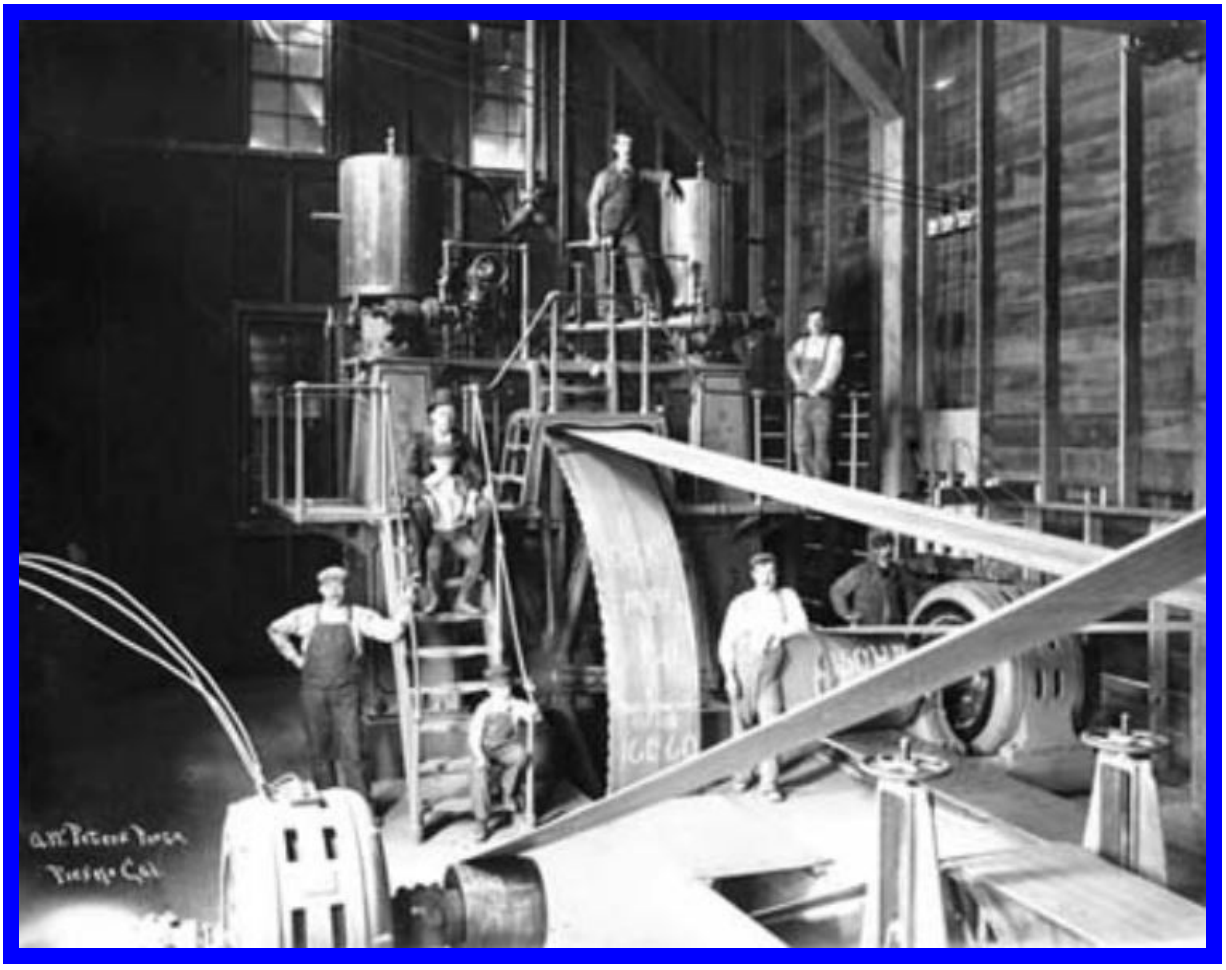
American Refrigeration: Cold Storage & Ice Making 1875-1915



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American Refrigeration
Cold Storage & Ice-Making 1875-1915

Introduction

The Heritage Group of CIBSE {Chartered Institution of Building Services Engineers} has considerable information on the history of Refrigeration. In addition, the Heritage Group Archive, compiled over some forty-five years, holds a large collection of textbooks, catalogues and technical papers on the subject, but most of it relates to refrigeration for comfort and industrial air conditioning. Comfort air conditioning really began in America in Chicago movie theatres around 1917. In the 1920s, this was transformed into a major industry, especially with the arrival of the "talkies" and the centrifugal water chiller. By comparison, air conditioning for office blocks started in 1928 at the Milam Building in San Antonio, Texas and early growth was slow.

Information held by the Heritage Group on **Cold Storage and Ice-Making** has, until now, been limited, probably because this specialist subject is generally not dealt with by CIBSE or its Members. The history of the harvesting and storage of natural ice has been dealt with in many publications. It was widely used in the Southern States of America until supplies to the Confederacy were blocked by the Union during the Civil War. This led to the development of refrigeration machines for ice-making and then for cold stores. This ebook covers the period from **1875** until the early years of the Great War in **1915**.

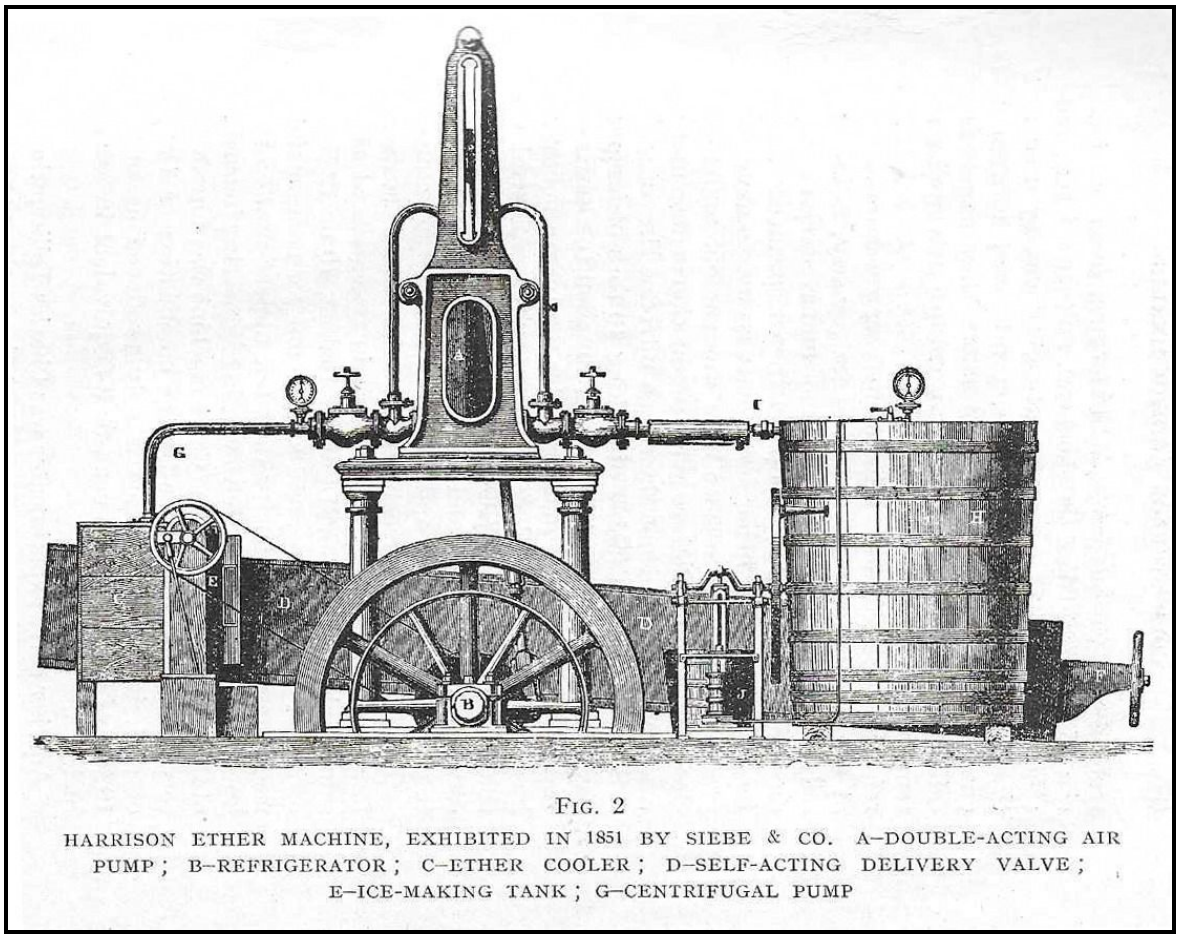
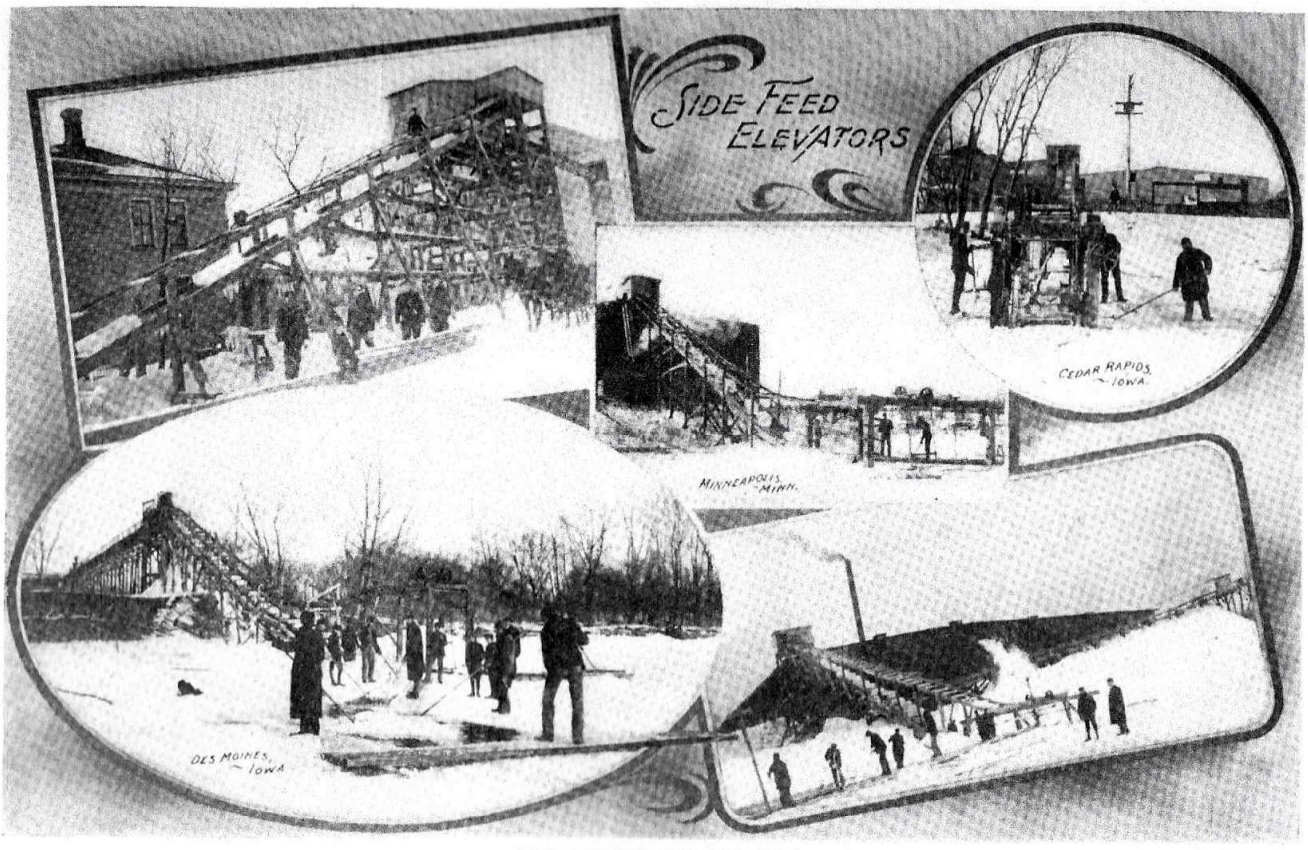


FIG. 2

HARRISON ETHER MACHINE, EXHIBITED IN 1851 BY SIEBE & CO. A–DOUBLE-ACTING AIR PUMP; B–REFRIGERATOR; C–ETHER COOLER; D–SELF-ACTING DELIVERY VALVE; E–ICE-MAKING TANK; G–CENTRIFUGAL PUMP

American Refrigeration
Cold Storage & Ice-Making 1875-1915

Natural and Artificial Ice



GROUP OF SIDE-FEED ELEVATORS.

Text from *THE SECOND EPOCH 1875-1914*
INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS 1979

2.2. NATURAL AND ARTIFICIAL ICE

2.20. Natural ice paved the way towards artificial ice and to mechanical refrigeration. The very first machines which were used in practice, from 1845 to 1860, namely those of Gorrie *, Twining *, Harrison *, and Ferdinand Carré *, were for making ice which was meant to replace natural ice. It is not possible to go back over the history of artificial refrigeration without a rather long discussion of natural ice, especially so since one often forgets that this was not only used in homes in the past (to chill drinks or preserve some especially perishable foods), but was also used at the commercial and even industrial level. Examples are: in breweries and in meat factories, or to cool large stores.

Everyone knows that the use of ice or snow by men goes back to far distant times. History records this, e.g. in the Bible or in Chinese poetry of the 2nd millenium. In the far distant past the use of ice took on, in certain countries, a ritual or almost religious character. Thus in ancient Japanese chronicles it is recorded that, about the year 300, a young brother of the Emperor Ninkotu offered him ice gathered on the mountain, a gift so much appreciated that later the 1st of June was named the "Day of Ice". On that day the Emperor invited the high civil and military dignitaries to his court and offered them fragments of ice; the ceremony was called "the Imperial Gift of Ice". This pretty and picturesque ritual will, I think, enchant refrigerationists. Anyhow the use of natural ice was widely spread in the entire world, wherever cold winters permitted its harvest. It was collected from rivers, lakes, ponds and near mountains, and especially from glaciers (mainly in France, Italy, Switzerland, Austria and Serbia...).

If all this is well known, what is less known is the considerable importance of the trade in natural ice in the last quarter of the 19th century, within certain countries and also internationally. This traffic culminated in the final years of the century.

2.21 INDUSTRIAL COLLECTION AND TRANSPORT OF NATURAL ICE IN THE UNITED STATES

2.211. The use of natural ice expanded rapidly in the United States, and in the last years of the 18th century developed a more technological aspect. Farmers almost everywhere made ice houses in which they kept, as well as they could, the ice they gathered from rivers and lakes during winter. In 1799, a large store for natural ice was built in Charleston (South Carolina). Thomas Moore, a Maryland farmer, took out a patent in 1793 for "cooling by ice", and in 1803 (1) he described a "refrigerator". This was in fact, a box cooled by a mixture of ice and salt.

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(1) "An essay on the most eligible construction of ice houses; also a description of the newly invented machine called the refrigerator".

Model of Frederic Tudor's ice ship, the Ice King. Ice shipments were not always warmly received. About 1820, the New Orleans mayor shocked the crew of the first sailing vessel to deliver ice to the city. He ordered the ice to be thrown into the sea.

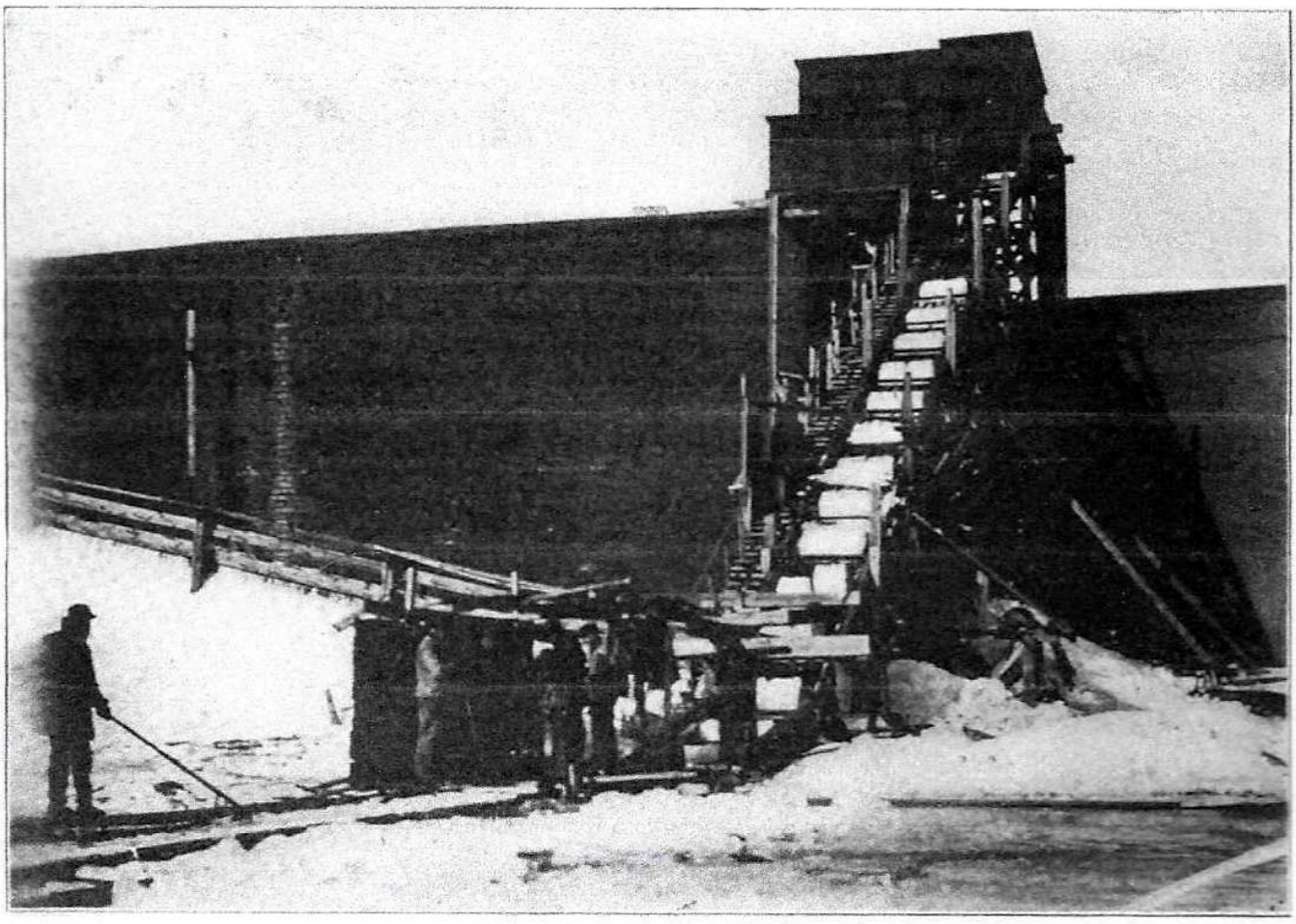


FIG. 55. OVERSHOT ELEVATOR AND CHIP CONVEYOR.

In 1806, Frederic Tudor, who afterwards became known as the "Ice King", began the international trade in ice by sending 130 tonnes from Boston to Martinique, and then, somewhat later to Jamaica, where it was meant to be used against yellow fever. He continued in 1815 with a cargo to Havana, where in 1816 he set up a pre-fabricated ice house, made in Massachusetts. From 1817 he began a coasting trade to supply ice to the southern towns of the United States; he set up a depot in New Orleans in 1820. Up to 1832, the business was on a modest scale, he having sent by sea 4 500 tonnes in 27 years. But he became bolder in 1833, when he sent 180 tonnes to Calcutta of which 120 tonnes remained on discharge, and in 1834 he supplied Rio de Janeiro and then, from 1840, Great Britain. American exports of natural ice culminated in 1872 at 225 000 tonnes; there were some exceptional cargoes to China and Australia. But in 1900, exports had fallen back to 14 000 tonnes.

In the eastern United States the large "strata" of natural ice were to be found in Maine and on the Hudson river. New York was largely supplied by barges (400 to 1 000 tonnes) pulled in trains of 6 to 12. In the west, San Francisco first received ice from Alaska, and afterwards, from 1880, from the Sierra Nevada, by rail. In 1880, the United States harvested 5 M tonnes of natural ice, and a record quantity of 25 M tonnes in 1899. In 1907, more than 15 M tonnes were still collected, and the decline was not felt until after 1910.

New York city alone used 12 000 tonnes of natural ice in 1843, 100 000 tonnes in 1856 and 1 M tonnes in 1879. In 1880, Chicago used more than half a million tonnes. New Orleans was more difficult to supply with natural ice, but its consumption rose from 350 tonnes in 1827, 8 000 tonnes in 1847, to 24 000 tonnes in 1860.

2.212. This considerable development of trade in natural ice was accompanied by mechanisation of harvesting and handling, and more orderly storage. At first hand saws were used. In 1825, N.J. Wyeth invented a cutter drawn by a horse, and later, mechanical circular saws were used. Two large companies, Gifford Brothers of Hudson, N.Y., and W.T. Wood, of Arlington, Massachusetts, specialised in equipment for havesting ice. The optimum thickness of the ice was considered to be 30 to 35 cm. The ice was mechanically lifted for stacking in immense stores, which most commonly had double wooden walls, insulated with sawdust. Some of these could hold 60 000 tonnes and the best could keep the ice for more than two years, with a loss of 10 to 25%. About 1855, elevators driven by steam engines, capable of lifting up to 600 t/h, were used. At the beginning of the 20th century, the Hudson river district had storage capacity for 4 Mt of natural ice.

About 1880, natural ice was "big business", and two large companies were set up to trade in the commodity, the Knickerbocker Ice Co. of Philadelphia and the Consolidated Ice Co. of New York. In 1896 they amalgamated, and afterwards sold 4 Mt/year. Rational organisation of the market brought the price down; in the south, ice was sold at 5 to 6 cents per pound in 1827, and had fallen to 1 to 3 cents in 1830. All

FIG. 29. UNDERSHOT ELEVATOR AND CAR LOADER. HASTINGS ICE COMPANY, HASTINGS, NEB.

the data available shows how important the ice trade was to the United States; in 1855 an Englishman wrote that "ice is an American institution".

Despite its decline at the turn of the century, trade in natural ice was still quite important in 1910, when the journal "Ice & Refrigeration" published a long series of very detailed technical articles on the best means of harvesting and handling natural ice. And in 1914, in New Jersey, a modern store was built to hold natural ice, with a steel framework and brick walls.

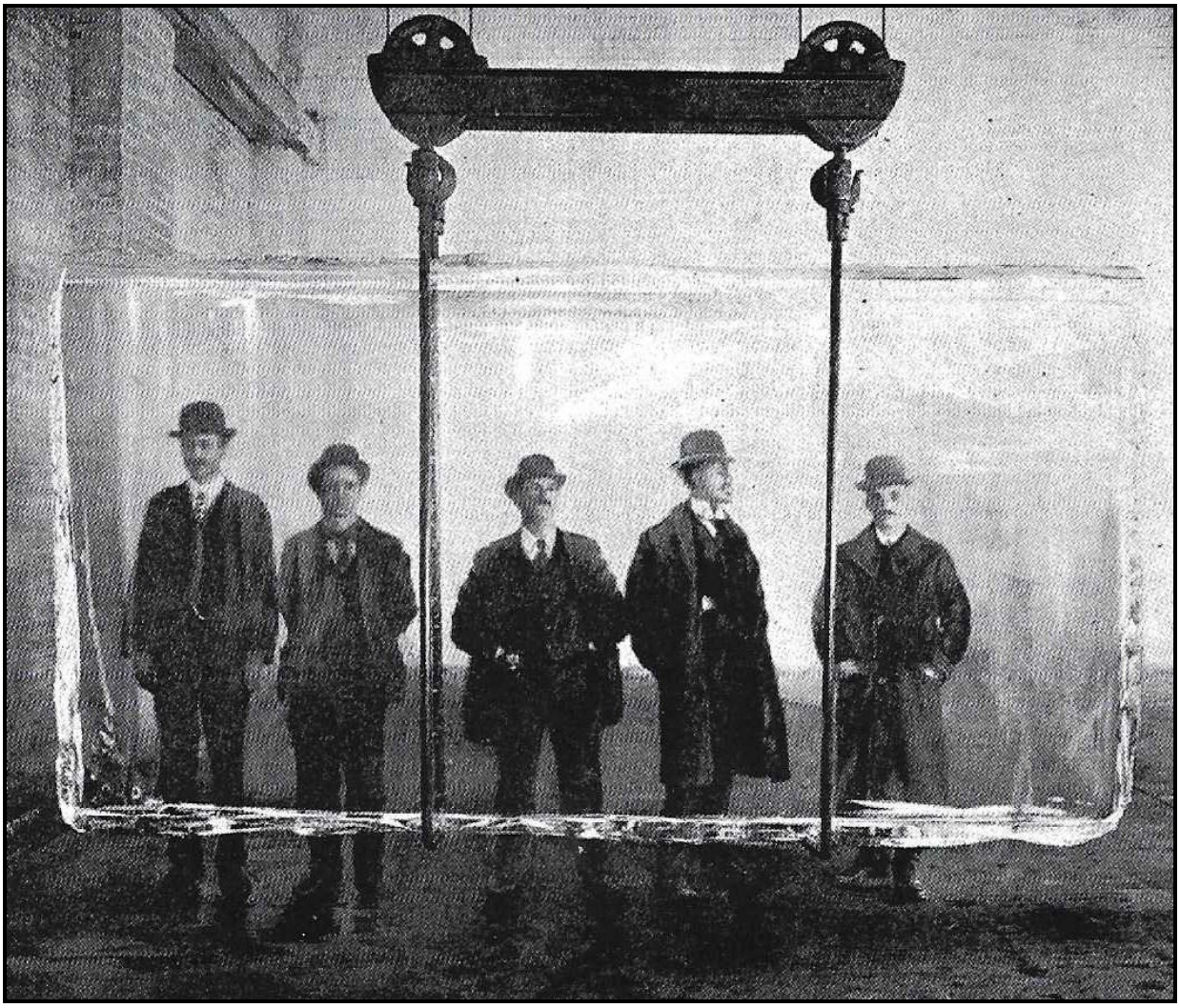
2.213. Natural ice had many uses. Naturally, cooling of drinks and preservation of perishable produce, especially butter and milk, were important, but the ice was also used (and this will be returned to, later) for cooling transport vehicles, cold stores (mainly for apples, but also for butter), and in brewing. In the large American cities, about 1880, 35 to 50% of the natural ice was sold to individuals, the rest being used by cafés and restaurants and in several industrial applications.

In the middle of the 19th century natural ice was God's own ice, and it was never contemplated that anything could replace it. The following tale ([1]) shows this clearly. In 1844, John Gorrie * had just made his air cycle machine, which produced ice; he had doubts about revealing this discovery in case he should be exposed to the religious censure of his fellow citizens. Accordingly, he published an account under the pseudonym "Jenner" in the form of a prediction of the possibility of making such a machine; this appeared in the local paper of Apalachicola. His fears were sound, since a well-known newspaper in New York, "the Globe", wrote shortly afterwards that "there is a crank, down in Apalachicola, Florida, that thinks that he can make ice by his machine as good as God Almighty". And Gorrie did not obtain an American patent until 1851.

Again, in 1903, in his excellent book "Practical Cold Storage", one of the best engineers of the epoch, Madison Cooper, extolled the use of ice for cooling stores for apples or butter, and recalled his father's words that ice was best made by God. ([2]).

American Refrigeration
Cold Storage & Ice-Making 1875-1915

Ice-Making Plants



Text from *THE SECOND EPOCH 1875-1914*
INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS 1979

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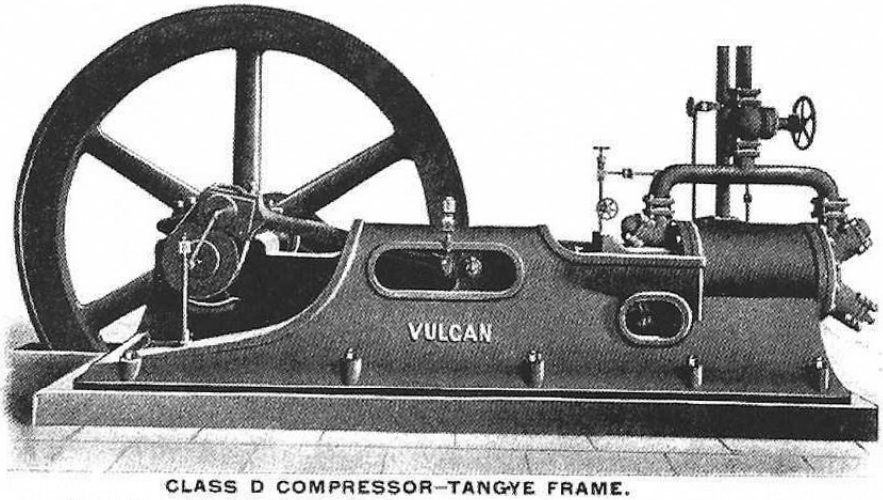
J. W. Dowdell, Mgr.



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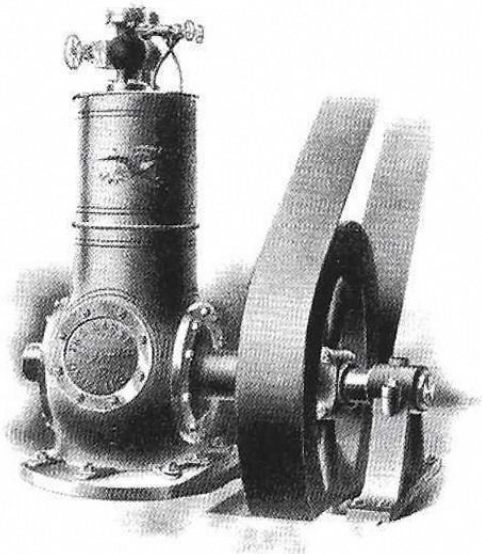

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2.23. ESTABLISHMENT OF ICE-MAKING PLANTS

2.231. **In the United States**

Manufacture of ice began in the southern United States; in these hot states the chance of obtaining natural ice was such that very rapidly they began to make ice artificially. At the beginning of the 1860's there were only two suitable machines available, world-wide, that of Harrison * and that of F. Carré *. The southern states chose Carré's absorption machine: it has already been noted that these were imported during the War of Secession (1861-1865) for use firstly in hospitals, and then for other uses.

In 1869, there were 5 ice factories in the United States, all in the south, in Louisiana, Texas and Tennessee. In 1870 a factory for 60 t/day was built in New Orleans. In 1879 there were 29 ice factories in the south, 5 on the west coast, and only one in the north. On the west coast the first installations were put together in an ad hoc fashion by J.M. Beath and S.B. Martin, of San Francisco. The first of these was built in Los Angeles in 1869, then followed San Francisco in 1870 and Portland, Oregon, in 1871. In 1889, there were 170 ice plants in the south and only 14 in the central states.

In the north of the United States, with favourable colder winters, natural ice resisted the advance of the artificial. Even in 1900, there were no ice-making plants in the seven coldest states. In 1908, Greater New York (4.5 M inhabitants) used 3 Mt of natural ice and 1.5 Mt of artificial ice. In 1914, two thirds of the ice used in Chicago was natural, and three quarters in Detroit. Two successive mild winters in 1888-89 and 1889-90, were favourable to the establishment of artificial ice plants. Further, hygienic considerations favoured artificial ice; the case of the Hudson river

is interesting in this respect; most of New York's ice came from this river. When there was alternative melting and refreezing, faults formed in the ice, through which rose the river water, the impurities in which were trapped in the new ice, on refreezing. This was to such an extent that the health services of the city forbade the use of ice of this type in direct contact with foodstuffs.

But natural ice made an energetic retreat; in 1910 the "Natural Ice Association of America" (1) was created, to unite the efforts. To read American journals of this time is to gain some idea of the strength of the competition. For a long time, the two ices existed side by side, not altogether peacefully, and it is piquant to read in a number of the journal "Ice and Refrigeration", in 1926, an article on organised harvesting of natural ice alongside one entitled "the distribution of ice, and the domestic ice box, they are finished, giving place to the mechanical refrigerator". Those who kept to natural ice even tried to provoke a patriotic "impulse" in 1917, when the United States entered the war: natural ice economised on fuel and ammonia.

Despite the resistance, artificial ice grew rapidly in the United States, as witness the following progression: 39 ice factories in 1879, 220 in 1889, 790 in 1899, 2 000 in 1909 making 12 Mt, and 5 000 in 1915 (26 Mt). On the latter date, artificial ice overtook natural ice and became "big business", which led to some financial and political backwash in about 1906-1907, and judicial actions against illicit commercial combines, especially the "American Ice Company" which ruled over the New York market. Manufacture of ice continued to make progress during a good decade, to level off between 1926 and 1931 around 56 Mt, from about 6 000 plants. From then on, mechanical refrigeration was directly used for more and more processes, and the production of ice declined, falling to some 30 Mt in 1939. It came back into favour around 1946, to about 50 Mt, and then a regular regression set in, to about 20 Mt at present. Some three quarters of this is used to ice wagons, and on fishing boats.

In 1900, 45% of the installed refrigerating machinery in the entire United States was for manufacture of ice, the proportions being 27% in the north and 75% in the south. At this time there were already very large factories, one in New York made 900 t/day and another in Baltimore, 600 t/day. In 1914, there was a factory in St Louis producing 1 200 t/day.

Urban distribution of such huge tonnages of ice posed problems. At first because most of it was done by horse-drawn vehicles. In 1856, the delivery of the 60 000 t of natural ice used in Boston needed 90 carts and 150 horses. In 1900, it was estimated that a factory producing 100 t/day needed a "stable" of 30 horses, and it is piquant to read, in old American refrigeration journals articles on the scientific and rational feeding of horses. About 1910, people began to think of using automobile trucks to deliver ice; there had been some isolated cases of experimental use of electric or petrol driven trucks, about 1907. It was not until 1912,

(1) It comprised 200 members when created, representing 6 Mt capacity of ice stores.

however, that this became common. To make the vehicles more profitable throughout the year, it was envisaged that they deliver ice in the summer, and coal in the winter. Evidently two such dissimilar forms of merchandise posed problems of convenient arrangement of the vehicles! Further, there was a trend towards having more points of sale for the ice, and about 1915 portable ice stations of small size began to appear.

2.232. **The situation in other countries**

The growth was much less rapid than in the United States, and it was not until after 1890 that ice manufacture had any significance in Europe. In *Great Britain,* the first ice manufacture was mainly for use in fisheries: the port of Grimsby in 1900 had a factory of 300 t/day and in 1907 a capacity of 600 t/day. In 1910, a factory of 200 t/day was added; this was the most modern in the country, at that date. Around 1907-1908, Great Britain made 600 000 t of ice per year. In 1914, London used no more than 300 000 t of ice per year, two thirds of which was artificial and one third natural. In *Germany,* it was the breweries which used the first ice, which was made from about 1877. Linde built his first "independent" ice factory in 1880. In *Austria* also, breweries used the first ice; Vienna was well equipped: in 1906 the city used 150 000 t of artificial ice and the same tonnage of natural ice. In *France,* the two first ice-making plants were installed in breweries, in 1859 and 1869. Paris had no artificial ice until 1872. Up to then, the Société des Glacières de Paris, founded in 1865, dealt in natural ice collected from the lakes in the Bois de Boulogne and the Bois de Vincennes. In 1908 about half a million tonnes of artificial ice were sold in France, about 180 000 t of this in Paris and its suburbs. The tonnage rose to a maximum of 1.2 Mt about 1956-57, and at present stands at about half a million tonnes. Some of the colonies were equipped fairly early; there was a Carré machine in Tunis in 1873.

In most countries in which refrigeration equipment became available at the end of the 19th century, the first uses were to make ice; in 1907, in Italy, Genoa and Milan each had a capacity of 300 t/day.

2.24. TECHNIQUES OF ICE MANUFACTURE

From the beginning, the bulk of the ice manufactured was frozen in moulds immersed in a tank of brine. The size of the moulds varied according to country, region and use to which the ice was to be put; 25 to 200 kg in the United States, 8 to 200 kg in Great Britain, and predominantly 40 kg in France. Soon, however, inventors had thought of other procedures, which however made no inroads, for half a century, on the sale of ice in blocks. Thus, David Smith (1834-1903) an American born in Scotland, introduced plate ice in 1872, the first installation being in Oakland, California. This process had some success in the United States

and Great Britain, but the handling of the plates, which were 25 to 30 cm thick and weighed several tonnes, was difficult. In the U.S.A. plate ice was less than 3% of the total in 1900; the proportion rose to 8% in 1908, then decreased to 5% in 1919. Another American, Daniel Holden *, the man who first improved the Carré absorption machine in the U.S.A. launched "Regealed Ice". This process consisted of making flakes of ice by scraping the film formed on a rotating drum, and then compressing them into bricks. The date of Holden's invention is uncertain, different sources give different dates. It seems that he had made a first machine with a horizontal drum in 1869, and had used this commercially in 1877. He made a machine with a vertical drum in 1894, the ice from this being compressed into blocks of about 100 kg. The principal advantage claimed was rapidity of manufacture. This is the first process for *small ice,* using direct expansion and not brine. It was between the two wars that small ice became commercially important, especially in the United States, with the "Flakice", "Pak Ice", "Tube Ice" and "Ribbon Ice" processes. More will be said of these, later.

About 1907, in addition to plate ice and regealed ice, there were two non-classic methods of manufacture, in the United States. The "Center-freeze" process, introduced by D.J. Havenstrite, consisted of plunging into water a sort of large vertical comb made up of tubular evaporators on which ice formed, until it united into a large vertical plate. The "Cell block system" made blocks of ice, of 200 to 500 kg, in a grid of "pigeon holes" of which the hollow walls were cooled by the refrigerant.

In Europe in the 1880's several ice plants were made featuring rotating moulds. The Linde machine (1880) had a horizontal axis (two of these were installed in Bombay and Paris), and the Lebrun machine (1887) a vertical axis. Note also Hill's process (1889) in Great Britain, in which ice was formed around columns of a pyramidal or conical shape plunged in water; refrigerant circulated in the columns.

However, after this digression into non-classic means of manufacture, it must be said again that the immense majority of ice was made in moulds, in the period 1875-1914. During this epoch, the main demand was for very transparent ice. This could be obtained, more or less well, by several processes. For example, one could use de-aerated boiled water; an idea applied in 1868 by Francis de Coppet * in New Orleans. "Alimentary" ice was made from distilled water, and had a long vogue from 1866, and about 1890 most of the ice made in the U.S.A. was from distilled water. But about 1910 the process began to be abandoned, as being too costly. It was replaced by agitation of the water in the moulds by suspended rods (a European invention) or by blowing air through the water in the moulds. The latter method was introduced in 1873-1874 by V. Becker and T. Turrettini, in Geneva. It is estimated that in 1919, 35% of the ice made in America was prepared by this method. De-aeration, to produce clear ice, was used in all countries: when manufacturers made an especial point of selling perfectly transparent blocks, they sucked out the core, not yet frozen and in which any salts are concentrated, towards the end of the operation.

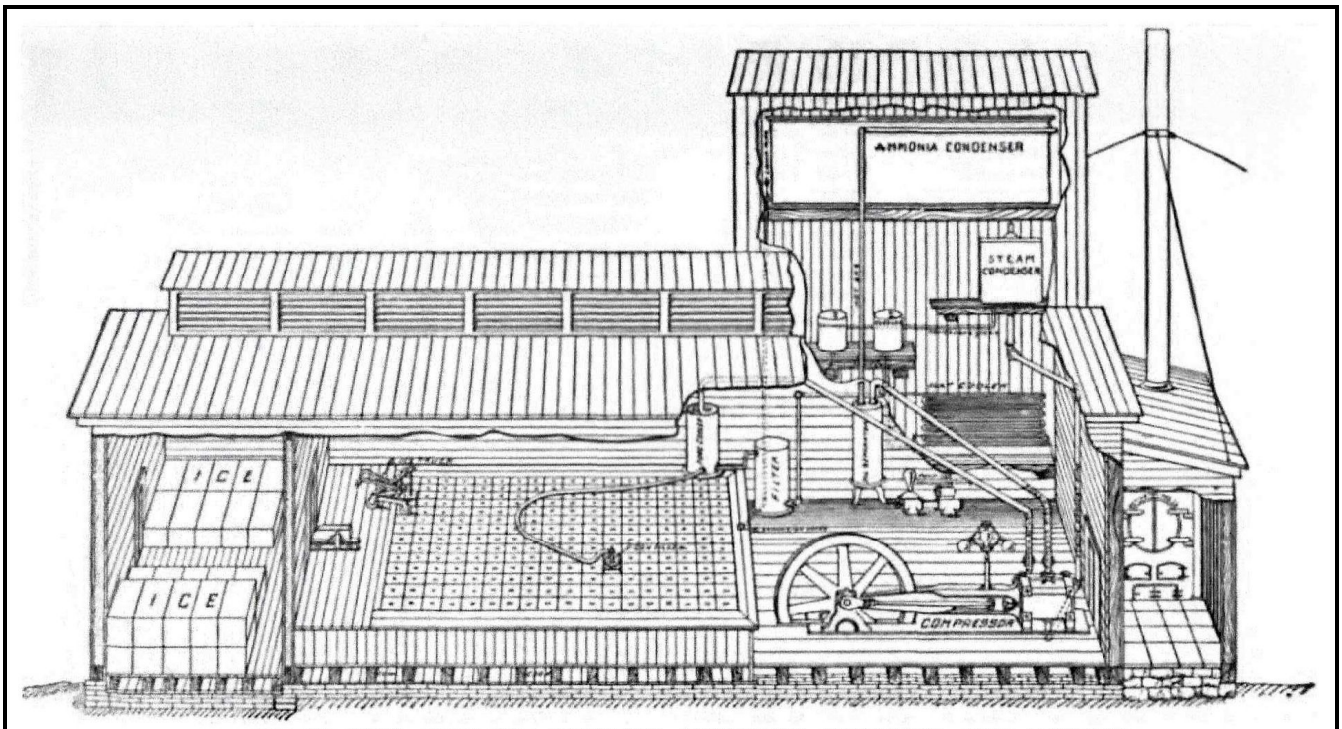
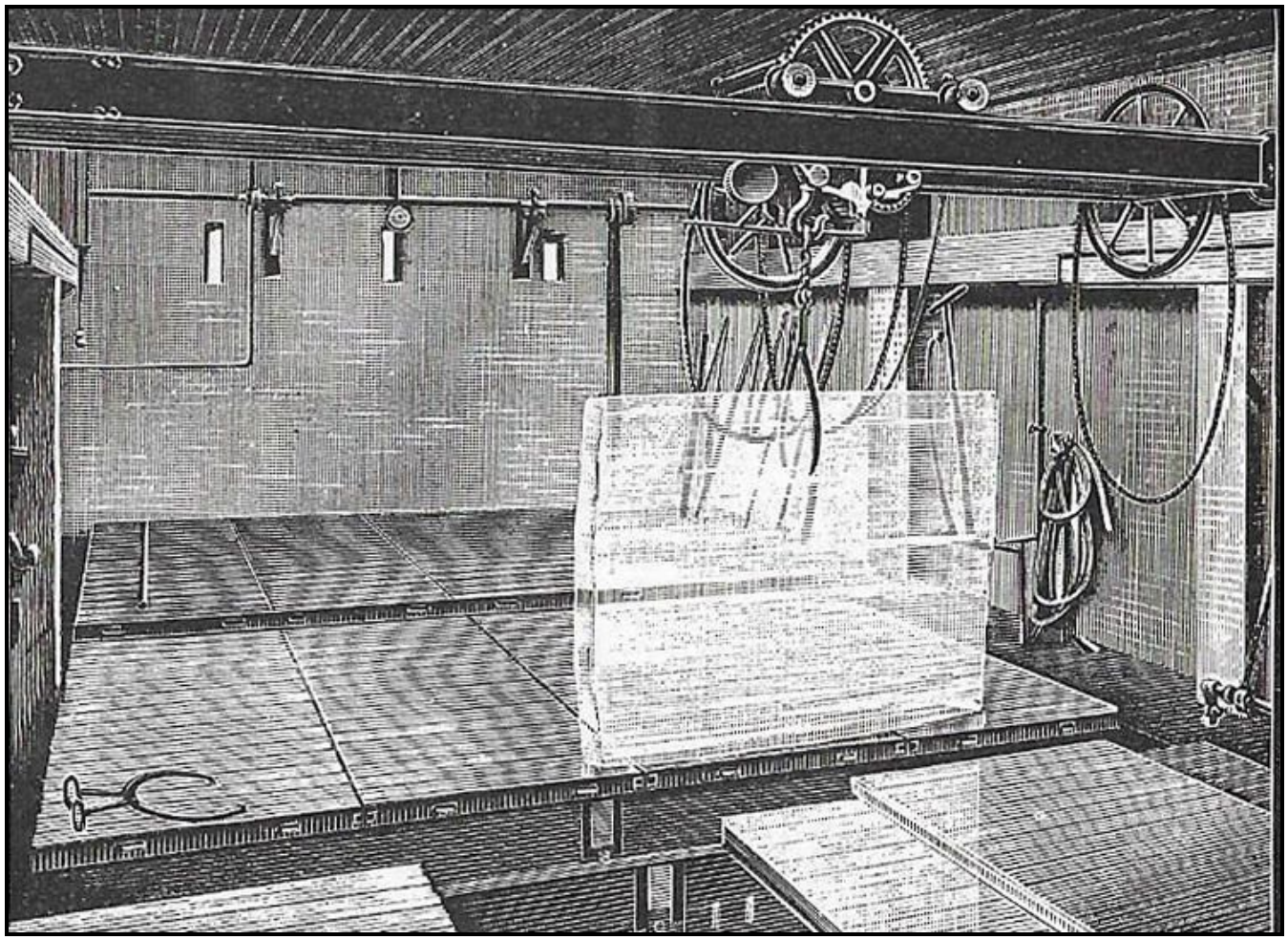


PLATE XIII.—CAN ICE FACTORY, TEN-TONS CAPACITY AND LARGER.



American Refrigeration
Cold Storage & Ice-Making 1875-1915

Cold Stores

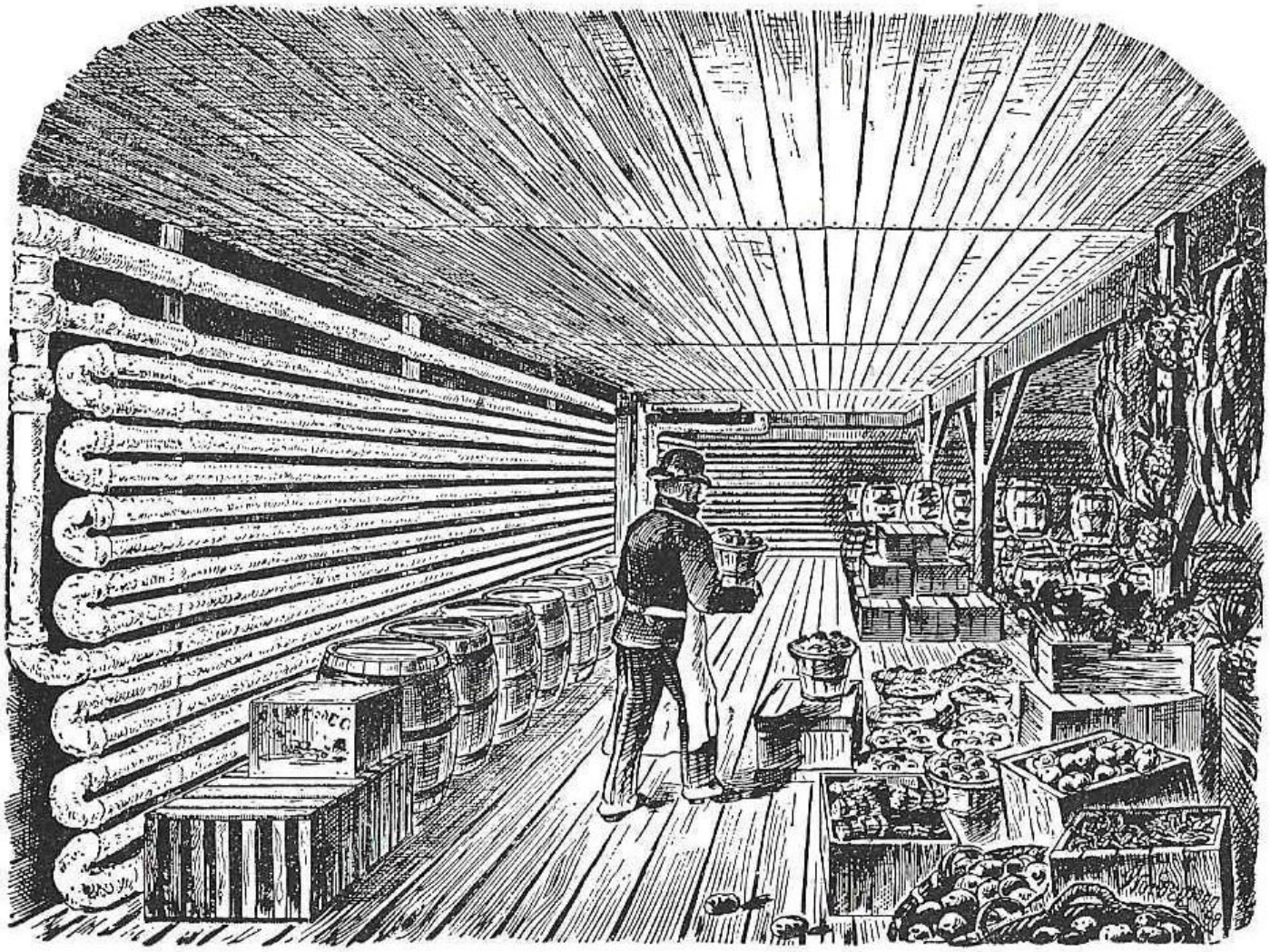


Fig. 1.1. An early cold-storage refrigeration application—from an 1890 Frick catalog. Courtesy Frick Co.

Text from *THE SECOND EPOCH 1875-1914*
INTERNATIONAL INSTITUTE OF REFRIGERATION, PARIS 1979

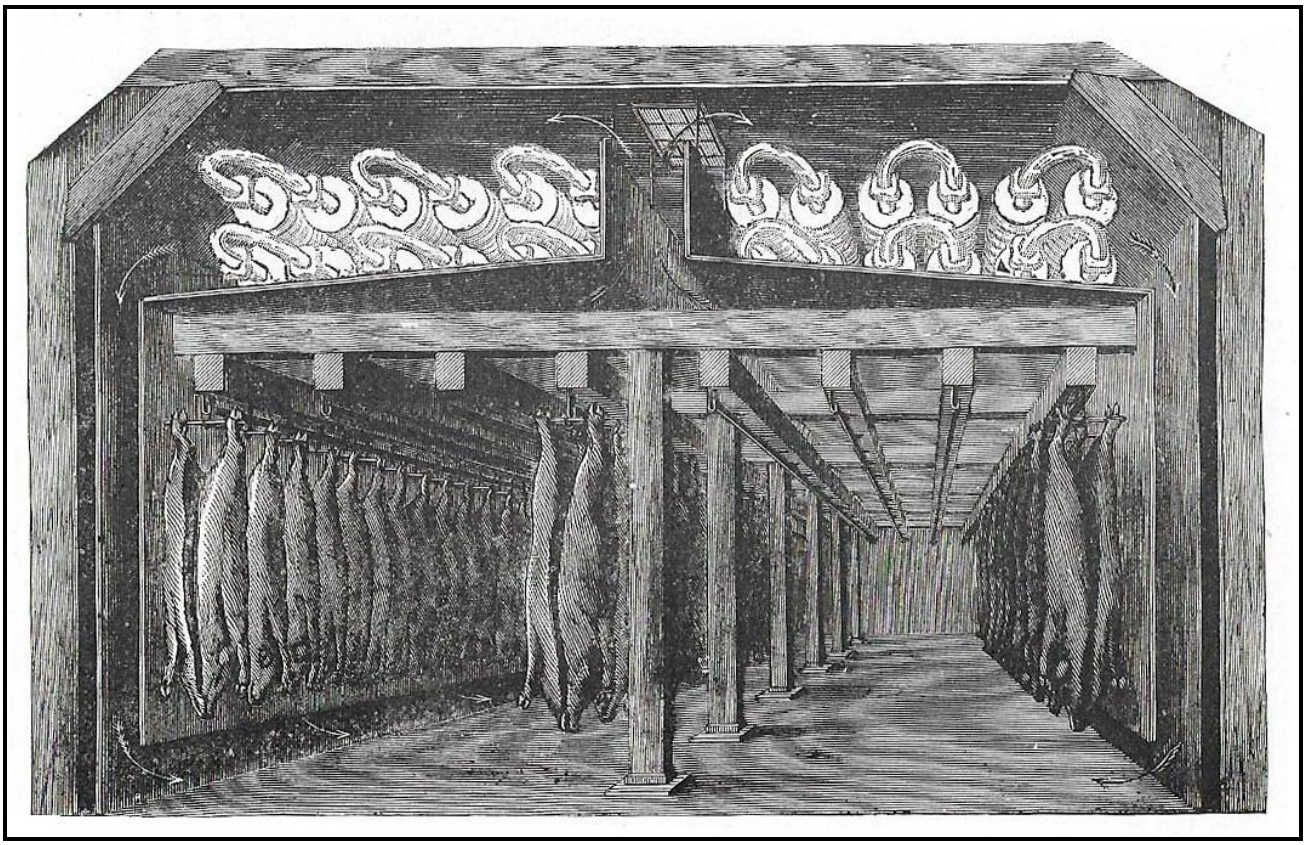
2.61. COLD STORES

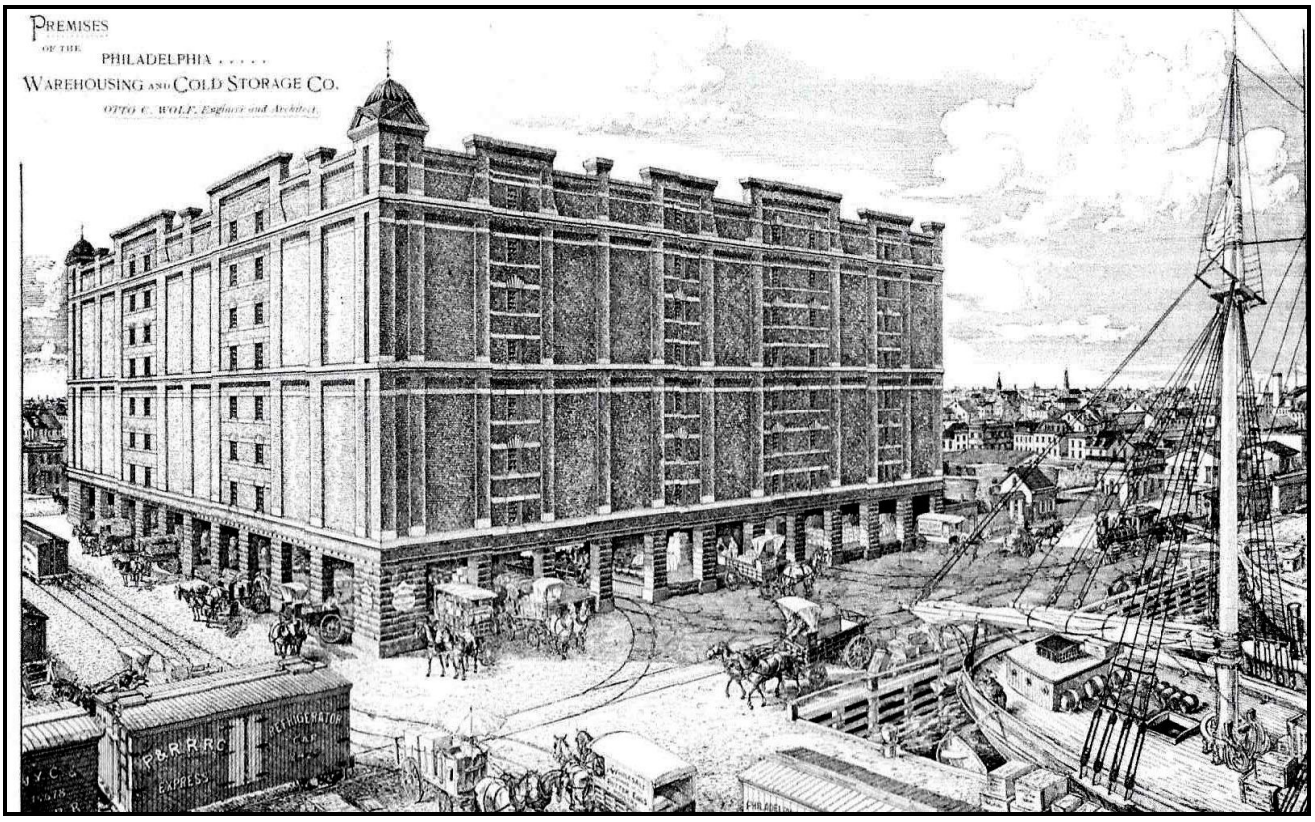
2.611. **In the United States**

Before 1880, a few public cold stores, cooled by natural ice with the addition of salt, were built in the United States. The first seems to have been built in Fulton Market, New York, in 1865, especially for poultry and game. Others were constructed in 1878, notably in Chicago, in which brine circulation in pipes and forced air movement by fans, were used. The first American store which was intended from the start to be mechanically refrigerated was built in Boston in 1881. Others followed in East Saint Louis, Illinois (1882), Baltimore (1886) and Chicago (1889). But natural ice was still used, and in 1890 a large cold store for freezing and storing fish, of 8000 t, was cooled by natural ice mixed with salt. In 1893, a 5 storey store was constructed in Milwaukee, of 10 000 m^3, again cooled by natural ice and salt; this was converted to mechanical refrigeration in 1900. One of the first stores in New York was supplied with natural ice by trains of up to 50 wagons! Madison Cooper estimated that in 1902 the stores cooled by natural or manufactured ice far exceeded those cooled directly by mechanical refrigeration. However, the latter rapidly took over. In 1891 an 8 storey store of 30 000 m^3 was erected in Philadelphia, and in 1894-95 one was built in Quincy Market, Boston, which at first had 1.5 M kcal/h of refrigerating machinery. This was later increased and it was to remain the largest cold store in the world (about 250 000 m^3 in 1907-1908, with 6 M kcal/h). In 1916 the Quincy Market Cold Storage Company had 420 000 m^3 of cold storage space in Boston. At the time this giant complex was celebrated. In 1902, the Merchants' store in Jersey City, which had just been enlarged, had a capacity of 210 000 m^3, and in 1911 this company had a total of 310 000 m^3. On the same date the Western Cold Storage of Chicago had 300 000 m^3.

In 1891, the American Warehousemen Association was set up in Chicago. Around 1900, in the United States, the most profitable goods stored were, in order, eggs, butter, Cheddar cheese and apples.

The capacity of American public cold stores rapidly increased; in 1904, 600 stores had a capacity of 2.9 Mm^3 (at this date the total cold storage space was 5.8 Mm^3); in 1914, 900 public stores had 5.7 Mm^3, and in 1916, 1000 stores had 7 Mm^3.

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