Innovations in Salt Evaporation Technology: US Patents 1795 - 1845.

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This paper details early patents relating to the heating processes for salt production.

1. INTRODUCTION

The nineteenth century saw the rise, consolidation, and, in some areas, the decline of the salt industry in the United States. There are many ways to trace the rise of salt production: economic history, anthropological investigations, cultural changes, legal decrees, etc.

An area that is frequently overlooked, however, is that of the technological innovations as described in the patents of the United States PatentOffice. Prior to the formation of the Constitutional Convention and the formation of the United States, many of the individual states had recognized the need for patent protection if their fledgling industries were going to survive and prosper. The first patent in the colonies was granted by The General Court of Massachusetts to Samuel Winslow in 1641 for a method to extract salt from seawater (1).

With the formation of the country, it was decided that a national patent policy was essential, and therefore the Patent Office was founded in 1790 under the Patent Act of 1790(2). It issued its first patents for salt in 1794, 1796, and 1799. James Fennel from Pennsylvania was issued a patent on 24 September 1794 for making salt from seawater (3). Between 1790 and 1873 there were over 125 patents issued for improvements to the processes for manufacturing salt. In the first 50 years of the Patent Office 46 patents were issued for improvements to the salt manufacturing process.

Unfortunately, because of a disastrous fire in 1836, all of the early records and patent models have been lost. The record is far from complete, but several of the early salt patents have been reconstructed because they were reported in various papers and journals of the time or the inventor had earlier sought patents in the various states. This paper examines the improvements in the critical evaporative processes as described in the early patents.

2. METHODS OF BRINE EVAPORATION

2.1. Evaporative processes involving heat

Three systems were used in the US in the 19 century: the pan system long in use in Europe and the kettle system both of which initially used direct heating, and the grainer system the American contribution to salt making technology which used direct or indirect steam heating.

In the pan process a single large pan is placed over a furnace. The pan may be divided or not, but if it is, the back pan is saturated to remove the gypsum while the front pan is where the NaCl precipitates. As the salt is formed, it is skimmed off of the surface onto the adjacent drain boards.

The kettle process consists of a series of kettles inset on arches in a furnace. The number of kettles can reach over 40, so a system of arches is needed to protect the first few pans from too high a heat. Each kettle is treated individually for the removal of the gypsum, and the salt is not of a uniform quality. This system is both labor and fuel intensive.

The grainer system involved the prior heating of the brine to the saturation point for gypsum precipitation using steam pipes inserted into the cistern. The heated brine is then further heated by coils passing through the brine above the bottom of the grainers. The brine flows through the grainers precipitating the NaCl which is collected and drained on the caps (4).

2.2. Fuel drives the need for better evaporation

Historically, brine evaporation occurred by two major methods - solar evaporation or by artificial heating. Throughout the history of salt making, there has been a constant search for ways to make the latter technique more efficient and less costly. Fuel has always been one of the major costs of salt production, and the scarcity of fuel and its costs have

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often contributed to the abandonment or limitation to salt production, including in the United States.

As an example of the importance of fuel to salt making, the brine in Warsaw, New York in 1885 contained 25% salt and required 28 pounds (12.7 kg) of coal to produce one bushel of salt; while in Saginaw, Michigan, with brine at 17.5% salt, 44 pounds (20 kg) of coal were required per bushel; and in Pomeroy, Ohio 112 pounds (50.8) of coal were required to produce one bushel of salt from 7.5% brine (4).

This paper describes some of the major patents affecting each of the above evaporative processes as they apply to the early efforts to increase efficiency and quality and reduce manpower and fuel needs.

3. THE KETTLE PROCESS

Because many of the inland brine springs contained gypsum and had low salt levels, the kettle process was commonly used in the early stages of inland salt manufacturing. In addition, this process was favored because kettles were commonly used in home cooking, soap making, dyeing, etc. and the potash kettles were the largest around. Manufactured large pans were generally not available.

Indeed, the earliest kettle systems in Kanawha, West Virginia and Pittsburgh, Pennsylvania were small - six to eight kettles per furnace (5,6). However, as competition increased, it became necessary to increase the number of kettles, and thus the need arose to develop improvements that would reduce manpower and increase fuel efficiency.

One ingenious but simple idea was patented by Henry Smith in 1843. He replaced the side and intermediary masonry walls with metal cases held together with metal tubes which are also the grating upon which the fuel is placed. The tubes were situated so that the embers could fall through between the tubes thus heating the bottom of the tubes. The metallic cases were filled with fresh water, which was heated to produce steam which was then conveyed to the cistern to preheat the brine. The condensate was then returned to the vats so that it was reused and never completely cooled down. In the accompanying drawing (Figure 1) Fig.

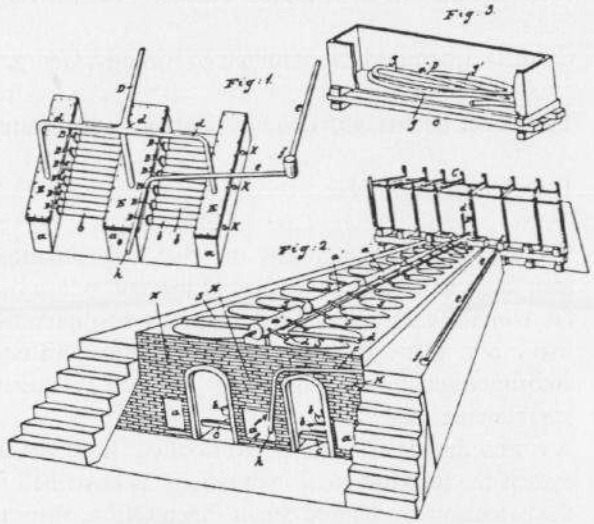

Figure 1. Kettle design of H. Smith (7).

1 is the metallic casing with b,b the grating tubes; E E E are the metallic casings filled with fresh water; Fig. 2 shows their emplacement in the block with d,d the pipe for transporting the steam for E E E to the cistern while a',a' is the pipe for withdrawing the heated brine in the cistern into the salt kettles. Fig. 3 is the heating coils for the cistern (7). A similar approach was also patented by Douglas later that year. It should be noted that these improvements in the construction of the block were all proposed after the introduction of the grainer

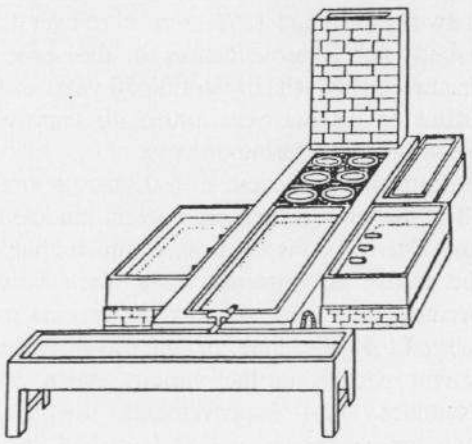

Figure 2. Parsons' Pan Process (11).

process in 1825 (see below) which showed how economical it was to preheat the brine by producing steam (8).

It should also be noted that such improvements were probably not entirely original with the American inventors. The concept of an iron grating for heating the brine had been proposed by W. W. Young in England in 1825 (9); while in the US, Guiteau had a "prior to 1825 patent" that involved improved heat transfer (see below), and Parsons (see below) obtained his patent for metal pipes in 1820. It is certain that salt manufacturing processes in Europe as well as those from other locations in the US were widely distributed because of publications such as the Franklin Journal.

As an adjunct to improvements in the kettle heating process, patents were sought and issued for improvements in the method to remove the bitterings from kettles and pan. Dear removed the brine and filled the kettles in the block with ley or fresh water and then dissolved kelp or potash in the kettles which is then heated to boiling and thereby softens the bitterings so they can be ladled out (10). This idea of adding something to aid in removal of the encrustations must have been a common practice, but at least one man had the foresight to obtain a patent on the technique.

4. THE PAN PROCESS

One of the earliest extant patents on the pan process was granted to Osborn Parsons on 4 April 1820. His improvement was to put metal tubes across the furnace and into the wooden cisterns on either side of the furnace with the goal of maintaining equal heating of the surface area in all of the pans Figure 2 (11). The source cistern could be turned on at the stopcock and because everything is at the same height, the water level would stay the same in all three units: the source cistern, the pan, and the troughs on either side. Parson claimed that this improved the efficiency of the fuel and the quality of the salt.

By 1824, Colquhoun had received a patent for a preheating of the brine in cisterns which would help to precipitate the iron that colored much of the salt from inland salt works (12).

The first major improvement in design of the evaporation pans was proposed by Blocksom and Fracker, Figure 3 (13). Their claim was that having the bottom and sides elliptical allowed for expansion and contraction of the metal without cracking. That this was indeed an improvement is noted by the fac that when Reynolds patented his improved furnace and pan design in 1838, he used convex (elliptical) pans (14). A similar design was developed by Griffin and Avery (1843) except that the bottom was movable and therefore could be replaced when needed (15), a design used in Michigan in the latter part of the nineteenth century (4).

Gradually, the improvements in the kettle process and the pan process were interchanged and both benefitted from the early work to capture the previously lost steam and heat and apply it to pre-heating the brine. This conserved fuel and improved salt production and quality.

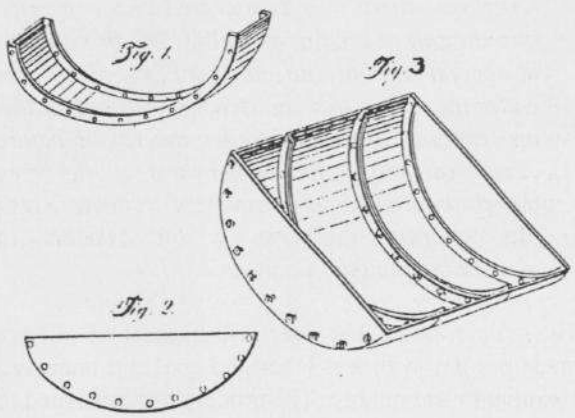

Figure 3. Innovation in pan design (13).

5. THE TRAINER PROCESS

By far the major contribution to the heated evaporative process was the invention of the grainer system. This system was originally described as the Patrick Evaporator, later the Michigan Process, and eventually just simply called the grainer process. The first description of the process occurs in the synopsis of Guiteau's earlier patent in the Journal of the Franklin Institute (15). The new patent is for adding steam to settling vats to draw off the impurities (which had been a problem in Kanawha and other inland brines) followed by allowing steam to flow through the "salting" vat, and the construction of the boxes and the mechanisms for adding the steam (16). Unfortunately, the original drawings are lost, and the most accurate description comes from the

Charleston, Virginia newspaper, The Banner October 11, 1832:

> *-consists of a large pan about 35 ft long set in a furnace and is closely sided up and covered over so as to prevent the escape of any portion of the steam evolved. Connected to this furnace is a vat made of plank 135 ft long and 16 ft wide , underneath and along the bottom of which is a trunk 16 inches square of strong plank which connects with the pan at the furnace and conducts the steam the whole length of the vat. The upper surface of this trunk or conduit is upon a level with the floor of the vat and is composed of lead. The pan is used to convert the water into brine which is then drawn off into vats and settled, when it is again conducted into the large vat where it is evaporated and converted into the salt of the finest quality. The fire applied in the furnace to the pan rapidly reduces the water into brine and the steam generated by this process and conducted under the vat as before described, raises the temperature of the brine therein contained to upwards of a hundred and fifty degrees and render the process of chrystalization (sic) very rapid.' (17)*

The article states that over 200 bushels of salt are made per day with less labor and coal and improved cleanliness and quality. The process was attributed to George H. Patrick because he worked with Isaac Noyes at the Kanawha works to implement the process (17,18). However, it is clear from the patent records and other sources that Patrick did not have a patent on the process, that Guiteau had probably offered the process to the Onondaga works in New York but was rejected as they had firmly established the kettle process, and Patrick took the technology to Kanawha where it found a favorable reception. From there it spread to the salt works along the Ohio River and then up to Michigan and finally back to New York state.

Other improvements included a new pan design by Guiteau (19), improvements in the pipes and case or covering for the salt vats and cistern (20,21), and the introduction of a piping system that revolved so that the steam pipes were always under water as the brine evaporated (22).

The most significant aspect of the grainer system, though, was that it led others to apply the same concepts to the kettle and pan processes - salvaging of "lost steam" to preheat the cisterns and running steam pipes within the salting vats to ensure even heating and even quality of salt crystals. The grainer process greatly reduced fuel and labor needs while improving the quality of the final product. As early as 1836 a patent had been applied for to adapt the vacuum method for evaporation of sugar to brines (23), while in 1829 Alexander Brown had received a patent for use of the scope heat from a high pressure steam engine (24). These eventually became industry standard practices after further improvements and innovations. Eventually the grainer process involved either high pressure steam or low pressure steam, and according to Chatard (54, low pressure was preferable for brine evaporation. The ultimate design used in Michigan in 1885 is shown in Figure 4 (4).

In conclusion, much can be learned about the development of an industry by studying the patent records of a country. Some of the ideas which are patented are more fanciful than practical (22) while others lead directly to innovations in other areas and become standard in the field such as the Guiteau patents.

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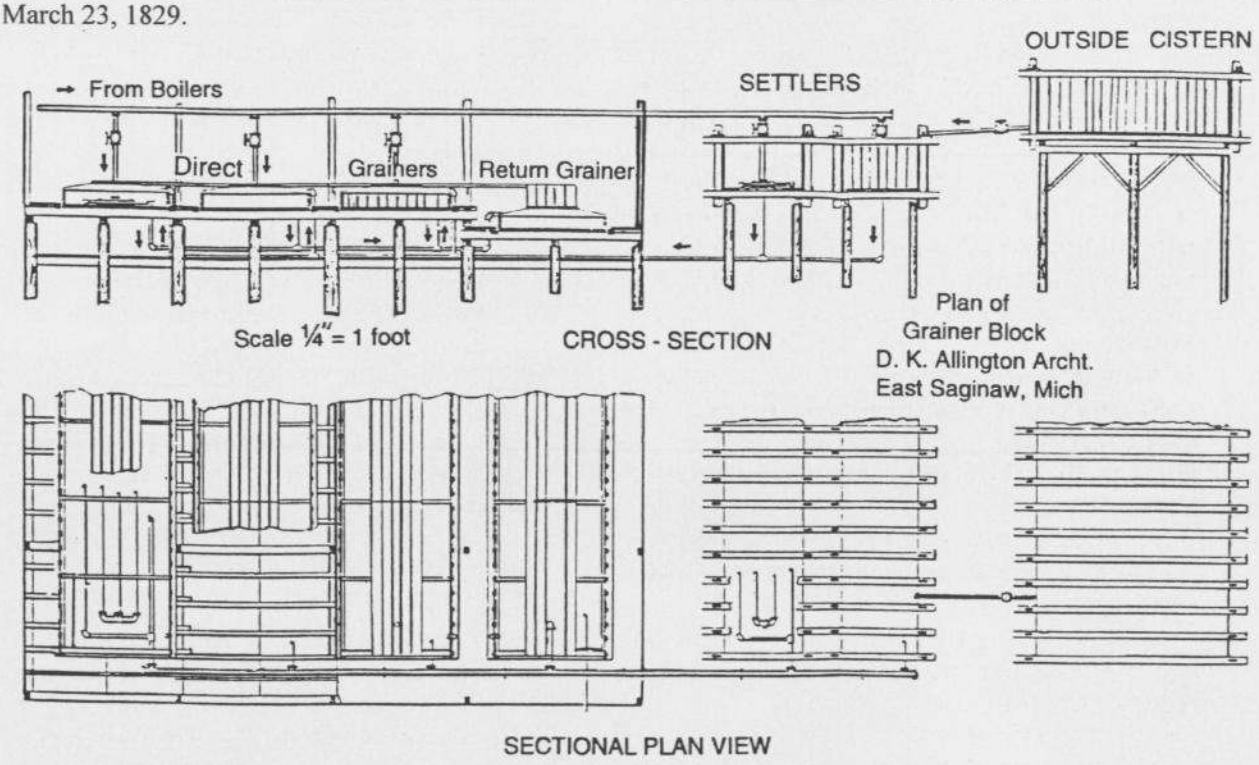

Figure 4. An 1880's grainer (4).