated toward the pouring aisle and the steel is poured into a waiting ladle. Any necessary alloy additions are also put into the ladle at this time to enhance mixing and the steel is processed in the conventional steel fashion. The actual blowing of a heat takes about 20 minutes with an entire cycle of about 45 minutes.

## BASIC OXYGEN PROCESS ADVANTAGES

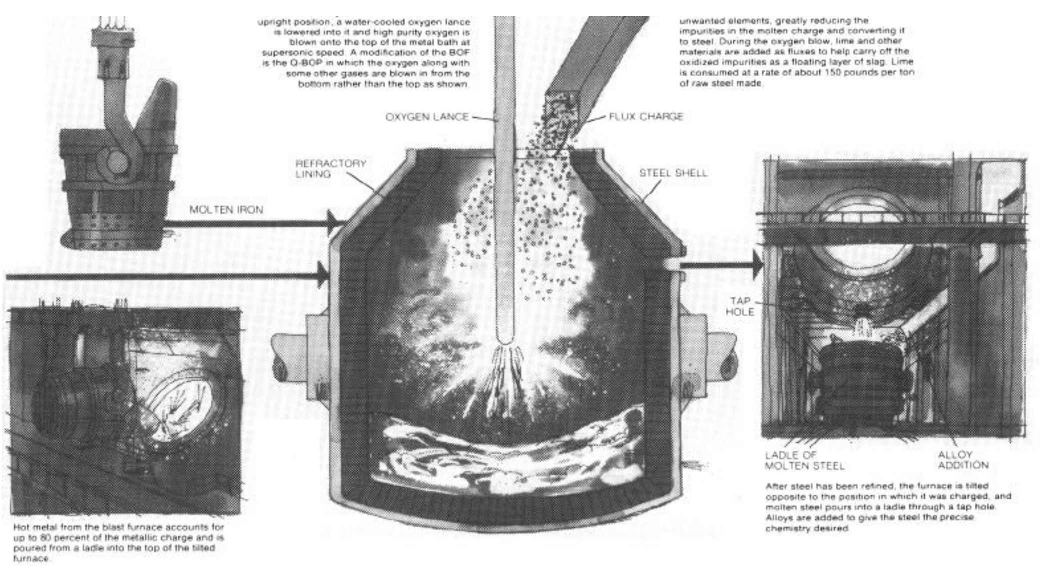
In 1955 the Bessemer converters were on their way out, electric furnaces accounted for only a small percentage and the open hearth produced about 90 percent of all the steel made in the U.S.

Today the Bessemers are gone and the open hearths are being phased out, while the electric steel furnaces are producing about 30 percent and B.O.P.'s about 65 percent of United States production.

The key advantages of the oxygen process are: 1) low capital investment. McLouth was able to produce 600,000 ingot tons per year with a 7 million dollar capital investment, which was much lower than that required by open hearth furnaces. (2) a tons-per-hour rate nearly three times that of the open hearth. As stated, these original vessels produced 60 tons on a 45 minute cycle. Today's refinements permit a 350 ton heat to cycle in one hour and (3) McLouth found that the oxygen produced steel of superior quality for the oxygen-process removed carbon and other impurities yielding a steel with reduced nitrogen levels far below any other process. Lower nitrogen levels gave the steel improved deep-drawing characteristics required by the automotive industry.

This new steel making technology, which was to have such an enormous impact on the international steel making future, was born in Austria, schooled in the United States, and put to work throughout the world.

CROSS-SECTION OF BASIC OXYGEN FURNACE



## THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The American Society of Mechanical Engineers (ASME) was founded in 1880 as an educational and technical society. ASME has consistently sought to provide an impetus for the continuing professional development of its individual members and advancement of the state-of-the-art of mechanical engineering.

The principal goals and objectives of ASME are:

- To provide a forum for the development, exchange and dissemination of technical information, particularly on mechanical engineering.
- To develop mechanical standards, codes, safety procedures and operating principles for industry.
- To encourage the personal and professional development of practicing and student engineers.
- To aid members of the engineering profession in maintaining a high level of ethical conduct.

The Society consists of more than 112,000 members, of whom some 20,000 are engineering students. ASME members are active in private engineering firms, corporations, academic and government service. A ten-member board governs the Society. Its headquarters are in New York City and it has five field offices - Chicago, Dallas, San Francisco, Danbury, CT and Burke, VA, plus a government relations office in Washington, D.C.

## THE HISTORY AND HERITAGE PROGRAM

The history and Heritage Landmark Program of the ASME began in September 1971.

To implement and achieve the goals of the Landmark Program, ASME formed a History and Heritage Committee, composed of mechanical engineers, historians of technology, and the curator of mechanical engineering of the Smithsonian Institution. The committee provides a public service by examining, noting, recording and acknowledging mechanical engineering achievements of particular significance.

## LANDMARK DESIGNATION

The Oxygen-Process Steel-Making Vessel is the 76th National Historic Mechanical Engineering Landmark to be designated since the ASME program began. In addition, 18 International and eight Regional Landmarks have been recognized. Each represents a progressive step in the evolution of mechanical engineering, and each reflects its influence on society, either in its immediate locale, nationwide or throughout the world.

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

## ACKNOWLEDGEMENTS:

The Southeast Michigan Section of the ASME gratefully acknowledges the efforts of all who participated in the landmark designation of the Oxygen-Process Steel-Making Vessel. We wish to extend special thanks to Milton Deaner, Frank Sove of the McLouth Steel Products and William V. Murphy.

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