

# The Centrifugal Rotary Engine Company of Lancaster, 1870-1871

by Donald J. Summar

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In 1904, J. M. W. Geist read before the Lancaster County Historical Society a paper titled "Gibson's Steam Turbine Engine," which concerned an attempt to manufacture turbines in Lancaster in 1870. Geist, who had been editor of the Lancaster Daily Express in 1870, was well qualified to write his paper for he knew the men involved and had witnessed a preliminary test of Gibson's engine.<sup>1</sup> Since the publication of Geist's article the papers of Judge Alexander L. Hayes (1793-1875) have been donated to the Lancaster County Historical Society; among them were a number of items which related the attempt of Hayes, Gibson, and others to perfect Gibson's turbine and organize a company called the Centrifugal Rotary Engine Company to manufacture it. This paper is based primarily on the Hayes papers.

Alexander L. Hayes, a native of Kent County, Delaware, and a graduate of Dickinson College in 1812, came to Lancaster in 1827 as Judge of the District Court for Lancaster and York Counties. From 1833 to 1849 he was President Judge of the District Court for Lancaster County. Hayes was one of the founders of the Conestoga Cotton Mills in 1845. He served as the firm's manager from 1846 to 1850 and as its president from 1850 to 1854. In that year Hayes was named Associate Law Judge of the Courts of Lancaster County. He served in that judgeship for over twenty years. Hayes was involved in numerous business enterprises in Lancaster and was the most ardent backer of Samuel Gibson, inventor of a steam turbine.<sup>2</sup>

Samuel Gibson was a resident of Safe Harbor and at one time had worked at the iron works there. In 1869 he listed his occupation as that of watchmaker.<sup>3</sup> He was already a successful inventor, having patented a paint brush which was made in York, Pennsylvania, by the Gibson Brush Manufactory, operated by Isaac W. G. Wierman. Wierman was also the proprietor of a cigar store at 139 North George Street in York.<sup>4</sup>

Samuel Gibson had first conceived the idea for a steam turbine (at that time called a centrifugal rotary steam engine) after reading about the reaction turbine made by Hero of Alexandria in the first century of the Christian Era.<sup>5</sup> Hero's engine consisted of a hollow metal ball on trunnions through one of which steam was piped from a boiler. The ball had bent pipes on opposite sides through which the steam was released, causing the ball to spin on its axis.<sup>6</sup>

Since Hero's time many efforts had been made to duplicate his principle in a practical rotary engine. One effort was patented in 1784 by Wolfgang von Kempelen of Pressburg, Hungary. Kempelen's engine was dismissed by James Watt, developer of the reciprocating steam engine in the 1770's, who reasoned that the high velocity of steam would give the rotary engine a speed, at efficient operation, that would be much too fast for the state of the mechanical arts at that time.<sup>7</sup>

Samuel Gibson had probably never heard of Kempelen's engine or other rotary engine experiments. Consequently, he started fresh with only the reaction turbine of Hero to base his designs on. By long study and a series of experiments he developed a rotary engine which he felt was economical in power, material, and space.<sup>8</sup> Gibson made application for a patent for "Improvement in Rotary Engines" on August 15, 1870.

In the Gibson rotary engine, steam was piped from a boiler to a hollow cylinder in the hub of the rotary wheel. The casing of the wheel was hollow and a series of buckets were cut on the inside circumference of the casing. Two tubes, opposite one another, directed steam from the stationary hub cylinder to the buckets in the movable wheel to provide rotary motion. The tubes were arranged so that the end of one tube was against a bucket while the end of the other was between two buckets, to give constant alternating power. Gibson claimed as new the combination of the wheel with its hollow casing and buckets, stationary steam tubes and hub cylinder, and tube heads.<sup>9</sup>

At about the same time, I. W. G. Wierman, who had an interest in Gibson's new patent, wrote up a stock prospectus for the proposed Centrifugal Rotary Engine Company. The prospectus stated that the company was to be capitalized at \$650,000 and was to pay Gibson \$350,000 in cash and \$300,000 in stock for his patent rights. The prospectus claimed that Gibson's invention would open a new era in the "steam world;" that the engine could be sold for one-half the price of other types of stationary engines and still provide the company with profits of two hundred or three hundred per cent; that the engine would "command as ready a sale as the sewing machine;" and that the company's entire capital stock could be sold to a few capitalists within forty-eight hours of its appearance on the market.<sup>10</sup>

The prospectus was altered by Wierman, who wrote to Gibson on September 14, 1870, and suggested several possible changes, including

an increase in the capital stock to \$1,250,000. Wierman suggested that Gibson speak to Judge Hayes about the prospectus.<sup>11</sup> The grandiose plan for a stock company named the Centrifugal Rotary Engine Company never materialized; the firm never existed except as a partnership of Hayes, Wierman, and Gibson.

Gibson's original engine, probably built in Safe Harbor, was tested during September at the foundry and machine shop of William Diller, located at 34 North Water Street, Lancaster. Those present, in addition to Gibson and Diller, were Judge Hayes, O. J. Kickey, Henry W. Hager, Charles E. Hager, and J. M. W. Geist. The Hagers were partners in Hager & Bros. dry goods and clothing, and Dickey was an attorney. Geist was a personal friend of Diller; the others were presumably potential investors in the stock company. The test was a complete success; the engine ran two lathes with "marked economy of steam." The spectators agreed that Gibson had "the correct principle of steam application" and that perfection of the mechanism was all that was necessary to insure the engine's success. Gibson himself was not satisfied with the test; he thought that the engine required better balance and other improvements. Further tests were therefore postponed.<sup>12</sup>

Although the partnership of Hayes, Gibson, and Wierman was still an informal one the three men hired William Diller on September 23, 1870, to begin building an engine. Diller was a skilled machinist; he and his employees manufactured reciprocating steam engines, drill presses, lathes, iron railings, shafting, and other products, and did mill work and gear cutting. Thus he was well prepared to build Gibson's engine. Because the patent had not yet been granted, Diller had a private room at the rear of his shop set up to keep construction of the engine away from prying eyes.<sup>13</sup>

Judge Hayes wanted the prototype centrifugal rotary engine exhibited at the Park Association Fair, which opened in Lancaster on October 4. It could not be shown because Gibson was taken ill in late September. Gibson went to Safe Harbor to recover and the engine could not be readied for display by others.<sup>14</sup>

On October 4, 1870, Gibson received his first patent (#108,016) on "Improvement in Rotary Engines." The patent was issued to "Samuel Gibson, Lancaster, assignor to himself and to I. W. G. Wierman, York, Pa."<sup>15</sup> Hayes had already agreed to purchase a one-eighth interest in Gibson's patent; the indenture to transfer such interest was signed October 10. Hayes paid one thousand dollars cash and also gave Gibson one-half interest in Hayes' patent of a method for preventing the explosion of steam boilers. The shares in patent #108,016 were thereafter: Gibson, 5/8; Wierman, 2/8; and Hayes, 1/8.<sup>16</sup>

In a letter to Wierman in October, Hayes suggested that the partners hire Diller to manufacture the Gibson engine, with Diller to provide everything except the design and the necessary capital. Diller had previously stated that with an increase in his work force he could build

two engines per day. Hayes thought that if sales of the engine proved successful, the Centrifugal Rotary Engine Company could establish its own factory after six months or so and thereafter buy castings from Diller.<sup>17</sup>

With the receipt of Diller's first bill, for \$236.45, on November 5, 1870, the partners formalized their partnership as the Centrifugal Rotary Engine Company, a name used informally prior to that date. No details of the partnership agreement are to be found in the Hayes papers.<sup>18</sup> Hayes served as treasurer of the firm; his memorandum of cash received and cash paid out has survived. Initial deposits of \$200 each to the company's account were made by Wierman on November 12, by Hayes on November 24, and by Gibson on November 29.<sup>19</sup> Diller's initial bill, for work done between September 23 and November 5, was paid by Judge Hayes on November 5 and was not recorded on the memorandum which he later made out.<sup>20</sup>

Work on the first engine built by Diller and referred to as the "small engine" was well under way by November 8, when a great many parts were purchased. Included were such vital items as the governor, the force pump, the steam gauge, the main shaft, and the foundation plate and grate bars. A boiler made by the John Best Company of Lancaster was purchased at the same time.<sup>21</sup> Work on the engine was carried on virtually every day from November 14 to December 10. The rate for skilled workers was fifty cents an hour while the rate for the helper was twenty-five cents an hour.<sup>22</sup> Bills were received regularly from Diller; Hayes paid out \$50 on November 12, \$100 on November 19, \$100 on November 26, and \$200 on December 10.<sup>23</sup> In addition to building the "small engine," Diller began work on additional engines. Castings were made for one engine on November 18, for three engines on November 25, and for another engine on November 28.<sup>24</sup>

Work on the "small engine" was completed in time for a test of its power on December 10, 1870. All those who had witnessed the test in September were present except Geist. Diller's engineer and senior machinist were also present. A total of eight men viewed the engine on its test bed in a room 12 x 14 feet. The test, which ended in tragedy, was described by Geist, who had learned the details from Hayes:

After the engine had been running fifteen or twenty minutes, attaining a great velocity, so great that Mr. Dickey remarked he did not think it safe, himself and others stepped back a few paces, which doubtless saved them from injury, for a minute later the revolving wheel burst with a loud report, breaking the solid rim of the engine, and hurling the fragments with great violence. Mr. Diller, who was holding a light, was knocked down and the light extinguished. Another light was procured, when it was found Mr. Diller had his right leg broken and Mr. Gibson was struck by a fragment on the forehead which had rebounded from the ceiling, cutting a gash into the bone. He was also struck on the instep and knocked down.<sup>25</sup>

None of the other men were injured. Judge Hayes wrote an explanation

of the cause of the accident for publication in the local newspapers. Apparently a rumor had circulated throughout the city that the explosion had been caused by steam. Hayes refuted this rumor but inadvertently made the engine itself suspect. He stated in part:

The sole cause of the accident was the strain of the centrifugal motion, which was too strong for the revolving wheel, which, after it had been cast, had been incautiously weakened by cutting a series of rectangular buttresses into its circumference to receive the impact of the escape steam and by perforating the same circumference with several apertures on one side to balance the wheel.

Weakened as the wheel was, had there been the gearing which was some days before attached to it, running two lathes belted up and down to and from the shaft, by which the speed of the wheel was diminished more than one-half, it would not have parted. Mr. Diller has an emery wheel which revolves 3,400 times in a minute, and he is of the opinion that the pulley on the countershaft of the centrifugal rotary engine was, on Saturday evening, driven at twice that velocity. There are two methods of guarding against a recurrence of a similar accident; one is by having the engine well loaded while in motion; the other by increasing the strength of the revolving wheel, using for that purpose metal of greater tenacity; or casting the wheel solid.<sup>26</sup>

The accident and the injury to Mr. Diller caused a great shock in Lancaster. Potential investors were discouraged and capital necessary to organize a stock company could not be raised. Geist recalled that the engine came to be called "Gibson's Folly." It is probable that Hayes' explanation of the accident made many men fearful of the engine's basic design. William Diller never fully recovered from his injuries and died on January 16, 1872, at the age of 64.<sup>27</sup>

In spite of the accident, Hayes and Wierman continued to support work on Gibson's engine. Gibson had already redesigned his engine and applied for another patent on November 3, 1870.<sup>28</sup> Castings for engines already under construction were altered, presumably to correct the faults which had caused the destruction of the "small engine." Work on the engines was carried on daily from December 20 to January 5 except for a New Year's Day rest. The last work done in the Diller shop was the completion of one of the engines on February 1 after eleven days work.<sup>29</sup>

In January 1871 the machine work and assembly of engines was transferred from Diller's shop to that of Heupel & Huber, general machinists and iron and brass founders, on the "Alley rear of Knapp's Lager Beer Saloon," now the 100 block of East Grant Street.<sup>30</sup> The change from Diller to Heupel & Huber may have been made to conserve capital, for Heupel & Huber's rate was ten cents per hour less than that of Diller.<sup>31</sup>

Payments of \$100 each were made to the partnership by Wierman on January 7 and by Hayes on January 9. Gibson made no cash deposit to the partnership. However, on January 10 he received his second patent (#110,912) for "Improvement in Rotary Engines." The patent was assigned jointly to Gibson, Hayes, and Wierman. Presumably this

Samuel Gibson's

Centrifugal Rotary Engine.

108016

Fig. 1

PATENTED OCT 4 1870

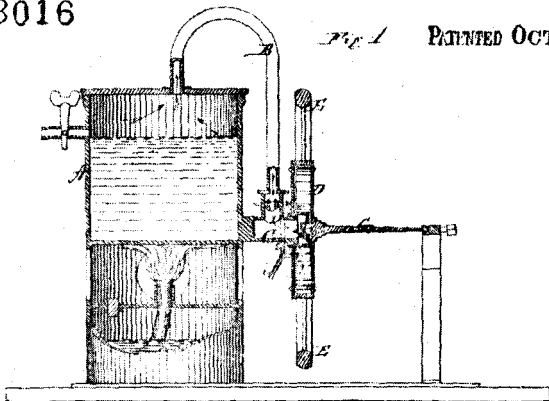
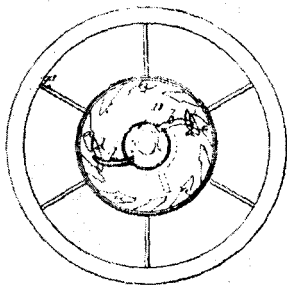


Fig. 2



Witnesses.

Harry King  
C. A. Gwertz

Inventor.

Samuel Gibson  
per  
Maudslayi & Co.

attys.

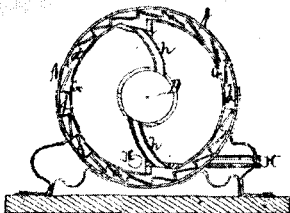
*Samuel Gibson*

*Impl. in Steam Engines*

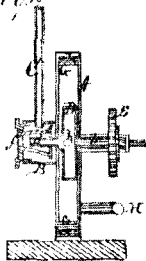
110912

PATENTED JAN 10 1871

*Fig 1*



*Fig 2*



Witnesses,

*J. Hutchinson*  
*C. L. Evert.*

Inventor.

*Samuel Gibson*  
*per*  
*Alvanor Mason*

was Gibson's contribution to the partnership. With cash on hand the bill of Diller for \$177.61 for work completed to January 5 was paid on January 9.<sup>32</sup>

Gibson's new patent appeared to be substantially similar to his first patent on the rotary engine. However, there was one outstanding change. In the new design, the outer wheel was stationary while the inner wheel revolved. This fundamental difference meant that the revolving mass was of much lower weight. Gibson had modified his earlier design by attaching the two steam tubes in a wheel which revolved inside the now stationary casing. The casing became the frame and the small inner wheel was connected to the main shaft.<sup>33</sup> Although the new design appeared to rectify the weight problem, it made the steam passage more difficult to seal and the machinery more difficult to lubricate.

Gibson's changes to his engine made pattern changes necessary; Heupel & Huber's patternmaker worked a total of sixty hours making changes. Apparently nothing had been done until the patent was granted. By February 3, 1871, the large engine completed by Diller had been set up in the Heupel & Huber shop and piped in, a rather expensive operation.<sup>34</sup> Just two weeks later a small engine based on the new patent was set up after the large engine had been taken down. Alterations to the small engine included changes from iron to brass castings for some parts.<sup>35</sup> This engine was tested in early March and apparently proved satisfactory. However, work on it was carried out throughout March. Brass castings for another engine were made at the same time.<sup>36</sup> Iron castings were supplied by the Variety Iron and Brass Works, R. Blickenderfer, proprietor, at the corner of Duke and Chestnut Streets, Lancaster. The Centrifugal Rotary Engine Company purchased 323½ pounds of iron castings during February and March. This presumedly was for parts for engines of the new pattern.<sup>37</sup>

Experiments on the engines, apparently conducted on a trial-and-error basis, put abnormal wear on the engine mechanism. The engine company had purchased a self-adjusting injector from William Sellers & Company, Philadelphia, and a steam regulator (governor) from Pickering & Davis, Portland, Connecticut, in mid-February.<sup>38</sup> Less than a month after delivery both injector and regulator had to be extensively repaired by Heupel & Huber.<sup>39</sup> During March the shafting, hangers, pulleys, and other fixtures for the engines were continually being taken down, worked on, put up, and readjusted.<sup>40</sup>

The partnership of Hayes, Gibson, and Wierman was apparently dissolved during March 1871. Hayes and Wierman had paid \$100 each to the company's account on February 9 and had made additional payments of \$133.65 each in late February. Bills continued to be received but no further payments were made to the accounts of the Centrifugal Rotary Engine Company.<sup>41</sup> The partners had apparently lost hope in the eventual perfection of Gibson's design. Although the various en-



gines had been set up, no really successful test of the new engine had been made. In early April, Hayes ordered Heupel & Huber to do no more work on any of the engines. Wierman and Hayes then made an inventory of parts on hand and wrote up a statement of bills paid out and payments made to the partnership. Wierman indicated they wanted a final settlement.<sup>42</sup>

On March 24, 1871, Gibson sold his rights in Patent #110,912 to Henry W. Hager for \$900. Hager, a partner in Hager & Bros. and postmaster of Lancaster, agreed to pay Gibson one-half if the patent was re-sold, one-half of any royalties, or one-half of any profits from manufacturing the engine. Gibson agreed to give Hager "services in construction of engine" and a one-third interest in any improvements to the engine.<sup>43</sup>

Although Hayes and Wierman had wanted work on the engines halted, Heupel & Huber worked many hours on the largest engine in late April, apparently at Hager's order. All bills for this work were sent to Hager, who had presumably taken over active management of the company's affairs by some arrangement with Judge Hayes. Hager received bills from Heupel & Huber for a total of 201 hours work on the engine from mid-April to mid-June. Work on all other engines had been halted in late March. When the large engine was completed on June 17 all work by Heupel & Huber for the Centrifugal Rotary Engine Company ceased.<sup>44</sup>

After payment of the final bill, Hager presented a statement of bills paid to Judge Hayes. On June 26, Hayes paid Hager \$57.70, which was one-half of the amount Hager had paid for all bills received.<sup>45</sup> Hayes had already paid the bill of Flinn & Brenneman, 69 North Queen Street, Lancaster, for \$45.48 worth of sheet iron.<sup>46</sup> The John Best Company of Lancaster finally presented a bill for the boiler and accessory parts on June 26. Hayes paid the bill, for \$269.55, on July 18.<sup>47</sup> That payment cleared all debts of the Centrifugal Rotary Engine Company but did not settle the firm's accounts, for in September 1871 Wierman owed more than \$150 to bring the partnership to equal terms of investment.<sup>48</sup> Excluding bills paid jointly by Hayes and Hager in the May-June 1871 period, the partnership showed a total of \$1,286.04 paid in and \$1,608.88 paid out.<sup>49</sup> From the extant Hayes papers it is impossible to determine if Hayes was repaid by Wierman. Hayes did receive \$150 when he sold the John Best boiler and equipment to Heupel & Huber in late 1872.<sup>50</sup> Final disposition of the Gibson engine finished in June 1871 is not known.

Although the Centrifugal Rotary Engine Company was a failure, neither Samuel Gibson nor I. W. G. Wierman gave up their efforts to perfect the engine and put it into production. Wierman was said to be "manufacturing engines" in York in August 1871. There is no evidence to show that he made a success of the venture. In 1873 he was proprietor of the Keystone Cigar Manufactory in York.<sup>51</sup>

Gibson continued work on the engine after moving to the Farmer's Hotel in York in late 1871. He received a patent on a combined rotary engine and boiler in January 1872, and had already designed further improvements to the engine. In February, Gibson offered a one-fourth interest in the patent to Hayes, his only remaining financial backer in Lancaster. Henry W. Hager, who had rights to a one-third interest in all future patents of Gibson, had died on December 22, 1871.<sup>52</sup> Gibson displayed a model of his improved design at the office of the *York True Democrat* in early February. The engine was described as a "revolving piston" engine. Gibson planned to build such an engine, 6 x 6 inches in size and having a capacity of five horsepower, to propel the press of the *True Democrat*. Gibson continued at his work, even listing his occupation in 1873 as "patentee Rotary steam engine."<sup>53</sup>

The Centrifugal Rotary Engine Company of Lancaster was doomed to failure when it began, primarily because of the flaws in Gibson's design; the basic inability of such a design to use steam efficiently except at very high speeds, proven to Watt's satisfaction in 1784; and the primitive state of metals technology in 1870. J. M. W. Geist stated in his paper that the practical success of the steam turbine was not demonstrated until 1884, when C. A. Parson developed a compound rotary engine.<sup>54</sup> What Geist failed to point out was the basic difference between the Gibson and the Parsons turbines. The Gibson engine was related to the type of turbine (perfected after 1884) known generically as the "impulse turbine." In such a turbine, high velocity steam is discharged against a series of small buckets on the circumference of a large wheel keyed to the driving shaft. The Parsons turbine is an "impulse-reaction turbine," in which the steam passes through a number of rings of fixed blades and of moving blades, expanding as it travels. The impulse turbine is basically a high speed turbine useful for running dynamos, while the impulse-reaction turbine is useful for marine engineering and for running most types of machinery.<sup>55</sup>

Gibson's basic design resulted in an engine too powerful to run machinery and obviously too powerful to withstand the centrifugal force it created. The disintegration of the small engine on December 10, 1870, was a direct result of such force. Whether the change from solid core and revolving wheel (patent 108,016) to stationary wheel and revolving core (patent 110,912) solved the centrifugal force problem is undetermined because of a lack of serious testing after December 1870. The engine certainly needed more work than was possible on any reasonable amount of capital which could have been raised in Lancaster.

Even had the engine been perfected it could not have been used as planned, for success depended upon a market where the engine could have been sold profitably. Such a market did not exist prior to the early 1880's, when Thomas A. Edison opened central stations for incandescent lighting in New York City (1882) and Sunbury, Pennsylvania (1883). When such stations were opened throughout the country, the dynamos were powered by the ubiquitous reciprocating steam engine.<sup>56</sup>

## NOTES

1. *Papers Read Before the Lancaster County Historical Society*, Vol. VIII, No. 5, March 4, 1904, pages 129-141.
2. Franklin Ellis and Samuel Evans. *History of Lancaster County, Pennsylvania*. Philadelphia, Everts & Peck, 1883, pages 230-231.
3. Geist, page 129. Lancaster County (Pa.) Tax Assessment for Manor Township, 1869, tenants on property.
4. Letter, I. W. G. Wierman to Samuel Gibson, September 14, 1870, on company stationery. *York County Directory*, 1870-1871, page 101. *Hayes Papers*
5. Geist, page 132.
6. H. W. Dickinson, *A Short History of the Steam Engine*. New York, MacMillan, 1938, page 186.
7. *Ibid.*, pages 187-189.
8. Geist, page 132.
9. Samuel Gibson, "Improvement in Rotary Engines," patent 108,016, October 4, 1870. An original copy is in the *Hayes Papers*.
10. Undated prospectus for Centrifugal Rotary Engine Company, apparently in handwriting of I. W. G. Wierman. *HP*
11. Letter, I. W. G. Wierman to Samuel Gibson, September 14, 1870. *HP*
12. Geist, page 130. *Directory of Lancaster County*, 1869-1870, pages 38 and 49.
13. Bill of William Diller to Samuel Gibson & Co., November 5, 1870. *HP* Geist, pages 129-130.
14. Letter, A. L. Hayes to Edmund H. Bell, October 3, 1870. Bell was a grandson of Hayes. *HP*
15. Geist, page 136.
16. Indenture between Samuel Gibson and Alexander L. Hayes, dated October 10, 1870; stamped by the United States Patent Office on October 19, 1870. *HP*
17. Letter, A. L. Hayes to I. W. G. Wierman, October 26, 1870. *HP*
18. Letter, W. C. Chapman to A. L. Hayes, January 11, 1873. *HP*
19. Centrifugal Rotary Engine Company, accounts to April 1, 1871, cash received. *HP*
20. Bill, William Diller to Samuel Gibson & Co., November 5, 1870. *HP*
21. Bill, William Diller to Samuel Gibson & Co., November 19, 1870. *HP*
22. Bills, William Diller to Samuel Gibson & Co., November 19, November 26, and December 10, 1870. *HP*
23. Centrifugal Rotary Engine Company, accounts to April 1, 1871, cash paid out. *HP*
24. Bills, William Diller to Samuel Gibson & Co., November 19, November 26, and December 10, 1870. *HP*
25. Geist, pages 133-134.
26. *Ibid.*, pages 135-136.
27. *Ibid.*, page 136. *Lancaster Inquirer*, January 20, 1872.
28. Samuel Gibson, "Improvement in Rotary Engines," patent 110,912, January 10, 1871. *HP*
29. Bill, William Diller to Samuel Gibson & Co., January 6, 1871. Bill, William Diller to Centrifugal Rotary Steam Engine Company, February 4, 1871. *HP*
30. Bill, Heupel & Huber to Messrs. Hayes, Gibson & Co., January 14, 1871. *HP*
31. Bill, Heupel & Huber to Messrs. Hayes, Gibson & Co., January 28, 1871. *HP*
32. Geist, page 137. Centrifugal Rotary Engine Company, accounts to April 1, 1871, cash received and cash paid out. *HP*
33. Samuel Gibson, "Improvement to Rotary Engines," patent 110,912, January 10, 1871. *HP*
34. Bill, Heupel & Huber to Messrs. Hayes, Gibson & Co., February 3, 1871. *HP*
35. Bill, Heupel & Huber to Messrs. Hayes, Gibson & Co., February 17, 1871. *HP*
36. Bill, Heupel & Huber to Messrs. Hayes, Gibson & Co., March 11, 1871. *HP*
37. Bill, R. Blickenderfer to Centrifugal Rotary Engine Co., March 16, 1871. *HP*
38. Bill, William Sellers & Co., Philadelphia, Pennsylvania, to A. L. Hayes, February 23, 1871. Bill, Pickering & Davis, Portland, Connecticut, to Centrifugal Rotary Engine Company, February 21, 1871. *HP*

39. Bill, Heupel & Huber to Centrifugal Engine Co., March 17, 1871. *HP*
40. Bills, Heupel & Huber to Centrifugal Engine Co., March 25 and March 31, 1871. *HP*
41. Centrifugal Rotary Engine Company, accounts to April 1, 1871, cash received and cash paid out. *HP*
42. Letter, I. W. G. Wierman to A. L. Hayes, April 12, 1871. *HP*
43. Indenture between Samuel Gibson and Henry W. Hager, dated March 24, 1871. *HP* Ellis & Evans, page 402.
44. Bills, Heupel & Huber to Mr. H. Hager, May 1, May 13, May 20, June 3, and June 17, 1871. *HP*
45. Statement of Expenditures of Rotary Co., May-June (1871), in the handwriting of Henry W. Hager. *HP*
46. Centrifugal Rotary Engine Company, accounts to April 1, 1871, cash paid out. Bill, Flinn & Brenneman to Messrs. Hayes, Gibson & Co., March 22, 1871. *HP*
47. Bill, John Best Company to Centrifugal Rotary Engine Co., June 26, 1871. *HP*
48. Letter, A. L. Hayes to Samuel Gibson, September 13, 1871. *HP*
49. Centrifugal Rotary Engine Company, accounts to April 1, 1871, cash received and cash paid out. *HP*
50. Memorandum dated August 12, 1872, and signed by A. L. Hayes and Messrs. Heupel & Huber. *HP*
51. Letter, John Gibson, York, to A. L. Hayes, August 19, 1871. *HP Eisenhart's York Directory*, 1873, page 111.
52. Letter, Samuel Gibson to A. L. Hayes, February 7, 1872. *HP*
53. *York True Democrat*, early February 1872. *HP Eisenhart's York Directory*, 1873, page 43.
54. Geist, page 138.
55. J. W. Sothorn. *The Marine Steam Turbine*. 2nd Edition. London, Whittaker, 1906, pages 10-11.
56. William Adams Simonds. *Edison: His Life, His Work, His Genius*. Indianapolis, Bobbs-Merrill, 1934, pages 215 and 224.