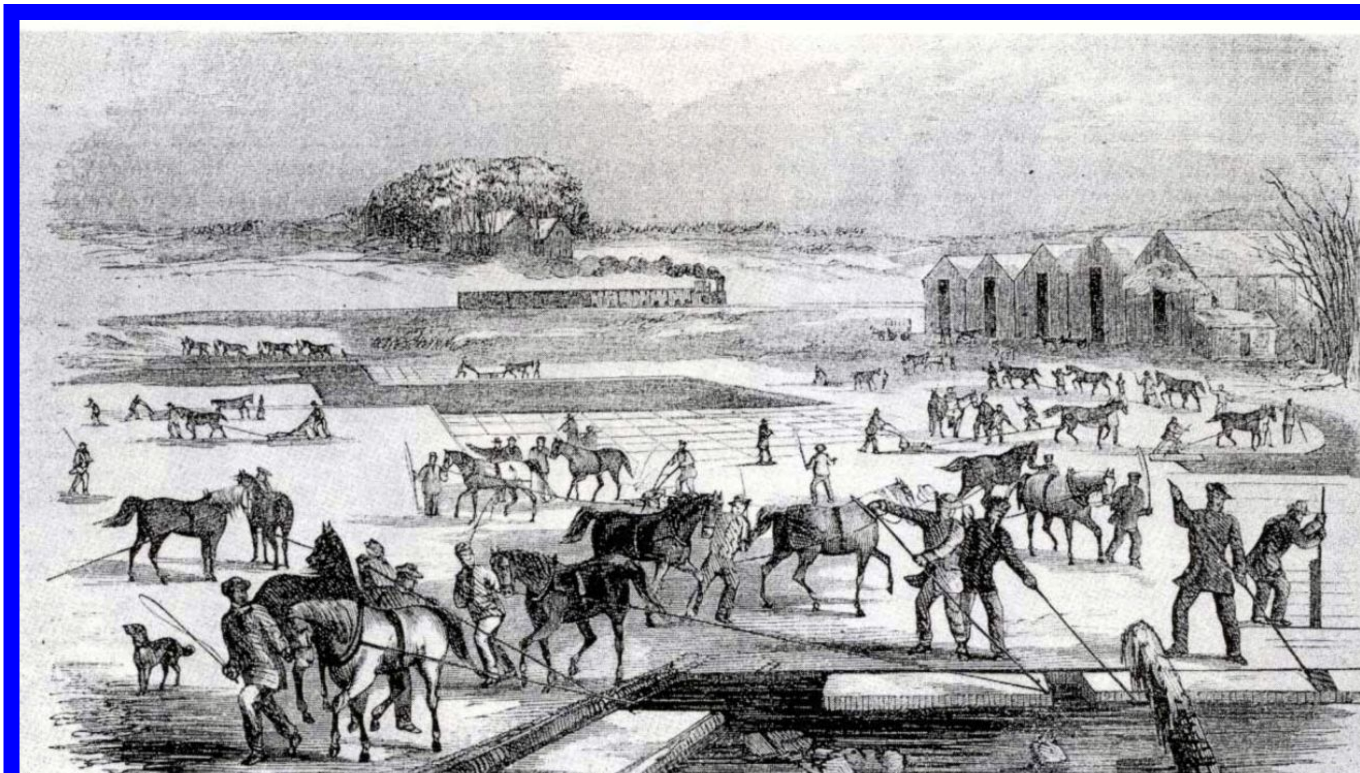
Refrigeration in American Breweries 1860-1920

Natural Ice Harvesting



Starting with *A REVIEW OF THE PRESENT STATUS OF BREWERY REFRIGERATION*
Peter Neff, The American Society of Refrigerating Engineers, December 1915

PRESENT STATUS OF BREWERY REFRIGERATION*

By Peter Neff, Canton, Ohio

It is apparent to all that but little attention at this time is being given by our engineers to the refrigeration of breweries.

The reason is obvious—there is not much new work being done. The industry is still a very large one, however, and refrigeration plays an important part in it.

Practically all existing breweries have refrigerating equipment in excess of actual requirements, and many of them operate at a higher cost than necessary.

The industry is in the position that, while it does not demand enlarged equipment, it is seeking to accomplish what is required with less operating expense and better conditions; here is our field of endeavor.

Lack of sufficient insulation is a common source of loss: Where rooms have to be rebuilt it is now usually practicable to install some modern type of insulation; even if no more than 3 inches of good insulation is used a very large saving will be effected. The insulation of exposed cold pipes will also help greatly. Where one machine can be made to do the work now done by two, the gains come fast.

I have in mind a brewery where two machines were constantly operated. During the month of June a shaft broke in one of these machines. The brewmaster was much worried, as it would require several weeks to install a new one. This occurrence gave them the cheapest lesson that they could have learned, for all that was necessary was a little more attention on the part of the engineer to successfully handle the work with one machine running full capacity, in place of the two machines running haphazard, as was formerly the case. We had tried to impress this fact upon them prior to the accident.

In many plants machines and other equipment have been added without giving proper attention to the connections. The loss of the liquid seal in receivers, with its consequent loss of plant efficiency, is as prevalent here as in other industries. Ancient customs and loose habits of operation are to be encountered. This can be changed only by the slow process of education.

The subject of refrigeration for the attemperators must be treated in accordance with the individual ideas of the brewmaster, which differ. Some use a small attemperator requiring a low temperature and a rather high velocity of the circulating medium, while others accomplish the same result with higher temperature by the use of large attemperator coils. As a rule, you cannot change the custom, but you can alter the method employed to cool the circulating medium.

In a certain plant a large refrigerating machine had at times to be continuously operated to do a small amount of work in cooling brine for the attemperators. As this was being done in a small tank with practically no insulation, it may be readily imagined what the installation of a large well-insulated brine tank did for this plant.

Incidentally, exposed steam pipes and steam pumps are frequently to be found in refrigerated rooms. No one seems to be responsible for such things; they have always been there, and it therefore appears all right. There are also many opportunities for the improvement of the power equipment whereby savings may be effected.

By far the most interesting field for our work is in the fermenting room, where the problem of ventilation must be met. Gases produced by the fermentation must be gotten rid of. The usual method employed for this is to provide openings in the wall near the floor, through which a large amount of cold air continually passes, carrying the gases with it. An equivalent amount of outside air comes into the room at the same time, generally through an opening in the ceiling. In the summer this outside air is frequently ladened with moisture, which causes the ceiling to drip, mould to grow, and makes trouble for the brewer in many ways. Thousands of dollars have been expended on this problem with varying degrees of success. In one instance where the condition was exceptionally bad, a firm of brewery architects advised the raising of the ceiling some 8 or 10 feet, which involved an expenditure of approximately $10,000 without in any way overcoming the difficulty. An expenditure of less than $1,200 finally accomplished the desired result. Another method for removing the gases is to use an exhaust fan. This method increases the amount of moisture-ladened air introduced, with consequent disagreeable results.

A few years ago Mr. Starr mentioned the use of indirect refrigeration in the brewery, and referred to some work done by Mr. Livezey. Upon examination, I found this method a good one, and, with certain modifications, have employed it in several instances. The fact that temperatures below 32 degrees are not required makes possible the use of a bunker room without defrosting loss.

By effectually closing all openings in the fermenting room and, at the same time, providing for a continuous supply of fresh air, refrigeration and ventilation will be accomplished economically, and as a result the fermenting room will be so dry that painting can be carried on in it at any time.

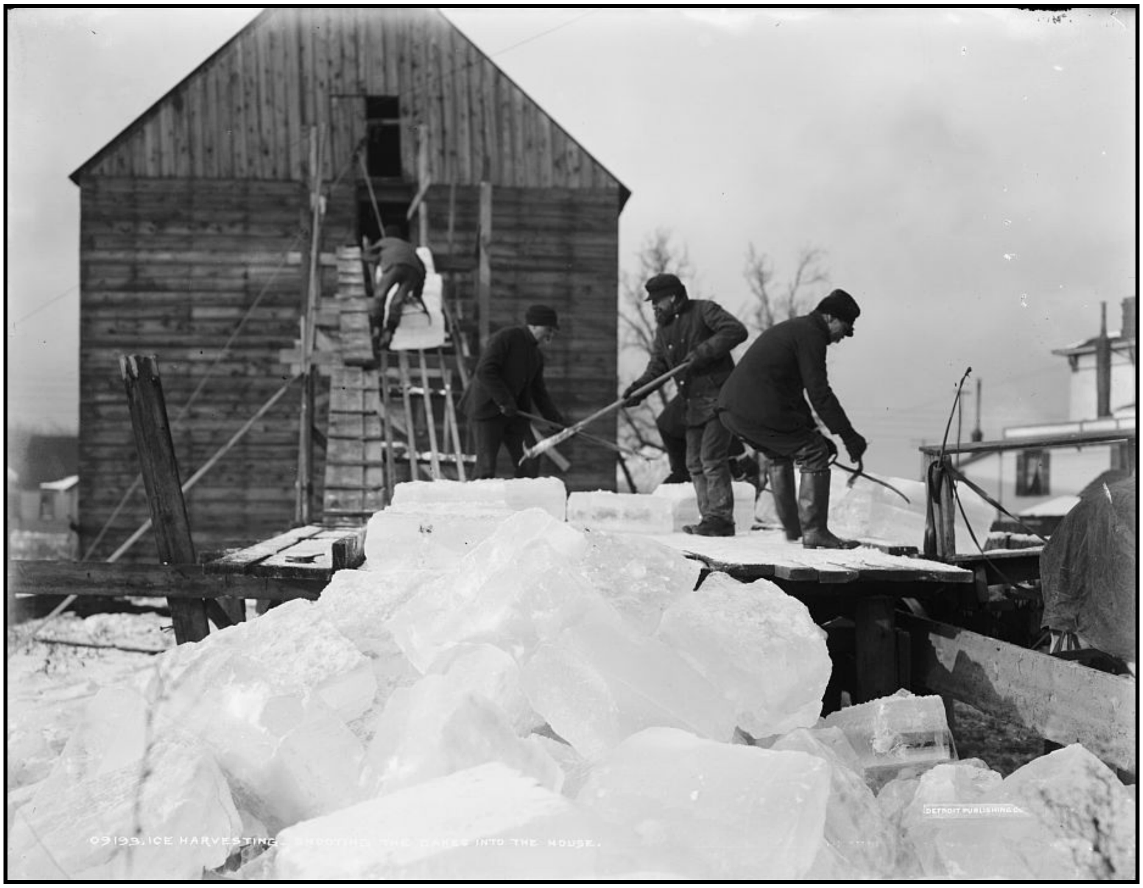
Where other rooms are handled on the same circuit, as, for example, a shipping or racking room, sufficient fresh air can usually be obtained, while in the case where the fermenting room is to be handled alone openings with dampers may have to be installed.

Several things have to be considered in such installations, openings, such as stairways leading to floors below, are not desirable, as they permit the gases to settle in the lower rooms, for it is a well-known fact that such openings cannot be kept tightly closed. Then, too, the air circulation must not be such as to disturb the layer of gas on the top of the fermenting beer in open tubs. The results accomplished by this method, in addition to producing a sweet and dry fermenting room, are that less pipe surface will be required for the refrigeration of the room, owing to the rapid circulation of the air over the pipes; that these pipes may be kept free from a large accumulation of ice; that a saving in refrigeration losses may be effected by having regulated openings for ventilation, and that defrosting may be carried out without loss of efficiency. In fact, it frequently happens that for nights and Sundays sufficient refrigeration may be had from the ice accumulated on the pipes, and the necessity of operating the refrigerating machine continuously may be avoided. In one instance this system has been extended until it now practically takes care of the entire brewery.

It is impossible to lay down fixed rules for the amount of pipe, capacity of fan, size and arrangement of ducts, etc., as each installation offers different characteristics which must receive the careful attention of the engineer. In some instances the ordinary ventilating type of fan is all that is needed, while in others the larger type of blower must be installed. In figuring the ducts, the cost of installation and space available must be balanced against velocity and friction, entailing increased power consumption.

I find that brewery refrigeration is far from a dead issue. To-day offers a field for refrigerating engineering in which economies can be worked out that are a revelation to brewery owners.

Old prejudices and customs must be overcome with tact and perseverance which are just as important requisities as education and experience.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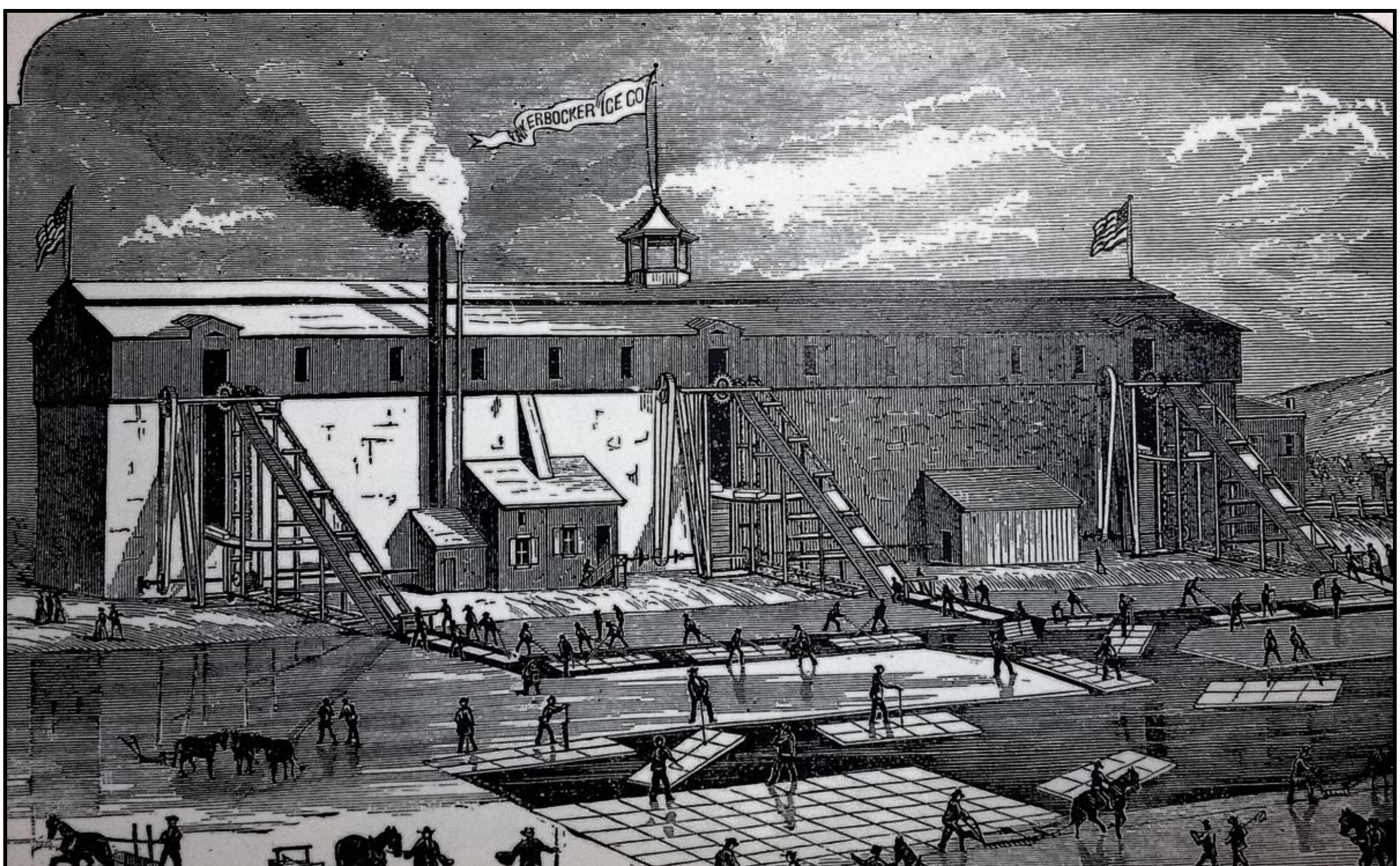
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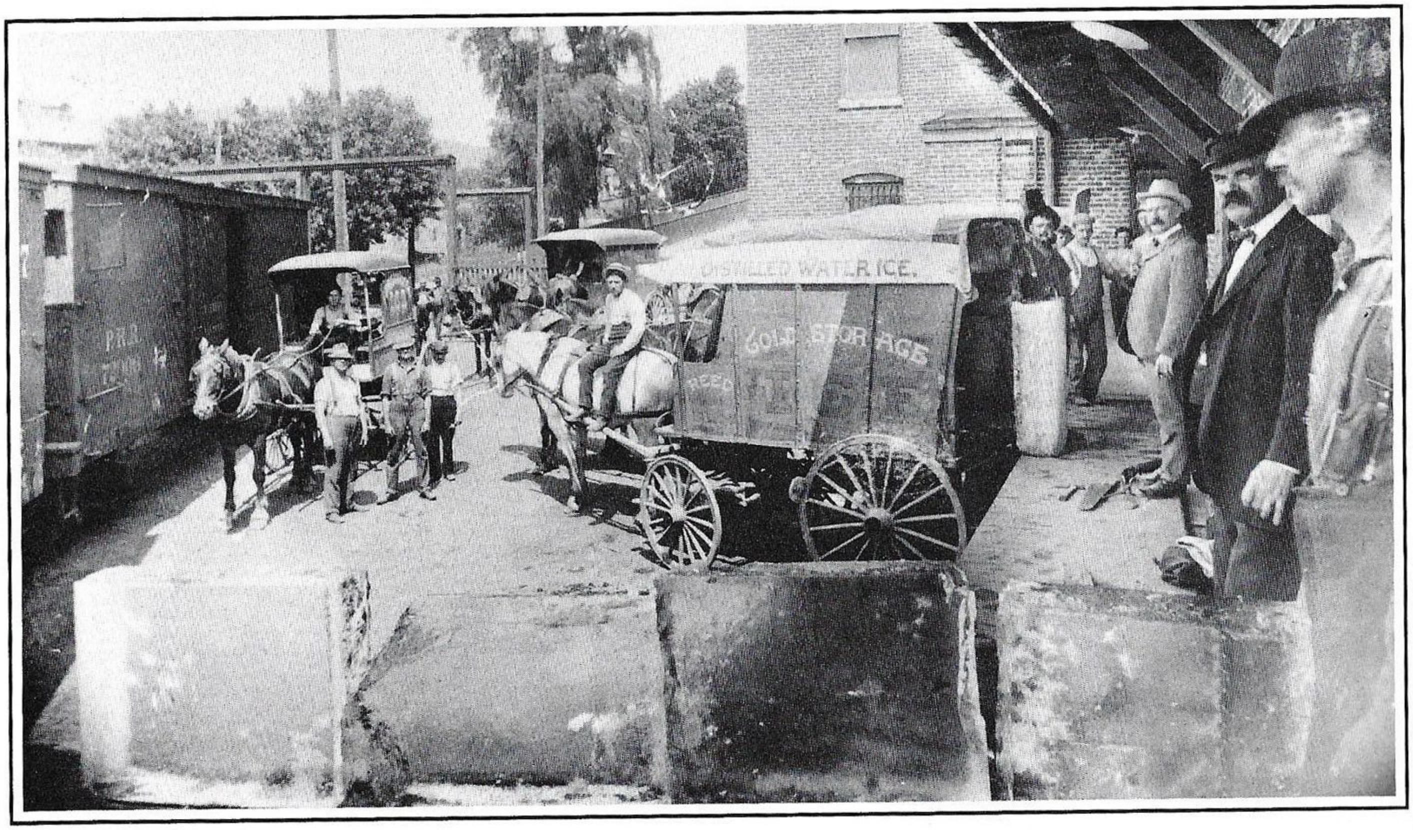


Figure 6-11 *Loading ice wagons at Keystone Cold Storage Co., Reading, Pennsylvania, in 1900 (from Ice and Refrigeration, August 1900, p. 45).*

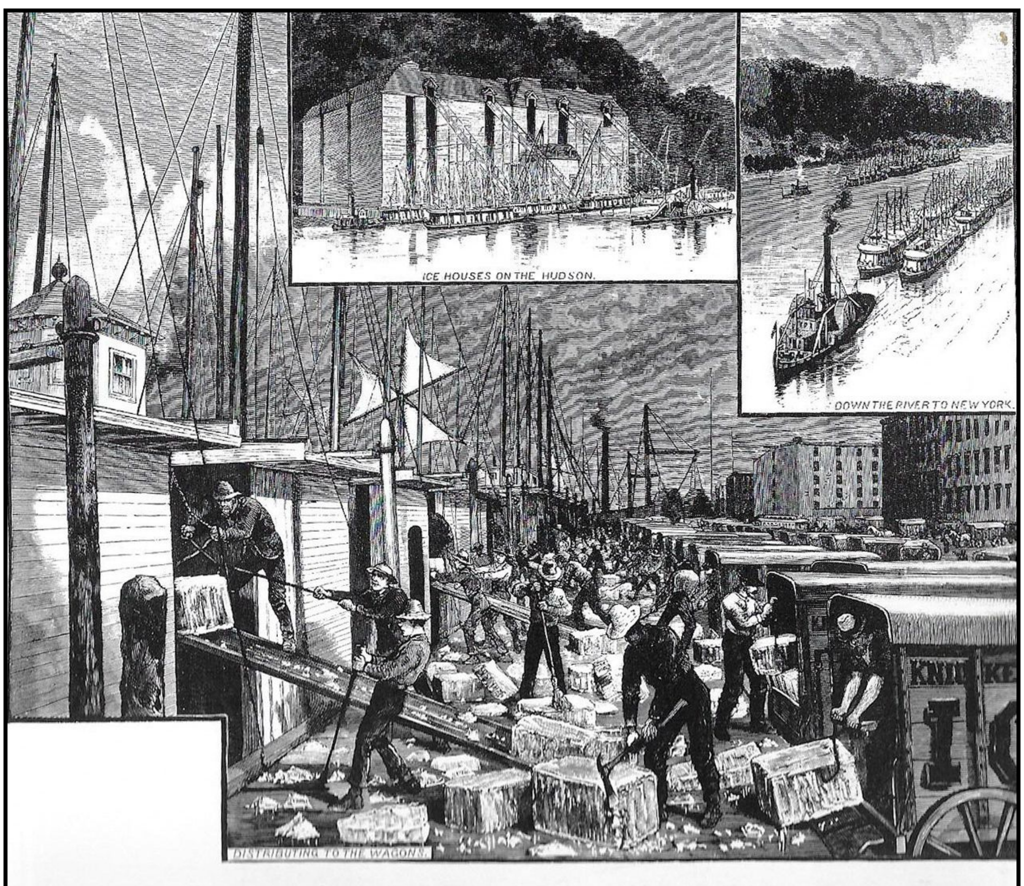


Figure 6-13 *Loading delivery wagons, 1880s (from Harper's Weekly, August 30, 1884, p. 562).*

Refrigeration in American Breweries 1860-1920

Natural Ice and the Brewing Industry

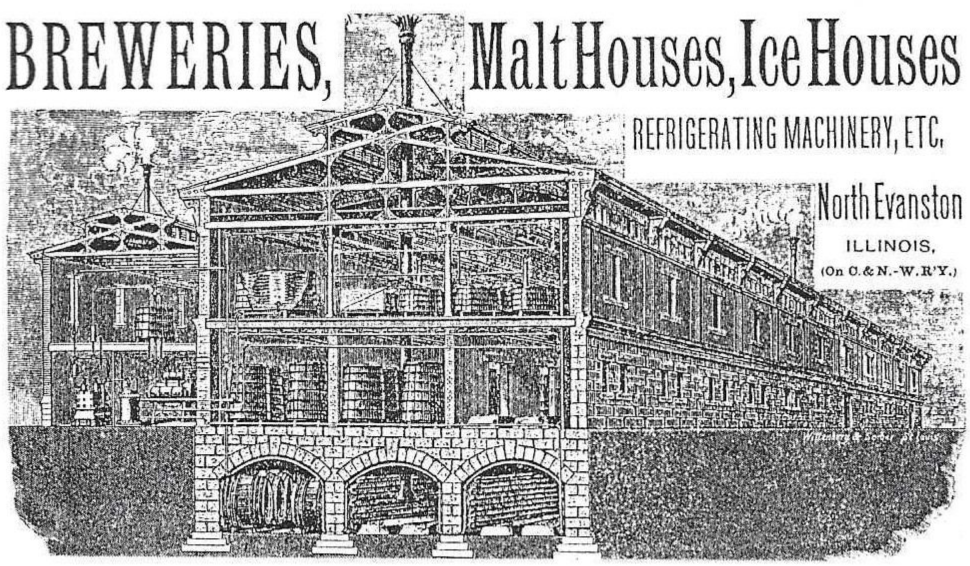


Figure 11. *Portion of an advertisement for Theodor Krausch, architect and engineer (Chicago), featuring his fully mechanical refrigerating system.* From *The Western Brewer* 10, 4 (April 1885):781.

From the article *ARTIFICIAL REFRIGERATION AND THE ARCHITECTURE OF 19th CENTURY AMERICAN BREWERIES* Susan E Appel, The Journal of the Society for Industrial Archeology, Vol. 16, Number 1, 1990

Artificial Refrigeration and the Architecture of 19th-Century American Breweries

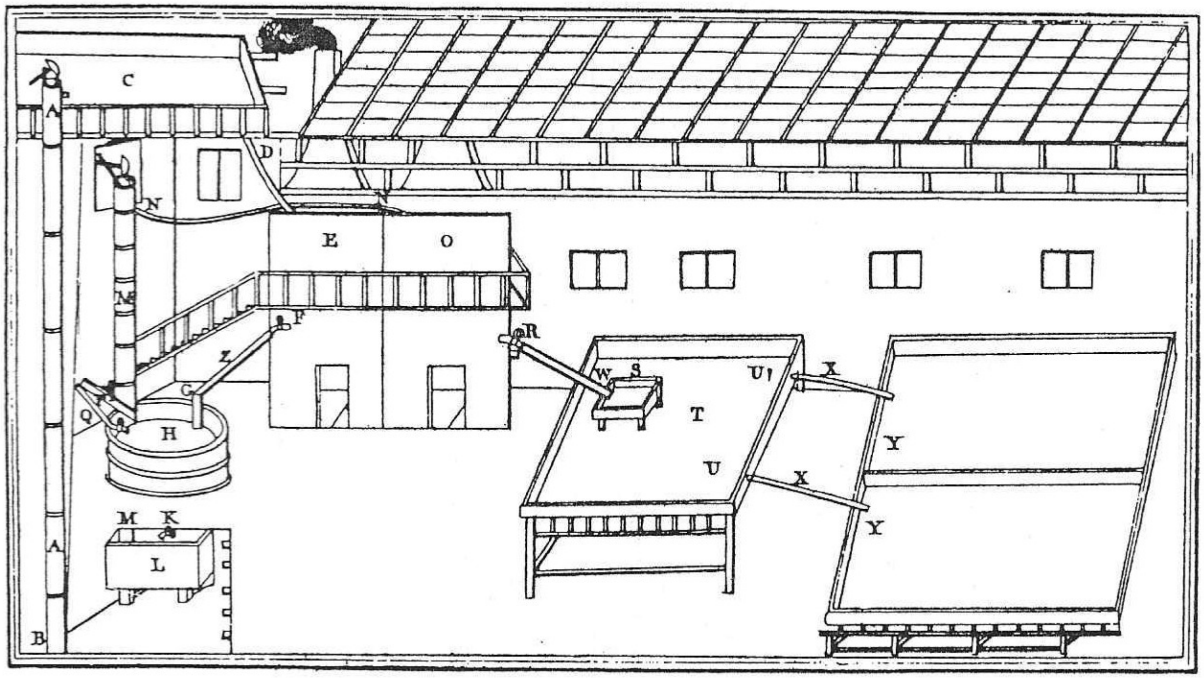
Susan K. Appel

In the 19th century, great changes occurred in American brewery architecture, stimulated in particular by the introduction of German lager beer. Lager's rising popularity, along with its special need for cool temperatures, led lager brewers to investigate and encourage important technological innovations, notably in artificial refrigeration. The refrigerated brewery passed through three distinct phases of development: the first was dependent on natural cooling in underground cellars, the second used natural ice in aboveground icehouses, and the third exploited fully developed artificial refrigeration in mechanically cooled aboveground stock houses. Each phase brought new architectural elements into the American brewery. As breweries became more complex, architects and engineers began to specialize in brewery design; they became vital components in the technological and architectural transformation of the 19th-century American brewery.

The United States brewing industry increased spectacularly in size and importance during the 19th century. At the beginning of that period, the average commercial brewery was a small enterprise, producing perhaps 1,300 barrels[1] of English-style ale and beer per year. By the end of the century, the average brewery had shifted to German-style lager beer and increased annual production to over 22,000 barrels;[2] several of the largest breweries were producing over one million barrels per year by 1900.[3] Underlying the meteoric rise of brewing was the fact that the taste for lager beer had spread from the huge numbers of German immigrants who first provided a market for it to the general population,[4] encouraging the founding of many breweries and the tremendous growth of the leading firms. Quite naturally, the buildings required by the increased production grew and changed substantially over this century, but the nature of these changes depended particularly on the fact that most breweries came to be lager breweries.

An early-19th-century American brewhouse was likely to be no more than two stories in height, perhaps with a louvered cupola for ventilation. Such buildings were constructed with traditional materials and techniques[5] and housed hand-operated equipment arranged to facilitate a partially gravitational flow of the developing product. A typical layout is preserved in an 1813 illustration (figure 1), which shows that the limited height of the buildings encouraged the process to spread out more horizontally than would be typical later in the century. As depicted from left to right in figure 1, the process began with more vertical and mechanical movements of raw materials. Initially, water was pumped to a reservoir on the highest level of the brewhouse, then ran downward into a copper for boiling, then down again into the mash tun, where it would be mixed with malt to become mash. Grains were strained from the mash as it drained into the underback, then pumps were again used to lift the mash up into the brew kettle for boiling into wort. Beyond that point, the equipment tended to be organized gravitationally and horizontally, especially requiring space for cooling the wort in large, shallow open pans. Once the wort was cool enough not to kill yeast, it flowed below to large vats, where yeast was added and fermentation took place; then the beer was stored in cool underground caverns.[6]

By contrast, the most advanced brewhouses of the later 19th century were not only larger, but also much more vertical in their general arrangement (figure 2). Their new forms revealed the impact on industrial architecture of new building techniques, especially the use of metal framing systems; these were relatively light, but strong enough to support several levels of heavy equipment and their liquid contents, now placed one above another. In such a structure the preparation of wort in much larger batches proceeded step-by-step, the raw materials being processed as they flowed downward by gravity from the top to the bottom of a four- to six-story building. An increasing amount of the work was performed by steam-powered machines. After the Civil War the whole attitude toward brewing beer gradually became more scientific and concerned with precision engineering of both the product and the equipment used to produce it. This attitude extended to the buildings in which the various stages of brewing came to take place, and it changed their forms. For example, the brewhouse in figure 2 was not only much taller and more vertically proportioned than that in figure 1, but also no longer contained large, horizontal cool-



VIEW OF INTERIOR OF BREW-HOUSE, 1813.

AA — Cold liquor pumps. B — Well. MM — Wort pumps. P — Mill spout. H — Mash tubs. C — Cistern or reservoir. D — Water outlet into copper. E — Liquor copper. F — Outlet of the copper. Z — Inlet into copper, conducting liquor to bottom of mash tub between bottom and false bottom. R — Wort cock. L — Underback. O — Wort copper. NN — Inlet to wort copper. A — Cold water inlet for mashing. T and Y — Hop bearer and coolers. RW — Copper outlet for wort. S — Hop drainer. U — Plugs. Below the cooler are the fermenting tubs, below which are the casks for filling.

Figure 1. *The interior of a brewhouse, in* The Domestic Encyclopedia, *published in Philadelphia, 1813.* From *One Hundred Years of Brewing* (Chicago: H. S. Richard Company, 1903), p. 77.

ing pans; the cooling of wort had been mechanized and transferred to the top of the adjacent stock house, which itself was a new kind of building in the brewery, reflecting considerable changes in practice. The late-19th-century brewery became an increasingly specialized complex of buildings, each designed or remodeled to accommodate particular functions that were more clearly thought out than in brewing's earlier history.

Many factors in addition to increased production levels contributed to the re-shaping of brewery architecture. Among the most influential of the technological innovations was the development of artificial refrigeration. The impact of artificial refrigeration on American brewery architecture was directly linked to the introduction of bottom-fermented lager beer by German immigrant brewers in the 1840s.[7] Making this lighter, more effervescent, less alcoholic beer[8] required lager brewers to be more concerned with the issue of refrigeration than had been necessary earlier, when English top-fermentation methods dominated. Lager needed to be cooled after cooking and before and during fermentation, as did English beers, but the German brew also needed an extended period of rest ("lagering") in a cool place before being drunk.[9] Too much heat could make the beer acidic or cloudy and could limit its keeping quality.[10]

For these reasons, then, providing properly cooled storage facilities was understandably important to lager brewers from the beginning; but it posed additional problems as lager's popularity increased. By the 1860s, thanks in large part to the market created by vast numbers of German immigrants, lager had begun to surpass English beers and would soon dominate the American brewing industry.[11] Greater demand meant that still more beer had to be produced and stored in cool places. Solving this problem was especially crucial for lager brewers,[12] and it took them and their breweries through three distinct stages of refrigeration development in the 19th century.

In the first of these stages, lager brewers relied on underground caves or vaults and natural cooling. Later, more to carefully regulate fermentation and storage environments, brewers developed ice chambers and icehouses stocked with natural ice. Finally, with the arrival of reliable mechanical refrigeration equipment, breweries grew larger and acquired such new architectural elements as the aboveground stock

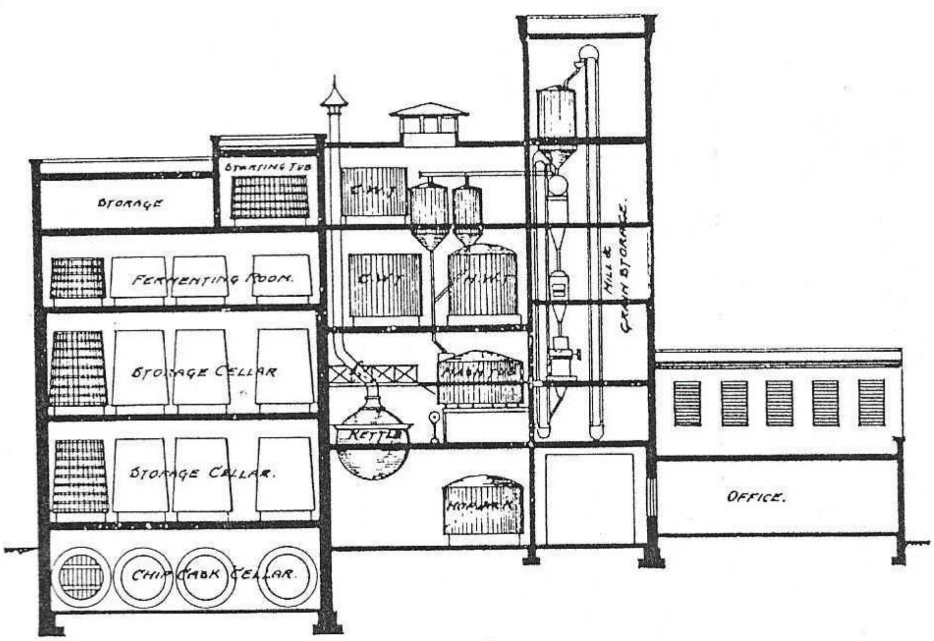


Figure 2. *Section drawing of a typical brewery c1900, with (left to right) stock house, brewhouse, mill house, and office.* From *The Western Brewer* 29, 10 (October 1904):456.

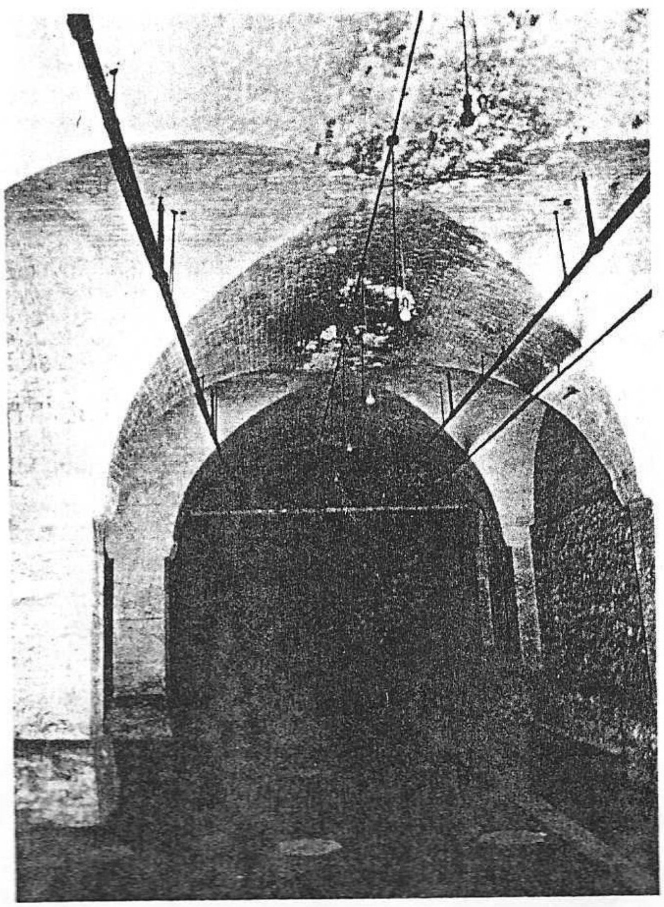


Figure 3. *Looking west into a portion of the groin-vaulted second basement below the former William J. Lemp Brewing Co. (now Interco, Inc.), St. Louis.* Photograph by the author, 1989.

house and the refrigerating machine house. Describing the characteristics of each of these stages of development and how each affected the architecture of the brewery is the primary focus of this article.

Cooling in Underground Cellars

The first steps toward artificial refrigeration coincided with the beginnings of lager brewing in this country. From the introduction of lager in the 1840s to its great increase in popularity during the 1860s, lager brewers fermented and stored their beer in underground cellars. These were either natural caves or man-made vaults dug out of rock, or a combination of the two. They were deep enough to have temperatures sufficiently low and uniform to allow lager fermentation to take place for at least part of the year.[13] To keep cold air stored during the winter as long as possible, the cellars were often divided into sections to prevent warming in still-filled sections as other areas were emptied of their casks.[14] Under these circumstances, the breweries with the best and most extensive cellars became the most famous,[15] and the underground caverns became as interesting visually as the rather modest breweries aboveground (figure 3).

While it is impossible to say with certainty where, when, or by whom the first lager in America was made, chances are good that the earliest was produced in Philadelphia in 1840 by the German immigrant John Wagner, who probably used it for private consumption among friends.[16] While the first American lager brewing on a commercial basis is often identified with Philadelphia, it seems likely that it began in the Midwest as early or earlier. Perhaps the earliest commercial lager brewery in Philadelphia was begun in 1844 by Charles Engel in partnership with Charles C. Wolf;[17] they completed the first underground storage vaults for lager in that area in 1845.[18] However, Adam Lemp, also a German-born brewer, probably began brewing lager in St. Louis in 1842.[19] Concurrent with the Philadelphia firm, Lemp in 1845 began excavating extensive lager cellars based in a natural cave just south of the city limits. This cave was described in 1845 as about 100 yards long, divided into three compartments with an average width of 20 feet, the whole roofed with finely built vaulted ceilings.[20] At first, Lemp's beer was manufactured in his small brewery in town, then carted to the cave for lagering. In the mid-1850s, however, Lemp began acquiring property in the vicinity of the cave, and from the 1860s on, in the hands of Adam Lemp's son, the brewery that rose there grew continuously; the William J. Lemp Brewing Company was the largest in St. Louis until the 1880s, when the Anheuser-Busch Brewing Association finally surpassed it.[21]

In the hilly Mohawk section of Cincinnati, too, brewers dug large cellars during the 1850s. One set consisted of two huge tunnels, each 35 feet wide and 200 feet long, burrowed into the hillside, with masonry arched walls three feet thick encompassing 14,000 square feet of floor space.[22] Not far away, but under flat land adjacent to the Miami and Erie Canal, Cincinnati's Windisch & Muhlhauser & Bro. (later the Windisch-Muhlhauser Brewing Company) dug large cellars in the 1860s (figure 4) and more in the early 1880s. By 1883 this company had 20 cellars and subcellars, 12 of them 18 by 150 feet and eight of them 18 by 80 feet.[23]

Early American lager breweries were thus built both above and below ground and might well be more extensive beneath the surface. The cellars might be arranged horizontally or dug underneath one another. Regardless, they were patterned after those used earlier in Germany; and in America, as in the old country, they were only partly successful.[24] In places like St. Louis and Cincinnati, the heat of summer sometimes made even the deepest tunnels too warm for lager.[25] The problem of excessive heat tended to encourage lager brewers to continue the time-honored practice of brewing only during the cooler months of the year.[26] However, the growing demand for more lager strained the capacities of the underground vaults and pushed brewers to consider longer brewing seasons. In response, brewers began accumulating ice during the winter, storing it to counteract the hot season,[27] and stimulating the development of new kinds of buildings to handle the ice. Although underground vaults continued to be constructed in some places for many years, they were gradually superseded in importance as refrigeration in brewing moved into its next stage of development.

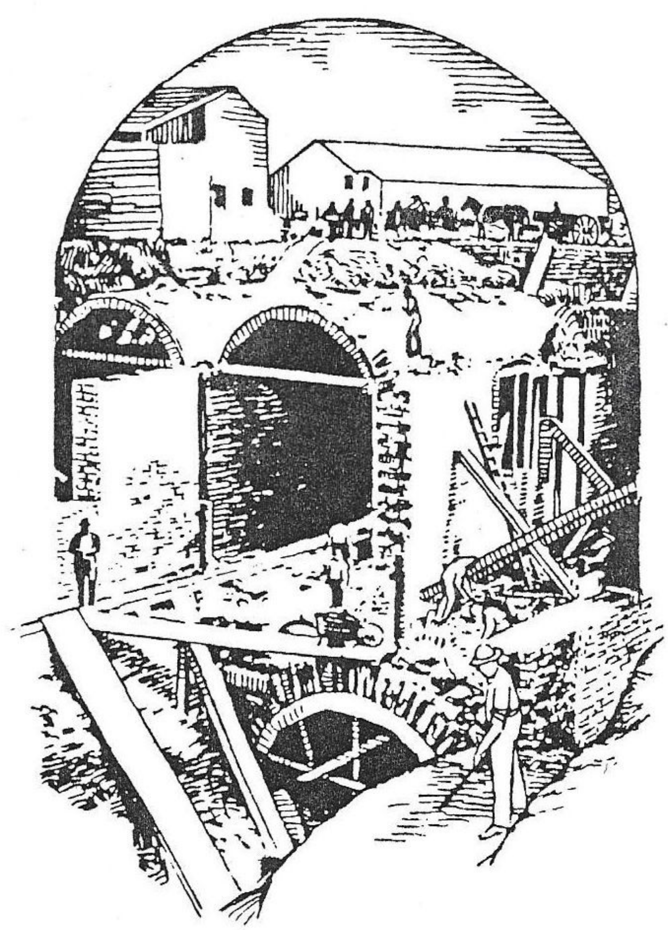


Figure 4. *Constructing underground cellars at the Windisch-Muhlhauser Brewing Company, Cincinnati, c1866*. From "Cincinnati & the Lion," 1933 pamphlet, n.p.

The Aboveground Icehouse

Brewery refrigeration's second stage dates especially to the 1860s and 1870s and is marked, architecturally, by the emergence of the brewery icehouse, filled with natural ice and used to cool a new arrangement of fermentation and storage rooms.[28] This changeover was gradual and never complete.[29] It began with brewers trying to improve cooling by storing ice in underground cellars or vaults near their beer.[30] This led to the introduction of ice rooms[31] and, finally, to aboveground icehouses (figure 5) wherever large

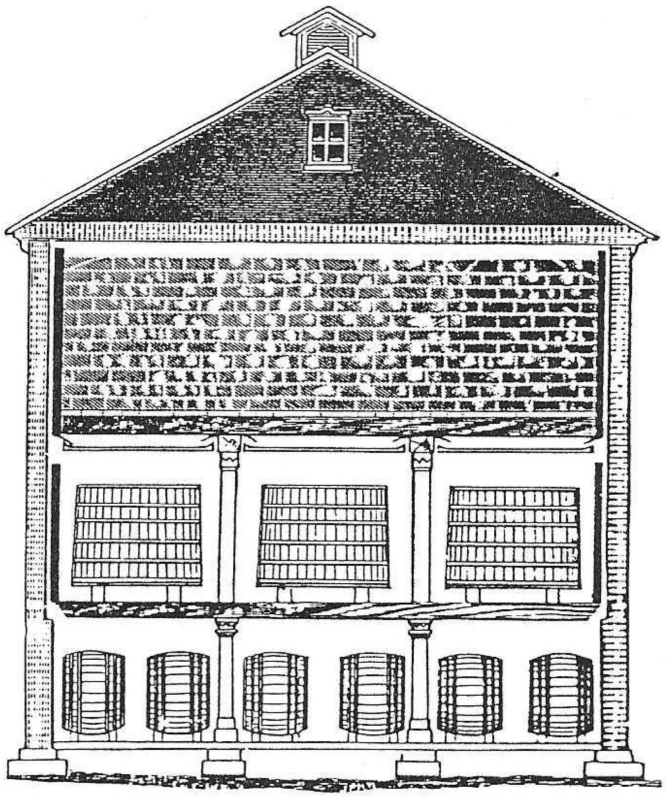


Figure 5. *Section drawing of aboveground icehouse.* From *One Hundred Years of Brewing*, p. 146.

enough supplies of ice were available to maintain the low temperatures desired for fermentation and lagering.[32] In this sequence of events, J. E. Siebel, a noted late-19th-century brewery scientist, saw a "series of improvements, which, while apparently accidental, were in fact but the result of a plainly expressed tendency,"[33] the tendency to develop and use artificial refrigeration on a large scale. Siebel felt that the manufacture of lager beers was a primary stimulus to the development of refrigeration, since lager brewing constituted "the first industry which required artificial refrigeration on an industrial scale."[34] He held up American brewers as models of this development and praised their activities for greatly changing the nature of the brewing industry and greatly improving the quality and popularity of lager beer.[35]

By the 1870s American breweries were almost universally refrigerated using natural ice.[36] This was made possible by the existence in many parts of the United States of a reasonable supply of ice during a long winter and a strong ice trade that had flourished since the late 18th century.[37] It was also made possible by the development of improved icehouse construction, stimulated by the brewers' use of massive quantities of ice.

Icehouses had existed for private and commercial use for a very long time,[38] but brewers' special needs now helped bring forth any number of different schemes for perfecting an industrial-strength brewery icehouse. At first, an ice chamber was placed above each separate (and usually underground) fermentation and storage room.[39] Over time, though, the brewery icehouse became a separate architectural entity, organized as a series of distinct "cellars," now stacked vertically above ground level, the whole surmounted by a very large ice chamber (figure 5). This arrangement functioned on a fairly simple principle: from the ice mass above, air shafts carried cold air downward naturally, while warmed air was allowed to rise up and out of the icehouse.[40] This type of building allowed a more certain form of cooling, somewhat less subject to the vagaries of weather than underground vaults. However, the ice chamber above might be 20 feet high, and when filled to the top, could represent a weight of perhaps 1,150 pounds per square foot, necessitating extremely heavy construction.[41] There often had to be as much space in the brewery devoted to ice storage as to beer storage,[42] so cooling by this means was not particularly inexpensive. Improving the basic arrangement of the icehouse was a natural field of exploration for the increasing number of architect-engineers associating themselves with brewery architecture in the 1870s.

Among those architect-engineers advertising their own patented icehouses in the 1870s were Charles Stoll in Brooklyn, New York,[43] and Theodor Krausch in New York City. Krausch advertised in 1877 that he was moving to Chicago,[44] a clear indication of the Midwest's increasing importance in the brewing industry. Anthony Pfund, also of New York City, likewise looked west, and in 1879 built a substantial icehouse for the Schaller & Gerke Eagle Brewery in Cincinnati.[45] Edmund Jungenfeld, who was fast becoming an exceptionally important brewery architect in St. Louis, was building numerous icehouses for St. Louis breweries in the late 1870s, acting as the local partner for Theodor Krausch & Company of Chicago.[46]

The first real improvement beyond the straight icehouse was the development of brewery refrigeration using a mixture of natural ice and salt. This combination had the advantage of maintaining a lower temperature than possible with ice alone (just above freezing), which cut down on bacteria, molds, and other substances harmful to beer and produced a better brew.[47]

The salt-and-ice idea was tried out in the 1882 remodeling of an older icehouse in Detroit. David W. Davis's patented "Non Plus Ultra Ice-House" (figure 6) was installed under the supervision of Detroit architect Julius Hess in the brewery of E. W. Voight.[48] Davis's plan divided into an upper and a lower chamber what had been a single 800-ton-capacity ice room atop two cellars. The new upper chamber became the ice receptacle, separated from a new fermentation room below by Gothic vaults of galvanized iron. The ice receptacle was filled with only 140 tons of ice, and in two months reportedly needed just 35 additional tons to keep it filled. Each day one barrel of salt was spread over the ice from above, the ice chamber then being kept as airtight as possible, except for flues allowing cold air to reach the cellars below. This system resulted in a steady temperature in the fermentation room of 34°F and 35 to 36°F in the two lower cellars.[49] It thus saved a great amount of ice, required little labor, provided better cooling, and, best of all, produced perfectly dry air, since all moisture froze on the metal receptacles overhead.[50]

In all these respects, Davis's icehouse suggested that "the days of the old fashioned ice houses [were] drawing to a close,"[51] and demonstrated that new ways could be devised to provide the refrigeration breweries needed. However, by the time of Davis's innovations, icehouse technology was already becoming outmoded, as the introduction of fully mechanical refrigeration began to create a whole new means of cooling in the brewery.[52]

Artificial Refrigeration and Brewery Architecture

Mechanical refrigeration began to be attractive despite the advantages of icehouses because ice was expensive and not always easy to acquire, and its cost could increase depending on the local climate, distance to the ice supply, and the weather.[53] Ice was also difficult to handle, especially in the quantities used by breweries, and required costly icehouses for storage.[54] In addition, under ordinary conditions it was hard to achieve low enough temperatures with natural ice to prevent irregular fermentation.[55] Finally, ice was messy, its use resulting in cellars that all too often were damp, dark, moldy, and bad-smelling, with water dripping from the ceilings, and floors wet and decaying.[56] As early as 1876, brewery architect Fred Baumann of Chicago conjectured correctly that the brewery of the future (and, as it turned out, the not very distant future) would use cold air, not ice, as the major coolant.[57] By the end of the century it had become almost impossible to consider refrigerating by natural ice, due to both its cost and inconvenience and in light of the much greater benefits offered by mechanical refrigeration.[58] Nevertheless, the icehouse made it possible

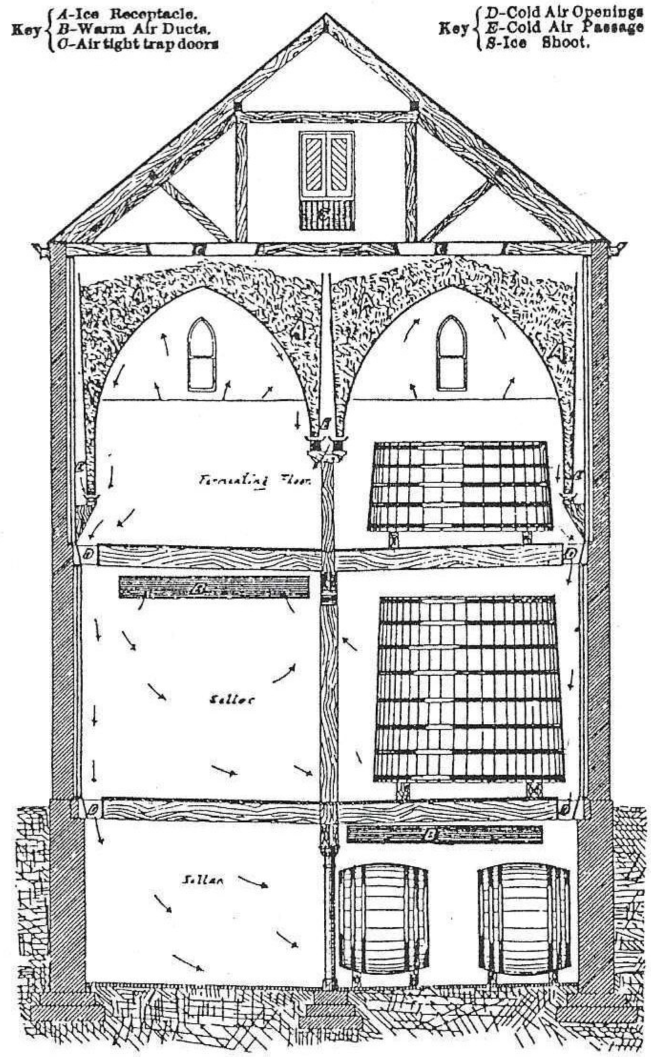


Figure 6. *David W. Davis "Non Plus Ultra" icehouse, erected in 1882 at the brewery of E. W. Voigt, Detroit, by Detroit architect Julius Hess.* From *The Western Brewer* 7, 4 (April 1882):546.

for brewers to brew all year round and in locations where it had not previously been possible at all.[59] Cooling with natural ice in such buildings also improved the quality of the beer, making it more uniform and healthy because of the more controlled fermenting conditions.[60] As a result, the icehouse served as an important stage in the development of artificial refrigeration.

The full development of artificial refrigeration in the brewery came with the introduction of mechanical refrigerating equipment. Such equipment was highly experimental in the 1860s and 1870s; only in the late 1870s and especially the 1880s was it sufficiently perfected to be reliable

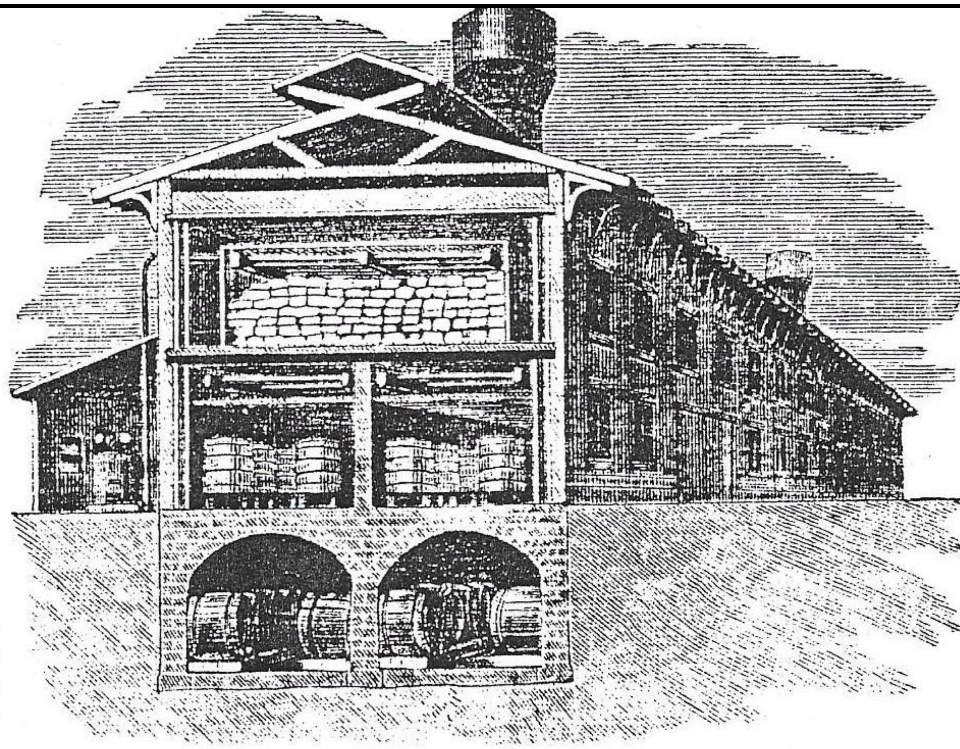


Figure 9. *Theodor Krausch's combination natural ice and mechanical refrigerating plant, c1877–78.* From *The Western Brewer* 22, 6 (June 1897):1050e.

NOTE: The remainder of the article deals with **Refrigeration and Brewery Architecture** and concludes with a list of 113 References.