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THE BRINE AND SALT DEPOSITS OF MICHIGAN
THEIR ORIGIN, DISTRIBUTION AND EXPLOITATION

by
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CHAPTER IV. SALT MANUFACTURE.

WELLS.

With the exception of the rock salt obtained from the shaft of the Detroit Salt Co., located at Oakwood, near Detroit, salt is manufactured in Michigan by the evaporation of brines, both natural and artificial, obtained from wells. The subject of manufacture should, therefore, properly begin with a discussion of wells.

Well-drilling machinery.[1] In the drilling of wells, two different methods of procedure are employed. One consists in erecting and equipping the derrick-house before beginning operations; the other in putting down the well with a portable rig and then constructing the derrick-house after the drilling has been completed. In the first, the well is drilled for a contract price which includes the complete equipment ready for operation; in the second, the drilling is paid for at so much per foot.

The derrick-house and equipment, a plan of which is shown in Fig. 22, consists of a derrick for raising and lowering the tools in the well, and a boiler and engine, the engine operating a walking-beam, to which the tools

are connected by an hemp or steel wire cable. The tools employed are the rope socket, sinker bar, jars, auger stem, and bit (see Fig. 23). Alt of these tools may or may not be placed in the string, depending upon the conditions under which the well is sunk.

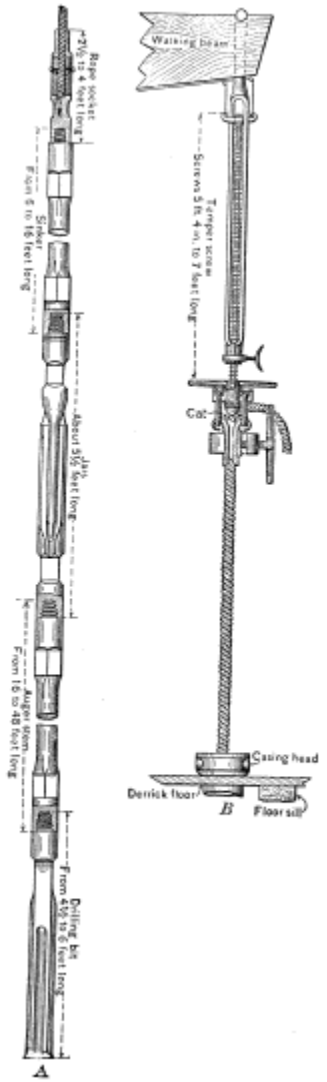

Figure 23. Showing the tools used in well drilling (after Bowman). U. S. Geological Survey Water-Supply Paper No. 257.

The rope socket consists of a steel bar several feet long, in one end of which the cable is fastened. In the other end is a bevel screw socket by means of which the other tools may be attached.

The sinker is a steel bar six to sixteen feet long, the purpose of which is to add weight and length, and so assist in sinking the tools and in keeping the hole straight. It is not used as often as formerly, except in the case of wet holes which require the frequent removal of the tools. In such a case it hastens the sinking of the tools against the bouyancy of the water.

The jars consist of a pair of linked steel bars which, on the upward stroke of the walking beam, exert a jerk upon the drill and so loosen it from the rock. The jars are not used to increase the effectiveness of the blow, but the length of the cable is so adjusted that the upper jar strikes the lower one only on the upward stroke. The jars are generally used only when drilling in rocks which do not chip readily and are therefore liable to imprison the drill.

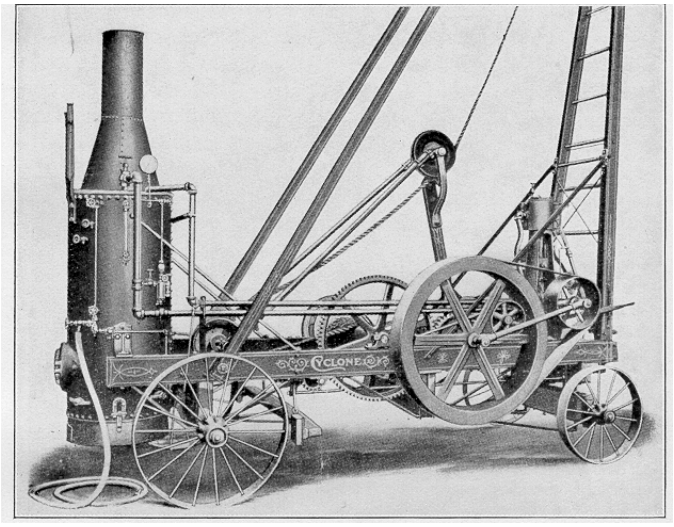

Plate I. A portable well-drilling rig.

The auger stem is a steel bar similar to the sinker bar and is placed just above the bit. By increasing the weight and length of the drill it performs two functions. The weight increases the effectiveness of the blow and the length keeps the hole straight.

The bit is a steel bar five to six feet long, sharpened at one end. There are a number of patterns in use, one of which may be seen from Fig. 23.

The pumping motion of the walking-beam causes the tools to rise and fall on the rock, thus breaking it up. In the earlier stages, it is necessary to twist the drill by hand so that it will strike in a different place each time and thus produce a round hole. After a depth of several hundred feet is reached; the torsion in the cable, induced in pulling it free from the rock, is sufficient to turn the drill without any attention from the driller. In dry wells, it is necessary to introduce a small amount of water to facilitate the drilling and also the removal of the material.

The fine materials which have been produced by the drill are removed by a bailer or sand-pump. The bailer consists of a tube of varying length, in the bottom of which is placed a valve which allows the water and powdered rock to enter and be drawn to the surface. If the drillings are thick and do not enter the bailer readily, the sand-pump is employed. This differs from the bailer in that it contains, in addition to the valve, a plunger which can be operated from above to suck the material into the tube.

The portable rig consists essentially of the same features as those described for the permanent outfit, except for the modifications necessary to render it movable. These machines are manufactured by a number of concerns and the general character may be seen from Plate I.

Well-boring methods. In beginning a well, a ten inch pipe is usually driven into the ground as far as possible. Inside of this, an eight inch pipe is sunk as fast as the drift material overlying the solid rock is broken up and removed with the bailer or sand-pump. The eight inch casing is carried to bed rock, at which point, the size of the hole is reduced to six inches and the well is continued uniformly to the desired depth. Whether the six inch casing is continued to the bottom of the well or not depends upon the firmness of the rock through which the well passes and also upon the necessity of shutting off flows of fresh water which might reduce the strength of the brine. It will be readily apparent that, in wells pumping natural brines, casing practically always will be necessary, inasmuch as fresh water channels nearly always exist above the brine-bearing stratum. On the other hand, where artificial brines are employed, if the rock is firm enough to prevent caving, so that no casing need be used, the influx of fresh water may be sufficient to dissolve the rock salt without the necessity of pumping water into the well.

Pumping methods. Three methods of pumping brines are in use, namely,—the plunger pump, pumping with compressed air, and pumping with water pressure.

The plunger pump is never used where it is necessary to pump water into the well to form the brine. The pump itself is an ordinary lift-pump and is operated by a walking-beam. The depth at which the valve is placed depends upon the height to which the brine rises in the well.

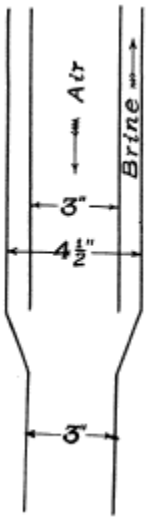

Figure 24. Showing one method of piping for pumping with compressed air.

The method of pumping with compressed air, although subject to minor variations in practice, may be described as follows: Tubing somewhat smaller than the bore of the well is lowered to the bottom. Inside of this, another set of tubing is placed, the depth to which it goes depending upon the height to which the water rises in the well. Air is then forced down the inner tube and allowed to rise through the outer one carrying with it the brine which is above the lower end of the air tube. This process may perhaps be better understood from Fig. 24. In this case we have a four and an half inch tube tapering to a three inch. The inner tube which is three inches in diameter, extends down to the point where the outer tube begins to taper. This system is reversible, that is, the air may be forced down the inner tube and the water allowed to rise through the outer tube, or the outer tube may be used as the air pipe. The above is the modification of the method which is very largely employed in the Ludington and Manistee districts. The air line in these wells extends down to a depth of seven hundred to a thousand feet and an air pressure of two hundred and seventy-five to three hundred pounds per square inch is employed.

Pumping with water pressure is the method employed by most of the companies operating along the Detroit and St. Clair rivers. This method is especially adapted to those conditions under which it is necessary to pump water into the wells in order to dissolve the rock salt; and consists in pumping water down one pipe under sufficient pressure to cause the brine, which has been formed, to flow from the other tube. When the cavities formed by the solution of the rock salt, have reached such a size that two of them unite it is customary to pump the fresh water into one well and allow the brine to flow from the other.

As to the efficiency of these different methods, the plunger pump is probably the least efficient. When a number of wells are in operation, each well must have its own power plant with a man to operate it; or the steam must be piped from the central power plant, affording an excellent opportunity for loss either by leakage or condensation or both. Furthermore, the plunger pump requires greater supervision than does either of the other methods. The air and water pressure methods have the advantage of operation from a central plant, are cheaper in operation, and possess a greater efficiency. The water pressure system is preferable where it is necessary to pump water into the wells, the air pressure where the natural flow in the rocks is sufficient to produce the desired amount of brine. The use of water is more advantageous than air in one respect, that is, it does not exert the pounding effect of the air and is not so liable to injure the tubing.

[1]A very complete report on well-drilling methods has been published recently by the U. S. Geological Survey as Water Supply Paper No. 257.

PRELIMINARY TREATMENT OF THE BRINES.

The treatment of the brine before evaporation depends very largely upon its composition and the method of evaporation to be employed. Practically no brines, either natural or artificial, are free from impurities, as may be seen from the analyses already given. The first problem which confronts the manufacturer Is to remove, in so far as it is economically possible, these impurities. Aside from whatever mechanical sediment there may be, there are also two chemical impurities, less soluble than the

sodium chloride, which may be present. These two compounds are ferrous carbonate and calcium sulphate. The more soluble impurities are very largely left in the mother liquors after the sodium chloride has been removed.

The brine as it conies from the wells is pumped into cisterns where it is allowed to settle, thus removing the foreign matter which is held in suspension. The cisterns differ somewhat in size and shape, some being circular and others, rectangular. An example of the rectangular type, which is the more common form, is shown in Plate IIA. They are built of planks two or three inches in thickness, gripped together and calked to prevent leakage.

If the brine contains iron in the form of the ferrous carbonate, slaked lime is added in the form of a paste to cause its precipitation. There are two methods of adding the lime. It may be added to the brine in the settling cistern, or the brine from the well may be caused to pass through a liming-house before reaching the cisterns. The liming-house[2] consists of a pyramidal-shaped tower about fourteen feet square at the base, in the top of which is a vat for slaking the lime, which is added to the brine as it enters at the top of the house. The brine, to which the lime has been added, then passes down over or through a series of trays placed one above another about a foot apart. Some of the trays consist merely of rows of slats while the others are made of perforated boards. The action of the trays, in breaking up the stream, gives a greater opportunity for aeration and oxidation, thus hastening the precipitation of the iron. From the liming-house, the brine is conducted to the cisterns through a series of open troughs, in the bottom of which are placed a series of riffles to further aid the aeration.

As a rule the brine is conducted from the cisterns to the preheaters, or hot settlers, if they are employed in the process. In one instance, that of the North American Chemical Co., Bay City, a filter is interposed between the cisterns and the preheaters. This filter is composed of a circular tank about ten feet in diameter and seven feet high filled to near the top with excelsior. On top of the excelsior is placed a wooden diaphram. The brine flows by the force of gravity from the cisterns into the base of the filter and up through the excelsior onto the diaphragm, from whence it is drawn off into the preheaters, if it is to be used in the grainers, or is conducted directly to the pans if the vacuum pan process is to be employed. These filters have been found to be very efficient and require cleaning only about twice a year. To clean the filters a stream of fresh water is forced through them from the top.

The preheaters, with one important exception to be noted later, are rectangular vats, sixty to one hundred and twenty feet long, eight to sixteen feet wide, and six feet deep, with steam pipes in the bottom. They are supposed to perform several functions, namely,—to complete the settling of the insoluble matter, to precipitate the gypsum, and to bring the brines to saturation. That they are of very low efficiency in removing the gypsum is shown by the following analysis of the refuse from a preheater made by F. Rusehaupt and Son, and very kindly furnished by the R. G. Peters Salt and Lumber Co., Eastlake.

ANALYSIS MADE FEBRUARY 11, 1908.

Sodium chloride	94.965%
Calcium sulphate	1.931
Calcium chloride	0.082
Magnesium chloride	0.056
Moisture	1.645
Insoluble matter consisting of very little fine free silica, aluminic silicate, and a little oxide of iron	1.333
Total	100.012

The superintendent of one of the largest plants in the state informed me that the retention of the preheater was largely a matter of sentiment, old salt makers believing it impossible to make good salt without preheating the brine. In the case of unsaturated brines, leakage might be produced in the grainers through the solution of the salt in the cracks. The increasing use of cement in the construction of grainers, however, will probably soon remove this excuse for the existence of the preheater.

The most effective means of removing the gypsum is the precipitation by means of chemical reagents. Of these, the most important are sodium bicarbonate, and sodium dihydrogen phosphate. The latter is the more efficacious of the two, but it is also the more expensive. The question of which, if either, of the compounds should be used may be best determined by experimentation. The factors to be considered in such an experiment are, the composition of the brine, the purity of the salt desired, and the cost of the materials.

[2]The liming-house described above is that of the North American Chemical Co . Bay City, Mich.

THE EVAPORATION OF THE BRINE.

After the brine has been prepared, as described above, it is then ready for evaporation. Inasmuch as there have been many advances in the methods of carrying out this portion of the process of manufacture, it might be well to review briefly the history of this development.

Historical. The process of evaporation first employed at Saginaw was known as the kettle process. The potash kettle was used and a series of kettles, finally reaching fifty to sixty in number, was placed between the furnace and the chimney. With this large number of kettles, the fire required to heat the back kettles was much too hot for those over the furnace. To overcome this, arches were built under the first ten or fifteen kettles. While this protected the kettles, it did not tend to an economy of fuel. The question of fuel, however, was not as important at that time as now, most of the blocks using the offal from the saw mills. It was therefore undoubtedly other disadvantages, (such as the difficulty in the control of the kettles and in the removal of salt; the

non-uniformity of the product due to the different rates of crystallization, and the small production) which early led to the substitution of the pan and grainer processes. Since both of these processes, although somewhat modified, are still in use they will not be described at this point.

Another process, which was early employed in the Michigan industry, was solar evaporation. In this process, the heat of the sun is made use of in driving off the water from the brine. The evaporation is accomplished in a series of vats; or "covers," so called because each vat is provided with a movable roof which can be rolled on or off according to the demands of the weather. On account of the slow rate of crystallization, the salt crystals formed by this process are very large and hard. They therefore dissolve very slowly, making the solar salt more effective for certain purposes, such-as packing fish, than that produced by artificial heat, and permitting it to command a higher market price. This process was not economically successful in Michigan and the last solar field, located at Zilwaukee, between Saginaw and Bay City, was abandoned some years ago.

That attempts at improved methods of manufacture were made early in the history of the Michigan industry, is shown by the patents granted for the same. Among these were the Chapin patent, granted March 18, 1862, and the Garrison Process, patented August 19, 1862. While neither of these processes gained any pronounced degree of success, yet they are historically interesting as showing the trend of the industry.

The following description of the Chapin process, invented by Nathan Chapin of East Saginaw, Michigan, is taken very largely from the Scientific American.[3] A typical plant, minus the power house is shown in Fig. 25. In the center of the building is a large vat, which is traversed throughout its entire length by two tubular furnaces, DD; floating on the brine in the first vat is a second triangular vat, (shown by the dotted line), traversed by a tubular furnace, H. The brine is drawn into the large vat at faucets in the hotter portion of the furnace. By the evaporation which takes place a current is maintained toward the rear of the vat, the less soluble impurities being deposited on the journey. At the rear of the large vat the brine flows into the upper vat, where the evaporation is completed. The upper vat being fitted with partitions, F, the brine takes a zig-zag course to the front of the vat, depositing the salt on the way. As often as necessary, the mother liquor, is drawn off at the front of the vat. The salt which is deposited on the slanting bottom of the upper vat is raked onto the perforated platforms, GG, where the brine is allowed to drain back into the lower vat. The impurities which adhere to the salt are washed off by the condensation of the steam upon it.

The Garrison process was patented by C. O. Garrison of East Saginaw. This description is also from the Scientific American. Fig. 26 represents a complete plant. The vats A, B, C, D, in which the brine is evaporated, are constructed with double bottoms to permit of the circulation of steam or hot air. Before the brine is run into the vats for final evaporation, it is partially evaporated in the large vat, E, containing partial partitions alternating from either end and thus compelling the brine to take a zig-zig course. This vat is also supplied with a double bottom so that the brine may be heated here and its clarification hastened. When the evaporation in the evaporating vats has been carried to the proper point, the mother liquor is drawn off and the salt allowed to dry in the same pan.

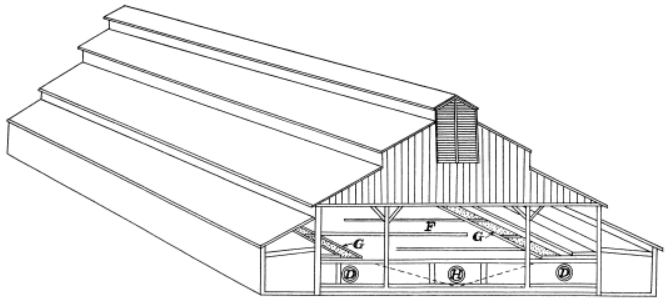

Figure 25. Showing salt block operated by the Chapin process (after the Scientific American).

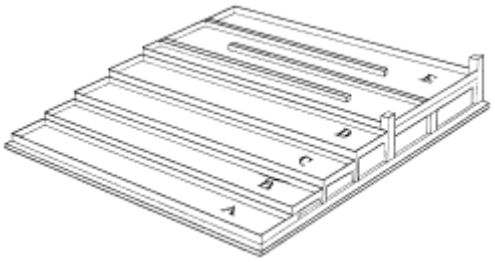

Figure 26. Showing the Garrison process (after the Scientific American).

Another process which was employed at this time, at least on a small scale, was that known as the Kanawha process, from its use in the Kanawha valley in West Virginia. This process may be considered as the forerunner of the present grainer process. With certain modifications, it is still in operation in West Virginia and may be described briefly as follows:[4] the plant consists of three parts, the furnace, settlers, and grainers.

The furnace is made of cast iron pans, eight to ten by three feet, bolted together and thus forming a section. Over the section is placed a wooden steam chest so constructed as to be steam and water tight. A number of these sections are placed side by side on the furnace walls and the preliminary evaporation is produced by the application of direct heat.

After the brine has been concentrated to a certain extent in the furnace, it passes into vats or settlers, about ten feet wide, one hundred feet long, and three to four feet deep, in which the brine is settled and saturated. The heat is supplied by passing the steam, which is formed in the furnace, through copper pipes placed in the settlers. From the settlers, the saturated brine passes into the grainers, which differ from the settlers only in depth, being about one half as deep. Here the salt is allowed to deposit.

As already stated the kettle blocks soon gave away to the pan and grainer blocks, the former gradually yielding in importance to the latter, until at the present time but three pan blocks are left in the state. Neglecting, for the present, improvements in grainer methods, the next step in the development of evaporating methods may be said to be the introduction of the vacuum pan into the salt industry, and finally the joining of the vacuum pans in a series. As the vacuum pan is to be described under the subject of present methods no further mention of it need be made here.

Present methods. On the basis of the method of applying the heat, the present processes may be divided into two classes, as follows:

1. Evaporation by the direct application of heat.

2. Evaporation by the use of steam, either exhaust or live.

Direct heat methods. At the present time, the only process in use in Michigan which employs direct heat is that of evaporation in open pans. The open pan process is a direct development from the kettle process. The pans are made of quarter inch boiler plate iron riveted together. At first, the pans were ninety to one hundred and twenty feet in length, divided into sections thirty to forty feet long, twelve to fifteen feet wide and ten to twelve inches deep, supported on three walls. In some cases, the pans had perpendicular sides, the salt being raked to the side of the pan and lifted with a shovel; in others, the sides of the pan were sloping and bolted to the draining boards so that the salt could be raked directly onto them. The heat was furnished by a furnace placed at one end about three feet below the pan, the bottom of the flue gradually rising toward the back end of the pan where it passed into the chimney.

The present pan block consists of a number of pans eighty to ninety feet long, eighteen to twenty feet wide, and about twelve inches deep with flanging sides bolted to the draining boards, which are about three feet wide and inclined toward the pans. Between the draining boards of two pans is a walk, six to eight feet wide from which a man operates the rake. As the evaporation takes place at or near the boiling point, the formation of salt is very rapid, and should be removed as fast as formed. This constant removal of the salt is necessary not only to prevent its baking but also because, when left, it forms a coating which retards the conduction of the heat to the brine and therefore increases the fuel consumption per barrel of salt made.

Two methods of applying the heat are now in use. In one the heat passes from the furnace at the front to the chimney in the rear as in the case of the earlier plants. In the other, the space under the pan is partitioned off into three flues. Two of these pass from the furnace to the back of the pan, where they open into the third flue which returns the smoke and heated gases to the chimney, located beside the furnace. The plan of an open pan is shown in Fig. 27.

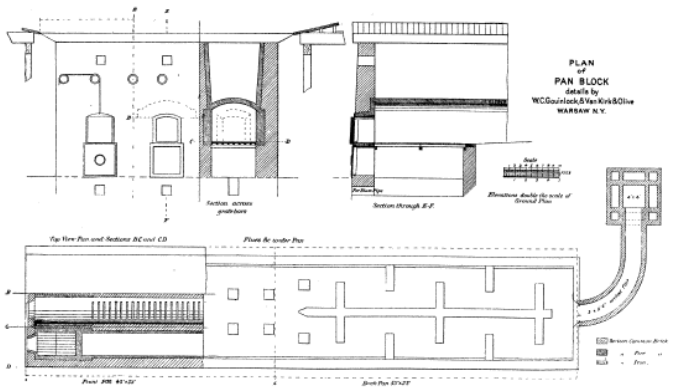

Figure 27. The open pan (after Chatard). U. S. Geological Survey, Seventh Annual Report, 1885-1886.

In the earlier days of the salt industry of Michigan, the pan blocks were operated in connection with saw mills, the refuse from which was used for fuel. At the present time all of these blocks are operated independently and use coal entirely.

Steam evaporation. Steam is employed as the evaporating agent in three different processes, namely,—the grainer, Alberger, and vacuum pan.

GRAINER SYSTEM. Grainers may be described in general as shallow vats in the bottoms of which are placed series of steam pipes. However, they present certain variations in size, shape, materials out of which they are constructed, the manner of piping, and the methods of lifting the salt.

The most common type of grainer is rectangular in form. Another type which is also in use is known as the V-shaped grainer on account of the fact that its cross section resembles that letter.

In size the rectangular grainers vary from forty to one hundred and sixty feet in length, from eight to eighteen feet in width, and from fourteen to twenty-four inches in depth. The characteristic size is one hundred and twenty feet by twelve feet by twenty-two inches. The V-grainers are about one hundred and twenty feet long by twelve feet wide at the top and possess a maximum depth of six to seven feet.

With respect to materials, wood, wood and tile, cement, iron, and steel are variously used in grainer construction. The older grainers were constructed of planks three or four inches thick, keyed together and well calked. In some instances, the wooden grainers have been lined with tile. This not only helps to protect the wood but also gives a smoother surface from which to remove the salt. In a number of instances, iron and steel have been used in grainer construction, especially in the case of the V-shaped grainers. Although the brine does not seem to have any injurious effect upon the metal while in contact with it, yet on exposure to the air it exerts a decided corroding action. The material which at present is gaining popularity, is cement. The first attempts in the construction of cement grainers were failures, owing to the fact that they were held rigidly by the supports. This did not permit of the accommodation of the alternate

expansions and contractions brought about by the fluctuations in temperature within the grainer. The result was a cracking of the cement and a rapid destruction of the grainer. Provision has now been made for the expansion and contraction by setting the grainer upon a sand bed.

The manner of piping grainers can best be understood from Fig. 28. This figure, which was very kindly furnished by Mr. J. J. Hubbell of the Buckley and Douglas Lumber Co., Manistee, shows one grainer piped for steam and two for tail water, that is, the water which is formed by the condensation of the steam in the pipes of the regular grainers.[5]

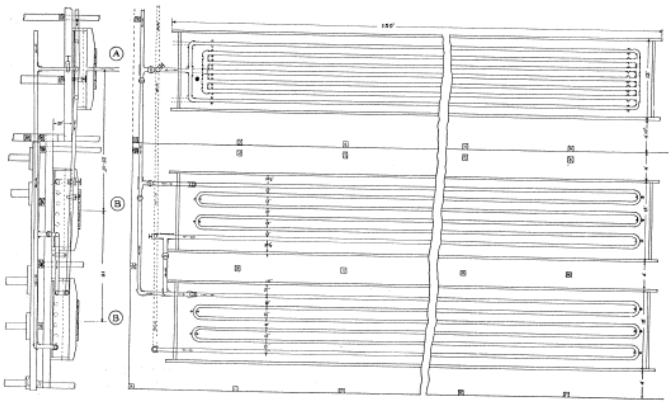

Figure 28. Showing the piping of grainers, both for steam (A), and tail water (B) (after Hubbell).

Two methods of lifting the salt are in use. In some grainers, the salt is lifted with a shovel. A walk four to five feet wide runs down the center of the grainer, and onto this the salt is shoveled every twenty-four to forty-eight hours, depending upon the rate of evaporation, and after being allowed to drain, is shoveled into carts and is carried into the stock house. A grainer of this type is shown in Plate II B. Other grainers are provided with automatic rakers. There are several varieties of rakers used. Among these may be mentioned the endless chain, and the reciprocating rakers.

The endless chain raker consists of two chains placed at the sides of the grainer and running over cogwheels at either end. At regular intervals sweeps are attached to the chains. The sweeps pass along the bottom of the grainer, beneath the pipes and up an incline draining board at one end, moving the salt with them, and then returning to the other end of the grainer in the air. As the salt accumulates on the draining board it is gradually pushed over the upper end; either into a conveyor or onto the floor, from whence it is wheeled to the stock room in carts. This method has the disadvantage of exposing the chains alternately to brine and air and so tends to corrode them very rapidly. This not only decreases the life of the apparatus but is also liable to give a red tinge to the salt and so lessen its value.

The nature of the reciprocating raker may be perceived from a study of Fig. 29, which is reproduced from an article on salt manufacture by Geo. B. Willcox[6] of Saginaw. Mr Willcox describes the apparatus as follows:

"The raker consists essentially of a frame-work comprising two steel angles (1) located within the grainer near the bottom and adjacent to the side walls. At intervals these two angles are connected by cross braces (2) and the frame-work so formed carries a series of feathering scraper blades (3) extending transverse the grainer and supported at their two ends on the two side angles by means of horizontally-projecting rocking pivots or fingers (3A)." By means of a steam or hydraulic cylinder the raker is operated with a forward and back movement, the sweep pushing the salt along the bottom and up the inclined draining board at the end, on the forward movement, and feathering on the back stroke, the salt is thus gradually removed from the draining board as in the case of the endless chain raker.

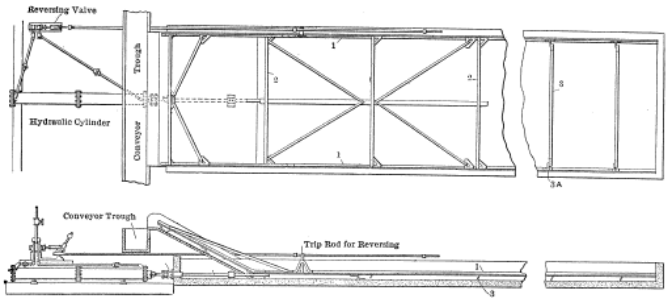

Figure 29. Automatic salt raker, with hydraulic drive (after Willcox).

Most plants using the grainer system are run in connection with some other manufacturing concern and utilize the exhaust steam from the same. The temperature of the brine is therefore considerably below the boiling point. Where the supply of exhaust steam is adequate, the temperature runs from 170° to 190°F. but in many cases it falls considerably below these figures. Several plants use live steam in their grainers, coal being employed as the fuel. This imparts to the brine a temperature which is at or near its boiling point depending upon the pressure at which the steam is carried.

As evaporation proceeds, the surface layer of the brine becomes supersaturated and the salt separates out. If the crystallization is rapid and the brine is not agitated, there is a tendency for a film of crystals to form at the surface, retarding the further evaporation. To aid the subsidence a small amount of callow or cotton-seed oil is sometimes added to the brine, or the brine is agitated from time to time, either by hand or by means of paddles operated by the rakers. When live steam is used the evaporation is generally so rapid that the film tends to break up almost as soon as formed.

ALBERGER SYSTEM. In this system the brine is pumped from the cistern into the heaters, which consist of cylindrical steel shells containing a number of tubes, resembling the flues of a boiler, through which the brine is forced and is heated by steam under pressure. The high heat causes the deposition of gypsum on the walls of the tubes necessitating frequent cleaning. This is

accomplished by removing the top of the heater and drilling out the tubes.

From the heater the superheated brine is forced through a rock filter, to remove the gypsum. In shape the filter very closely resembles the tube mill used in cement plants for grinding cement, and consists of a hollow steel shell supported at either end by bearings so that it may be revolved. The shell is partially filled with pebbles and the hot brine being forced through deposits the gypsum on the pebbles. When the accumulation of gypsum has reached the point where its removal is necessary, the brine pipe is removed, fresh water is let in, and the filter revolved. The revolution of the filter causes the pebbles to pound together, thus loosening the gypsum, which is then washed out.

After passing through the filter, the brine passes into an evaporator, which is merely an air dome and serves to reduce the pressure, and then into the pans. The temperature of the incoming brine is about 226°F. and after making a complete circuit of the pans it passes back into the heater at a temperature of 170°-200°F.

The plan of the evaporating pan is shown in Fig. 30. The brine enters at (D), is swept around the pan by the rakers (A), and flows out at (C). The salt is also moved along until it drops into a well at (B). The pans are eighty-eight by forty-four feet by twelve inches and. are constructed of steel.

The salt having fallen into the outlet is let down, in the form of a paste, into a centrifuge where it is whirled for about three minutes and then, in the only plant using this process, passes into the dryers and thence to the separators.

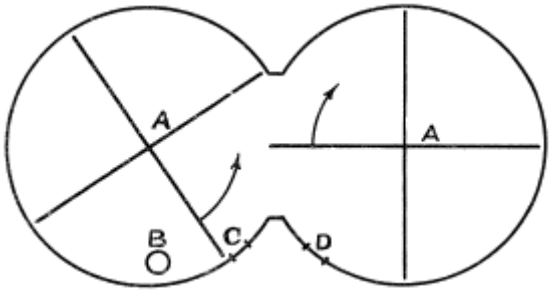

Figure 30. Plan of the Alberger plan.

VACUUM PAN PROCESS. Although the vacuum pan had long been used in the manufacture of sugar and other products, according to Mr. Geo. Ray,[7] its first application to the salt industry was in 1887; when a pan was erected by Mr. Joseph Duncan at Silver Springs, N. Y. A year or two later, two small pans were built at Ludington for the Butters and Peters Lumber Co. This was followed by a number of “single effect” pans, and in the early nineties, Mr. Peters conceived of the idea of joining two pans in a series, the steam for the second pan being formed in the first. The plans and details were worked out by Mr. Geo. Ray and the first "double effect" pan for the manufacture of salt was erected in 1895 at the plant of the R. G. Peters Salt and Lumber Co., Manistee, by the Manistee Iron Works. In 1904, the Manistee Iron Works constructed for the Salt Union of England, Winsford, Cheshire, the first "triple effect" pan, and in 1907, the first "triple effect" pan in Michigan was erected for the Anchor Salt Co., Ludington. It is also interesting to note that in the same year the first "quadruple effect" pan was built at Ludlowville, New York. The only "quadruple effect" pan in Michigan was erected for the Rapid Evaporator Co., at the Plant of Stearns Salt and Lumber Co.. Ludington. in 1910-11.

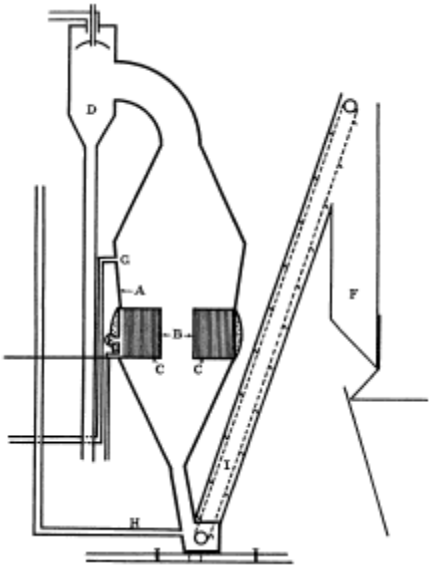

Figure 31. Section of a vacuum pan (after Hubbell).

The principle involved in the vacuum pan evaporation is that of decreasing the pressure on the surface of the brine so that the boiling point is correspondingly lowered. While the pans, in which the evaporation is carried on, differ in some of the minor details, the general principles of the process may be seen from Fig. 31. The pan consists of a steel cylinder (a) tapering at both ends, the upper and lower portions of which are separated by the steam belt (b) through which pass the copper tubes (c) to permit the circulation of the brine and also to increase the heating surface. The steam is supplied through the inlet (e) and the condensation escapes at (d). The brine is supplied from the cisterns to the pan at (g). When there is no vacuum on the pan it may be filled through the pipe (h) which connects with a brine tank placed at a sufficient height to cause the brine to rise in the pan to the desired point. The steam formed in the pan by the evaporation of the brine is condensed in the condenser and the salt as it forms falls to the bottom of the pan and is removed by the bucket elevator (i). The salt is dumped into the bin (f), where it is allowed to drain and then is carried to the stock room in carts.

When two or more pans are run "multiple effect” the steam formed in the first pan, instead of passing to the condenser, is conducted to the belt of the second pan, on which a greater vacuum is carried, and supplies the heat for the evaporation. Likewise the steam formed in the second pan is carried to the belt of the third and so on.

The following records of the pans at the R. G. Peters Salt and Lumber Co., give an idea of the vacuum and temperature of the steam on entering and leaving the pans.

	Vacuum.	Temperature.	
		Belt.	Elboe.
Pan No. 1	10 in.	234°F.	204°F.
Pan No. 2	20 in.	191°	170°
Pan No. 3	27.7 in.	160°	122°

Pressure in belt No. 1, 10 pounds.

It must be kept in mind that the values for pressure and temperature given above will fluctuate depending upon the steam supply, the freedom of the pans from gypsum, etc.

The advantage of the “multiple effect" over the “single effect" pan lies in the fact that there is a greater utilization of the heat of the original steam, which is used only in the first pan. According to Mr. Geo. Ray, one ton of coal evaporating 16,000 pounds of water will make two tons of salt in a "single effect” pan, four in a “double effect,” six in a "triple effect," and eight in a "quadruple effect.” In some plants the pans are operated with live steam, in others exhaust steam is employed.

Some experiments performed by Mr. J. J. Hubbell at the plant of the Buckley and Douglas Lumber Co., Manistee, show that when run in moderation the fuel and brine costs per barrel are much lower than when the pans are crowded. The actual results obtained are as follows:

To make 700 barrels in 11 hours.

Steam—485,987 B. T. units of heat, cost approximately	4.80c per bbl.
Brine—105 gallons, cost approximately	5.02
Total	9.82c

To make 1,000 barrels in 11 hours.

Steam 668,943 B. T. units of heat, cost approximately	6.7c
Brine—150 gallons, cost approximately	7.5
Total	14.2c

[3]Scientific American, Vol. VII, New Ser. p. 97.

[4]Grimsleys G. P., W. Va. Geol. Sur., Vol. IV, p. 304.

[5]In a number of plants the practice is made of placing at the end of a series of grainers piped for steam another grainer through which the condensed vapors are passed to utilize the heat left in the water. This grainer is at a lower elevation than the others so that the water is moved by the force of gravity. On account of the lower temperature, the evaporation is much slower and a correspondingly coarser grade of salt, known as packers, is produced.

[6]Loc. cit.

[7]Personal communication.

TABLE SALT.

In order to prepare the salt manufactured by the above processes, for human consumption further treatment is necessary. The crude salt is first passed through dryers, which are rotary kilns about thirty-five feet long and six feet in diameter, with a steam cylinder about three feet in diameter running through the center. The kilns are slightly inclined so as to cause the salt to move slowly from one end to the other. Meanwhile a hot air blast is blown through the kiln in the opposite direction to that in which the salt is moving. The kilns turn at the rate of about twelve or thirteen revolutions per minute and it requires about twelve minutes for the salt to pass through the kiln. The temperature varies but is usually maintained at about 240°-250°F. The dried product is next elevated to hoppers from whence it passes into the screens or separators. The screens are in the form of cylinders of wire cloth of different sized mesh, joined end to end, and placed in a position slightly inclined from the horizontal. As they revolve the salt passes from one end to the other and is separated into the various sizes.

STORING, PACKING AND SHIPPING.

The stock house is a large room traversed by runways near the roof which cuts it up into small squares or rectangles. The salt is transported from the evaporators in carts to the desired portion of the stock house and dumped from the runway onto the floor below. Here it is allowed to age, at least twenty days being required by the state inspection law, and is then ready for shipping.

The crude salt is shipped in bulk, barrels, and sacks, both by rail and by boat. When shipped in bulk, the salt is taken from the stock house floor, loaded into carts, and after having been weighed is wheeled to a belt elevator which carries it up to a chute which conveys it into the car or boat. Plate VB shows a boat loading bulk salt at the No. 1 plant of the Louis Sands Salt and Lumber Co., Manistee.

When packed in barrels, the packing is done by hand and 280 pounds constitute a barrel. Some plants manufacture their own barrels, others buy them from the manufacturers. The vacuum salt being more hygroscopic than the grainer salt packs much harder. It is therefore often necessary to use dynamite to loosen it before it can be shoveled into the barrels. Furthermore this packing permits the use of a barrel only two-thirds the size of that required for the grainer salt. After packing, the barrels are loaded on a truck and wheeled into a car or onto the dock as the case may be.

Of the crude salt, only the packers is shipped in sacks. These sacks are made of gunny cloth and hold 56 pounds. Table and dairy salt is packed for the most part in white cloth bags of various sizes. These sacks are filled by automatic sackers and the smaller ones are sewed by machinery, the larger ones being sewed by hand. Some companies also use pasteboard cartons for small packages of table salt.

CHAPTER V. THE PRODUCT.

The product of the early years of manufacture failed in competition with salt from other states owing to a lack of uniformity. To improve these conditions; local inspection was early adopted by some of the manufacturers, and in 1869, the state inspection law was passed. This law as amended in 1873, 1875, 1877, 1879, 1883, 1887, 1899, 1903, and 1905 is given in Appendix B. The office of State Salt Inspector was abolished by the legislature of 1913.

CHARACTER OF THE PRODUCT.

As may be seen from the following analyses of crude salt the product of the Saginaw valley differs from that of the other districts generally in possessing a lower content of calcium sulphate. This salt is therefore less liable to cake so hard. It does however contain a larger percentage of calcium chloride and magnesium chloride and is therefore more hygroscopic. Up to the present time, the Saginaw valley product has not been successfully used in the manufacture of table salt.

TABLE XXIV.[1]

	93.	94.	95.	96.	97.	98.	99.	100.
Calcium sulphate	0.3165	0.697	0.478	0.2	0.7685	1.354	1.436	1.573
Calcium chloride	0.3564	0.329	0.365	0.8	0.148			0.231
Calcium carbonate								0.016
Magnesium chloride	0.1408	0.340	0.694	0.3		0.021	0.047	0.197
Sodium sulphate						0.208	0.283	
Sodium chloride	95.8422	97.288	94.366	93.5	99.0835	97.183	96.591	95.748
Ferrous carbonate								0.004
Ferric oxide and alumina						0.172	0.158	
Silica								0.207
Organic matter								0.006
Moisture	3.3441	1.346	3.478	5.2		0.432	1.485	2.218
Total	100.0000	100.0000	100.000	100.00	100.0000	100.000	100.000	100.000

[1]The values are given in percentages.

93. East Saginaw Salt Manufacturing Co., East Saginaw, Mich. Kettle salt. Analysis by Dr. C. A. Goessmann. (Geol. Sur. Mich.? Vol. III, p. 194.)

94. Bay City Salt Co., Bay City, Mich. Pan salt. Analysis by S. S. Garrigues. (Geol. Sur. Mich., Vol. III, p. 194.)

95. Buffalo Salt Co., East Saginaw, Mich. Steam salt. Analysis by Dr. C. H. Hahn. (Geol. Sur. Mich., Vol. III, p. 195.)

96. North American Chemical Co., Bay City, Mich, Vacuum pan salt. Analysis by A. Llewelyn Allen. Furnished by Mr. M. L. Davies.

97. Filer and Sons, Filer City, Mich. Vacuum pan salt. Analysis by W. and H. Heim, Saginaw, Mich. 1888. Furnished by Mr. E. G.. Filer.

98. Buckley and Douglas Lumber Co., Manistee, Mich. Vacuum pan salt. Analysis by Fred Ruschaupt and Son, Milwaukee, Wis. Feb. 14, 1910. Furnished by Mr. J. J. Hubbell.

99. Same. Grainer salt.

100. Louis Sands Salt and Lumber Co., Manistee, Mich. Grainer salt. Analysis by J. E. Siebel, Chicago, Ill. 1881. Furnished by Mr. T. B. Jones.

The composition of Michigan table salt is shown in Table XXV.

TABLE XXV.

	101.	102.	103.	104.	105.	106.	107.
Sodium chloride	99.334	99.313	99.391	98.86	98.55	98.23	98.30
Calcium sulphate	0.495	0.600	0.560	0.98	0.61	0.49	0.57
Calcium chloride	0.102		absent		0.25	0.41	0.47
Magnesium chloride	absent	absent	absent	trace	0.11	0.045	
Water at 100° C.	0.040	0.076	0.049	0.16	0.47	0.82	0.65
Insol. in water	0.029	0.012	trace	0.003	0.01	0.005	0.007
Total	100.000	100.000	100.000	100.103	99.40	100.000	99.997

101. Delray Salt Co., Delray, Mich. P. S. Brand, table and dairy salt. Analysis by Prof. F. S. Kedzie, Sept. 5, 1908, who states, "The sample contains no magnesium salts." Furnished by Mr. Jos. P. Tracy.

102. Same. Delray Table Salt. Analysis by Prof. F. S. Kedzie, Jan. 28, 1909, who states, "Practically free from calcium chloride as I found but 1-1000 of 1% of this substance in the sample tested." "The sample contained no salts of magnesia." Furnished by Mr. Jos. P. Tracy.

103. Same. Analysis by H. Spurrier Feb. 6, 1910. Furnished by Mr. Jos. P. Tracy.

104. Port Huron Salt Co., Port Huron, Mich. Analysis by the Michigan Techinal Laboratory, Detroit, Mich., June 4, 1910. Analysis furnished by Mr. Otto Huette.

105. Same. Analyst, unknown. Furnished by Mr. Otto Huette.

106. Michigan Salt Co., Marine City, Mich. Cadillac Brand, table salt. Analysis by Robt. E. Devine, 301 Park Bldg., Detroit. Mich., June 30, 1910. Furnished by Mr. Sidney C. McLouth.

107. Same.

Rock salt is produced in Michigan only at the shaft of the Detroit Salt Co., Oakwood. An analysis of their product, as given by J. W. Turrentine,[2] is as follows:

	108.
Potassium chloride	trace.
Sodium chloride	97.3
Calcium chloride	trace.
Magnesium chloride	1.2
Sodium sulphate	1.5
Calcium sulphate	trace.
Total	100.000

108. Detroit Salt Co. Sample from roof to floor at working face. Representative of stratum being removed. 1911. R. F, Gardner, analyst.

[2]Turrentine, J. W. Jour. Ind. and Eng. Chem., Vol. 4, No. 11, p. 831.

PRODUCTION.

The development of its salt industry was so rapid that, in 1876, after only sixteen years of production, Michigan became the leading producer of salt in the United States. This position it held until 1893, when New York assumed first place. In 1901, Michigan again acquired the leadership, only to yield it once more to New York in

1902. However, in 1905, Michigan passed its rival for the third time and has since then[3] maintained the first rank by a considerable margin.

The annual production of salt in Michigan, from the foundation of the industry to 1910, as reported by the state salt inspector, is given in Table XXVI, column 3. Since these figures represent inspection rather than absolute production, they are only approximate. In column 4, the figures as given in Mineral Resources, U. S. G. S. are shown. From 1893 on these statistics were obtained directly from the manufacturers and therefore represent the true annual production. They also include the salt in the brine used in the manufacture of soda ash, etc., or what is known as "brine salt." While this salt is not produced in the solid form, yet it should properly be considered as part of the saline wealth of the state. The large discrepancy between the production as given by the state salt inspector and that given by the United States Geological Survey is due to the inclusion of the brine salt by the latter.

Column 2 represents the total production of the United States, and Column 5, Michigan's percentage of the total, based on the data given by the United States Geological Survey. From this it will be seen that, since 1880, Michigan has never produced much less than one-quarter, with a number of years approaching one-half, and an average of nearly two-fifths of the entire production.

This table shows that, with one or two exceptions, the growth of the industry in Michigan was steady up to 1887. Then for a period of about six years the production remained practically stationary. This was due in part to a drop in prices and also to the competition from new districts. The big increase of nearly one million barrels, in 1893, is more apparent than real and was due to a change in the method of obtaining the statistics. The decrease recorded in the inspection for 1894 was undoubtedly due to the tariff act of that year, which placed salt on the free list. The competition of the imported salt with the eastern salt forced it to seek a new outlet which brought it into closer competition with the western salt. By the tariff act of 1897, a duty was again placed on salt. The results of this are reflected in the increased production of 1898, as shown by the increased inspection. The still greater production recorded by the United States Geological Survey was due to the development of the soda ash industry in Wayne county. The sudden and enormous decrease of over three million barrels, in 1903, was due in part to the closing down of a large number of plants as a result of the great drop in price the preceding year, which resulted in a decrease in manufacture of nearly a million barrels. The balance represents the decrease in brine salt. Although there was a decreased inspection in 1909, the salt inspector's report shows that there was an increase in production of over four hundred thousand barrels, in spite of the fact that a number of plants were closed down.

TABLE XXVI.

Year.	U. S. Production.	Michigan Production.		Per cent. of total.	Value.	Price.
		Salt Inspector.	U. S. G. S.			
1860		4,000				
1861		125,000				
1862		243,000				
1863		466,000				
1864		529,072				
1865		477,200				
1866		467,997			$734,395	$1.80
1867		474,721			840,255	1.77
1868		555,690			1,028,027	1.85
1869		561,288			786,885	1.58
1870		621,352			820,185	1.32
1871		728,175			1,063,135	1.46
1872		724,481			1,057,742	1.46
1873		823,346			1,127,984	1.37
1874		1,026,970			1,220,004	1.19
1875		1,081,856			1,190,042	1.10
1876		1,482,729			1,556,865	1.05
1877		1,660,997			1,411,847	0.85
1878		1,855,884			1,577,501	0.85
1879		2,058,040			2,099,200	1.02
1880	5,961,060	2,676,588	2,485,177	41.69	2,271,931	0.75
1881	6,200,000	2,750,299		44.35	2,418,171	0.85
1882	6,412,373	3,037,317	3,037,317	47.36	2,126,122	0.70
1883	6,192,231	2,894,672	2,894,672	46.74	2,344,684	0.81
1884	6,514,937	3,161,806	3,161,806	48.53	2,392,648	0.757
1885	7,038,653	3,297,403	3,297,403	46.84	2,967,663	0.900
1886	7,707,081	3,667,257	3,667,257	47.58	2,426,989	0.661
1887	8,003,962	3,944,309	3,944,309	49.17	2,291,842	0.581
1888	8,055,881	3,866,228	3,866,228	47.99	2,261,743	0.585
1889	8,005,565	3,846,979	3,856,929	48.17	2,088,909	0.541
1890	8,776,991	3,838,637	3,837,632	43.72	2,302,579	0.600
1891	9,987,945	3,927,674	3,966,784	39.52	2,037,289	0.513
1892	11,698,890	3,812,594	3,829,478	32.81	2,046,963	0.523
1893	11,807,208	3,514,485	3,057,898	25.70	888,837	0.287
1894	12,968,417	3,138,941	3,341,425	26.53	1,243,619	0.375
1895	13,669,649	3,529,362	3,343,395	24.46	1,048,251	0.315
1896	13,850,726	3,336,242	3,164,238	22.89	718,408	0.229
1897	15,973,202	3,622,764	3,993,225	24.99	1,243,619	0.313
1898	17,612,534	4,171,916	5,263,564	29.88	1,628,081	0.311
1899	19,708,614	4,732,669	7,117,382	36.14	2,205,924	0.309
1900	20,869,342	4,738,085	7,210,621	34.55	2,033,731	0.282
1901	20,566,661	5,580,101	7,729,641	37.58	2,537,677	0.328
1902	23,849,231	4,994,245	8,131,781	34.10	1,535,823	0.188
1903	18,968,089	4,387,982	4,297,542	22.65	1,119,984	0.260
1904	22,030,002	5,390,812	5,425,904	24.62	1,579,206	0.309
1905	25,966,122	5,671,253	9,492,173	35.24	1,851,332	0.196
1906	28,172,380	5,644,559	9,936,802	36.31	2,018,760	0.203
1907	29,704,128	6,298,463	10,786,630	35.39	2,231,129	0.208
1908	28,822,062	6,247,073	10,194,279	35.34	2,458,303	0.241
1909	30,107,646	6,055,661	9,966,744	33.10	2,732,556	0.274
1910	30,305,656	5,597,276	9,452,022	31.18	2,231,262	0.236

The annual inspection of salt, since the adoption of the state inspection law, according to grades, is given in Tables XXVII and XXVIII. Previous to 1898, table salt was included under "fine." The figures given under "table" in Table XXVIII include all fancy grades.

TABLE XXVII.

Year.	Fine.	Packers.	Solar.	Second quality.	Common coarse.
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
1869	513,989	12,918	15,264	19,117	
1870	568,326	17,869	15,507	19,650	
1871	655,923	14,677	37,675	19,930	
1872	672,034	11,110	21,461	19,876	
1873	746,762	23,671	32,267	20,706	
1874	960,757	20,090	29,391	16,741	
1875	1,027,886	10,233	24,336	19,410	
1876	1,402,410	14,233	24,418	21,668	
1877	1,590,841	20,389	22,949	26,818	
1878	1,770,361	19,367	33,541	32,615	
1879	1,997,350	15,641	18,020	27,029	
1880	2,598,037	16,691	22,237	48,623	
1881	2,673,910	13,885	9,683	52,821	
1882	2,928,542	17,208	31,335	60,222	
1883	2,828,987	15,424	16,735	33,526	
1884	3,087,033	19,308	16,957	38,508	
1885	3,230,646	15,480	19,849	31,428	
1886	3,548,731	22,221	31,177	71,235	3,893
1887	3,819,738	19,385	13,903	73,905	17,378
1888	3,720,319	18,126	26,174	87,694	13,915
1889	3,721,099	19,780	17,617	93,455	4,987
1890	3,655,331	20,337	18,896	143,068	
1891	3,764,108	11,400	17,335	121,269	13,559
1892					
1893	3,421,607	16,550	11,893	64,435	
1894	3,072,241	14,944	7,744	44,012	
1895	3,421,706	15,350	39,907	52,309	
1896	3,262,699	14,895	28,869	29,779	
1897	3,568,833	13,973	5,644	34,314	

TABLE XXVIII.

Year.	Medium.	Granulated.	Packers.	Solar.	Table.	Second quality.
	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.	Barrels.
1898....	2,702,312	1,199,553	14,649	.....	198,002	43,178
1899....	2,706,430	1,744,961	29,892	17,353	189,107	44,922
1900....	2,789,982	1,680,614	26,750	24,238	162,590	53,902
1901....	3,361,616	1,895,093	39,400	11,323	188,068	84,311
1902....	3,065,417	1,604,180	71,858	.....	219,016	133,774
1903....	2,601,932	1,459,029	92,316	8,571	281,514	44,600
1904....	3,120,647	1,775,148	95,424	12,535	360,533	36,525
1905....	.....	.....	.....	.....	.....	.....
1906....	2,977,518	1,988,759	120,658	7,200	520,313	30,111
1907....	3,230,561	2,227,137	137,567	7,414	655,436	39,140
1908....	3,309,365	2,192,486	119,454	.....	573,681	50,770
1909....	2,871,274	2,354,635	118,184	.....	650,138	62,030
1910....	2,702,372	1,910,680	112,561	.....	779,756	91,907

[3]To 1910.

VALUE OF THE PRODUCT.

The total value of the product and the average net price per barrel are given in columns 6 and 7 of Table XXVI. Previous to 1880, the value has been calculated from the average price as given by the United States Geological Survey, and from that time to date, the price has been determined from the total value. It should be pointed out that the values given for 1893 and following years represent the actual value of the salt itself, whereas, before that date, the cost of the package is included. This not only explains the apparently great drop in price in 1893, but also gives fictitious values for the preceding years. If we allow twenty cents as the cost of the barrel (this is probably somewhat below the present cost), we see that the price per barrel has decreased from $1.65 per barrel in 1868 to $0.188 in 1902, with an average for the ten years (1901-10) of $0.244. The above figures are the average for all grades. Table XXIX gives the production for the five years; 1906-10, classified as to grades with the corresponding values. From this it may be seen, that while table salt has commanded for 1910 an average net price of $0.708 per barrel, brine salt was worth but $0.051; common fine, $0.331; common coarse, $0.349; and packers, $0.475 per barrel.

TABLE XXIX.[4]

Year.	Table and dairy.		Common fine.		Common coarse.		Packers.		Brine and other.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Barrels.	Dollars.	Barrels.	Dollars.	Barrels.	Dollars.	Barrels.	Dollars.	Barrels.	Dollars.	Barrels.	Dollars.
1906.....	909,905	362,368	2,927,478	737,479	2,021,287	618,727	91,089	33,733	4,387,043	246,462	9,936,802	2,018,769
1907.....	657,509	392,641	3,601,270	914,154	1,743,840	471,378	119,459	48,455	4,664,552	235,729	10,786,630	2,062,357
1908.....	584,452	629,647	3,454,062	968,617	2,029,956	610,286	134,726	53,669	3,991,083	205,484	10,194,279	2,458,303
1909.....	585,370	732,907	3,530,303	1,125,095	2,103,719	647,878	93,357	39,833	3,048,395	185,051	9,966,744	2,732,556
1910.....	798,434	565,653	2,216,181	734,823	1,992,465	596,301	92,426	43,942	4,104,934	211,317	9,652,022	2,231,262

[4]Compiled from U. S. G. S., Mineral Resources.

CHAPTER VI. THE INDUSTRY BY DISTRICTS.

For purposes of discussion, it has seemed advisable to limit the various districts to be discussed by county lines. Neglecting the early unsuccessful attempts to manufacture salt, as at Grand Rapids, the industry in the various counties will be taken up in chronological order. The general location of plants, both those which are producing and those which have been in operation in the past, is shown in Fig. 32.

Figure 32. Map showing producing salt districts of Michigan. Circles represent present producing districts. Crossed circles represent former producing districts.

SAGINAW COUNTY.

From the first production of salt in 1860 by the East Saginaw Salt Manufacturing Co., the industry grew very rapidly. Plants were established along both sides of the Saginaw river; at Salina and East Saginaw on the east side, and at Saginaw City, Florence, Carrolton, Zilwaukee, and Melbourne on the west side. In addition to these plants, salt blocks were built at Bridgeport and along the Cass River, at Buena Vista, Paines, Garfield, and later at St. Charles. All of the blocks at which salt is or has been manufactured are shown, as far as their location could be learned, in Fig. 33.

The manufacture of salt in the Saginaw valley has been and still is essentially a by-product industry. In the early days of the kettle and pan blocks, the refuse from the saw mills was used as fuel in evaporating the brine. When later the grainer process, the only one now employed in this district, was instituted, the slabs and sawdust were used to make steam for the saw mills and the exhaust steam was used in the grainers. More recently salt blocks have been operated in connection with industries other than lumber. Thus the Saginaw Plate Glass Co. utilizes its exhaust steam in the manufacture of salt, the Germaine block is run in connection with the Germaine Piano Co., and the Saginaw Salt Co., St. Charles, secures its steam from the Robt. Gage Coal Co. The decline of the salt industry in this county seems to have been correlative with the passing of the lumber, so that now but seven plants are in operation where once there were ten times as many.

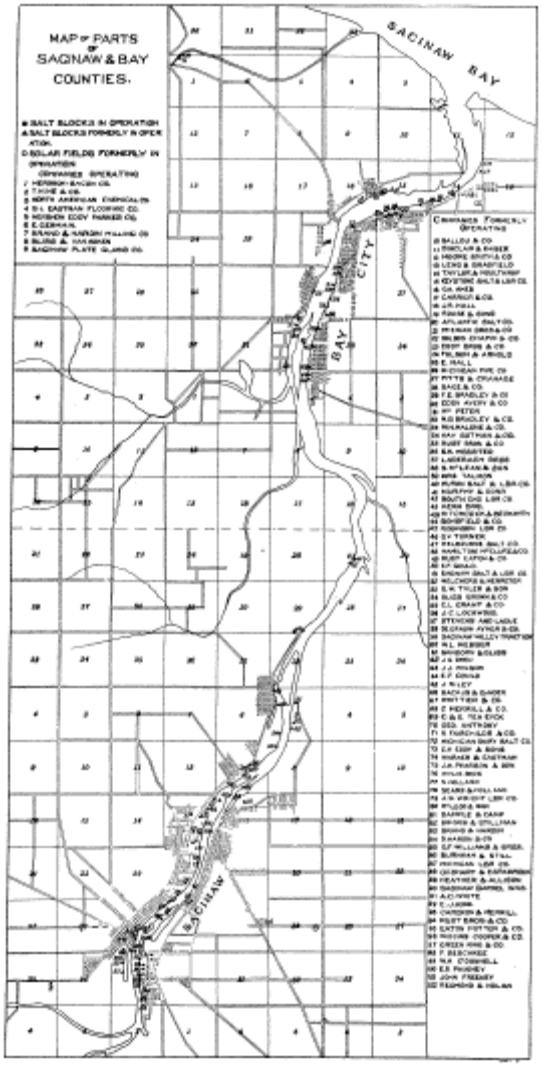

Figure 33. Map of parts of Saginaw and Bay counties.

Two brines have been used in the manufacture of salt, the Parma and the Napoleon. The latter, on account of its greater concentration, has been the more largely used and is the only one employed at the present time. This brine, the composition of which is shown by the analyses given, is found at a depth of about 650 to 820 feet.

The characteristic geological section of this district may be seen from the record of the No. 4 well of the Saginaw Plate Glass Co.,[1] which also contains references to other wells in that vicinity.

Saginaw Plate Glass Co., Well No. 4, 600 A. T. Near the S. E. cor. Sec. 33, T. 12 N., R. 4 W.

	Thickness	Total depth
Pleistocene.		
Fine sand. Algonquin beach (¼ mm.)	5	5
Plastic red clay	20	25
Like that at Paines, lacustrine, calcareous.		
Clay, blue	53	78
Bottom 6 feet "putty." All calcareous.		
Gravel with water	2	80
Till "hardpan" with coal	21	101
106 ft. in No. 1.		
8" casing 111 ft. in No. 2.		
122 ft. in No. 3.		
Saginaw formation.		
Dark shale, Lower Verne coal horizon? "Bastard"	14	115
Light (fire clay) and dark shale	7	122
Blue shale	17	139
Black shale	15	154
Coal, large Saginaw seam? or Middle Rider	7	161
Water Sp. Gr. 1.000.		
White shale with black impressions	4	165
"Fire clay."		
Dark shale. Saginaw coal horizon?	8	173
Blue shale with some hard seams	5	178
White shale and brittle blue shale	½	178.5
(probably some sediment).		
Dark gray shale	19.5	198
Very dirty shale	13	211
Coal horizon? Lower rider? Water Sp. Gr. 1.005.		
Dark shale	9	220
Gray shale	79	299
Water at 280, Sp. Gr. 1.005.		
Shale, part dark, part "fire clay" light	9	308
Lower coal horizon?		
Shales with nodules or bands of siderite	56	364
Very dark shale, coal horizon? Bangor Rider	12	376
Water at 375 Sp. Gr. 1.006.		
Blue shale	19	395
Micaceous sandstone	9	404
Very dark shale; almost coal	21	425
Near 410-425 coal horizon. Bangor coal?		
Dark shale	49	474
Water at 476 Sp. Gr. 1.016. Much gypsum.		
Parma Conglomerate and Sandstone.		
Transition sandstone, fine grained	24	498
Sand rock	23	521
Conglomeratic sandstone	14	535
Two samples missing, 535-583. I think they were Bayport limestone. Top beds at 476 contain some petroleum "gum" inspissated in a cavity. There was a ten inch drop of the tools. The base samples are full of split white quartz pebbles. In No. 2 this stratum is said to come at 520 to 555. In No. 7 this stratum is said to come at 485.		
Compare at East Saginaw 202.5-399; Litchfield, Carrollton, 302-411; Ketchem well 310-430; Gallegher 345-482; Southerland 341-408.		
Bayport or Maxville Limestone.		
Top at	535?	or 583
Limestone	81	616
Water at 561 ft. Sp. Gr. 1.012.		
Note that the water was fresher than at the top of the Parma. There was probably much erosion just above this, and the division between it and the Parma is irregular. In No. 2 it is from 555 to 625. Temperature 56° at 630 ft. by thermometer 9101, March 23, 1906.		
Michigan Series.		
Black and dark shale	35	651
Gypsum	25	676
Near margin of this basin at this time?		
Compare No. 2 gypsiferous shales to 717.		
Dolomite	12	688

	Thickness.	Total depth.
Alma 695.	58	746
Base shale		
With lime and gypsum at the top, sandy 735-743.		
Alma 905-945.		
Water at 620 Sp. Gr. 1.024.		
Note the doubling of salinity on striking the Michigan. Casing to keep out the gypsum goes to 698 feet. This second casing to cut off the gypsum somewhat over 600 feet deep is noticeable in all the wells.		
Gray limestone	5	751
Dark gray shale	9	760
Gray limestone	14	774
Water at 775 ft. Sp. Gr. 1.120?; more salt, less gypsum.	21	795
Blue limestone	14	809
Sandy shale	11	820
In No. 7, 3 ft. of red shale at 785 ft.		
Dolomite	78	898
Base in No. 6 at 812 ft. In No. 7 at 822 ft. In No. 2 from 717 to 822 ft., is dolomitic limestone.		
Upper Marshall (Napoleon) sandstone	2	900
In No. 7 at 887. In No. 2 at 913.		
Water at 27.5°C. has Sp. Gr. 1.193. By Salinometer 83° to 94°.		
Lower Marshall.		
Red clay		
5 ft. in No. 7 to 892; 3 ft. in No. 6, in No. 1 at 906 ft. In No. 3, 500 ft. West there is said to be more lime in the sand rock.		

On account of the large amount of impurities in the brine possessing a greater solubility than the sodium chloride, a bittern is formed after the evaporation process has been carried on for some time. It is therefore necessary to remove the bittern from the grainer and replace it with fresh brine. These bitterns are and have been for the most part thrown away. They have, however, been used in the manufacture of by-products. Until recently the only product obtained from the. bitterns was the bromine. The method employed consists, briefly, in treating the mother liquor with sulphuric acid and potassium chlorate in a stone still and distilling off the bromine into an earthenware receiver. The only stills now used in this district are at the plants of the Saginaw Salt Co., and they were not in operation at the time of

visitation. Recently the Saginaw Plate Glass Co., has installed a plant for the recovery of the calcium chloride (Plate IIIA). The process consists of evaporating the mother liquors with steam under pressure until a certain consistency is obtained and the product is then run into iron drums, sealed, and allowed to solidify.

It has been found impossible to obtain complete statistics of production from this district, but the data given in Table XXX affords a general idea of the rise and fall of the industry.

TABLE XXX.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1875	461,902	1887	1,115,169	1899	424,432
1876	590,976	1888	1,050,265	1900	418,053
1877	674,641	1889	--	1901	557,138
1878	--	1890	1,006,854	1902	331,250
1879	--	1891	962,954	1903	179,533
1880	1,148,644	1892	842,235	1904	187,285
1881	1,083,990	1893	640,837	1905	156,978
1882	1,287,273	1894	462,983	1906	143,502
1883	1,185,957	1895	479,887	1907	328,083
1884	1,245,912	1896	428,493	1908	337,161
1885	1,178,910	1897	284,337	1909	334,729
1886	1,213,764	1898	424,044	1910	357,576

Companies.

Saginaw Plate Glass Co. (Plates III and IVA), Saginaw, Mich. Incorporated Dec. 1909. Capital stock, $500,000.00. President, W. J. Wicks; vice president, A. D. Eddy; secretary-treasurer, Geo. C. Eastwood.

The plant consists of fourteen grainers (150'x12'x18" sloping to 21"), ten of which are run on exhaust steam and make medium salt, and four utilize the tail water from the others and make packers salt. The grainers are constructed of cement and those making medium salt are equipped with reciprocating rakers. The brine is obtained from ten wells ranging in depth from 892 to 917 feet. The brine is pumped with walking-beam pumps and stored in cisterns of which there are six (150'x20'x7'). Before passing into the grainers the brine is settled at a temperature of 175°F. to 180°F. There are three settlers (150'x12'x4'), (150'x12'x32"), and (150'x12'x6'). Exhaust steam from the glass works is used in evaporating the brine. The capacity of the plant is 1,000 barrels per day. Medium and packers grades are manufactured; and the product shipped by rail in barrels, sacks, and bulk, is sold through the Michigan Salt Association. Fifteen men are employed in operating the plant.

Brand and Hardin Milling Co., Saginaw, Mich. Incorporated, June 16, 1908. Capital stock, $50,000.00. President, J. F. Brand; vice president, C. H. Brand; secretary-treasurer, W. E. Dewitt.

The equipment consists of two wooden grainers (120'x10'x22"), three cisterns (20'x30'x6'), and one settler (120'x8'x6'). The brine is supplied by one well about 800 feet deep, the pumping being done with a walking-beam pump. The plant is operated with live steam and coal is used for fuel. The capacity is 100 barrels per day and six men are employed. The product is shipped in barrels entirely by rail. At the time of visitation the plant was not in operation.

Mershon Eddy Parker Co., Mershon, Mich. Re-incorporated, February, 1909. Capital stock, $500,000.00. President, F. E. Parker; vice president, C. A. Eddy; secretary-treasurer, A. H. Hempstead.

The salt block of this company is run in connection with and utilizes the exhaust steam from the planing mill and box factory. It consists of four wooden grainers (110'x12'x18") which make medium salt and are lifted by hand every forty-eight hours. The brine is supplied by two wells that were put down thirty to thirty-five years ago and have an approximate depth of 700 feet. There are four cisterns (30'x20'x5') and two settlers (120'x8'x5'). Tail water is used to supply the heat for the settlers. The capacity of the plant is 150 barrels per day and it has storage facilities for 5500 barrels of bulk salt. Shipments are made entirely by rail and largely in barrels, the product being sold through the Michigan Salt Association. The operation of the plant requires the services of five men.

S. L. Eastman Flooring Co., Carrolton Township, Saginaw Co., Mich. Incorporated, January 1, 1904. Capital stock, $80,000.00. President and treasurer, S. L. Eastman; secretary, W. H. Erwin.

This plant formerly the T. Jerome plant, is equipped with four wooden grainers, two of which are 7' 3"x115'x18" and two are 8'x110'x18". The salt is lifted by hand every forty-eight hours. Two wells, respectively 730 and 740 feet in depth are in operation. The thickness of the salt rock (that is the brine-bearing stratum) at this point is about 100 feet. Additional equipment consists of four cisterns (24'x24'x6') and two settlers (115'x7'x7' and 110'x10'x7'). The daily capacity is 100 barrels of medium salt. Both exhaust and live steam are used in the evaporation, but no coal is employed for fuel. The product is sold direct, mostly in barrels, and is shipped by rail. Number of men employed, six.

Bliss and VanAuken (Aaron T. Bliss and W. G. VanAuken), Saginaw, Mich. This plant consists of two wooden grainers (170'x10'x22"), equipped with automatic rakers, seven cisterns (80'x60'x5'), and one settler (170'x10'x5'). The brine is furnished by four wells ranging in depth from 800 to 1,008 feet, and the daily capacity is 100 barrels. The storage capacity is 12,000 barrels of bulk salt. Exhaust steam is obtained from the saw mill for evaporating the brine and the salt which is sold direct in barrels is shipped by rail. Six men are employed.

E. Germaine, Saginaw, Mich. The equipment consists of four wooden grainers (150'x12'x22") which are lifted by

hand, five cisterns (30'x30'x6') and two settlers (150'x10'x5'). The brine is supplied by two wells having a depth of 725 feet. On the day the plant was visited, the brine registered 96° by the salinometer. Exhaust steam is used exclusively and is furnished by the planing mill and piano factory. Storage capacity is 8,400 barrels in bulk. Shipments are made entirely by rail and mostly in barrels. The number of men employed is six.

Saginaw Salt Co., St. Charles, Mich. Offices at Bay City, Mich. Incorporated. Capital stock, $50,000.00. Presdient, Chas. Coryell; vice president, F. T. Woodworth; secretary-treasurer, F. W. Urch.

Plant No. 1 is operated in connection with the No. 1 shaft of the Robt. Gage Coal Co., and consists of five wooden grainers (150'x12'x 30") with hand lift and four cisterns (24'x12'x6'). The two wells have a depth of about 850 feet. The daily capacity is 100-150 barrels as operated, and the storage capacity is 20,000 barrels in bulk. The plant is also equipped with a still for the recovery of bromine from the bitterns. Plant No. 2 which is located at shaft No. 2 is a duplicate of plant No. 1. The product is sold direct in bags, barrels, and bulk, and shipped by rail. Fifteen men are employed.

[1]Geol. Sur. Mich., Ann. Rpt., 1908, p. 102. Corrections have been made in the figures for the thickness of the strata at 154-161 and 474-498. The two samples reported as missing at 535-583 show the sample from 535 to 561 to be a sandy limestone somewhat stained with limonite and from 561 to 583, a hard limestone with a slight clay odor.

BAY COUNTY.

Soon after the initiation of the industry in Saginaw, it spread to Bay county and the Bay City Salt Manufacturing Co. started boring in June, 1860. The first production however was made by the Portsmouth Salt Manufacturing Co., which began boiling July 28, 1861, the former company beginning operations in October of the same year. From this time on, salt blocks were constructed rapidly on both sides of the Saginaw river from Salzburg to Saginaw Bay. Two small salt blocks were also erected in connection with saw mills at Kawkawlin. The location of these blocks as far as could be learned is shown in Fig. 33. With regard to the development of the mechanical side of the industry, its history is practically that of Saginaw county except that it-has perhaps gone a step further in that we find here the vacuum pan in operation. As in Saginaw county, the manufacture of salt in this district is and always has been a by-product industry. At the present time the three blocks remaining in operation use exhaust steam; two of them being operated in connection with saw mills and the third, that of the North American Chemical Co., utilizes the exhaust from the chemical works.

Strictly speaking but two brines (the Parma and the Napoleon) have been employed as a source of the salt, although the deep well of the North American Chemical Co., the record of which is reproduced from the Geological Survey of Michigan, Annual Report for 1905; as well as the one sunk on the property of Pitts and Cranage, pierced the Berea. At the present time, with the exception of the small amount of Berea brine from the North American Chemical Co's. deep well, only the Napoleon brine is utilized. In addition to salt, the brine is used in the manufacture of sodium chlorate by the above named chemical company. The process consists in purifying the salt by recrystallization and then treating it electrolitically.

The Napoleon sandstone is here encountered at a somewhat greater depth than at Saginaw and so we find that the wells put down to strike this sandstone vary from 830 to 850 feet in depth. The characteristic geological section of the district is shown in Fig. 34.

With the exception of one or two years the production since 1875 is shown in Table XXXI. This table shows that the maximum production was reached in 1882, when, after remaining stationary for a few years, it began a decline, which with the exception of a small revival beginning in 1903 and culminating in 1905, has continued up to the present time.

TABLE XXXI.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1875	493,516	1887	891,462	1899	405,079
1876	657,288	1888	805,834	1900	404,053
1877	706,701	1889	--	1901	371,482
1878	--	1890	820,103	1902	137,903
1879	--	1891	811,890	1903	225,081
1880	1,081,841	1892	691,334	1904	225,984
1881	1,107,617	1893	593,550	1905	336,968
1882	1,158,279	1894	438,647	1906	282,314
1883	1,106,461	1895	573,960	1907	294,791
1884	1,110,445	1896	365,034	1908	206,880
1885	951,814	1897	340,894	1909	178,415
1886	907,384	1898	402,231	1910	104,987

Companies.

North Amercian Chemical Co., Bay City, Mich. Incorporated. Capital stock, $1;000,000.00. President, John Brock; secretary-treasurer, M. L. Davies.

This company which took over the wells of the McGraw Lumber Co., in Portsmouth township, just south of Bay City city limits, was formed to manufacture sodium chlorate, the manufacture of salt being carried on to utilize the exhaust steam from the chemical works. Both the grainer and vacuum pan processes are employed. The grainer block contains eight wooden grainers (144'x11'x22") and the vacuum pan block, two "single effect" pans, twelve feet in diameter. The brine is supplied by twenty-five wells. In addition to the above operating wells, the company also has six wells which have been abandoned. The average depth of the wells is about 950 feet, and the strength of the brine may be seen from the following data taken from the daily report sheet for February 14, 1910.

Well No.	%	Well No.	%	Well No.	%
1	100	11	--	21	--
2	100	12	--	22	100
3	91	13	88	23	100
4	--	14	95	24	100
5	--	15	100	25	--
6	76	16	100	26	--
7	--	17	--	27	--
8	91	18	--	28	100
9	88	19	100	29	100
10	--	20	--	30	100
				31	100

The average flow in the wells is equivalent to about fifty barrels of salt per well per day. The pumping is done by walking-beam pumps operated by electricity, and the brine after treatment as indicated on a former page, is stored in seven cisterns (40'x30'x8'). From the cisterns the brine passes through a filter into the hot settlers of which there are six (90'x9'x7') and thence into the graniers. The daily capacity is 1,000 barrels and storage is provided for 100,000 barrels.

Mershon-Bacon Co., Bay City, Mich. Incorporated. Caiptal stock $50,000.00. President, A. W. Bacon; vice president, E. C. Mershon; secretary-treasurer, W. B. Mershon.

This company, which is the successor of the Mershon Eddy Parker Co., Eddy Sheldon Co., etc., operates a small grainer block in connection with its saw mill. The block contains four wooden grainers (145'x12'x18") which are "lifted" by hand. The brine is supplied by three wells having a depth of approximately 1,000 feet, the pumping being done with walking-beam pumps. At the time the plant was visited, the strength of the brine was reported to have been falling off rapidly and considerable trouble was being experienced from gypsum.[2] The brine is stored in five cisterns (20'x20'x6') from whence it is drawn into the hot settlers of which there are two (145'x8'x6'). Only packers salt is manufactured and the daily capacity is 90 barrels. The storage capacity is about 9,000 barrels and the product is sold through the Michigan Salt Association. Shipments in bulk, barrels, and bags are made by rail. Five men are employed.

Theo. Hine and Co., Bay City, Mich. This company operates a small grainer block in connection with a planing mill. It contains two wooden grainers (150'x12'x18") which are "lifted" by hand. The brine is supplied by one well (the company has two wells but one is non-producing) and is stored in three cisterns (20'x30'x6'). Before entering the grainers the brine is preheated in two hot settlers (70'x12'x6'). The capacity is about 50 barrels per day.

[2]While the decrease in the strength of the brine might be due to an influx of fresh water through abandoned wells that have not been plugged, the increase in gypsum would seem to indicate that both difficulties are due to leaky casings which not only admit of an influx of fresh water but also of the Parma brine with its higher gypsum content.

HURON COUNTY.

The first salt well in Huron county was sunk by Ayres and Co., at Pt. Austin[3] in 1863. Later a salt block was erected and the industry gradually spread to Caseville, Pt. Crescent, Grindstone City, New River (1874), Port Hope (1874), Harbor Beach (Sand Beach) (1876), and White Rock (1872). A block was also erected at Old Bayport but was never in operation. As in the Saginaw valley, the manufacture of salt was associated very largely with the lumber industry and when the timber was removed and the saw mills closed down, the salt blocks disappeared, and in some instances the towns themselves, as for example Pt. Crescent and New River, no longer exist. Plate IVB shows the remains of the pan block of the Port Hope Salt Co. at Port Hope.

The brine employed in this district was obtained largely from the Berea sandstone which occurs at depths varying from 495-555 feet at White Rock, through 603-664 at Harbor Beach, 716-787 at Port Hope, 1,010-1,080 at Grindstone City and 1,160-1,225 at Port Austin, to 1,650-1,770 feet at Caseville. The composition of the brine is shown on a former page.

Complete statistics of production were not available but from Table XXXII a general idea of the magnitude, growth and decline of the industry may be obtained. No salt production has been reported from Huron county since 1896.

It was found to be rather difficult to locate definitely all of the wells of the various companies and even to determine the exact number of plants, as in some instances one plant was operated at different times by different companies and therefore all of the companies given in the state salt inspector's and other reports do not represent different salt blocks.

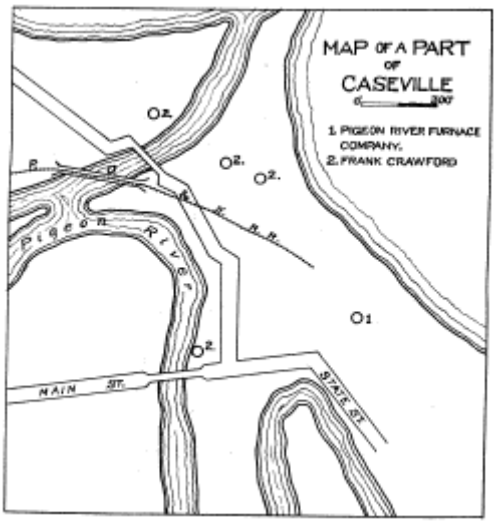

Figure 35. Showing location of salt wells at Caseville.

Figure 36. Showing location of salt wells at Port Austin.

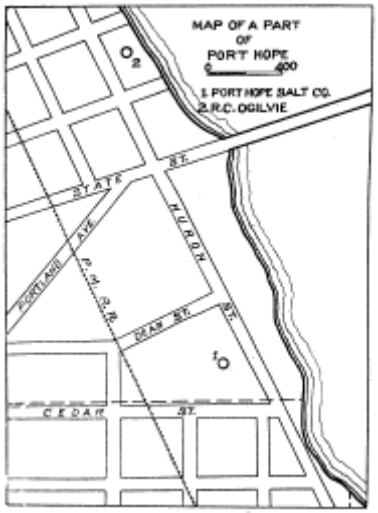

Figure 37. Showing the location of salt wells at Port Hope.

TABLE XXXII.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1870	15,296	1879	--	1888	163,209
1871	--	1880	256,841	1889	--
1872	--	1881	326,854	1890	55,861
1873	--	1882	255,012	1891	47,407
1874	--	1883	256,965	1892	31,159
1875	102,526	1884	313,832	1893	19,040
1876	184,884	1885	306,664	1894	21,335
1877	239,213	1886	240,569	1895	24,860
1878	--	1887	176,582	1896	2,665

The location of most of the wells of the various companies are shown in Figs. 35, 36 and 37, and the following table is believed to represent the different blocks together with the companies operating them.

Location.	Block.	Companies.	Process.	Wells.	Depth.
Old Bayport	1	Tremain and Clark[1]		1	2000[2]
Caseville	1	Frank Crawford	Pan	4	1760 —[3]
		Caseville Salt Co			2290
	2	Frank Crawford	Steam		
		Curran Flack & Conley			
		Flack and Conley			
	3	Pigeon River Furnace Co	Steam	1	1760[4]
Pt. Crescent	1	N. B. Haskell			
		Haskell Razek & Co		1	1250
	2	Williamson Eaken & Co		1	
		Eaken & Soule			
		C. F. Soule			
		D. L. Davis			
Port Austin	1	Ayres Learned & Co	Pan	1	1284[5]
	2 (?)	Ayres & Co., (Skene well)	Pan	1	1225[5]
	3	Thos. Winsor & Co	Pan	2	1300
		Port Austin Mfg. Co			
		R. W. Irwin			
		Razek & Irwin			
		R. Winsor & Son			
Grindstone City	1	Worthington & Co	Steam[6]	2	1080[6]
		Cleveland Stone Co			
New River	1	New River Salt Co	Pan	2	1029[10]
Port Hope	1	R. C. Ogilvie	Pan	1	
	2	Port Hope Salt Co	Pan	1	785[11]
		W. R. Stafford			
Harbor Beach. (Sand Beach)	1	Jenks & Co	Pan	2	702[12]
		Huron Dairy Salt Co	later Steam.		900 1920
White Rock	1	Thomson & Bro	Pan	3	555[13]
		R. Winsor & Co			700[13] 1311[13]

[1]Plant never operated.
[2]Lane, A. C., Geol. Sur. Mich., Vol. VII, Part II, p. 224.
[3]According to Mr. Wm. Johnson. 1198 feet according to Geol. Sur. Mich., Vol. V, Part II, p. 75.
[4]Geol. Sur. Mich., Vol. V, Part II, p. 76; Vol. VII, Part II, p. 224.
[5]Lane reports a pan block. Mr. Johnson a steam block.
[6]Geol. Sur. Mich., Vol. V, Part II, p. 62.
[10]For section see Geol. Sur. Mich., Vol. V, Part II, pp. 72-5.
[11]Geol. Sur. Mich., Vol. V, Part II, p. 76; Vol. III, p. 201.
[12]Geol. Sur. Mich., Vol. V, Part II, pp. 80-2.
[13]Same, p. 86.

[3]Lane, A. C., Geol. Sur. Mich., Vol. VII, Part II, p. 224.

MACOMB COUNTY.[14]

In the late sixties, a well was put down at Mt. Clemens for oil. The well was sunk to a depth of 1,000-1,100 feet and although no oil was found; a strong brine was obtained and the well was taken over by Snook, Bush and Mosher, who erected a salt block and for several years produced a small amount of salt. (An attempt to obtain statistics of the production failed). The venture however proved unsuccessful owing to the fact that the well did not pierce the rock salt of the Salina, but stopped in the Monroe formation and the brine contained too high a percentage of bitterns to be satisfactory for the manufacture of salt.

While this salt project proved a failure, it resulted in the discovery of the curative properties of the mineral waters which have made Mt. Clemens one of the most noted of health resorts. There was employed at the salt block a man by the name of Kellogg who was afflicted with salt rheum. He had formerly lived near the ocean and had observed that the sea water benefited his ailment and so he asked permission to use some of the brine. His request was granted and he built himself a small bath house at the plant, in which he effected a cure. The brine was then investigated by Dr. Taylor, who had the brine drawn from the well to his house in a tank wagon and used it in treating some of his patients with such success that the fame of the waters spread and the industry grew rapidly. The composition of these waters may be seen from analyses 58-60.

[14]For the major portion of the data, the author is indebted to Mr. John R. Snook, Mt. Clemens, Mich.

IOSCO COUNTY.

The first salt block in Iosco county was erected by Grant and Son at East Tawas in 1872. Later blocks were erected at Tawas City, Oscoda and AuSable. According to Mr. William Elliott, the well driller, the first well at Oscoda was put down for Smith, Kelley and Dwight in 1875, two wells being drilled for Loud, Gay and Co., at AuSable the next year.

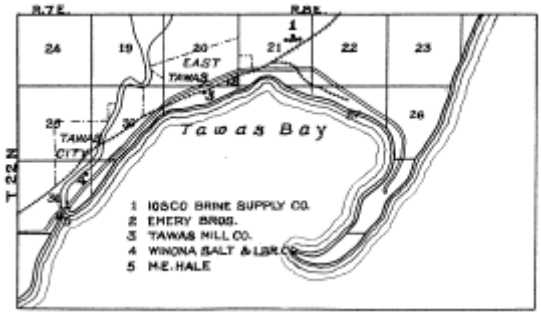

Figure 38. Sketch map showing location of wells at East Tawas.

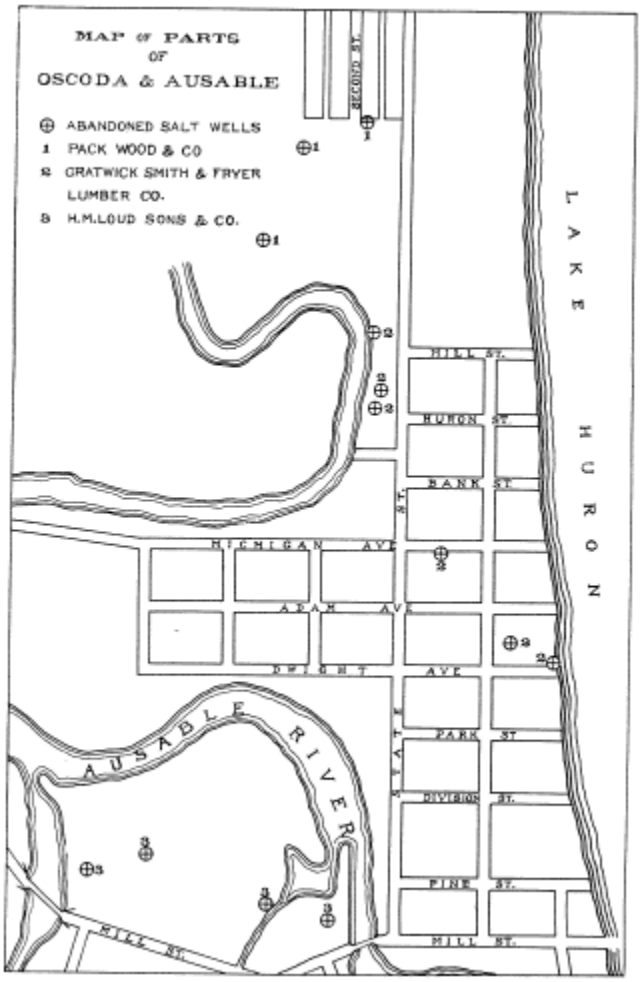

Figure 39. Showing the location of salt wells at Oscoda and AuSable.

The brine employed was the Berea, which was obtained at a depth varying from approximately 835 feet at East Tawas to 1,200(?) feet at AuSable.

The production as far as data are available is shown in Table XXXIII. No production has been made since 1902 and about all that remains of the industry is shown in Plate VA. In addition to salt, bromine was also manufactured by Emery Bros., at East Tawas.

TABLE XXXIII.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1875	8,895	1885	236,543	1895	97,592
1876	29,592	1886	235,143	1896	129,715
1877	40,342	1887	309,008	1897	42,231
1878	--	1888	346,369	1898	58,358
1879	--	1889	--	1899	5,601
1880	147,800	1890	289,232	1900	28,847
1881	147,579	1891	239,365	1901	17,128
1882	211,667	1892	230,897	1902	3,045
1883	210,644	1893	157,228		
1884	224,687	1894	87,100		

The location of the various plants and wells as far as determinable is shown in Figs. 38 and 39, and the following table gives the various blocks, companies operating them and such other data as are available.

Location.	Block.	Companies.	Process.	Wells.	Depth.
Tawas City	1	A. M. McBain & Sons, Winona Salt & Lumber Co.	Steam	1	
	2	M. E. Hale	Steam	1	
East Tawas	1	Tawas Mill Co, Weekes Bros.	Steam	1	835[15]
	2	W. G. Grant and Son, Emery Bros	Steam	1	883[16] or 903
	3	G. F. and H. B. Smith, Iosco Brine Supply Co.	Steam	5	
Oscoda	1	Pack, Wood & Co	Steam	7	
	2	Smith, Kelly and Dwight, Smith, Gratwick & Co., Gratwick, Smith & Fryer Lumber Co.	Steam	2	1070[16, 17] 1103
AuSable	1	Loud, Gay & Co, Oscoda Salt & Lumber Co. H. M. Loud & Sons L. Co.	Steam	4	1100–[18] 1200
	2	Potts Lumber Co	Steam	0[19]	

[15]Geol. Sur. Mich., Vol. V, Part II, p. 57.
[16]Same, p. 75.
[17]According to Mr. Elliott bottom of sandstone is at 1060 in first well, sandstone, 60 feet thick. According to Wright (Geol. Sur. Mich., Vol. V, Part II, p. 75), 80 feet thick.
[18]Personal communication from Mr. Loud.
[19]Obtained brine from Iosco Brine Supply Co.

MIDLAND COUNTY.

According to Mr. E. P. Rice, from whom the samples indicated in connection with the geological section shown in Fig. 40 were obtained, the first successful salt well in Midland county was put down at the Larkin plant in 1878 or 1879. Following this a number of plants were erected and a small production was maintained until 1903. Of much greater importance however has been the production of bromine by the Dow Chemical Co., who are the largest producers of that product in the United States. In addition to bromine, they manufacture a large number of other chemicals, most of which are by-products. A partial list of their products is as follows:

Bromine	Tetrachlorethylene.
Chlorine	Hexchlorethane.
Bromides	Dichlormethane.
Bromates	Benzyl chloride.

Bleaching powder	Sodium benzoate.
Carbon tetrachloride	Benzoate of lead.
Sulphur chloride	Arsenate of lead.
Chloroform	Lime-sulphur wash.
Chloride of iron	Chloride of zinc.

The brine employed at Midland is that from the Napoleon sandstone (for analyses, see subject of Napoleon brines)[20] which occurs at an average depth of 1,245 feet and varies from 75 to 125 feet in thickness. A complete geological section prepared from the record as given by Lane (Geol. Sur. Mich., Vol. VIII, Part II, p. 163) compared with samples from the No. 13 well of the Dow Chemical Co., is shown in Fig. 40.

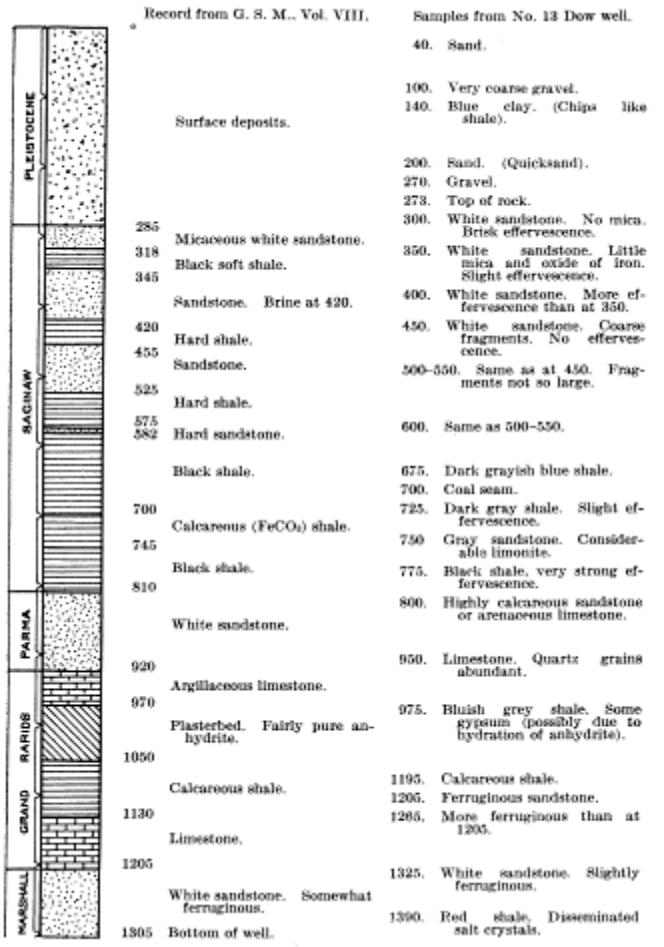

Figure 40. Section from record in Volume VIII, Michigan Geological Survey. Notes on samples from Well No. 13, Dow Chemical Company, Midland, Michigan, by C. W. Cook.

The production of salt for the district as far as data were obtainable is given in Table XXXIV.

TABLE XXXIV.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1880	41,462	1888	43,837	1896	24,358
1881	74,537	1889	--	1897	34,056
1882	80,239	1890	49,609	1898	31,799
1883	66,135	1891	40,603	1899	26,700
1884	65,726	1892	33,380	1900	34,021
1885	62,710	1893	40,524	1901	26,664
1886	67,121	1894	29,458	1902	14,967
1887	41,256	1895	24,275		

The plants which have been operated in this county together with various data concerning them are given in the following table.

Location.	Block.	Companies.	Process.	Wells.	Depth.
Midland	1	Larkin and Patrick Chas. Brown.	Steam	2	1300–1325[21]
	2	Wm. Patrick John Maloney.	Steam	1	
	1 and 2	Midland Salt & Lumber Co			
	3	J. Herrick and Co W. E. Cram.	Steam	2(?)	
	4	Samuel Foster Foster & McGill. Van Kleek & Co.	Steam	1	
	5	Dow Chemical Co	(Do not make salt)	13	1305–1390

[20]Mr. Dow states that the Midland brine is about equivalent to that at Saginaw boiled down two-thirds

[21]Geol. Sur. Mich., Vol. V, Part II, p. 69.

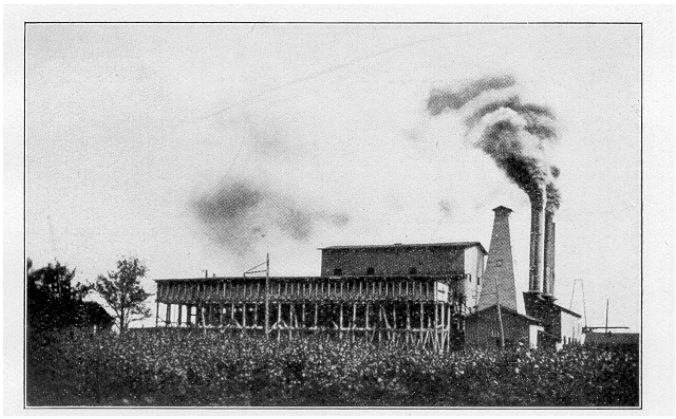

Plate II. A. Davidson-Wonsey Company, Marine City, Michigan, showing settling tanks.

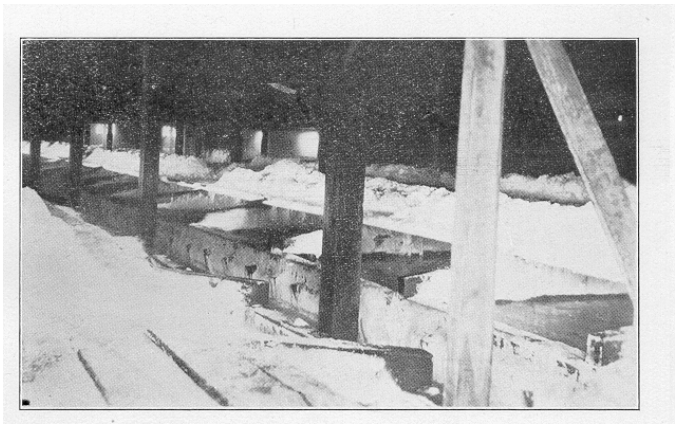

Plate II. B. A hand lift grainer, Stearns No. 2.

GRATIOT COUNTY.

Salt was first manufactured in Gratiot county at St. Louis, in 1882, by T. E. Holcomb. The plant consisted of a small grainer block, the brine, that of the Napoleon sandstone, being supplied by three wells. A small production (see Table XXXV) was maintained for several years, the plant being operated in turn by T. E. Holcomb,

H. T. Holcomb and A. T. Greenough. Later the wells were taken over by the St. Louis Chemical Co., and a plant erected to manufacture salt cake, sulphuric acid, hydrochloric acid, and bromides. The venture however did not prove a financial success and after changing hands several times the plant was finally closed. After having been considerably wrecked by a wind storm, the salvage was sold in 1910 at a receiver's sale for $25,000.00.

TABLE XXXV.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1882	3,285	1884	3,500	1886	350
1883	6,186	1885	3,115	1887	2,069

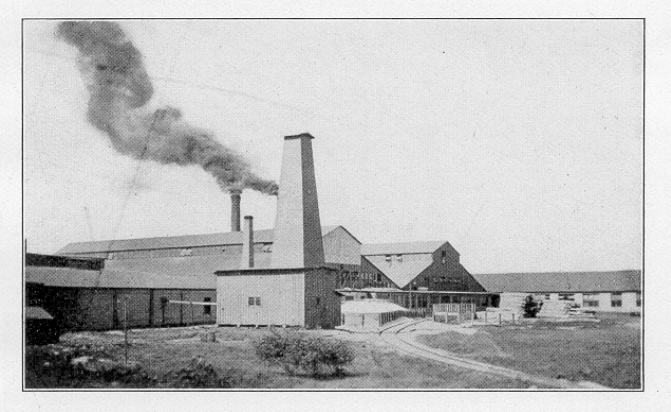

Plate III. A. Saginaw Plate Glass Co., Saginaw, Michigan. Glass works.

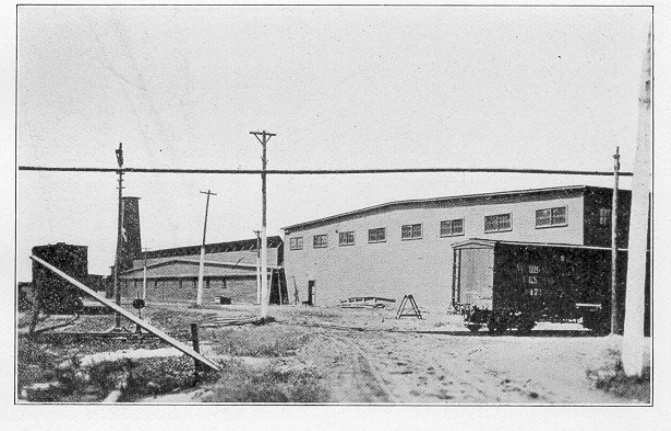

Plate III. B. Saginaw Plate Glass Co., Saginaw, Michigan. Grainer block.

MANISTEE COUNTY.

The beginning of the salt industry in Manistee county dates from September 10, 1881, when, according to Mr. Wm. Pehrson, the first lift of salt was made at the Rietz (now Sands No. 2) plant. The original well, which was begun in 1879, was put down for oil and gas and was started by a group of men of which Mr. Charles Rietz was the leading spirit. The funds were exhausted without any results having been attained and the well was taken over by Mr. Rietz who continued it on personal account. At a depth of 1,936 feet a salt bed 32 feet thick was encountered after an expenditure of about $19,000.00. From this beginning the industry grew rapidly, plants being established near the mouth of the Manistee river and along both sides of Manistee Lake at Manistee, Eastlake, Filer City, and Stronach, until to-day this district produces about one-third of the entire Michigan output of salt.

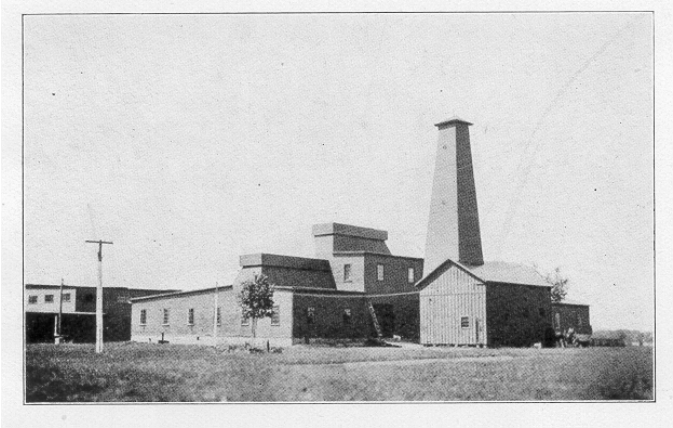

Plate IV. A. Saginaw Plate Glass Co., Saginaw, Michigan. Chemical works.

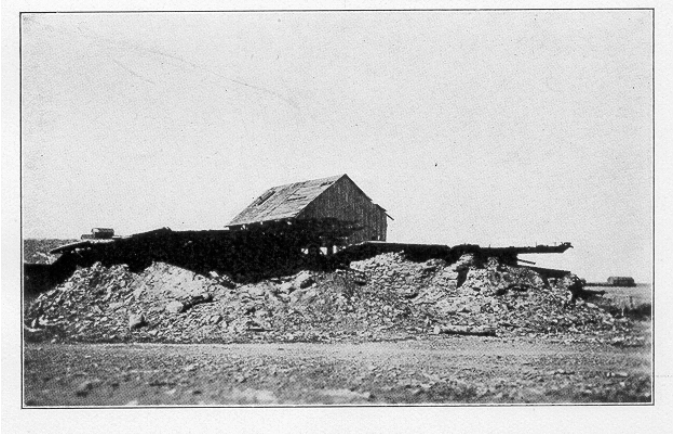

Plate IV. B. Ruins of Port Hope Salt Co., Port Hope, Michigan.

As in the case of the Saginaw valley and Lake Huron districts, the salt industry here has been associated with the lumber industry. Both the grainer and vacuum pan processes are in operation, exhaust steam from the saw mills being utilized in the evaporation.

The brines from which the salt is manufactured are obtained by dissolving the rock salt of the Salina formation. The salt beds have a thickness varying from 20 to 34 feet and are found at a depth ranging from 1,912 feet at the old Wheeler and Canfield well near the lake (Michigan) and 1,930 feet at Stronach, to 1,988 feet at Eastlake.

Plate V. A. Salt well at East Tawas, Michigan.

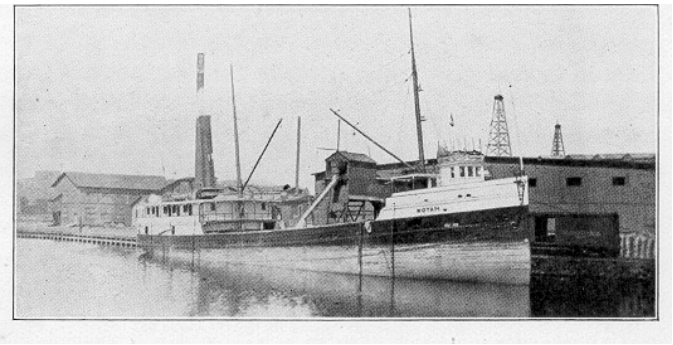

Plate V. B. Steam barge loading bulk salt at the No. 1. Plant of the Louis Sands Salt and Lumber Co.

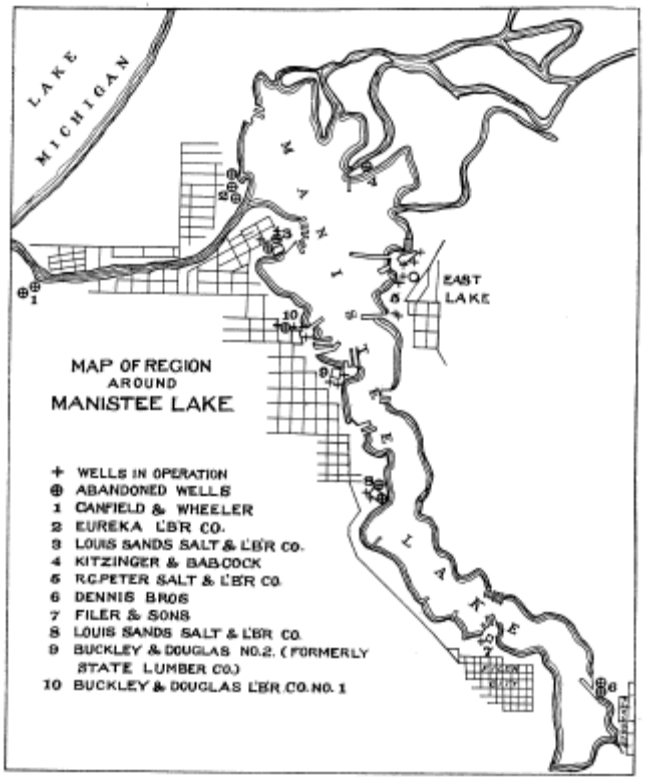

Figure 41. Map of the region about Manistee Lake showing location of producing and abandoned salt wells.

The characteristic geological section of this district is shown by the following well record compiled from the samples taken from the Peters well No. 7, the samples having been kindly furnished by Mr. R. A. Nickerson.

R. G. Peters Salt and Lumber Co., Well No. 7, N. W. ¼, N. W. ¼, Sec. 7, T. 21 N., R. 16 W., Alt. 600.

	Thickness.	Total depth.
Pleistocene drift	593	593
Antrim.		
Soft blue shale	4	597
Bluish gray calcareous shale	203	800
Hard black shale	187	987
Traverse.		
Porous limestone showing well developed crystals of dolomite	347	1325
Sandy limestone. Pronounced effervescence	75	1400
Grayish black limestone containing crystals of selenite. Harder than at 978	25	1425
Reddish brown limestone containing some bituminous matter	25	1450
Same. Somewhat softer and more bituminous. Samples at 1450 and 1475	37	1487
Top of "Cave rock." Soft grayish blue argillaceous limestone	13	1500
Calcareous shale. Softer and lighter colored than at 1487	50	1550
Crumbly soft shale resembling blue clay. Some effervescence	45	1595
Hard black limestone	10	1605
Dundee.		
Hard grayish brown (buff) limestone containing sand	15	1620
Reddish brown limestone containing bituminous matter	18	1638
Grayish shaly limestone. Sets up hard in bottle	7	1645
Fairly hard gray limestone. Does not set up in the bottle as does the above. Samples also at 1650 and 1652 which appear successively harder	11	1656
Softer brown limestone containing bituminous matter	2	1658
Monroe (Salina not separated).		
Harder grayish brown limestone	3	1661
Same as above except softer	19	1680
Hard reddish brown limestone	20	1700
Decidedly reddish limestone, softer than above	62	1762
Brown limestone with coating of gypsum on the grains	18	1780
Very hard yellow limestone	20	1800
Somewhat softer with more of a reddish tinge	10	1810
Buff limestone	10	1820
Softer brown limestone containing some gypsum	10	1830
Hard gray limestone. Sample at 1850 appears somewhat harder	32	1862
"Cave rock." Cherty limestone	8	1870
Soft grayish brown limestone	25	1895
Dark gray dolomitic limestone	10	1905
Dark gray porous dolomitic limestone containing selenite crystals in the cavities	15	1920
Harder brown limestone containing gypsum	10	1930
Same. Softer and darker colored	10	1940
Similar to above but lighter in color and containing gypsum	24	1964
Blackish gray porous limestone with gypsum	16	1980
Salt at 1980.		
Total depth of well		2000

Note: Gas was encountered at 730, 1100, 1654, and 1911 to 1916 it increased rapidly. Oil was encountered from 1916 to 1925.

There is sufficient flow of water in the rocks to cause the solution of the rock salt, so that it is not necessary to pump water into the wells for that purpose. In some instances, a small amount of water is pumped into the wells between the casing and the tubing to prevent the corrosive action upon the tubing of gases, especially the hydrogen sulphide which comes from the Devonian shales.

Three grades of salt are manufactured,—medium, granulated, and packers—and the product is shipped largely by boat to Chicago and Milwaukee for western distribution. Plate VB shows a boat loading bulk salt at the No. 1 plant of the Louis Sands Salt and Lumber Co.

The location of all the plants now in operation as well as those which have operated in the past is shown in Fig. 41.

The salt inspected in the Manistee district since the establishment of the industry is given in the following table.

TABLE XXXVI.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1881	1,642	1891	1,125,696	1901	2,670,094
1882	41,562	1892	1,294,139	1902	2,332,507
1883	48,544	1893	1,303,042	1903	2,202,054
1884	123,033	1894	1,134,244	1904	2,283,459
1885	432,637	1895	1,318,139	1905	1,921,634
1886	683,103	1896	1,416,709	1906	2,005,881
1887	871,575	1897	1,827,427	1907	1,966,335
1888	850,383	1898	1,555,006	1908	2,329,940
1889	--	1899	2,205,183	1909	2,107,489
1890	1,006,525	1900	2,253,769	1910	2,081,048

Companies.

R. G. Peters Salt and Lumber Co. (Plate VI A and B), Eastlake, Mich. Incorporated, March 2, 1884. Capital stock, $1,000,000.00. President, R. G. Peters; vice president, Wm. H. Anderson; secretary, A. W. Farr; assistant secretary-treasurer, J. R. Peters; assistant to the president, R. A. Nickerson.

This plant, which is the largest in the state, employs both the vacuum pan and grainer processes. The vacuum pans, of which there are three, are run "triple effect" and operate on exhaust steam. They are thirty feet in diameter and have a daily capacity of 4,500 barrels. On the average they are run at only sixty per cent capacity. There are twenty-one grainers (120'x16'x22") which are constructed of wood and equipped with reciprocating rakers, with a capacity of 3,200 barrels and an average daily output of 1,600 barrels. Exhaust steam is also employed in the grainers. Seven wells are in operation and one has been abandoned. The average depth of the wells is about 2,000 feet and the salt bed ranges from twenty to thirty feet in thickness. The brine from the wells is stored in three cisterns (300'x24'x8') and settled in the same number of preheaters which are of the same size as the cisterns. The pumping is done with compressed air from a depth of 850 feet under a pressure of 250 pounds. The storage capacity of the plant is 325,000 barrels. Two grades of salt are manufactured, granulated in the vacuum pans and medium in the grainers. The product, which is sold to the Morton Salt Co., is shipped almost entirely by boat; in bulk and barrels. 220 men are employed.

Louis Sands Salt and Lumber Co. (Plate VII A and B), Manistee, Mich. Incorporated, March 16, 1905. Capital stock, $1,000,000.00. President and general manager, R. W. Smith; 1st vice president, Isabella Sands; 2nd vice president, Louis M. Sands; secretary, Geo. M. Clifton; treasurer, Geo. M. Burr.

Two plants are operated by this company. The No. 1 plant which is located in the third ward may be described as follows: The brine which is obtained from two wells, respectively 2,012 and 2,014 feet deep, the pumping being done with compressed air under 250 to 300 pounds pressure, is evaporated in cement grainers of which there are fifteen (150'x12'x22"), the salt being removed by automatic rakers. There is one cistern (160'x24'x9') from which the brine passes into five preheaters of which four are 155'x12'x7' and one, 124'x24'x7'. The temperature of the preheaters is about 145° to 160° F. The daily capacity is 1,000 barrels and the storage capacity, 67,000 barrels. Two grades of salt, medium and packers, are produced.

Plant No. 2 is located in the fourth ward and is equipped with eleven grainers, ten of which are 150'x12'x20" and one is 160'x9'x20". During the day, exhaust steam is obtained from the saw mill and at night live steam is used. In addition to the refuse from the saw mill, about thirty tons of coal per week are used for fuel. The temperature of the grainers is 185° to 190° F. and the tail-water which leaves the grainer at a temperature of 150° F. is used in the four preheaters (2—190'x13'x 7.5'; 1—190'x15'x7.5'; 1—150'x10.5'x8.5'). The brine is obtained from two wells, respectively 1,962 and 1,969 feet deep. The salt bed has a thickness of thirty to thirty-two feet. The pumping is done with compressed air from a depth of 700 feet. The daily capacity of the plant is 600 barrels and the storage capacity, 60,000 barrels in bulk and 8,000 barrels in barrels. The product of both plants is sold to the Morton Salt Co., and is transported by boat. From the No. 1 plant the salt is shipped both in barrels and bulk in about equal amounts, while from the No. 2 plant the entire output is shipped in barrels. One hundred and twelve men are employed.

Buckley and Douglas Lumber Co. (Plate VIIIA), Manistee, Mich. Incorporated, December 31, 1892. Capital stock, $1,000,000.00. President, Edward Buckley; vice president, ...; secretary, T. J. Elton; treasurer, Edward Buckley.

As at the Peters plant, both the vacuum pan and grainer processes are here in operation. The vacuum pans, of which there are two, are the "single effect" type and have a diameter of eleven feet. There are fifteen cement

grainers (150'x12'x22"), twelve of which are equipped with automatic rakers and make medium salt, and three which utilize the tail-water and make packers salt. Both live and exhaust steam are employed and a considerable amount of coal is used for fuel. The company has four wells in operation and one which has been abandoned. Fig. 42 shows the condensed record of well No. 5 together with the casings and equipment for pumping the brine with compressed air. The brine is stored in two cisterns (230'x12'x8' and 170'x12'x8') and is settled in six preheaters (3—200'x12'x8' and 3—150'x12'x8'). The preheaters are carried at a temperature of about 160° F. The capacity of the plant is about 670,000 barrels per annum, the grainers being run the entire year and the vacuum pans for eleven months. The storage capacity is 450,000 barrels. The product, which consists of granulated, medium and packers salt, is sold direct and shipped entirely by rail.

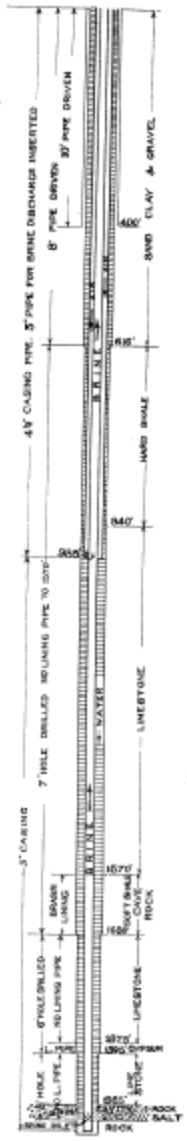

Figure 42. Section of the Number 5 well of the Buckley and Douglas Lumber Company, Manistee, Michigan, showing the geology and method of piping (after Hubbell).

State Lumber Co.[22] (Plate VIIIB), Manistee, Mich. Re-incorporated, April 18, 1907. Capital stock, $50,000.00. President, Patrick Noud; vice president, Thomas J, Noud; secretary-treasurer and general manager, Robert Blacker.

At the plant of this company only the grainer system is employed. There are seventeen grainers (170'x10.5'—12'x14"), all of which are constructed of wood. Eight of the grainers are equipped with automatic rakers and nine are lifted by hand. Both live and exhaust steam are used and the temperature of the grainers varies from 170° to 190° F. The brine is supplied by three wells having depths of 1,993, 1,995 and 2,003 feet respectively. The thickness of the salt bed in all of the wells is about twenty-five feet. The pumping is done with compressed air at a pressure of 275 to 300 pounds to the square inch and the air line extends to a depth of 900 feet. The brine is settled in three preheaters (212'x15'x8') which are carried at a temperature of 160° to 170° F. The plant runs about ten and one-half months in the year and has an annual capacity of 290,000 barrels, with a storage in bulk of 75,000 barrels.

Filer and Sons (Plate IXA), Filer City, Mich. E. G. Filer, managing partner. The plant contains one vacuum pan thirteen feet in diameter which uses the exhaust steam from the saw mill, refuse being employed as fuel. The brine is obtained from one well which was put down originally in prospecting for oil. The rock salt is encountered at 1,955 feet and has a thickness of 31 feet. The pumping is done with a beam plunger pump, the pumping station being 529 feet below the top of the well. Five settling tanks, all of which are piped for steam, are used alternately as cisterns and preheaters. The temperature of the preheaters is. maintained at about 170° to 180° F. According to Mr. Filer, a temperature of 172° F. gives the best results for the removal of gypsum in the preheaters. The capacity of the plant is 500 barrels of granulated salt per day and the plant operates about six months during the year. The storage capacity is 80,000 barrels.

[22]This company suspended operations in the fall of 1910 and the plant is now operated by the Buckley and Douglas Lumber Co., as their No. 2 plant.

ST. CLAIR COUNTY.

In 1882,[23] a well was sunk by the Marine City Stave Co., at Marine City, which, at a depth of 1,633 feet, encountered a bed of rock salt which was penetrated 115 feet without passing out of the salt. The following year a salt block was erected and a small amount of salt was produced. Later other plants were erected here and also at St. Clair, Port Huron, Algonac and Pearl Beach. At the present time no salt is produced at the two latter places. Perhaps the most striking characteristic of the industry in the St. Clair district is its independence from any other industry. All of the steam blocks in operation use live steam, and coal is employed as fuel. The location of the blocks on the St. Clair river provides cheap transportation for both the fuel and the finished

product. The sites of most of the plants are shown in Figs. 43 and 44.

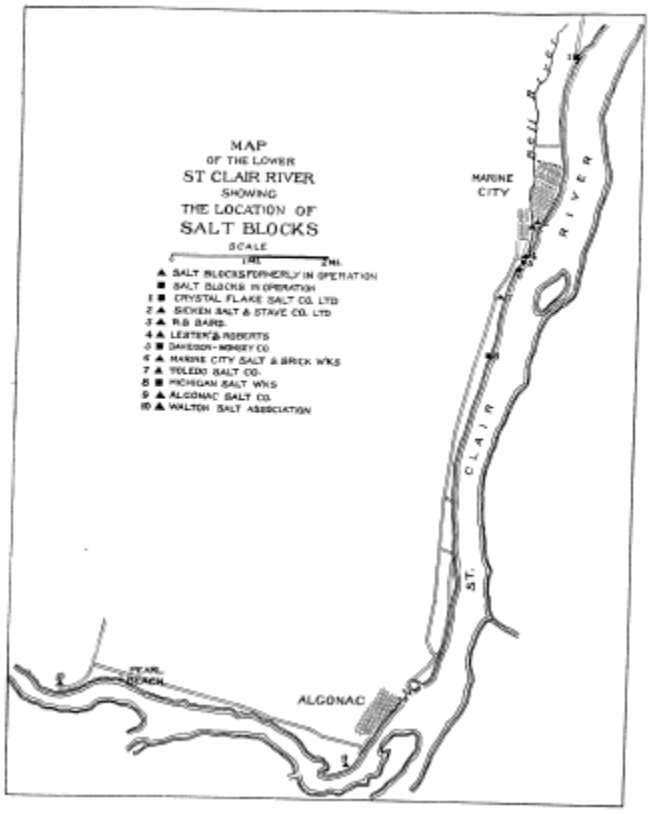

Figure 43. Map showing location of salt blocks along the St. Clair river.

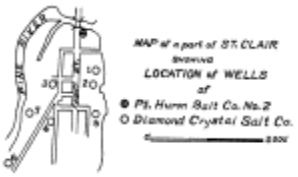

Figure 44. Showing the location of wells of the Diamond Crystal Salt Company and the Port Huron Salt company No. 2, St. Clair, Michigan.

Four different processes, vacuum pan; Alberger, grainer and open pan are in operation. All of these processes may be seen at St. Clair, the first three at the plant of the Diamond Crystal Salt Co., and the fourth at the No. 2 plant of the Port Huron Salt Co., on the adjoining property.

The brines are formed by the solution of the rock salt of the Salina formation. The salt beds vary somewhat in thickness and position at the different manufacturing points within the district as may be seen from the following well records.

Port Huron Salt Co., No. 5 well Sec. 32, T. 6 N., R. 17 E. A. T. 590.'

Record from driller's log and samples compiled by A. C. Lane.

	Driller's log.	Samples.
0–100	Unconsolidated deposits.	
100–305	Chocolate soft rock.	Brown bituminous shale with pyrite.
305–310		Blue argillaceous limestone.
310–327	Gray limestone.	Brisk effervescence.
327–337	Soapstone.	Soft blue shale. Calcareous.
337–393	Gray lime.	Blue and white mixed.
393–415	Soapstone.	Thin bedded blue limestone.
415–425	Gray lime.	
425–601	Soapstone.	
601–710	Light lime.	Limestone. Fierce effervescence.
710–715	Lighter lime.	Limestone, pure.
715–730	Gray lime.	
730–793	Lime.	Limestone, pure. Fragments coarse.
793–835	Mixed lime.	Lime and gypsum.
835–849	Lime and gypsum.	Mainly gypsum. Some selenite.
849–980	Limestone.	Dark dolomite, oily smell.
980–985	Black lime. Show of oil.	Oily dolomite or oil sand.
985–1240	Gray lime.	Dolomite very light.
1240–1300	Hard gray lime.	Dolomite.
1300–1305	Slate.	Dark blue dolomite.
1305–1325	Soft clay.	Soft blue shale. Slow effervescence.
1325–1332	Slate rock.	Blue shale, harder.
1332–1500	Slate. (1500, 1500, 1510, and 1408 in the other wells).	Dolomite and anhydrite.
1500–1595	Salt and shale mixed.	
1595–1665	Red lime.	Dolomite.
1665–1680	Salt.	
1680–1710	Red lime.	
1710–1740	Salt.	
1740–1750	Soft lime.	
1750–1775	Salt.	
1775–1887	Hard lime.	
1887–1920	Salt.	
1920–1965	Soft shale.	
1965–1991	Hard lime.	Dolomite.
1991–2190	Salt.	
2190–2195	Hard lime.	

Diamond Crystal Salt Co., St. Clair. Composite record[24] of wells Nos. 6 and 7 from driller's log. Started, February 10, 1909. Record furnished by Mr. F. W. Moore.

0-115	Clay.
115-153	Hard pan and gravel.
153-305	Blue shale or slate.
305-500	Brown shale.
500-512	Lime.
512-522	Blue shale.
522-542	Lime.
542-565	Blue shale.
565-590	Lime.
590-700	Soapstone.
700-710	Lime.
710-760	Soapstone.
760-820	Lime.
820-830	Sharp hard lime.
830-1120	Lime.
1120-1128	Hard brown lime.
1128-1160	Lime.
1160-1180	Hard sandy lime.
1180-1200	Very hard lime.
1200-1345	Very sharp lime.
1345-1400	Lime.
1400-1485	Very hard lime.
1485-1490	Mud vein.
1490-1495	Red shale.
1495-1570	Lime.
1570-1600	Hard brown lime.
1600-1620	Hard gray lime.
(First salt at 1630 in No. 5, 1620 in No. 6, and 1623 in No. 7.)	
1623-1653	Salt.
1653-1675	Lime.

1675-1685	Hard brown lime.
1685-1705	Lime.
1705-1743	Very hard lime.
1743-1763	Salt.
1763-1768	Lime.
1768-1778	Salt.
1778-1854	Shale.
1854-1884	Salt.
1884-1892	Lime.
1892-1902	Salt.
1902-1912	Lime
1912-2020	Salt.
2020-2025	Lime.
2025-2130	Salt.
2130-2135	Lime.
2135-2165	Salt.
2165-2200	Brown lime.

Michigan Salt Works, Marine City, Well. No. 2. Drilled in 1898. Log furnished by Mr. S. R. McLouth.

0-150	Clay.
150-165	Hardpan.
165-200	Clay and gravel.
200-400	Black slate.
400-415	Lime.
415-465	Soapstone. Hard to mill. Could cut about four feet per hour with 4" stem 43' long.
465-575	Darker and harder.
575-730	Lime. Averaged two feet per hour with 5⅛" stem, 38' long. Struck sulphur water at 710 and salt water at 725.
730-780	Brownish limestone. Soft. Easy on bits.
780-795	?
795-800	Streak of gypsum.
800-825	Hard streak of lime.
825-830	Gypsum.
830-850	Hard.
850-860	Gypsum.
860-870	?
870-875	Hard streak of lime.
875-900	Soft blue gypsum. (Anhydrite?)
900-970	Limestone.
	Shelly at 900.
970-1000	Averaged 15" per hour.
1000-1040	Flint limestone. Good drilling. 18' in twelve hours.
1040-1100	Same.
1100-1160	Sandy limestone. Hard.
1160-1300	Hard.
1300-1370	Caving rock and gypsum.
1370-1400	Record lost.
1400-1500	Hard.
1500-1570	Same.
1570-1595	Salt. (The record at this point is not clear, reading 10' lime, 10' salt, to 1605. Lime to 1612 -- lime 11'. Top of salt 1623).
1623-1751	Salt.
	Lime at 1751.

The production of salt in St. Clair county by years is given in Table XXXVII.

TABLE XXXVII.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1883	4,780	1893	285,583	1903	913,954
1884	74,671	1894	404,628	1904	1,309,764
1885	125,014	1895	463,094	1905	1,540,513
1886	250,602	1896	310,917	1906	1,365,256
1887	328,699	1897	297,064	1907	1,632,969
1888	325,616	1898	596,547	1908	1,543,844
1889	--	1899	432,929	1909	1,561,352
1890	242,011	1900	509,776	1910	1,296,605
1891	255,525	1901	871,915		
1892	347,242	1902	824,984		

Companies.

Port Huron Salt Co. (Plate IXB). Offices 717 Ry. Exchange Bldg., Chicago, Ill.; plants, Port Huron and St. Clair, Mich. Incorporated, January, 1900. President, Joy Morton; vice president, Mark Morton; secretary, Sterling Morton; treasurer, Daniel Peterkin; general manager. Otto Huette.

Two plants are operated by this company. The No. 1 plant is located about one mile south of the Port Huron city limits, and contains both a grainer and a vacuum pan block, in addition to which the plant has apparatus for the manufacture of table salt. The grainer block contains nine grainers, five, 18; wide and four, 14; wide. The vacuum pan is twelve feet in diameter. Live steam, supplied by fourteen Wicks boilers, is employed in evaporating the brine, which is obtained by dissolving the rock salt of the Salina formation through the medium of eight wells. The wells have a depth of about 2,200 feet, although the first salt bed is encountered between 1,500 and 1,600 feet. The annual production is about 400,000 barrels of which approximately one-half is table salt. The daily capacity is 3,000 barrels and the number of men employed is 200.

The No. 2 plant is located at St. Clair and was formerly operated by Thomson Bros. It is an open pan block containing five English direct heat pans (3—18'x77' and 2—18'x87'). The brine is furnished by one well, about 1,700 feet in depth. Coal is used for fuel and about forty men are employed in operating the plant.

Diamond Crystal Salt Co. (Plate X A and B), St. Clair, Mich. Capital stock, $650,000.00. President, C. F. Moore; vice president, P. R, Moore; secretary-treasurer, F. Moore; general manager, H. Whiting.

Three different processes, the vacuum pan, grainer, and the Alberger, are employed by this company. The chief process is the Alberger and the block contains five pans (44'x88'x12"). The grainer block contains six steel grainers and the vacuum pan block, one six-foot vacuum pan. Live steam, supplied by sixteen Wicks boilers, is used in evaporating the brine which is furnished by seven wells, ranging in depth from 1,630 to 2,200 feet. The daily capacity is 2,850 barrels. At present the plant is operating at about fifty per cent capacity and eighty per cent of the output is turned into table and dairy salt. 200 men are employed.

Crystal Flake Salt Co., Ltd. (Plate XIA). Plant, Marine City, Mich. Offices, Minneapolis, Minn. President, J. E. Vebleu.

The plant operated by this company contains six cement grainers (128'x12'x22"). Live steam is employed in evaporating the brine, which is furnished by one well 1,675 feet in depth. The average daily output is 320 barrels of medium and 18 barrels of packers salt. The storage capacity is 11,500 barrels and the number of employees, eight.

Davidson-Wonsey Co. (Plate IIA)., Marine City. Mich. Capital stock, $60,000.00. President, James Davidson; vice president, C. L. Doyle; secretary-treasurer, Palmer Davidson.

The company operates a vacuum pan block containing two "single effect" pans, twelve feet in diameter. Live steam for the evaporation of the brine is furnished by five marine boilers. The brine is supplied by two wells, respectively 1,750 and 1,900 feet in depth. The daily capacity is 1,000 barrels and the storage capacity is 21,500 barrels. Forty men are employed.

Michigan Salt Works. (Plate XIB), Marine City, Mich. Re-incorporated, 1903. Capital stock, $100,000.00. President, Wm. A. Hazard; vice president, Edwin J. O'Bryan; secretary-treasurer, Sidney C. McLouth.

The salt block is located about two miles south of Marine City and contains eight grainers, as follows: two cement grainers (164'x18'x22"); two steel V-grainers (100''x18'x6'), one wood and three cement grainers (120'x12'x22"). Steam for evaporating the brine is furnished by five marine boilers. The brine is supplied by two wells, respectively 1,630 and 1,851 feet in depth. The daily capacity is 800 barrels, about 20% of the output being turned into table salt. The storage capacity is 60,000 barrels and the number of employes, seventy-five.

[23]Report of the State Salt Inspector for 1882, p. 8.

[24]The record of the No. 7 well was not saved until after the first salt bed was reached at 1623 feet, compared with 1620 in No. 6. From the top of the first salt the record of the No. 7 well is used since it passed through the last salt bed whereas the No. 6 well did not.

MASON COUNTY.

The salt industry in Mason county has been centered around the city of Ludington. The only plant outside of the city was that of the Butters Salt and Lumber Co., located at Buttersville. across Pere Marquette lake from Ludington. This plant which burned in the fall of 1909 (Plate XIIA) and has not been rebuilt, is of historical interest as the home of the first vacuum pan used in the manufacture of salt in Michigan.

The search for salt was begun at Ludington in 1883 when, on June second, drilling was started by the Pere Marquette Lumber Co. The well was completed in 1885 at a depth of 2,220 feet.[25] The following year Mason county entered the list of producers with an inspection of 79,221 barrels. The industry advanced rapidly as is shown by the following table which gives the inspection to the close of 1910.

TABLE XXXVIII.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1886	79,221	1895	531,542	1904	512,505
1887	208,489	1896	547,843	1905	665,001
1888	280,715	1897	522,324	1906	679,187
1889	--	1898	557,838	1907	974,861
1890	367,617	1899	560,123	1908	679,564
1891	444,231	1900	718,654	1909	851,669
1892	341,668	1901	650,689	1910	818,728
1893	474,681	1902	514,745		
1894	500,546	1903	466,125		

The brine is obtained, as in Manistee county, by the solution of the rock salt of the Salina formation, which is encountered at a depth of about 2,275 feet. The geological section is shown by the following well records.

Anchor Salt Co. well No. 4.

Completed, March, 1908. J. H. Brogan, driller. Record furnished by Mr. P. Hardy.

	Thickness.	Total depth.
Sand and gravel	267	267
Clay	27	294
Hardpan	19	313
Clay	36	349
Sand	85	438
Clay	5	443
Hardpan and sand	25	468
Sand	40	508
Hardpan and gravel	2	510
Sand	4	514
Gravel	4	518
Sand	34	552
Gravel	6.5	558.5
Brown shale	3.5	562
Sand	1	563
Shale	10	573
Sand and gravel	2	575
Shale	60	635
Lime stone	14	649
Slate (probably hard shale)	24	673
Limestone	6	679
Red limestone	17	696
Lime	74	770
Sharp lime	112	882
Lime	18	900
Shale	167	1067
Lime	20	1087
Shale	146	1233
Black shale	29	1262
Brown shale	176	1438
Black shale	58	1496
Lime	44	1540
Water at 1536.		
"Trenton" lime	37	1577
Water at 1560.		
Brown sandstone	108	1685
Gypsum at 1686 and a vein of sand at 1617.		
Sharp sandstone	10	1695
Black sandstone	46	1741
Sharp sand	29	1770
Black sand	8	1778
Brown sand	57	1835
Dark sand	13	1848
Sharp sand	8	1856
Black sand	9	1865
Brown sand	20	1885
Yellow sand	33	1918
Brown sand	34	1952
Black sand	27	1979
Sharp sand	7	1986
Streak of shale	3	1989
Limestone	6	1995
Shale	69	2064
Black lime	10	2074
Brown lime	235	2309
Salt	20.5	2329.5
Bottom of salt at 2329.5.		

Anchor Salt Co. Well No. 5. Driller's log furnished by Mr. J. H. Brogan, driller. The top of No. 5 is 47 feet below the top of No. 4.

	Thickness.	Total depth.
Sand	90	90
Gravel	42	132
Sand	92	224
Gravel and hardpan	176	400
Sand	90	490
Blue clay	44	534
Slate	61	595
Blue lime	15	610
Slate and limestone	725	1336
Brown shale	147	1482
Hard limestone	468	1950
"Cave"	80	2030
Hard limestone	233	2263
1st salt	20	2283
Hard white lime	14	2297
2nd salt	12	2309
Limestone	25	2334
3rd salt	7	2341
Limestone	13' 9"	2354' 9"
4th salt	5	2359' 9"
Limestone	44' 9"	2404' 6"

The No. 3 well with a total depth of 2,360 feet showed three beds of salt, respectively 20, 9, and 8 feet in thickness. This well which has about the same elevation as No. 5 is located about 1,000 feet west and 700 feet north of it.

At present three plants are being operated by two companies. Their capacity is given by the state salt inspector as 1,650,000 barrels.

Companies. (See Fig. 45.)

Stearns Salt and Lumber Co. (Plate XIIB), Ludington, Mich. Incorporated. Capital stock, $500,000.00. President, J. S. Stearns; vice president, W. T. Culver; secretary-treasurer, R. L. Stearns.

Two plants are operated by this company. The Number 1 plant is equipped with nineteen wooden grainers (150'x12'x22"), thirteen of which are fitted with mechanical rakers. The grainers are carried at a temperature of 170° F., when making medium salt, and have an average daily capacity of 1,000 barrels. When making packers salt the daily capacity is reduced to 300 barrels. The evaporation is carried on entirely with exhaust steam, which is obtained from the saw mill, planing mill, and Stearns Light and Power Co. Both refuse from the saw mill and coal are used for fuel. The company, has three wells in operation, one abandoned, and one under construction. The brine is pumped with compressed air and stored in five rectangular cisterns (4—100'x13'x8.5' and 1—65'x18'x6'). Before entering the graiers, the brine is settled at a temperature of 130°—135° F. in preheaters of which there are six (4—150'x12'x8.5' and 2-65'x18'x6'). The storage capacity is 160,000 barrels in bulk and about 7,000 barrels in barrels. The product is sold direct, about four-fifths in barrels. Shipments are made both by rail and boat, the market being south and west of Michigan. At the time of visitation, in addition to the above, a twelve foot "single effect" vacuum pan was being installed, and the company was planning the addition of dryers and screens to make table salt.

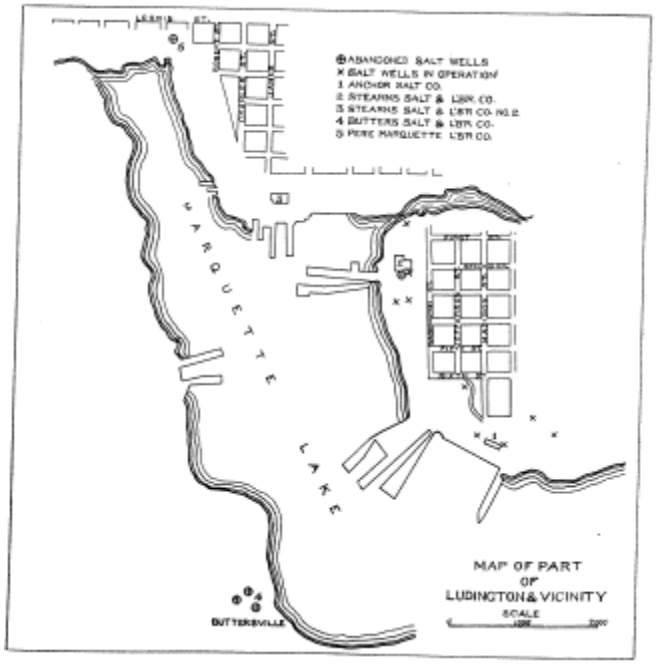

Figure 45. Map of a portion of Marquette lake showing the location of salt wells in that region.

The Rapid Evaporator Co., Detroit, Mich., likewise have under construction a "quadruple effect" vacuum pan of the Fallar type, the pans of which are rectangular, 12 by 9 feet, with an expected capacity of 30 tons of coarse or 90 tons of fine salt on a consumption of 24,000 pounds of steam. The Stearns company were to furnish the brine and steam for this plant.

The Stearns plant No. 2 is owned by the Cartier Lumber Co., and leased to the Stearns Co. Six wooden grainers (150'x12'x22") are in operation, the brine being supplied from the No. 1 plant and the steam being obtained from

the saw mill of the Cartier Lumber Co. The temperature of the grainers varies from 175° to 190° F. The salt is lifted by hand every twenty-four hours. The brine is settled in one preheater (110'x16'x7') at a temperature of 170° to 180° F. The daily capacity is 400 barrels and the storage capacity is 15,000 barrels in bulk and 4,000 barrels in barrels. The number of men employed is twenty, and the plant is operated about eight to nine months a year.

Anchor Salt Co. (Plate XIIIA). Plant, Ludington, Mich.; offices, Railway Exchange Bldg., Chicago, Ill. President, Joy Morton; vice president, Mark Morton; secretary. Sterling Morton; treasurer, Daniel Peterkin.

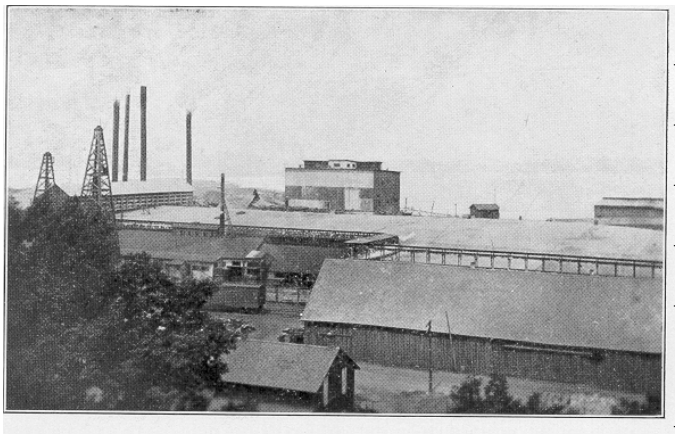

Plate VI. A. R. G. Peters Salt and Lumber Co., Eastlake, Michigan.

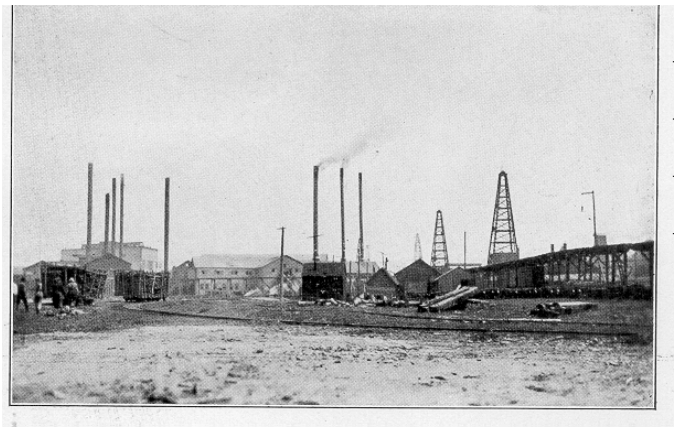

Plate VI. B. R. G. Peters Salt and Lumber Co., Eastlake, Michigan.

This company took over the Percy block and has replaced it with a vacuum pan block. The vacuum pan house is constructed of brick and contains three pans of the Ray type, respectively 18, 19 and 20 feet in diameter, which are run "triple effect" with provision for a fourth pan. The evaporation is carried on with live steam, coal being used for fuel. This is the only salt block in the Lake Michigan area which is operated independently of the lumber industry. The plant also contains three wooden grainers (150'x12'x22"). These however are not used. The brine, supplied by five wells, the logs of some of which have already been given, is pumped by air pressure and stored in three cement cisterns (44'x16' — 12'x136'). The cisterns are constructed in the side of the bluff shown at the right in Plate XIIIA so that after being allowed to settle the brine may be drawn by gravity into the pans or hot settlers of which there are three (160'x14'x10'). The rated daily capacity of the plant is 2,000 barrels and the storage capacity, 150,000 barrels in bulk and 6,000 barrels in barrels. Most of the product is shipped in bulk by boat to Chicago.

[25]The record of this well is given in Geol. Sur. Mich., Vol. V, Part II, Plate XXVII.

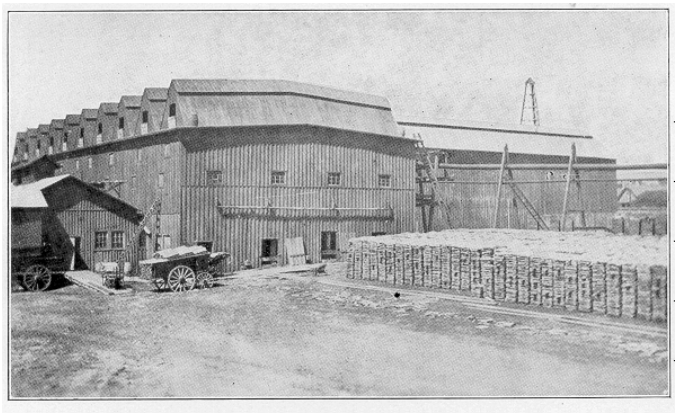

Plate VII. A. Louis Sands Salt and Lumber Co., No. 1, Manistee, Michigan.

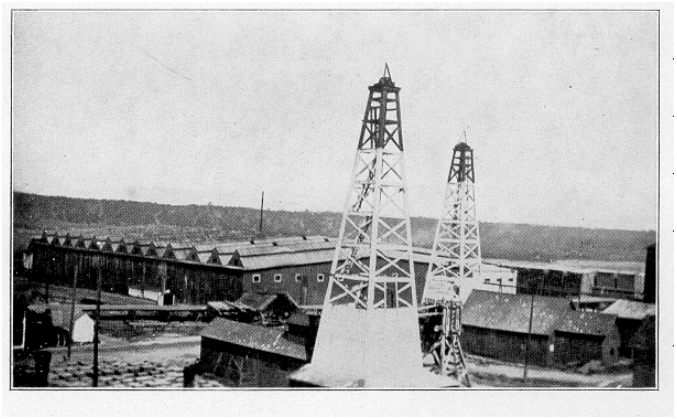

Plate VII. B. Louis Sands Salt and Lumber Co., No. 2, Manistee, Michigan.

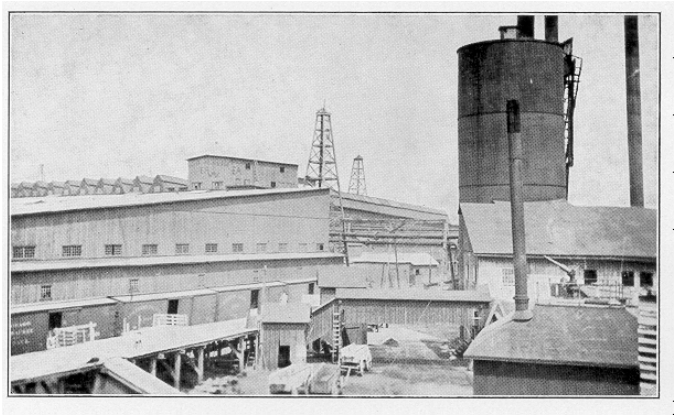

Plate VIII. A. Buckley and Douglas Lumber Co., No. 1, Manistee, Michigan.

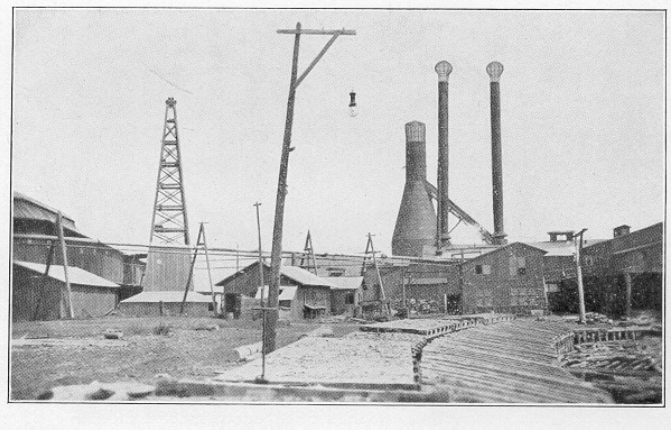

Plate VIII. B. Buckley and Douglas Lumber Co., No. 2, (State Lumber Co.), Manistee, Michigan.

Plate IX. A. Filer and Sons, Filer City, Michigan.

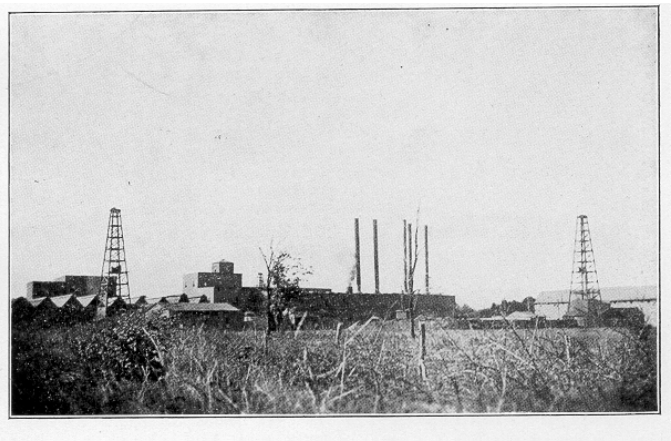

Plate IX. B. Port Huron Salt Co., Port Huron, Michigan.

WAYNE COUNTY.

The first production of salt in Wayne county was made at the plant of the Detroit Salt Co. at Oakwood in 1895, the total output for that year being 13,077 barrels. The next year blocks were constructed at Ecorse by the Tecumseh Salt Co., and at River Rouge by the Carter Salt Co., the former being a vacuum pan and the latter an open pan block. Neither of these plants produced any salt until 1897, when a production was also reported by the Morton Salt Co., at Wyandotte and by Brownlee and Co., at River Rouge. Since then the industry has grown quite rapidly and since 1906 the annual production has averaged over 1,000,000 barrels.

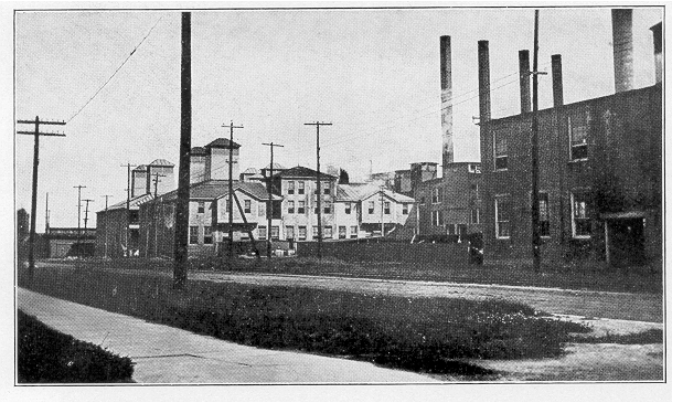

Plate X. A. Diamond Crystal Salt Co., St. Clair, Michigan.

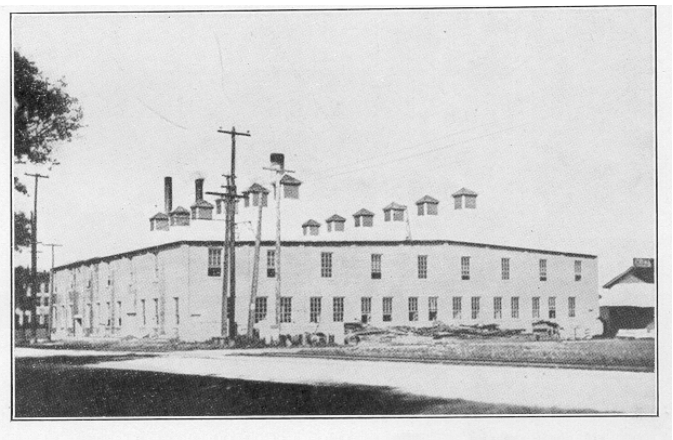

Plate X. B. Diamond Crystal Salt Co., St. Clair, Michigan. Grainer block.

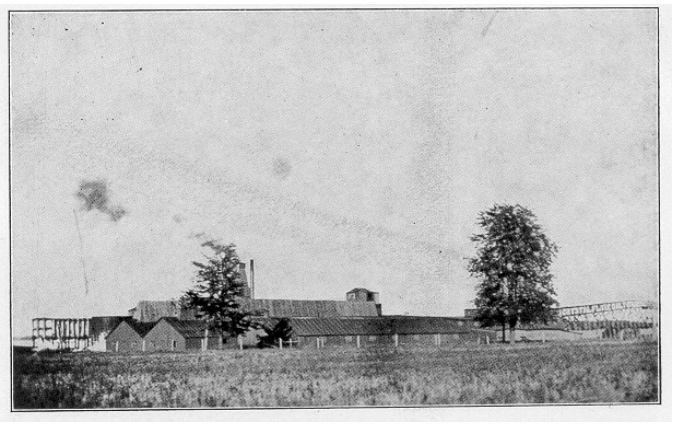

Plate XI. A. Crystal Flake Salt Co., Ltd., Marine City, Michigan.

In 1906 a radical departure in the salt industry of Michigan was made, when the Detroit Salt and Manufacturing Co., started sinking a shaft at Oakwood. Innumerable difficulties were encountered, the greatest perhaps being the strong flows of water which were struck at various depths, the strongest occurring in the upper portion of the Sylvania sandstone at a depth of 420-430 feet. Some loss of life was caused by hydrogen sulphide fumes, also financial difficulties beset the

company and it was reorganized as the Detroit Salt Co., which succeeded in reaching the rock salt and starting production in 1910. Operations being unsuccessful, the company defaulted the interest on its bonds and went into the hands of a receiver in the spring of 1911. The plant was later taken over by the Watkins Salt Co. of Watkins, N. Y.[26] and in 1913 by the International Salt Co.,[27] through the purchase of the stock of the Watkins company. The shaft is now[28] reported to be 1,150 feet deep and the production 12,000 tons per month.

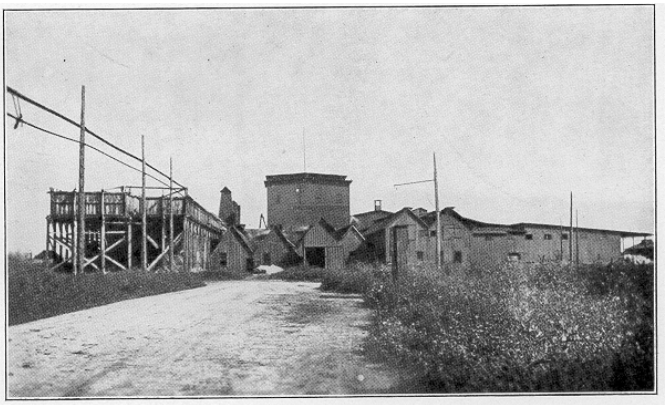

Plate XI. B. Michigan Salt Works, Marine City, Michigan.

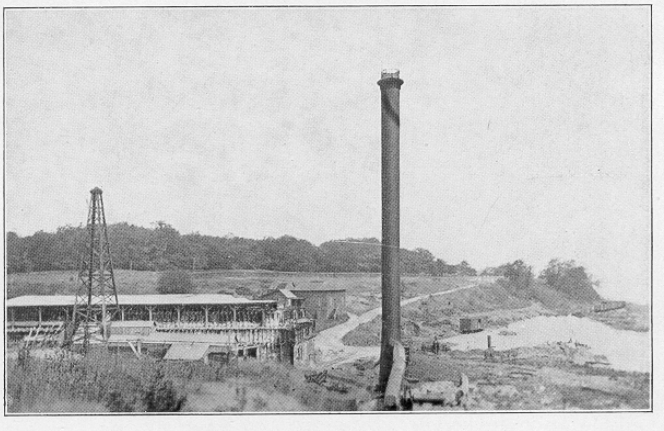

Plate XII. A. Ruins of the Butters Salt and Lumber Co., Buttersville, Michigan.

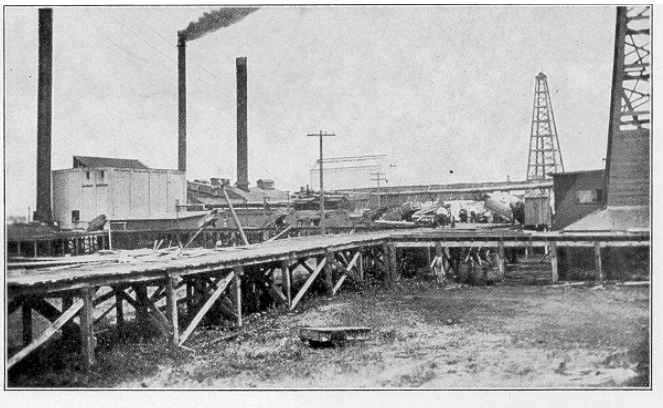

Plate XII. B. Stearns Salt and Lumber Co., Ludington, Michigan.

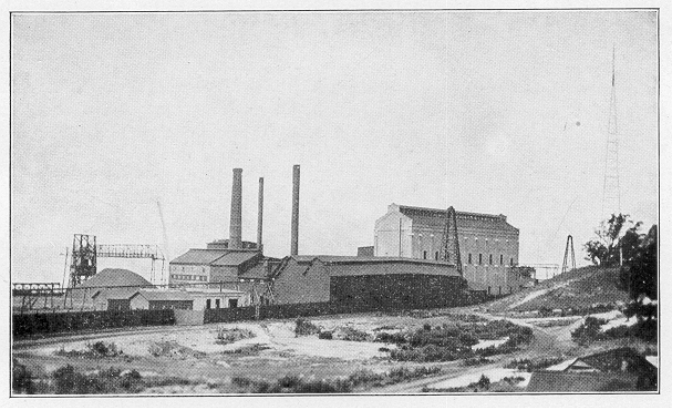

Plate XIII. A. Anchor Salt Co., Ludington, Michigan.

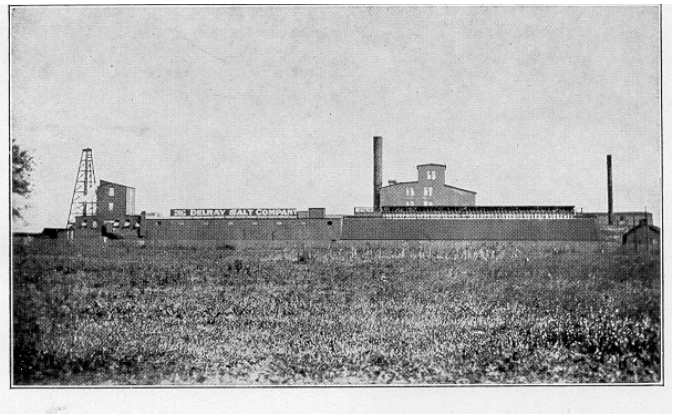

Plate XIII. B. Delray Salt Co., Delray, Michigan.

The salt deposits of the Salina formation in Wayne county are probably of more importance however, as a source of part of the raw materials for the manufacture of soda ash, bleach, caustic, etc., than as a source of salt itself. Large plants are operated by the Solvay Process Co. at Solvay, the Michigan Alkali Co. at Ford City and Wyandotte, and the Pennsylvania Salt Manufacturing Co. at Wyandotte, the last named company being the only one of the three to produce any salt and it is here merely a by-product. The processes employed by these companies are secret and description of the chemical works will not be attempted.

In addition to the rock salt produced at the shaft at Oakwood, three processes are employed in recovering the salt from the brine, the vacuum pan, open pan and grainer. Table salt is also manufactured by a number of the companies. In the main the salt blocks are run independently of any other industry, the exception being that of the Pennsylvania Salt Manufacturing Co.

The brine (the composition of which is shown in analyses) is obtained by solution of the rock salt of the Salina formation. There are a number of salt beds in this district, the beds varying in number, thickness and position from place to place. The general relationships can best be seen from the record of the No. 4 well of the Morton Salt Co., as compiled by Lane[29] with references to other wells. This is an exceedingly valuable record as samples were saved every five feet.

Morton Salt Co. Well, Wyandotte.[30]

Record begins with bed rock and the depths of samples are numbered therefrom. To find the depth from the surface add 62 feet to the sample number.

Pleistocene.		
Muck. Thin clay. Surface deposits	62	62
Silurian.		
Monroe above Sylvania.		
Light buff dolomites at 10 feet, perhaps oolitic. At 20-30 feet rather brisk effervescence, generally moderate to slow, some rounded sand grains. Samples 35, 40, 45, 50, 55, 60, 65, 70, 75 feet, light buff with moderate effervescence with acid. Occasional sand grains in 35, 40, 45. Sulphur in 60, and 65.	75	137
Dolomites. Dark brown, bituminous, with sulphur and sometimes pyrites, with moderate effervescence. S. 80, 85, 90, 95, 100, 105, and 110 not quite so dark; 115 brown; 120, lighter. Compare Church No. 5 down to 290.	60	197
Sylvania. Quartz sand, clear, very fine, most of the grains from .5 to .2 mm., rounded down to somewhere between .1 and .25 mm. S. 135, 140, 145, 150, 155, 160 very fine, 165, 170, from 175 on fine. 180, 185, 190, 195. Compare Ford 23, 285-325; Mt. Clemens, 965.	65	262
Dolomite. Light, effervescence moderate, in specks (due to crystals perhaps) faster. S. 200, 205, 210, 215. Compare Ford 23, 325-340.	20	282
Siliceous dolomite. Dark brown, with red, rust quartz sand and pyrites in spots, and very cherty at the base. S. 220 and 235 (with red rusty quartz sand). From 225 to 245 are dark brown, with brisk to moderate effervescence. S. 240 and 245 have rusted pyrite and grains of quartz sand. S. 250 has a lot of chert and quartz. Compare Ford No. 23, 375-435.	35	317
White sand like that above. S. 255, 260, 265, 270, 275, 280, 285.	35	352
Sandy dolomite. Grains rounded down to .16 mm. S. 290, 295, dark, with .16 mm. rounded quartz grains which may have dropped in from above.	10	362
Monroe below Sylvania?		362
Cherty dolomite. S. 300, marls cheri like Edison, Ft. Wayne, well at 625; 305, 310, 315 (drab color). At 320, 325, 330, 335 largely chert; at 340 to 345 almost solid chert, not effervescent. Compare Ford No. 23 at 440, and Church No. 5 at 420-520.	50	412
Dolomite. Dove colored, with relatively little chert. S. 350, 355, 360, 365. Compare Ford No. 23, 445, 450, 455, 460, 465.	20	432
Dolomite. Bluish, buff, massive. Coarse chips at 375-385; S. 370, 375, 380, 385, 390, 395. Compare Edison 462-477.	30	462
Brown dolomite. S. 400, 405, 410.	15	477
Light dolomite. S. 415, 420, under microscope rounded brown grains.	15	492
Dark dolomite. S. 425, 430, oolitic; 435, 440, with pyrite; 445, 450, 455, dark, bituminous, possibly oolitic; 460 quite dark and rusty; 465 lighter, sharp pieces, oolitic signs?; 470, 475, 480. Note that Ford No. 23 is oolitic at 465-470.	40	527
Light dolomite. Stylolitic with black specks. Compare Ford No. 23, 505-510, 545, 550. S. 485, 490 are sugary but not oolitic, but the latter has grains of gypsum.	25	552
Beginning of Salina?		
Impure gypsum. Bluish, with some dolomite, and nearly pure at 525 feet. S. 495 stuck together; n. m. largely gypsum; 500 to 505 some gypsum; 510 bluish gypsum, with part limestone, briskly effervescing; 515 and 520 blue with white gypsum; 525 largely solid white gypsum; 530 brown and white gypsum and dolomite. Compare Ford No. 23, 590-640, Edison Ft. Wayne, 900-950, especially 925 with 525, this well running about 400 feet less (minus 62 ft. drift) than the Ft. Wayne; about 100 feet less than the Ford No. 23. Compare Church No. 5 at 720. S. 535, 540 oolitic with dark, oval bodies, 445, 450. Anhydrite is quite abundant at 565 +62 ft. S. 555, darker, bluer, slow effervescence with gypsum; at 560 gypsum streaks; 565 mainly anhydrite. Compare Edison Ft. Wayne 1000 ft., Ford No. 23, 615-640. S. 570, 575 mixed; 580 cleaner buff dolomite; 585 n. m. mainly dolomite, bluish; 590, 595 mixed and bluish gray.	45	597
Dolomite. (Oolitic at 602 ft.)	20	617
Bluish dolomite and anhydrite. S. 600, 605, 610, 615, 620, 625, 630, 635, 640, 645, 650, 655, 660, all bluish, coarse chips, with occasional faint specks of anhydrite; 665, 670 similar, thinner brown calcilutites; 670, 675, 680 similar; 685 n. m. almost wholly dolomite; 690, 695 and 700 the same; 705, 710, 715, lighter, with crusts of anhydrite and gypsum; 720 dolomite with no anhydrite; 725 stuck together, salty. At 730 ft. is the first salt. Compare 795 at Ford No. 23. The Edison Ft. Wayne well seems to have salt at higher levels, the first salt there at 1010 ft. belonging to the upper part of this group, apparently.	175	792

Compare Church No. 5 at 890 ft.

Eureka Wyandotte	730–800
Ford No. 23	795
Ford No. 22	819
Ford No. 21	820
Ford No. 7	792
Ford No. 1	830
Ford No. 4	783
Solvay No. 11 and 12	865
Solvay No. 13	880
Solvay No. 14	875
Solvay No. 15	865
Solvay No. 16	890
Romulus (Laurence and Griffeth)	925
Tecumseh Salt Co.	828
River Rouge Improvement Co	815
Brownlee	875
River Rouge Salt Co.	871
Saliotte & Ferguson	855
Penn Salt Co.	830
Detroit Salt Co.	906
Stroh	1150
Royal Oak	1543
New Baltimore	1600
St. Clair	1600
Marine City	1604
Port Huron	1500

Salt. S. 730 bluish, like rock above; 730-775 brown salt. This is the bed most likely to contain potash. S. 730, 735, 740, 745, 750, 755, 760, 765, 770, 775.	50	842
Dolomite. Hard. S. 780, 785, 790, 795, 800, slow effervescence, n. m. very little anhydrite, more just above the salt; S. 805, 810, 815, 820, blue and buff. Compare Ford No. 23, 922-927. S. 825, 830, 835, 840, 845, 850, 855, clear, buff, bluer at the bottom, very little anhydrite. Compare Wyandotte 870-900. Ford No. 23, 937–1000.	80	922
Dolomite with anhydrite. S. 860 n. m. much anhydrite; 865 anhydrite and dolomite.	10	932
Anhydrite with salt. S. 870, 875. While this is the second salt in this well, and would thus correspond to 940 ft. at Wyandotte Eureka, and 852 at Ford No. 23 (probably really to 1027) it is probable that these salt beds are not persistent. Edison Ft. Wayne 1280–1292 may also correspond. Ford No. 1 is the same.	10	942
Dolomite. This is merely a parting, but seems fairly persistent. Compare Ford No. 1, 968–976; Wyandotte 960.	5	947
Salt. S. 885 light gray, 890 white, 895 impure gray salt. Compare Ford No. 23, 1022–1046.	15	962
Dolomite, anhydrite and clay. 900 bluish and dark buff; 905 stuck together, salty, gray, and the rest of the samples to 995 are more or less stuck together; the effervescence moderate to slow; a little anhydrite generally visible under the microscope; the color, 910 gray and pink; 915 bluish and gray; 920 and 925 reddish and blue, salty; 930 not quite so red; 935 the same; 940 bluish, thin bedded, shaly; 945 the same; 950 quite muddy; 955, 960, 965 bluish; 970 blue, shaly; and 975, 980, 985, 990, 995, all similar, but the shaly stuff may have washed in from above. However, the coarser fragments are a bedded lime mud rock (dolomilutite). These correspond to the "slate" shaly beds in Ford No. 23, from 1046–1124. Compare also Wyandotte 970–1045; Church No. 6, 960–1160.	100	1062
Almost solid anhydrite. S. 1000 solid anhydrite, lighter in color and less shaly looking. Compare: Edison Ft. Wayne 1400 ft. Wyandotte 1045 " Ford No. 23 "	5	1067
Dolomite and anhydrite. S. 1005 n. m. dolomite and anhydrite, buff; S. 1010 bluish, salty; 1015 like 995; 1020 buff; 1030 rather buff; 1035 a shade bluer; 1040 and 1045 some anhydrite is scattered in large grains in in dolomite. The base of this is the top of the main and it seems to me the most persistent salt bed.	50	1117
Salt, dolomite and anhydrite mixed	5	1122
Salt. Samples to 1075 +62	201	1323

We should then compare:

?Church No. 6, Trenton	1280
Wyandotte Eureka	1080–1235 (less 45?)
Moerton	1119–1323
Romulus	1475–1600 with partings.
Milan	1540–1545
Zug Island	1290–1528
Solvay No. 11	1370–1602 with parting.
Edison Fort Wayne	1445–1656
Stroh	1565–1815
Royal Oak	2115–2475
Port Huron	1991–2190

Not including the brine salt, the production for Wayne county is shown in Table XXXIX.

TABLE XXXIX.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1895	13,077	1901	414,927	1907	1,101,424
1896	110,508	1902	734,844	1908	1,150,367
1897	274,431	1903	399,235	1909	1,012,007
1898	546,093	1904	871,815	1910	938,332
1899	672,623	1905	1,020,159		
1900	370,912	1906	1,168,629		

Companies. (See Fig. 46).

Delray Salt Co. (Plate XIIIB)., Delray, Michigan. Incorporated, 1901. Capital stock, $100,000.00. President, N. W. Clayton; treasurer, A. A. Nelson; general manager, Jos. P. Tracy.

The plant of this company which is located at the corner of Anspach and West Jefferson Ave., employes both the grainer and the vacuum pan processes. The grainer block contains six cement grainers (160'x 16'), which are equipped with mechanical rakers. The brine, supplied by two wells, is stored in one cistern and preheated in one preheater before passing into the grainers. The vacuum pan block contains three pans, respectively 9, 10 and 11 feet in diameter, which are operated "triple effect." Live steam, supplied by three 335 horsepower boilers, is used in both the grainers and the vacuum pans. The daily capacity of the grainer block is 800 barrels of medium salt and that of the vacuum pan block,

1,200 barrels of granulated. The plant is also equipped to manufacture table salt, being therefore a producer of all grades of salt except rock salt. The storage capacity is 100,000 barrels and shipments are made both by rail and by boat.

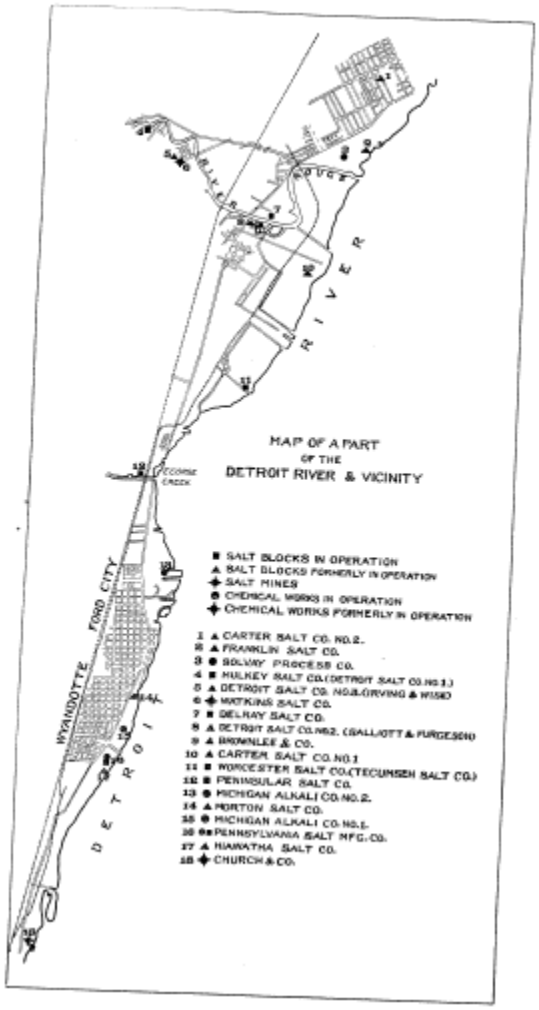

Figure 46. Map showing the location of salt blocks in Wayne county.

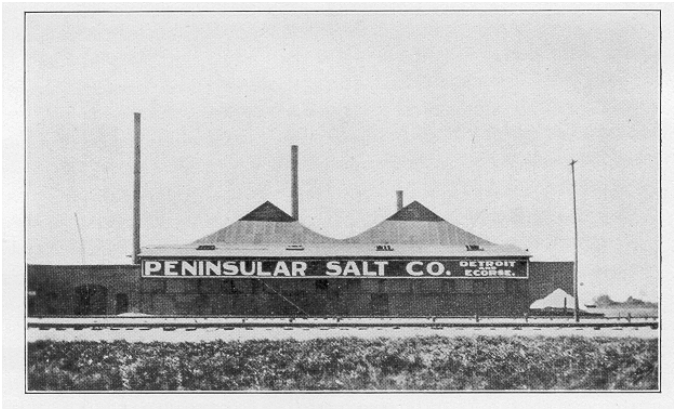

Plate XIV. A. Peninsular Salt Co., Ecorse, Michigan.

Peninsular Salt Co. (Plate XIVA), Ecorse, Michigan. J. R. Bemer, general superintendent.

The plant of this company, which is located at the south limits of Ecorse, at the junction of Ecorse creek and the Michigan Central tracks, was not in operation at the time of visitation and has not been operated since. It is equipped with two direct heat open pans (22'x100'); one cistern, which is piped and uses the exhaust steam from the pumps, and one well. The steam for the pumps is supplied by one 150(?) horsepower boiler.

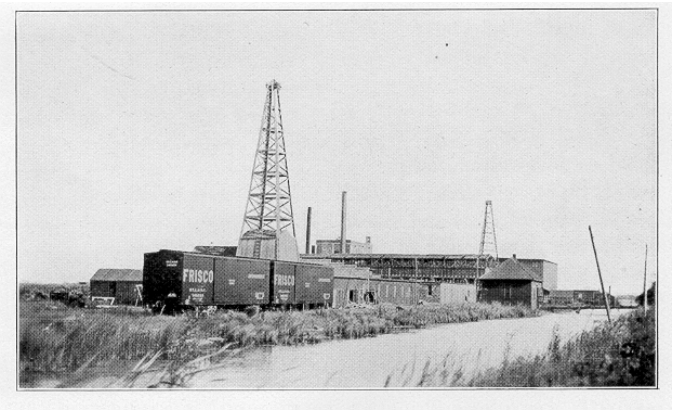

Plate XIV. B. Worcester Salt Co., Ecorse, Michigan.

Worcester Salt Co. (Plate XIVB), Ecorse, Michigan. Main offices, 168 Duane St., New York City. President and secretary, Lorenzo Burdick.

This company, which also has a plant at Silver Springs, N. Y., operates the plant formerly operated by the Tecumseh Salt Co. Both the grainer and vacuum pan processes are employed, the grainer block containing eight iron grainers (140'x12'x22") and the vacuum pan block, three ten-foot pans, two of which are run "double effect" and one, "single effect." Live steam is used in the evaporation and is supplied by six boilers, while the brine is furnished by two wells having a depth of approximately 1,525 feet. The daily capacity is 2,500 barrels and about forty per cent of the output is turned into table salt. Fifty men are employed in operating the plant.

Pennsylvania Salt Manufacturing Co., Wyandotte, Michigan. Offices, 115 Chestnut St., Philadelphia, Pa. Capital stock, $10,000,000.00. President, Theo. Armstrong; vice president, Austin Purvis; secretary, J. T. Lee; treasurer, A. E. Rice.

Salt is manufactured by this company only as a by-product in the production of caustic and bleach, the exhaust steam from the chemical plant being used to evaporate the brine. The salt block contains one twenty-foot vacuum pan of the Ray type with a daily capacity of 200 tons. The product is disposed of to the Morton Salt Co.

Morton Salt Co. Offices, 717 Railway Exchange Bldg., Chicago, Ill. Plant; Wyandotte, Michigan.

The plant of this company, which has not been operated for several years, contains five wooden grainers provided with automatic rakers. Originally it also contained six V-grainers but preparations were being

made to remove them at the time of visitation. The company possesses four wells the log of one of which has already been given. The steam for evaporation is supplied by twelve 150-horsepower boilers.

Detroit Salt Co., (Plate XV).

This company formerly operated two open pan blocks at Oakwood grainer blocks at River Rouge and Wyandotte (Hiawatha Salt Co.), and the salt shaft at Oakwood. The larger of the two Oakwood blocks, known as Detroit Salt Co., No. 1, is now operated by the Mulkey Salt Co. The other block which was located at the salt shaft has not been operated for some years. The block at River Rouge burned in 1909 and the Hiawatha block was not in operation at the time of visitation. The mine as already indicated has been taken over by the International Salt Co.

The No 1 block contains six open pans with no return flue, which have a daily capacity of 1,000 barrels. The brine, supplied by three wells, is stored in seven cisterns (16'x32'x6') and is not preheated before passing into the pans. About one-third of the output is turned into table salt. The storage capacity is 30,000 barrels and 125 men are employed.

Hiawatha block. This block contains three iron grainers (120'x14'x22") equipped with mechanical rakers. The brine is furnished by one well and is stored in a cistern (120'x10'x6') and preheated in a pre-heater of the same size. The plant also contains five boilers the grainers having been operated on live steam.

Salt shaft. The description of the equipment is taken from the Engineering and Mining Journal,[31] which also contains an account of the difficulties encountered in the sinking and the manner in which they were overcome. The equipment consists of a steel headframe 125 feet high m which is located a crushing plant similar to that employed for crushing coal. The hoist is of the Thompson-Greer type and is capable of operating to a depth of 1,500 feet at a speed of 1,800 feet per minute. The shaft is a three compartment one (6'x16') in the clear, and at the present time[32] has a depth of 1,150 feet.

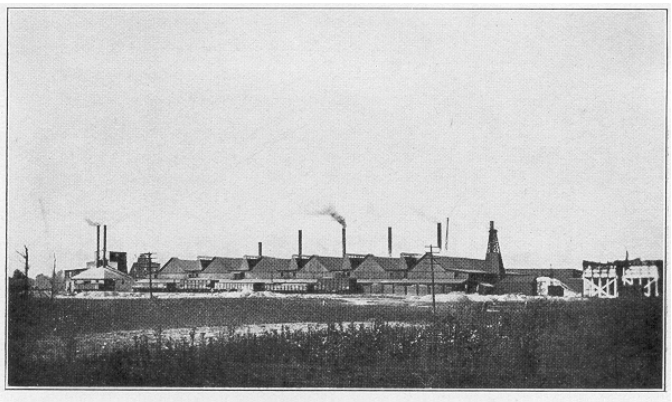

Plate XV. A. Mulkey Salt Co., Oakwood, Michigan.

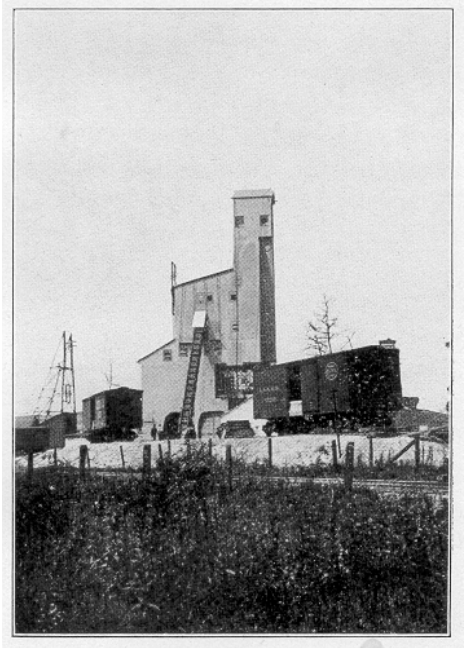

Plate XV. B. Shaft of Watkins Salt Co., Oakwood, Michigan.

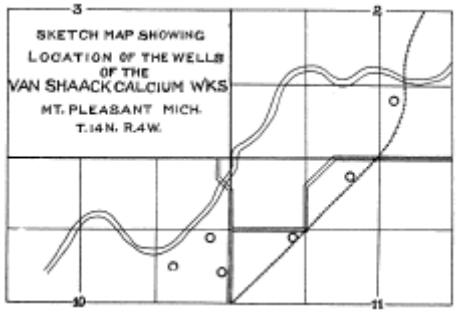

Figure 47. Sketch map showing the location of the wells of the VanSchaack Calcium Works.

[26]Detroit News, August 2, 1912.

[27]Detroit News. January 9, 1913.

[28]Ibid.

[31]Fay, Albert H., Engineering and Mining Journal, Vol. 91, No. 11, 1911, pp. 565-569.

[32]January, 1913.

ISABELLA COUNTY.

Since 1908, Peter Van Schaack and Son have manufactured a small amount of salt at Mt. Pleasant. As admission to the plant was denied, no description of the process or equipment can be given. The salt is manufactured as a by-product in the manufacture of calcium chloride and bromine, the former by Van Schaack and Son and the latter by the Dow Chemical Co. The brine employed is that of the Napoleon sandstone and at this point is much higher in the earthy chlorides than at Midland. The brine is obtained from six wells (see Fig. 47) with an average depth of 1,560 feet. The geological section at Mt, Pleasant is shown in the following well record.[33]

Peter Van Schaak and Son, Mt. Pleasant. Elevation of the top of the well about 770 A. T.

Pleistocene.
80 80 gravel, glacial outwash.
20 100 blue till.
20 120 quicksand.
160 280 blue till.
74 354 porous bed with water, coarse gravel on top, fine sand below.
26 380 red clay.
55 435 ground moraine till with broken coal measures.
Saginaw Coal Measures.
185 620 black shale with streaks of coal (410', 435', 460') sandstone, limestone, or carbonate of iron and fire clay, mostly less than five feet thick.
90 710 fine white sandrock with mineral water.
80 790 gravelly sandrock with a strong flow of water, not so salt.
30 820 shale and red limestone.
Parma and Maxville.
30 850 white limestone.
120 970 white sandstone with very salt water.
55 1025 white limestone fiercely effervescing.

Lower Grand Rapids or Michigan Series.
5 1030 shale.
20 1050 sandstone.
75 1125 dolomite and shale.
100 1225 anhydrite and dolomite.
45 1270 anhydrite nearly pure (gypsum).
103 1373 dolomite, shale and anhydrite.
8 1381 sandstone.
5 1386 shale.
4 1390 sandstone.
15 1405 shale.
Napoleon Sandstone.
160 1565 sandstone, dark with heavy brine.

The production which has been exceedingly small is given in Table XL.

TABLE XL.

Year.	Barrels.	Year.	Barrels.	Year.	Barrels.
1908	8312	1909	9373	1910	4954

[33]See Geol. Sur. Mich., Vol. IX, Part II, p. 90. Napoleon sandstone has been inserted, otherwise record is unchanged.

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APPENDIX B. AN ACT TO REGULATE THE MANUFACTURE, AND PROVIDE FOR THE INSPECTION OF SALT.

(323)[1] Sec. 1. The people of the State of Michigan enact, That no salt manufactured or mined in this State, after this act takes effect, shall be sold within or exported from this State until the same shall be duly inspected, as provided in this act. Any persons who shall violate the

provisions of this section shall pay, for the use of the people of this State, as a fine, the sum of one dollar for each barrel or portion thereof of salt sold or exported contrary to the provisions of this act. In case any manufacturer or producer of salt shall, knowingly, sell or export, or permit to be sold or exported, salt, contrary to the provisions of this act, he shall, upon conviction thereof, be liable to a fine not exceeding one thousand dollars or imprisonment in the county jail not exceeding ninety days: *Provided*, That nothing in this act shall apply to salt packed or purchased and in the hands of producers or dealers when this act takes effect.

(4912)[2] Sec. 2. Immediately after the expiration of the present inspector's term of office, and every two years thereafter, there shall be appointed by the governor of this state, and by and with the advice and consent of the senate, an inspector of salt, who shall be a person of competent skill and ability, and who shall hold his office for two years and until his successor shall be appointed and qualified, unless sooner removed for cause. He shall at all times be subject to the removal of the governor for cause; and in addition to other causes which may arise, incompetency and inefficiency in the performance of the duties devolved upon him by this act, shall be deemed good cause for removal. In case of vacancy in the office, it shall be the duty of the governor to fill the same by appointment, immediately upon receiving notice thereof, and such appointment shall hold until the close of the next session of the senate; and, in the meantime, the governor shall, with the consent of the senate, appoint to fill the vacancy for the unexpired portion of the term.

(4913) Sec. 3. Immediately after his appointment and qualification, the inspector shall divide the salt-making territory of this state into so many inspection districts as he may judge necessary, and shall appoint for each district one or more competent and efficient deputy inspectors, who shall hold office at the pleasure of the inspector, and for whose acts he shall be responsible. Such districts may be changed from time to time, as may be necessary. The inspector shall give his entire time, skill and attention to the duties of his office, and shall not be engaged in any other business or occupation.

(323) Sec. 4. The inspector shall be entitled to receive an annual salary of fifteen hundred dollars; he shall also be allowed the further sum of three hundred dollars, annually, for the expenses of providing and furnishing his office and for clerk hire, stationary, books and printing; and such further sum as he may actually and necessarily expend in traveling, and other expenses, in an amount not to exceed seven hundred dollars per annum, which shall be incurred in the proper discharge of his duties; his deputy shall be entitled to such sums in each case as he may approve, not exceeding, in any case, the sum of one hundred dollars per month for the time actually employed: *Provided*, That such deputy inspectors may be allowed their necessary expenses in addition to the above sum when employed outside their respective districts. All salaries and expenses provided for by this act shall be retained by the inspector out of the money received, under the provisions of section five of this act, and accounted for and paid out by him, as provided by this act, which salaries shall be paid monthly: *Provided*, That in case the money received for the inspection of salt, according to the provisions of section five of this act, shall not be sufficient to pay the salaries and expenses of the inspector and his deputies, as provided for herein, that the amount of such deficiency shall be deducted from said salaries, pro rata to each.

(323) Sec. 5. Each person, firm, company, and corporation engaged in the manufacture or production of salt, or for whom any salt shall be inspected, shall, from time to time, as salt is inspected, or offered for inspection, pay on demand, to the salt inspector or the deputy of the district where the salt is inspected, three mills for each two hundred eighty pounds of salt inspected or offered for inspection: *Provided*, That the same may be required by the inspector to be paid in advance: *And provided further*, That but one inspection fee shall be paid upon the same salt. In case any person, firm, company, or corporation shall neglect or refuse to pay such inspection fees on demand at his, their, or its office, manufactory, or mine, the party so refusing, shall be liable in an action therefor, in the name of the inspector, and the certificate of inspection, with the proof of the signature of the inspector or deputy inspector, giving the same, shall be prima facie proof of the liability and the extent of the liability of the party so in default; and it shall be lawful for the inspector and his deputy to refuse to inspect salt manufactured at the works, manufactory, or mine so in default, until the amount due is paid. All money received by or paid to any deputy inspector, under this section, shall be forthwith paid to the inspector. The inspector shall keep just and true accounts of all money received under this section, and an account of the amounts received from or paid by each person, firm, company, and corporation engaged in the production of salt, and all other things appertaining to the duties of the office, and the said books and accounts shall always, during office hours, be subject to the inspection and examination of any person who may wish to examine them, and shall be handed over to his successor in office, together with all the money and effects appertaining to said office.

(4916) Sec. 6. The inspector shall, before entering upon the duties of his office, take the oath prescribed by the constitution of this state, which oath shall be filed in the office of the secretary of state. He shall execute a bond to the people of this state in the penal sum of seven thousand dollars, conditioned for the faithful performance of the duties of his office, which bond shall have at least two sureties, and shall be subject to the approval of the state treasurer; and when approved shall be by such treasurer filed and deposited in his office; and the inspector shall renew his bond each year. Any person or corporation injured by the neglect or default of such inspector, or by his misfeasance in office, or by the neglect, default or malfeasance (misfeasance) of any of

his, deputies, may maintain an action on such bond in the name of the people, for the use of the party prosecuting, and shall be entitled to recover the full amount of damages sustained.

(4916) Sec. 7. Each of the deputies appointed by the inspector shall take the oath of office prescribed by the constitution, and shall give bond to the inspector in such sum, and in such sureties as he may approve, conditioned for the faithful performance of his duties as such deputy; and in case said inspector shall be obliged to pay any sum for the neglect or default, or misfeasance of any deputy, he may recover of such deputy, and his sureties on such bond, the amount he was obliged to pay, with accruing costs.

(323) Sec. 8. The inspector shall keep a principal office in some one of the principal salt producing districts of this State, and the deputy inspector for the district, in which such office is located may occupy the same office. Such office shall be open at all times during business hours. All the books, records and accounts shall be kept in such office, and each deputy inspector shall, at least once a month, make a written report, by mail or otherwise, to the inspector, of salt inspected by him, during the month, stating for whom, and the quality and quantity thereof. Abstracts of these reports shall be entered in books for that purpose. Said inspector shall, in proper books, keep a complete record and account of all his transactions, and such books shall also be open for the examination of all persons wishing to examine the same during office hours.

(4919) Sec. 9. The inspector shall not be concerned in any way in the manufacture or selling of salt, or have any interest, directly or indirectly, in any salt manufactory, or erection for manufacturing salt in the state of Michigan, or in the profits of any such manufactory.

(4920) Sec. 10. It shall be the duty of the deputy, in each district, to visit once in each day, Sundays excepted, each salt manufactory in his district, when in operation, and to ascertain if there be therein any salt of bad quality, and such as ought not to pass inspection.

(4921) Sec. 11. It shall be the duty of the inspector to visit the manufactories in which salt is made, that may be in operation in the different districts, as often as practicable.

(4922) Sec. 12. The inspector or deputy, at each visit, as provided in this act, shall carefully examine the salt in the bins, and the brine in the kettles, or pans, or vats in which the salt is manufactured; if the salt in the bins, or any part thereof is of bad quality, and such as ought not to pass inspection, or if the brine in the kettles, or pans, or graining vats have not been cleansed, he will direct and see that the owner, or occupant, or boiler, or other person having charge of the manufactory, remove the bad salt from the bin, and place it with the second quality salt, or throw it among the bitterns, as the inspector or deputy may direct, and the impure brine in the kettles, or pans, or graining vats be thrown out, and new brine substituted.

(4923) Sec. 13. No lime or lime water shall be used by any person in the manufacture of salt, in the kettles, or pans, or graining-vats used for manufacturing, under a penalty of twenty-five dollars and costs for each offense, to be sued for in the name of the people of this state; *Provided*, That iron vessels used in the manufacture of salt may be whitewashed, when cool, to prevent the accumulation of iron rust.

(4924) Sec. 14. Every person desiring to have salt inspected, shall apply to the inspector or deputy inspector of the district where the same shall be, which inspector or deputy inspector shall thereupon actually examine the salt so offered for inspection, in the package in which the same may then be.

(4925) Sec. 15. To facilitate such examination, it shall be the duty of the person or company offering the salt for inspection, to unhead or bore the barrel, or to open the bag or other package in which the salt is contained, as may be directed by the inspector or the deputy inspector, so as to expose the salt to his touch, view and examination.

(4926) Sec. 16. The inspector, or deputy inspector, shall not pass any salt as good, unless he shall find it well made, free from dirt filth and stones, and from admixture of lime, or ashes of wood, and of any other substance which is injurious to salt, fully drained from pickle, the bitterns properly extracted therefrom, and manufactured as directed by this act, and the rules and regulations of the inspector.

(4927) Sec. 17. The company or persons offering the same for inspection, shall in all eases provide the necessary force to lift the salt while the deputy or inspector measures it, and shall also furnish the necessary help and material to brand the salt for and under the direction of the inspector or deputy inspector.

(4928) Sec. 18. Each manufacturer shall provide a scale or balance at his works, to be examined from time to time, and approved by the inspector, in which all the salt offered for inspection at his works may be weighed,

(4929) Sec. 19. Each inspector or deputy shall deliver to the party for whom lie shall inspect the salt, a certificate of the quality and quantity inspected, and shall thereupon direct the employees of the manufacturer to brand and mark, under his personal, supervision, with durable paint, the package containing the salt so inspected, with the surname of the inspector at length, and the initials of his christian name, with the addition of the word "inspector" in letters at least one inch in length, and shall also be caused to be marked or branded by the employees of the manufacturer upon the head of the barrel, cask, or package, the weight prescribed for such barrel, cask, or package by the inspector, when such weights are in conformity to the rules and regulations prescribed by the inspector in that regard; and if such weights do not correspond to the rules and regulations

he shall cause the same to be repacked so as to conform thereto.

(4930) Sec. 20. If the said salt shall be put up in barrels it shall not be marked unless the barrels are thoroughly seasoned, stout, and well made, with such number of hoops as shall be prescribed by the inspector, to be well nailed and secured.

(4931) Sec. 21. Every person who shall falsely or fraudulently make or counterfeit, or cause to be made or counterfeited, or knowingly aid or assist the false or fraudulent making or counterfeiting the mark or brand of any inspector or deputy inspector, on any package containing salt, shall be deemed guilty of felony, and on conviction thereof, shall be subject to a fine of not less than one hundred nor more than one thousand dollars, or be imprisoned in the state prison for a term not less than one and not more than six years, or both in the discretion of the court.

(4932) Sec. 22. No manufacturer or other person shall pack, or cause to be packed, or sell, or offer for sale in barrels, casks, boxes, sacks, or in bulk, any salt, until the inspector shall have determined, upon actual examination, that the same is sufficiently drained of pickle, and otherwise fit to pack. All salt shall stand in the boxes at least twenty days before packing, and the time will be taken to commence from the last discharge of wet salt into the bins; nor will the packing of any such salt be allowed until the same has been declared fit for that purpose upon actual examination by the inspector or his deputy, and the packing of any salt without express permission, although twenty days may have elapsed, shall not be allowed.

(4933) Sec. 23. The inspector and his deputies, in their daily examination of the several salt manufactories, shall examine all bins of salt for the purpose of ascertaining whether any salt is packed contrary to the provisions of the foregoing section.

(4934) Sec. 24. If any manufacturer or other person shall pack any salt before the inspector or one of his deputies shall have determined that it is fit for packing, he shall forfeit the sum of twenty-five cents for every bushel of salt so packed.

(4935) Sec. 25. Barrels, casks or sacks in which salt shall have been packed and inspected, shall not be used again for the packing of salt therein, until the marks or brands made by the inspector shall first be cut out or removed; and if any person shall pack, or cause to be packed, or shall aid or assist in packing any uninspected salt in any such barrels, casks, or sacks, without first cutting out or removing such marks or brands, he shall forfeit, for every bushel of salt so packed, the sum of one dollar.

(4936) Sec. 26. It shall be the duty of every manufacturer to brand or mark, with durable paint, every cask or barrel of salt manufactured by him, with the surname at full length of the proprietor or owner of the manufactory at which the same shall have been made, and the initial letters of his christian name, and if the same shall have been manufactured for a company, or association of individuals, he shall mark or brand, in a like manner, upon every such cask or barrel, the name by which the company is usually called: *Provided*, That no second quality salt shall be so marked.

(4937) Sec. 27. No inspector or deputy inspector shall inspect or pass any barrel, cask, box, or sack of salt which shall not be marked or branded in the manner prescribed in the last section, and the inspector or deputy shall not affix his brand to any barrel which shall not have been so branded by the manufacturer offering the same for inspection: *Provided*, That none of the provisions of this section shall apply to second quality salt: *And provided further*, That the inspector may. by regulations prescribed by him, provide that both the brand of the manufacturer and that of the inspector shall be put upon each package at the same time.

(4938) Sec. 28. Salt of an inferior quality—dirty, damaged or condemned—may be sold loose, or in bulk, by the manufacturer thereof, at the works, the inspector making bills of the same, designating the quantity by weight, as in ordinary cases, and distinguishing the same as "second quality;" or such inferior salt may be packed in boxes, barrels, casks or sacks, and branded by the inspector with the words "second quality salt," in plain, letters not less than one inch in length, and such inspector shall add the initials of his name, and no other or different brand shall be placed thereon; and said second quality salt, subject to the provisions of this section, may be sold or exported by the owners as such.

(4939) Sec. 29. Every person who shall forge or counterfeit the name so required to be put on by the manufacturer, or shall cause, or procure to be put on any barrel or cask in which salt shall be packed, the name of any person other than that which should properly be placed thereon according to the provisions of this act, shall, for every such barrel, cask, or sack, forfeit the sum of one hundred dollars, and shall be liable for all damages to the party aggrieved.

(4940) Sec. 30. The inspector shall, by regulation from time to time, specify the quantity of salt that shall be contained in bags or other packages which shall be offered for inspection. And it shall not be lawful for him to authorize the inspector's brand to be placed upon any package that does not correspond with said regulation.

(4941) Sec. 31. The inspector shall by regulation, require that all ground salt manufactured and put upon the market, shall be legibly marked upon each keg, box, sack, bag, or other package containing the same, with the words “ground solar,” “ground boiled,” or "ground steam," or "ground Chapin," as the fact may be. Such marking to be done by letters not less than one inch in length.

(4942) Sec. 32 . If the inspector shall consent to, connive at, aid or abet, the smuggling of salt, or the transportation of the same away, so as to invade the inspection thereof, or shall accept of any bribe, or sum of

money, or any gift, or reward whatsoever, upon any expressed, or secret or implied trust, or confidence that he shall connive at, or consent to any evasion of the laws for the inspection of salt, such inspector shall forfeit his office, and pay to the use of the people of this state the sum of one thousand dollars.

(4943) Sec. 33. If any deputy inspector shall be guilty of the offenses specified in the last section, or any of them the inspector appointing such deputy shall forfeit to the use of the people of this state the sum of two hundred and fifty dollars, for the recovery of which his bond shall be put in suit.

(4944) Sec. 34. The inspector and each of his deputies shall be exempt from serving on juries, and from all military service, except in the case of actual invasion or insurrection; and the commission or appointment in writing of any such officer or deputy shall be evidence of the facts stated therein.

(4945) Sec. 35. The inspector shall have the power from time to time, to make and ordain such necessary rules and regulations as he may deem expedient, concerning:

First, the manufacturing and inspecting of salt not inconsistent with the provisions of this act;

Second, the daily examination, and reporting by his deputies, of the operation and extent of the several salt manufactories, so as to determine whether the quantity inspected at each manufactory, is equal to the quantity actually manufactured thereat;

Third, the districting of the salt-making territory in this state, and the duties of his deputies under this act, and he may alter and revoke such rules and regulations at his pleasure.

(4946) Sec. 36. The inspector shall have the power to annex penalties, not exceeding ten dollars in any case, to the violation of such rules and regulations; such rules and regulations shall be printed and posted up in the office of the inspector, and in each manufactory, and published at least once in some newspaper in each county where salt is manufactured, and shall, after they have been posted and published as aforesaid for one week, be binding upon all persons concerned.

(4947) Sec. 37. It shall be the duty of the inspector and his deputies, upon being applied to by any manufacturer to inspect salt in his district, to inspect the same forthwith; and in no case shall the inspector, or any deputy, delay the inspection beyond twelve hours of daylight, excluding Sundays, after such application unless such manufacturer shall consent to the delay. For the violation of this section by the inspector, or any one of his deputies, the inspector and his sureties shall be liable to the party aggrieved in the sum of fifty dollars over and beyond actual damages sustained.

(4948) Sec. 38. Nothing in this act shall be construed so as to prevent the sale or exportation of the bitterns from any manufactory of salt, such bitterns to be sold or exported in bulk, or if in casks or barrels, to be branded as bitterns, and sold or exported as such.

(4949) Sec. 39. In case of any vacancy from any cause, in the office of the inspector, the deputy who has been longest continuously in office shall possess the powers and perform the duties of the inspector until such vacancy shall be filled; and the bond of the inspector and his sureties shall continue to be liable for the acts of all the deputies until such vacancy shall be filled.

(4950) Sec. 40. The inspector shall annually, in the month of December, and on or before the fifteenth day thereof, make a report to the governor of this state, which shall contain:

First, the number of districts into which the salt-producing territory of the state may then be divided, with the name and locality of each, and the number and capacity of the works of each district;

Second, the quantity and quality of salt inspected in each district during the preceding year;

Third, the amount received, and the expenses incurred under this act for the preceding year, in detail;

Fourth, such suggestions and recommendations as he may think proper to make concerning the manufacture of salt, and the operation of the inspection laws upon the same, and as to what further legislation upon the subject, if any, would be advisable. A copy of such report shall be published immediately after its date, in some paper in the Saginaw valley.

(4951) Sec. 41. The inspector shall establish a grade of "fine" salt, the grain of which shall be at least as fine as the average grain of salt made in kettles. He shall cause the word "fine" to be marked on packages containing such salt, in large letters, and the word "fine" without any qualification, shall not, under any circumstances, be placed on salt of coarse grain; but all other grades shall be designated on the packages by some truly descriptive mark or brand, and the inspector may mark salt "second quality" for imperfect grain, as well as other defect.

(4952) Sec. 42. Nothing in this act contained shall be construed to prevent the sale or shipment of salt in bulk, after the same shall have been duly inspected, and a certificate thereof given by said inspector, or any deputy; and nothing in this act shall be construed to prevent manufacturers from putting such private trade-mark or brand on their salt as they may see fit: *Provided*, It contains no untruth, or statement calculated or intended to deceive the purchaser.

(4953) Sec. 43. In case the inspector shall, at the time of making any annual report, have a surplus of money arising from the inspection fees in this act provided for, in his hands, he shall apportion back and pay such surplus to the persons, firms or corporations for whom salt has been inspected during the last preceding year in proportion to the amounts paid by them respectively for inspection fees: *Provided*, That in no case shall the

state be held liable for any obligation or expenditure in consequence of any of the provisions of this act.

[1] (323), etc., Public Acts of 1905.

[2] (4912), etc., Compiled Laws of 1897.

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