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Entrepreneurship and Obsolescence: Owen W. Davis, Jr. and The Katahdin Charcoal Iron Company 1876-1890

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When Owen W. Davis, Jr., took charge of the Katahdin Iron Works in 1876, he was representative of the best of the new managerial class which arose in the years following the Civil War. Davis was bright, imaginative, and aggressive, and yet he was able to maintain excellent relations with both labor and stockholders. However, he had applied his many talents to an obsolescent industry – charcoal iron making – and, more particularly, to an antiquated plant in a remote and underdeveloped section of the United States – northern Maine. Despite some remarkable entrepreneurial and technical achievements, Davis – like many other nineteenth century businessmen in declining industries – was bound to fail.

The Katahdin Iron Works had been constructed in 1845 to produce pig iron from an ore deposit discovered on the side of a small mountain in the Maine woods fifty miles north of Bangor, the booming lumber capital of the East, located at the head of tide on the Penobscot River. The iron works, the village built to support it, and the township of land which surrounded it had been acquired in 1846 by David Pingree of Salem, Massachusetts, a wealthy merchant turned timberlands investor, who had accepted the property in payment of a debt. The iron works ceased operations after ten years, plagued by two major problems which Pingree had been unable to solve: the high cost of transporting the heavy pig iron by wagon to the port of

Bangor; and a puzzling smelting problem which produced pig iron of widely varying quality and gave the product a bad reputation in its main market, Boston, Massachusetts.[1]

Pingree died in 1863, and after several efforts to purchase the iron works and put it back into operation failed, it was finally acquired by a group of businessmen headed by Thomas N. Egery, a Bangor iron founder, which incorporated in 1868 as the Piscataquis Iron Works Company.[2] Egery and his associates undertook a major effort to have a branch railroad line extended to the iron works, but when it failed, they apparently decided to resume production without it.[3] In 1873, the old stone blast furnace was put back into operation after a fifteen-year lapse, but three years later Egery's firm determined to abandon direct management of the enterprise in favor of leasing the property to another company that would run the iron manufacturing operation.[4]

The leader of the new group, Owen W. Davis, Jr., was characterized by a local newspaper as "a man of great energy and business capacity."[5] Davis was an enthusiastic representative of the new managerial class which arose in the United States in the years following the Civil War. He lacked the financial assets of men like David Pingree and Thomas Egery, but he did have a keen eye for economic opportunity and the ability to convince others to join him. Even though Davis lacked the means to establish a large industrial enterprise, he managed those he was given the responsibility for with passion and dedication. By early in 1876 Davis had convinced four other Maine men to join him, and they were incorporated as the Katahdin Iron Company.

Rather than attempting to purchase the assets of the Piscataquis Iron Works Company, Davis and his associates leased all the property of Egery's firm. While stock was being sold in the new company and financing for the renovation of the plant arranged, Davis traveled around

the country, visiting all the major iron works. He then immersed himself in a study of the latest technology and production processes.[6]

By the time sufficient capital had been obtained, the bulk of it from long-term loans, Davis felt that he was prepared to construct and operate a modern, efficient iron manufacturing plant. Two turbine water wheels were installed to replace the old wooden one. The extra power produced was used to operate a huge new blowing apparatus which enabled Davis to add ten feet to the height of the furnace stack, increasing productive capacity almost two and one-half times. A huge bell and hopper were installed on the top of the stack to capture waste gases which could then be used to heat the air blast, raising the efficiency of the furnace. The second water turbine powered an elevator that carried the ore, charcoal, and limestone flux to the top of the heightened furnace. Several new charcoal kilns were built to increase fuel-producing capacity to meet the new demands of the enlarged furnace. In addition, repairs and improvements were made to the iron works village, and an old boarding house was rebuilt and renamed a hotel in an effort to attract tourists.[7]

Davis probably had the blast furnace in operation by late 1876, and he was soon facing the problem with the iron sulphide ore which had given David Pingree so much difficulty. Davis reported later:

> . . . [The] ore was roasted in heaps, on piles of wood, and readily yielded most of the combined water, and a large per cent of the sulphur, and when fairly well roasted in this manner, it produced, with ten per cent of lime and a hot furnace, a very handsome open-grained iron, very soft and fluid . . . . But the action of the furnace was irregular, and unsatisfactory; changes and slips being frequent and sudden, all the iron above the grade of the soft No. IX . . . showing a lack of strength, and an unhealthy fracture not to be expected in a good charcoal iron. Occasional analyses of samples of iron sent away for test, showed an excessive and unusual amount of silicon, which varied but slightly in the different grades from No. 1 to white iron.[8]

Davis' problem was compounded in 1877 when the beds of largely oxidized ore on the surface of the deposit began to give out. The secondary layer of ore was not as fully oxidized as that on the surface, and thus contained more sulphur, and in a sulphide form which could not be oxidized by the traditional roasting method. When this new ore was worked in the blast furnace, the results were much more irregular and unsatisfactory than before. Davis tried endless experiments with the furnace, changing the design of the interior, adding fifteen feet to the height of the stack, and increasing the pressure of the air blast, all to no avail.[9]

Undaunted, Davis turned his attention to improving the facilities for roasting the ore before it was put into the blast furnace. He constructed a series of permanent roasting platforms, constructed of stone and iron, which permitted more uniform oxidization of the iron sulfide. When the ore roasted in this manner was smelted in the remodeled blast furnace, the quality of the resultant pig iron was improved and fuel consumption decreased.[10] Convinced that he was on the right track, Davis decided to continue his experiments during the winter of 1878:

> It seemed apparent, at this time, that the outlook for the iron trade was such as to encourage the belief in better times in the ensuing spring, and to warrant some further effort at overcoming the difficulty; and it was determined to make a thorough investigation into the causes of our trouble, in the hope of removing them.
>
> To accomplish this, a chemical laboratory was fitted up at the works, and we were fortunate in securing the services of Mr. Ernst Sjostedt, of Sweden, a graduate of the school of mines at Stockholm, to conduct the investigation.
>
> Complete analyses of ores, iron, fluxes, and cinders from recent and former blasts were made, and it very soon became evident that our real antagonist had been, not silicon, but sulphur, which met us on every hand and in quantities much greater than anticipated. One analysis after another confirmed the theory that the relation between sulphur and silicon in our pig was very intimate . . . .[11]

Davis and Sjostedt theorized that the high heat needed in the furnace to make the sulphur combine with the lime flux and pass off as slag, also made the silicon unite with the iron rather than the flux. The obvious solution was to attempt to remove all the sulphur from the ore before it was smelted, so that a lower furnace temperature could be used which would cause the silicon to pass off in the slag rather than combine with the molten iron. Thus, the roasting process would have to be still further improved in order to heat all of the ore to temperatures required to break down the sulphide compound, and, in Davis' words, "do it uniformly, regularly, and on a large scale."[12]

The logical next step after experimenting with the roasting platforms was to build a large oven or kiln in which the ore could be more precisely oxidized. Sjostedt, assisted by George D. Colby, the agent at the iron works, selected the Westerman kiln, widely used in Sweden, as a model, and built a large cylindrical oven of brick, ten feet in diameter at the bottom and five at the top, and twenty-two feet high which was topped with a thiry-five foot chimney four feet in diameter. The kiln was fired by wood and the ore dumped into the stack through charging doors near the base of the chimney from a trestle similar to the one at the blast furnace.[13]

Tests of the new furnace showed that although the ore was uniformly oxidized, some of the sulphur tended to settle back on the ore and recombine with it. To overcome this problem, a small flue, less than two feet in diameter was built in the center of the kiln, extending into the base of the chimney. Three rows of openings in this flue were designed to draw off the sulphur as soon as it was oxidized in order to prevent it from recombining with the ore.[14]

The center flue proved to be very effective, but several more minor procedures were added to the roasting process to ensure the effectiveness of the operation. The

raw ore was sorted to remove any foreign matter and broken into small lumps before being shoveled into the furnace to insure that it would be uniformly heated. Finally, the roasted ore was drawn from the kiln, while still hot, directly into a trough of water to remove any remaining sulphur.[15]

Davis reported on the results of the experimentation in a paper read at the annual meeting of the United States Association of Charcoal Iron Workers, October 20, 1880, in Chambersburg, Pennsylvania:

> This arrangement is now in use at our works, and with results entirely satisfactory . . . . [The] resulting pig is of superior quality, of great strength, and shows a high chill, and it is selling freely for car wheels to some of the largest car wheel shops in the country.[16]

The desulphurized ore not only produced a superior iron, but also required less fuel. The furnace was turning out fifteen to eighteen tons of pig iron per day using an average of only eighty-three bushels of charcoal per ton, an accomplishment which the *Maine Mining Journal,* published in Bangor, boasted was "unprecedented in the history of charcoal iron-making in this or any other country."[17]

Interest in the roasting kiln was sufficient for Davis and Colby to patent the oven, and smelting experiments were continued in spite of the success of the process. Davis took the opportunity presented by a fire which halted operations for a few weeks in June, 1881, to make a number of improvements in machinery and methods which resulted in an increase in monthly production from 500 to 600 tons. The following year, Davis purchased a cargo of Spanish iron ore which could be obtained at relatively low cost due to the proximity of the deposits to the sea and the number of vessels looking for return cargo to the United States. He undertook experiments to see if a mixture of the rich, hard Spanish ore and the powdery

native material would smelt more efficiently, and when the tests proved successful, Davis ordered another shipment.[18]

In 1883, Davis and Colby designed and constructed a gas furnace which they felt would heat the roasting kiln more uniformly and economically. The specially adapted furnace was built to burn worthless charcoal braize, an annoying residue which accumulated from the charcoal in the coal sheds, and thereby save some 15,000 cords of wood annually along with the labor of two or three men. The brick furnace was ten feet square at the base, six feet at the top, and twenty feet in height. It was fired with a blast of air carried through a pipe from the main works, and another funnel carried the gas formed by the burning charcoal braize to the roasting kiln where it was used to heat the ore.[19]

Davis also attempted to increase profits by moving into the production of iron castings. In the fall of 1882, he began taking orders for cast iron railroad car draw bars and mining machinery components, and he expressed the hope that eventually the entire output of the blast furnace could be turned into castings rather than the less profitable pigs.[20]

After the smelting problem had been solved, however, the main focus of Davis' attention was placed on the other difficulty which had plagued the iron works from the beginning – the high cost of transportation. Although the distance over which the iron had to be transported by relatively expensive horse and wagon had been reduced from fifty to fifteen miles when a railroad was built from Bangor to the nearby town of Milo, the hauling fee had increased to $4.50 per ton, almost what it had cost to haul it the entire distance in 1850.[21]

Davis concluded that the only way to reduce transportation costs was to extend the railroad to the iron works. When the railroad company declined to build a

branch line, Davis took the initiative and talked Thomas Egery into organizing their own railroad. On June 20, 1881, the Bangor and Katahdin Iron Works Railway was formed with a capital stock of a mere $72,000. Davis was elected president, and he made clear his determination to build the road as expeditiously and economically as possible. On June 10, even before the company was organized, a civil engineer was surveying the proposed route, and on July 29, ground had been broken and the contractors had begun work.[22]

On the same date, the stock in the railroad had been oversubscribed, and a prominent banker had offered a premium for the first mortgage bonds. One year later, before the line was fully completed, the last lot of bonds were sold, closing out the entire issue of $100,000, all of which sold at par and accrued interest, which the *Maine Mining Journal* called "a fact almost or quite unparalleled in the history of a new railroad enterprise."[23]

In order to keep costs down, Davis built culverts and bridge abutments of wood rather than stone and purchased used rails and rolling stock rather than new. The rails were laid as far as the village of Brownville, a few miles below the iron works, by November, 1881, and freight trains began running on that section the following week. Construction began again in the spring, and by September 15, 1882, trains were running through to the iron works.[24]

The transportation problem had hardly been solved when Davis was faced with a financial crisis. The failure of a major creditor of the iron works in Portland forced the firm into bankruptcy on November 25. A meeting of all the major creditors was held four days later and after listening to Davis, they voted their confidence in the company and his leadership, and agreed to either accept twelve cents on the dollar or capitalize the indebtedness. It

is not clear which alternative was most utilized or what the effect was on the control of the firm, but the crisis was quickly surmounted, and the iron works continued to operate without interruption.[25]

Almost a year later, November 13, 1883, Davis was faced with another crisis which could not be so easily dealt with. A hurricane swept through northern New England, inflicting heavy damage in Piscataquis County. It passed just south of the iron works, and during the height of the storm, debris from the charcoal kilns which had been dumped on the river bank was fanned into flames. Sparks were carried to the buildings and the iron works burned to the ground. A local newspaper reported, "Nothing escaped the conflagration except the blacksmith shop and storehouse, although a part of the machinery and the tall stone furnace stack were saved in a damaged condition."[26] The Katahdin Iron Company could not avoid failure this time since the property was uninsured.

The prospects for rebuilding the iron works did not look very promising after the fire since the property was uninsured and many charcoal iron furnaces were idle because of low iron prices; undaunted, Davis immediately began laying plans for the reconstruction of the works while making the best of the situation at hand by harvesting the tremendous number of trees that had been blown down in the storm. Two new saw mills were built, and Davis was soon turning the toppled timber into spool and match stock, and box boards. Later in the year, Egery built a new shingle and clapboard mill, and soon the products of this operation were being added to Davis' freight of lumber and also pulp wood leaving on the iron works railroad.[27]

George Colby resigned as agent in February, 1884, and left for Port Leyden, New York, to take charge of the extensive mines and works of the Geer Iron and Mining Company.[28] Davis, however, remained and began working

for the reconstruction of the iron works as soon as his temporary lumbering operations were completed. The *Maine Mining Journal,* which had been renamed *The Industrial Journal,* reported that Davis' plans were based on the requests of many of the company's former customers:

> . . . [The] Katahdin iron had established a reputation and a place for itself in the market, and the demand for it continued notwithstanding the supply had failed. The car wheel and machine shops in New Hampshire, Massachusetts, New York and other states which had been using the iron, among them some of the largest and best known in the country, had come to consider it almost a necessity in their business, and strongly urged the rebuilding of the works, as they were loath to abandon an article which they had used with such satifactory results. Mr. O.W. Davis, Jr., . . . was well satisfied that the iron would meet with ready sale at prices ensuring a good margin over the cost of production, with suitable facilities for manufacture.[29]

In May, 1885, Davis secured a new lease from the Piscataquis Iron Works Company on more favorable terms, giving him control of the mines, timber, and other property for fifty years. He then set out to interest the businessmen of the Bangor area in forming a new stock company to rebuild and operate the iron works on an enlarged scale. Although some out-of-date companies were reportedly interested in becoming associated with the enterprise, Davis argued that control should be kept in Bangor. The *Industrial Journal,* published there, called Davis' offer a simple business proposition. The iron works was a proven success, the entire cost of operations could be shown, and the margin of profit made apparent. The market price, which was at its lowest point since 1878, was known to be "at the lowest ebb of its periodic fluctuations."[30]

The businessmen of Bangor agreed with the *Journal's* optimistic appraisal, and by the end of June the success of Davis' new undertaking was ensured. In July, the work of clearing away the fire debris at the iron works began, and Davis rehired Ernst Sjostedt, this time to serve as agent.

On July 31, the Katahdin Charcoal Iron Company was officially organized in Bangor, and Davis was elected general manager. He and the other officers reported that the capital of the new concern was sufficient to rebuild the works in a substantial manner and that "the fires of the furnace are expected to be burning before snow flies."[31]

Davis may have been secretly grateful for the destruction of the iron works for it gave him an opportunity to rebuild almost from scratch, making whatever changes and modifications he felt necessary. Of course, the stone blast furnace stack, and brick roasting kiln had survived with little damage, and the brick charcoal kilns were intact. But the rest of the plant was almost a total loss, including the dam which had been carried away by high water earlier in the year.[32]

Davis built a new and more substantial dam and a flume of heavy masonry to carry the water to the machine house. The huge turbine water wheels and auxiliary steam engines, which Davis had installed for use in times of low water, were saved, repaired, and put back into operation. New coal sheds were built along with several new charcoal kilns to increase productive capacity. The blast furnace was relined and the fire brick core was again extended some fifteen feet above the furnace to increase its size. Rather than heat the air blast at the top of the heightened furnace stack, Davis built a hot blast oven on the ground beside it, enabling the air to be piped directly from the blast machinery, through the oven, and into the blast furnace. A mammoth bell and hopper was placed on the top of the stack to collect the hot waste gases and direct them through a huge conductor to the hot blast oven on the ground. A branch pipe carried some of the gases to a new roasting kiln designed to use them as fuel.[33]

Although the general layout of the new works was similar to the old plant, modifications were made so that every building was in the most convenient position for

utmost efficiency of operation. Most of the new structures were of frame construction sided with corrugated iron and roofed with sheet iron to give excellent protection against another fire. A new enlarged casting house was constructed and, on the opposite side of the furnace, a two-story building through which a double-compartmented elevator shaft extended to the top of the stack. On the first floor of this structure the roasted ores and fluxes were mixed in the proper proportions for charging the furnace, and the second story was connected by a platform with coal sheds on the bank behind. Two new safety elevators carried the ore, flux, and charcoal to the top of the stack where it was fed into the furnace. A limestone crusher was installed near the machine house and the old de-sulphurizing kiln was used to roast the crushed lime rock. By the end of November, the iron works was complete, and with its new innovations, arrangements and modifications Davis believed he would be able to turn out more quality iron at less expense than ever before.[34]

Later in the month representatives of the Bethlehem Iron and Steel Works and the Reading Iron Works visited the Katahdin Iron Works in order to inspect the new plant and especially the new roasting kiln. The visitors were impressed by the roasting process and complimented Davis on the efficiency of its operation.[35]

In the early spring of 1886, with the reconstructed plant working smoothly and efficiently, and orders for iron coming in well ahead of production, Davis left for a trip through the West where he made numerous sales of iron.[36] A year later the United States Navy purchased a shipment of Katahdin pig to be used in making cylinders for the steam engines of some new cruisers then under construction.[37] In September, 1887, Davis suggested increasing the diameter of the furnace hearth and stack in order to further increase the capacity of the furnace, and

when the major stockholders agreed, the work was completed ahead of schedule.[38]

In November, 1886, Davis had been elected vice-president of the National Association of Charcoal Iron Workers at their annual meeting in Philadelphia.[39] This was to be the last public recognition Davis would receive, and it was a hollow one at that since his furnace was one of only about fifty small charcoal furnaces that remained of the hundreds which had supplied the bulk of American iron before 1855.[40] In December, 1888, two young Bangor businessmen, Charles D. Stamford and Fred W. Hill, purchased a controlling interest in the Katahdin Charcoal Iron Company and took an active role in the management of the firm, shunting Davis aside. Although Stamford and Hill appear to have been optimistic about the future of the iron works initially, and the demand for the Katahdin pig iron remained good, the new managers must have soon come to the conclusion that a charcoal iron furnace could not be made profitable, no matter how modern and efficient it was.[41] On March 21, 1890, the *Industrial Journal* reprinted without comment this cryptic epitaph for the iron works from the *Piscataquis Observer:*

> Work will be suspended at the Katahdin Iron Works in a week or two, the kilns having been filled for the last time. No wood has been cut this year. There are various opinions as to the ore supply, but it is a fact that it costs more to get it than the prices received for it warrant. Various parties have at different times attempted to operate these works but none of them have ever made any considerable amount of money, and several have sunk a good deal.[42]

Owen W. Davis, Jr., had accomplished some remarkable things while managing the Katahdin Iron Works. He had solved a complex smelting problem, built a railroad to reduce transportation costs, introduced innumerable improvements in plant and procedure, and, perhaps most remarkable, successfully organized a second iron company

after the first had twice failed. Ironically, the name of that second firm contained its own epitaph – charcoal – for charcoal iron furnaces were obsolescent. Owen Davis, despite his remarkable achievements, was bound to fail.

– NOTES –

[1] For the early history of the iron works see Joel W. Eastman, "David Pingree's Iron Works," Essex Institute *Historical Collections,* CIII (July, 1967), 189-198. Both the above and the present article are drawn from a larger study of the same author, entitled, "A History of the Katahdin Iron Works" (Unpublished M.A. thesis, University of Maine, 1965).

[2] *Acts and Resolves of the Forty-seventh Legislature of the State of Maine, 1868* (Augusta: Stevens & Sayward, 1868), p. 430.

[3] Amasa Loring, *History of Piscataquis County, Maine* (Portland: Hoyt, Fogg and Donham, 1880), p. 221; *Private and Special Acts Passed by the Forty-sixth Legislature of the State of Maine, 1867* (Augusta: Stevens & Sayward, 1867), pp. 310-314; *Private and Special Acts Passed by the Forty-seventh Legislature of the State of Maine, 1868* (Augusta: Stevens & Sayward, 1868), pp. 406-411, 469.

[4] American Iron and Steel Institute, *Statistics of the American and Foreign Iron Trades* (Philadelphia: American Iron and Steel Institute, 1873).

[5] *Maine Mining Journal,* July 23, 1880, p. 55.

[6] *Acts and Resolves of the Fifty-fifth Legislature of the State of Maine, 1876* (Augusta: Sprague, Owen & Nash, 1876), pp. 174, 175; *Maine Mining Journal,* July 23, 1880, p. 55.

[7] *Maine Mining Journal,* July 30, 1880, p. 55.

[8] *Ibid.,* December 24, 1880, p. 409.

[9] *Ibid.*

[10] *Ibid.*

[11] *Ibid.*

[12] *Ibid.*

[13] George N. Colby and Company, *Atlas of Piscataquis County, Maine* (Philadelphia: Bourquin, 1882), p. 66; *Maine Mining Journal,* December 24, 1880, p. 409.

[14] *Maine Mining Journal,* December 24, 1880, p. 409.

[15] *Ibid.*

[16] *Ibid.*

[17] *Ibid.*, July 23, 1880, p. 55.

[18] *Ibid.*, March 18, p. 169; April 29, p. 264; July 22, 1881, p. 40; July 21, p. 453; August 4, 1882, p. 487.

[19] *Ibid.*, September 1, p. 554; August 11, 1882, p. 506; *Mining and Industrial Journal*, April 13, 1883, p. 2. (Formerly *Maine Mining Journal*).

[20] *Maine Mining Journal*, November 24, 1882, p. 4.

[21] Iron Tickets, 1853, Katahdin Iron Works Collection, Raymond H. Fogler Library, University of Maine at Orono; *Maine Mining Journal*, October 21, 1881.

[22] Bangor and Katahdin Iron Works Railway, Articles of Association (copy), July 16, 1881, and Interstate Commerce Commission, Finance Docket, No. 1720 (official copy), December 23, 1921, p. 3, both in Katahdin Iron Works Branch File, Bangor and Aroostook Railroad Company, Hermon, Maine; *Report of the Railroad Commissioners of the State of Maine for the Year, 1881* (Augusta: Sprague & Son, 1882), p. 5; *Maine Mining Journal*, June 10, p. 362; June 24, p. 395; July 29, 1881, p. 59.

[23] *Maine Mining Journal*, March 17, p. 172; July 7, p. 421; July 29, 1882, p. 60.

[24] ICC, Finance Docket, No. 1720, p. 3, Bangor and Aroostook MSS; *Maine Mining Journal*, November 25, p. 333; December 9, 1881, p. 364; June 9, p. 363; September 15, p. 587; November 3, 1882, p. 3; *Report of the Railroad Commissioners of the State of Maine for the Year, 1882* (Augusta: Sprague & Son, 1883), p. 32.

[25] *Mining and Industrial Journal*, December 1, 1882, p. 3.

[26] *Ibid.*, November 23, 1883, p. 5.

[27] *Ibid.*, January 25, p. 4; February 8, p. 4; May 23, p. 1; October 10, 1884, p. 1; *Industrial Journal*, November 6, 1885, p. 2 (formerly *Mining and Industrial Journal*).

[28] *Industrial Journal*, February 8, 1884, p. 4.

[29] *Ibid.*, November 6, 1885, p. 2.

[30] *Ibid.*, November 6, p. 2; May 15, 1885, p. 4; United States Bureau of the Census, *Historical Statistics of the United States* (Washington: Government Printing Office, 1960), pp. 365-366.

[31] *Industrial Journal*, July 24, p. 5; August 7, p. 1; November 6, 1885, p. 2.

[32] *Ibid.*, November 6, 1885, p. 2.

[33] *Ibid.*

[34] *Ibid.*, November 6, p. 2; December 4, 1885, p. 4.

[35] *Ibid.*, December 4, p. 4; December 25, 1885, p. 4.

[36] *Industrial Journal*, May 7, 1886, p. 4.

[37] *Industrial Journal*, July 1, 1887, p. 1.

[38] *Industrial Journal*, September 23, pp. 1, 2; October 21, 1887, p. 1.

[39] *Industrial Journal*, November 19, 1886, p. 4.

[40] *Ibid.*, November 22, 1889, p. 4; April 25, 1890, p. 4; Stephen L. Goodale, *Chronology of Iron and Steel* (Cleveland: Penton Company, 1931), p. 139.

[41] *Industrial Journal*, December 7, 1888, p. 1; Memorandum of Agreement between Piscataquis Iron Works Company and General Chemical Company, July 2, 1927, April 4, 1928, copy in Piscataquis Iron Works Company Records, in the possession of George D. Carlisle, Bangor, Maine.

[42] *Industrial Journal*, March 21, 1890, p. 1.

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