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Review

The early ice making systems in the nineteenth century

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ABSTRACT

Introduction of artificial refrigeration became one of the most remarked technological events in the nineteenth century. The development of different systems for making ice was the result of separated efforts of combined applications of several chemical and physical principles in order to satisfy an increasing domestic and industrial demand. This account of the first ice making machines reveals details of the high sense of creativity showed by their designers and the yields individually reached.

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Les systèmes de fabrication de glace au 19e siècle

Mots clés : Glace ; Histoire ; Système à absorption ; Système à compression ; Frigorigène ; Système de fabrication de glace

1. Introduction

The importance of using ice as an article for industrial and domestic purposes dates from the beginning of the nineteenth century. Until the 1850s natural ice was the only available source to meet the demands for conservation and transportation of fresh foods, manufacture and storage of some alcoholic and non-alcoholic beverages, butter and frozen creams, besides other improved living conditions for the population of every day larger cities. Ice was stored during winter months in the earth's northern and colder parts in specially constructed buildings located near ponds, lakes or rivers, from where it was taken and sent to regions near the equator.

\However, ice supply was highly dependent on season's conditions and consequently very uncertain. Ice crops failures were usually followed by shortage, marketplace disruptions and price increases in the following summer. Natural ice shipments from North to Central and South America, West Indies and India, and from Norway and

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Sweden to England and the German ports on the North Sea, slowly reached their maximum capacities in the second half of the nineteenth century. On the other side, the significant increase in ice consumption in different parts of the world during the same time period caused that in the 1880s, for example, the annual ice supplies of around two million tons transported through the Hudson river become inadequate for a city as New York, forcing in turn imports from countries such as Canada and Norway. Similar measures must to be also taken to make up for the deficiencies in the usual provision from Scandinavian Alps in order to cover the needs of about ten million ice tons for the residents of Paris. Artificial refrigeration emerged then to satisfy this growing demand, freeing the market from being weather dependent, and to additionally calm down the worry caused by the constantly increasing contamination of the water sources in the vicinity of large cities, from which the ice-crops were harvested. Although the harvested ice producers advertised, in view of the imminent competition, that their natural refrigeration resource did not fail like the recently devised mechanical systems, it was a fact, that the different apparatus and mechanisms designed between the middle of the nineteenth century and the first quarter of the twentieth century not only competed with harvested ice but successfully exceeded all expectations.

This article shows the main characteristics of the first nineteenth century devised systems to artificially manufacture ice, and some details of the most representative machines for each one of them. A classification and subsequent ordering based on the respective scientific principle used by each system has been chosen for the treatment along the text, instead of a strictly chronological one, because of the difficulties associated with the interlaced citations that this latter model would imply. The first part of the discussion refers to the chemical process systems based on the use of refrigerating mixtures and the corresponding designs of the so-called domestic apparatuses for especially low production capacities, which may be considered as an intermediate stage or bridge between natural and artificial ice. The remaining sections are devoted to those systems based on physical or mechanical principles. Although the principles on which the different studied systems are based were formulated in the period lasted between 1750s and the middle of the following century, all machines discussed in the article correspond to designs of the XIX century.

2. Refrigerant mixtures and domestic apparatuses

Experiments in order to obtain artificial reductions of temperature, and thereby producing ice, were made as far back as the XVI century. It was maybe the Spanish physician Blasius Villafranca who discovered about 1550, that temperatures could be artificially reduced by the dissolution of saltpetre (and, later, common salt) in water. Half a century later, in 1607, the Italian physician and professor Latinus Tancredus was able to congeal water for the first time, by putting it in a direct contact with a mix of snow or ice also with salts (Anonymous, 1893a). These facts became the opening to what was later called the refrigerant mixtures method for producing artificial cold. The method is based on the energetic balance established in the melting process of mixtures of some salts and water or acids, or some salts with ice, with freezing points below their original temperatures. The temperature decrease exhibited by such mixtures due to the significant difference between the heat required for their melting and the heat externally available was an empirically well-exploited scientific fact from antiquity, becoming one of the first methods proposed for making ice, at least on a small scale. The equilibrium temperature resulting from the energy balance, dependent on the state of hydration of the salt and the mixture composition, became one of the criteria for the choosing of many refrigerant mixtures exhibiting this behavior.

Many domestic apparatus designs, also called “glaciers de familles”, based on this principle, were specially proposed in the 1850s and 1860s. The first practical ice machine of this class was patented in 1855, by the British civil engineer Charles Williams Siemens (1823–1883), using an aqueous solution of calcium chloride as refrigerant mixture (Siemens, 1855; Gamgee, 1877). The apparatus, with which it was possible to obtain reductions in temperature close to 16 K, was not well received because it was expensive to operate compared to mechanical ice machines. The by then most known model of domestic apparatus was, however, the “Italienne Glacière”, proposed by the French civil engineer of Italian origin Jean-Baptiste Toselli (1807–1883). His first design worked by the combined action of two different cycles: one with vessels for the refrigerant mixture and the corresponding recovering of the vaporizable liquid, connected by a tube that simultaneously served as axis of vertical rotation in order to improve the heat exchange, and the other for the cooling system of those vapors (Fig. 1a) (Toselli, 1866, 1868a, 1869a). Although the decreasing in temperature reached with this assembly was close to 30 K and allowed the owner to simultaneously obtain

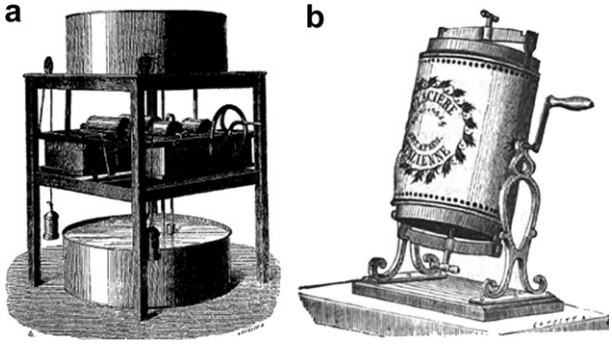

Fig. 1 – Toselli’s domestic apparatuses (a) design with two different cycles; (b) design with two concentric compartments. *Credit*: (a) From Toselli, J.-B., 1866. Fabrication artificielle de la glace: glacière à vapeur d’eau. Le génie industriel 32, 11–13; (b) From Toselli, J.-B., 1878. Appareil pour produire le froid artificiel, applicable à la fabrication de la glace ou des glaces, ainsi qu’au refrodissment et à la conservation des liquides. Italian patent 115973, December 11th.

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