FROM ASCENDING ROOMS TO EXPRESS ELEVATORS:

A HISTORY OF THE PASSENGER ELEVATOR IN THE 19TH CENTURY

BY LEE E. GRAY

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Introduction

This book traces the history of the passenger elevator in the U.S. from circa 1850 to 1900. My original plan had been to address the history of the elevator in terms of its technological development, its impact on office building planning and use patterns, and its social impact and cultural assimilation, balancing the text evenly between these three broad areas. Although I attempted to follow this outline, there is no doubt that the elevator's technological history occupies the pride of place in the completed book. This shift in focus occurred as I pursued this project and gradually realized that, if I was to understand the architectural and social impact of the elevator, I had to fully understand its mechanical operation from the basement to the attic. I should, I suppose, also confess to having developed a peculiar fascination with the workings of these extraordinary machines. As this project unfolded, I also realized that the development of the elevator was as much a commercial history as it was a technological and architectural history. Therefore, the story of the emerging elevator industry has been incorporated into this work and often provides the context needed to understand the course of invention and innovation. And, finally, I developed a genuine fondness for the ingenious and, occasionally, quirky inventors who gave life to the modern passenger elevator and, thus, where possible, I have provided basic biographical information for this intriguing cast of characters.

My research effort focused on three primary groups of materials: articles drawn from 19th century newspapers and scientific, technical, engineering and architectural periodicals; a small collection of manufacturers' catalogs; and over 2,500 elevator patents awarded between 1850 and 1900. A secondary body of material consisted of industrial and commercial histories of manufacturing centers located in the Northeast and Midwest: Boston, New York, Philadelphia, Buffalo, Cincinnati, Chicago, etc. Otis Elevator Co. also generously provided access to their extensive corporate archive, which includes a wealth of information on both Otis and the history of the elevator industry. Conspicuously absent from this body of research material were books devoted to elevator technology. In fact, the first American book on this subject did not appear until the early 1900s and, although the elevator has long been recognized as a pivotal component of modern buildings, particularly the skyscraper, it has received surprisingly limited scholarly attention (please see the note that precedes the Bibliography for a summary of 20th century elevator scholarship).

The collection of approximately 700 articles included accounts of elevator accidents, editorials, brief untitled notices of new innovations and full-length illustrated articles. Many of the latter were clearly intended to advertise a particular company's product as well as inform readers of the latest developments. Indeed, it was not uncommon for an illustrated article on a particular company's products to be followed by advertisements in subsequent issues, often featuring the same illustrations. It was equally common for the article's text and images to later appear in a manufacturer's catalog. In many instances, there seems little doubt that the article's text originated from the manufacturer rather than from the pen of an unbiased reporter. The editorials comprise an almost unrelenting call for improvements in elevator technology and operation, with their primary focus being passenger safety. The accidents, which often prompted these editorials, recounted in articles filled with typical 19th-century drama and horror, served as a useful source for determining both causes of mechanical failures and passenger use patterns and behavior.

The manufacturer's catalogs, which survived the 19th century, are principally those produced by the major elevator builders, including Crane Brothers of Chicago, L.S. Graves & Son of Rochester and, of course, Otis Brothers of Yonkers, New York. These works were typically heavily illustrated, including images of elevators placed in appropriately graceful architectural settings as well as images of the most pragmatic technical features, such as improved control valves, steam engines, etc. The catalogs not only informed potential buyers regarding the quality of a company's products, they also were a commercial battleground where manufacturers often praised their own products while disparaging those of their competitors. Although individual rivals were rarely mentioned by name, those familiar with the industry could easily identify the intended target. Although most catalogs were essentially collections of engravings with minimal text, there were a few notable exceptions. The most text-driven catalog was produced by Otis Brothers in 1869 and was 71 pages long featuring only 11 engravings. Perhaps the best use of text and images were the catalogs produced by L.S. Graves & Son in the 1880s, which paired beautiful full-page engravings with pages of descriptive text.

The collection of elevator patents comprises a continuous narrative of invention which parallels events found in other sources. This narrative, comprised of patent illustrations and text, served as a rich source for understanding the overall sequence of invention for both critical developments and the quaint and, occasionally, bizarre technical solutions that 19th-century inventors often favored. The illustrations provide a kind of visual barometer of development tracing the shift from freight hoists to fully equipped passenger cars outfitted with doors, comfortable seating and skylights. The text served as a useful means of making connections between inventors and their colleagues and individual companies: identifying instances of collaboration through the co-listing of inventors' names and through the assigning of full or partial patent rights (such statements, when appropriate, followed the inventor's name). The latter was especially helpful in following Otis Brothers' corporate strategy, which included the founding of holding companies whose sole purpose was to retain ownership of specific groups of patents.

The commercial histories of New York, Chicago, Cincinnati, etc. were useful sources on company ownership, history and product lines. These works occasionally provided important biographical information on inventors, including birth and death dates, training, apprenticeship and insights into individual personalities. Biographical information was also drawn from a survey of obituaries published in the proceedings of the American Society of Mechanical Engineers and the American Society of Civil Engineers. Where appropriate, this material has been included. However, in far too many instances (at least from the author's point of view), this critical data was either missing or incomplete. The history of the passenger elevator cannot be fully understood without an understanding of the remarkable men and women who invented, manufactured and marketed these machines. Their business acumen and entrepreneurship, epitomized by the extraordinary business skills of Norton and Charles Otis, resulted in the creation of a new industry.

The elevator industry, of course, still survives and thrives today. Now, the chief competitors are global rather than national rivals. While, by the 1890s Otis Brothers had branch offices scattered across Europe, most commercial competition, regardless of country, was limited to local or regionally based companies. For this reason and, more importantly, because the history of the passenger elevator in Europe follows a very different path, in terms of both technology and use, I limited this study to the development of the elevator in the U.S. Thus, I have excluded Otis' foreign endeavors and, although some European events make their way into this history, they are limited to a supporting role. In fact, the history of the passenger elevator in England, France, Germany and elsewhere in Europe remains to be written. This fact leads to another and perhaps obvious observation regarding the scope of the present book: this work is not a comprehensive history of the elevator in the 19th century. In fact, the author is well aware that potential readers will likely note areas where they might desire more information (although I fully realize that few people have my level of interest in this subject and that some readers may, indeed, find more than they need to know about some topics).

Among those areas not explored in the current book is the emergence of support industries related to elevator production and use. These included firms that specialized in automatically operating hatchway covers and doors, iron works that manufactured custom elevator shaft enclosures, etc. Although the former is touched on, the latter remains a topic for future study. Since this book is the product of almost 20 years of sustained interest (which had its origin as a research paper written at the University of Virginia in 1982), there is a reasonable possibility that any topic over looked or left out will, eventually, be investigated by the author. My interest in this topic remains strong, and I look forward to continuing this investigation over the next 20 years.

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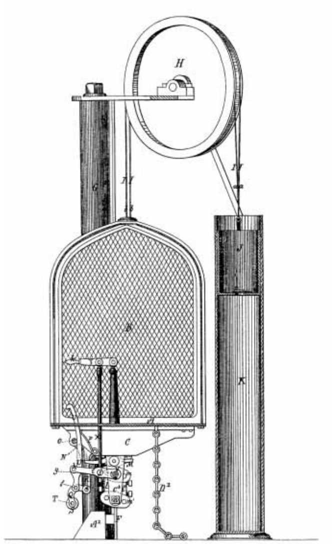

Chapter Four

**New Settings and New Problems:
The Elevator and the Early Skyscraper,
1870 to 1875**

Although freight hoists had been employed in office buildings since the 1850s, passenger elevators did not appear until the early 1870s. The introduction of the passenger elevator into this setting was one of several key aspects in the emergence of a new type of office building – the skyscraper. This introduction sparked a debate concerning appropriate elevator technology and methods of operation required in different architectural environments. Elevator systems designed in the Equitable Building, the Western Union Telegraph Building and the *New York Tribune* Building showcased the best available technology and illustrated diversity in solving the problem of providing safe and efficient vertical transportation. This chapter will examine these various technologies, their impact on the development of the early skyscraper and architects, users, and the general public's reaction to their presence in this new environment.

Paradigm for Progress, Part One

The Equitable Life Assurance Society Building in New York City, completed in 1870 and designed by Arthur Gilman, Edward Kendall and George Post, was the first office building in the U.S. to use passenger elevators. By the late 1860s, the Equitable Life Assurance Society was one of the best-known life insurance companies in the U.S. due to its rapid growth, aggressive and successful business operation, and dynamic founder – Henry Baldwin Hyde. Hyde has been recognized by architectural historians as the individual who initially proposed using elevators in the Equitable building. He has been characterized as a visionary who triumphed over the opposition of his board of directors and the doubts of New York "real estate men" regarding the use of passenger elevators in his new building.[1] This characterization prompts an intriguing question: Why, given the established presence and successful use of passenger elevators in hotels, did Hyde face opposition to using this new technology?

One answer to this question lies in the character of the setting where the elevator experienced its initial success. Its early use in hotels created a perception of the elevator as essentially a residential device with little connection to the business world. Its gradual introduction into New York's fashionable retail establishments did little to change this perception. The primary function of the elevator in a hotel or store was to provide a safe, smooth and often opulent ride to the upper floors. The nature of this experience was summarized as follows:

> You enter a charming little room nicely carpeted, around three sides of which a low cushioned seat extends. The walls are furnished with polished and variegated woods, and adorned with mirrors. Quaint panes of stained glass admit light at the top, but this would be insufficient, even at noonday, were it not for a pretty and petite chandelier, fed with gas by a rubber 'flexible' which itself is ingeniously arranged.[2]

The emphasis in the design of these elevators was on comfort and safety, not on speed of operation. The nature of business operation in America in the 19th century was defined then as now by its fast pace. Immigrants to New York wrote back to family and friends in Europe about the fast railroad pace of business and labor in the U.S.[3] The elevator, as defined by its use in hotels, had no place in Wall Street.

Hyde's desire to employ passenger elevators in his building also presented a challenge to his architects. Although the building's designers lacked any precedent for integrating this new technology into the typical office plan and building fabric, fortunately for Hyde, the team of architects selected for the Equitable Building possessed the requisite design and technical skills.

Arthur Gilman and Edward Kendall served as the lead architects for the building with George Post as a consulting architect in matters of construction. Gilman had been one of Boston's leading commercial architects. He moved to New York in 1866 and in 1867 formed a partnership with Kendall, a young architect at the start of his career. Kendall also from Boston had worked in the office established by Gridley J.F. Bryant (with whom Gilman had also worked). Bryant's firm was the largest architectural office in Boston and designed over 150 buildings for Boston's central business district. Both men were well equipped to design commercial buildings. Post, like Kendall, was at the start of his career. He had graduated from New York University in 1858 with a BS in civil engineering. This was followed by two years apprenticeship in Richard Morris Hunt's office. Following the Civil War, Post established his own office.

Gilman and Kendall produced an elegant and highly functional design for the Equitable Society. The building occupied an irregular trapezoidal site at the corner of Cedar Street and Broadway. The architects responded to the site's geometry by using a primary grid perpendicular to Cedar and a secondary grid that responded to the Broadway site line. A wedge of service spaces was inserted at the intersection of the two grids, and the elevators and stair formed a circulation core adjacent to an interior light court opposite Cedar (Figure 4.1).

Upon its completion in 1870, the Equitable Building was the tallest office building in New York City at 130 feet high from the sidewalk to the top of its mansard roof. It consisted of nine stories: a below grade cellar, a basement at street level and seven upper floors. The cellar contained mechanical spaces, a large walk–in fireproof storage vault with related office space and a large washroom. The basement and first floor were designed for banks and other insurance

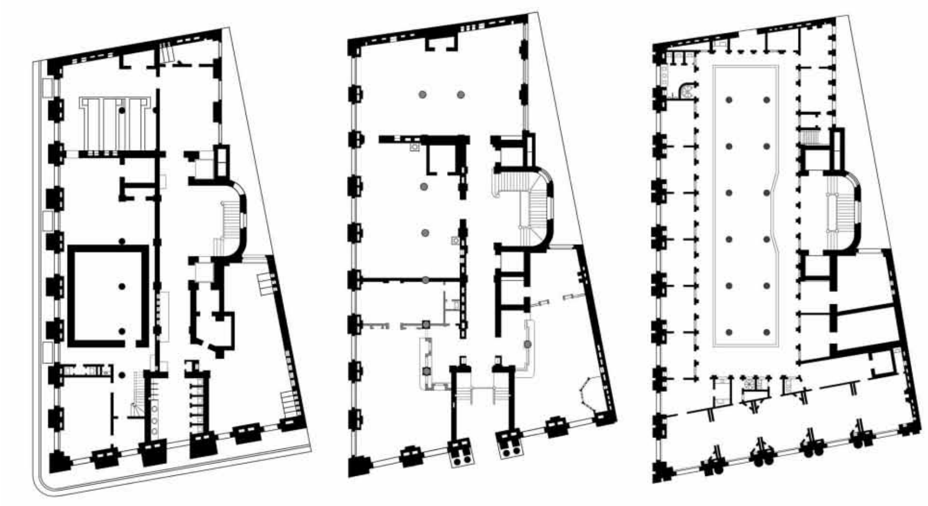
Figure 4.1: Cellar, first floor and second floor plans, Equitable Life Assurance Society Building, New York City, designed by Arthur Gilman, Edward Kendall and George Post, 1870

companies. The second and third floors housed the Equitable's offices, and the remaining floors were leased to commercial tenants.

The elevators were placed at the heart of the building, making them an integral aspect of the building's operation. In the cellar, basement and first story, the elevators opened directly onto a main corridor, reflecting the use patterns and functional order of those floors. On all remaining floors, their entrances shifted 90°, and the elevators opened onto a vestibule adjacent to the stairway. This shift was made possible due to a decrease in floor heights as the building rose above the first floor. This reduced the length of stair and allowed the creation of a combined stair and elevator lobby on the top five floors.

One of the elevators also served as a freight hoist, a separate compartment located below the passenger car carried packages and supplies. The custom design of the elevator cars reflected the ingenuity of their manufacturer as well as a willingness to provide a product specifically made for the building. This came as no surprise to New Yorkers as the man who introduced the elevator to the office building was the same who had earlier introduced it to the hotel: Otis Tufts.

The Tufts' Elevator Works received the commission for the Equitable Building, besting among others, Otis Brothers. As noted in the previous chapter, during the 1860s, Tufts had focused on improving traditional elevator systems that employed a car suspended by wire ropes. Although the precise nature of the elevators installed in the Equitable Building is unknown, their probable design may be inferred from Tufts' patents and surviving contemporary accounts. Each elevator had its own steam engine, fitted with Tufts' patented steam valve and used a worm gear connection to turn the winding drum. His well-known concern for safety was addressed by six wire ropes used to suspend each car.

The elevators may have also utilized safety devices designed by Tuft's son, Otis Tufts, Jr., patented in 1869.[4] Hotel elevators occasionally encountered obstacles, such as a steamer trunk projecting into the shaft, impeding car movement. If the elevator car stopped moving, and the engine continued to run, the wire rope would unwind from the drum either became tangled or created a large degree of slack. In turn, when the obstacle was removed, the car would plunge down the shaft. Tufts, Jr. devised a safety that automatically stopped the car if it hit an obstruction. He placed a spring on one end of the worm shaft and a friction clutch on the end attached to the steam engine. Any loss of tension on the hoisting cable would cause the spring to move the shaft and disengage the clutch, stopping the car. Although the steam engine would continue to run until stopped by the elevator operator, the winding drum would not move because the spur gear could not drive the worm. Tufts, Jr. also designed an automatic shutoff mechanism for the steam engine and a belt shipper that moved the belts to the loose pulley, both of which were activated by the displacement of the worm shaft.

The elevators operated at a speed of 75 feet per minute, traveling silently along their guide rails using a system of leather-faced wheels designed in 1866. Additional noise protection was provided by solid masonry shafts. The shafts projected the exact opposite of the image typically associated with 19th century elevators, where the elevators traveled through open metal cages. Tufts seems to have preferred enclosed shafts, and the *New York Sun* noted that, at 130 feet high, these were the tallest elevator shafts he had ever designed. The reason for his use of solid enclosures may have also been linked to concerns regarding fireproof construction. His customer, Henry Hyde, was known for fireproofing a building as much as possible. The elevator cars that traveled through these shafts were original, in their double doors, and typical, in their benches, skylights and gas chandeliers. Additional light may have been gained from a skylight at the top of each shaft and windows set into the shaft doors.

Tufts' Elevator Works designed, built and installed the two elevators for US$29,657.39. The cost per elevator (roughly US$15,000) placed them on par with Otis Brothers' top-of-the-line passenger elevator. The prestige of this commission and subsequent publicity positioned Tufts' company at the forefront of the emerging elevator industry. Regrettably, its founder was not there to enjoy the fruits of his long labors. Following a visit to New York to oversee completion of the work on the Equitable Building, Tufts died of heart failure on November 5, 1869 in Boston. It is quite possible he returned home with a clipping from the *New York Sun* in his pocket which described his elevators as "incomparable" and the "the only secure ones constructed."[5] *The New York Times'* obituary praised his accomplishments as an inventor and his contributions to elevator design, noting his pioneering involvement with the Fifth Avenue Hotel and the Equitable Building.

When the building opened in May 1870, the popular press and the public enthusiastically embraced the elevators. The *Insurance Times* noted that in a single day, 2,417 people visited the building and used the elevators. This observation was accompanied by the following social commentary:

> A phenomenon was observed in connection with this proceeding which seemed to involve a physical and moral paradox. It was remarked that the members of the rising generation invariably

> availed themselves of the "lift," while many of the adults and aged were content to ascend the stairs by use of the pedal extensions which Dame Nature herself provided for their locomotion. Is this a sign of the degeneracy of the times, or of Young America's innate and practically appreciative adoption of every mechanical improvement?[6]

The rising generation was not alone in their acceptance of this technology. The Equitable's board of directors, all members of the older generation, quickly forgot any prior reservations and enthusiastically embraced the use of elevators in their building. The 1872 *Annual Report for the Equitable Life Assurance Society* included a history of the building where earlier objections were forgotten, and the board's courage celebrated:

> The Directors of the Equitable, confident that their experiment would be successful, constructed their building to the height of eight stories, which never before had been attempted by landlords who contemplated disposing of their rooms as offices.[7]

The Board noted with pride that their company had "introduced the use of passenger elevators in office buildings," a decision they claimed would produce a revolution in office building design. Hyde had been right, his gamble paid off, and the building was viewed as a great success.

While this success marked the beginning of a new era of office building design, it also marked the last great commercial success of the Tufts' Elevator Works. At the time of his death in November 1869, newspaper accounts claimed that Tufts, Sr. had achieved an international reputation and that he had sold US$1 million in elevators in his 10-year career.[8] Although the accuracy of this figure may be questioned, there is no doubt that his company entered the 1870s occupying a strong position with Tufts, Jr. in control of the company. However, in early 1873, a prospectus labeled "For Private Circulation Only" began to be circulated in New York and Boston. This prospectus outlined a proposed merger of the Tufts Elevator Works with Otis Brothers & Co.

The origins of this proposal are unclear as to which side made the initial suggestion, what is clear is the seriousness with which it was pursued. The prospectus included a brief history of each company, a combined financial statement averaging their sales and income over the past three years and a plan for sale of stock. The proposed name for the new business was the Union Elevator Co. This name may have been chosen, at least in part, because it recognized and celebrated Otis' pioneering Union Elevator Works. It is also interesting to note that the prospectus claimed that "the late Otis Tufts erected the first practicable Passenger Elevator ever made, so far as known, for any hotel or public building in the world." All in all, it presented a balanced, and only slightly self serving, story of the important role each company played in the development of both freight and passenger elevators.

The average combined income of the two firms for the years of 1870, 1871 and 1872, was listed as US$448,554.64 with a net profit of US$103,378.15. The Otis factory was the larger of the two, allegedly capable of producing US$500,000 worth of elevators per year, while the output of the Tufts' Elevator Works was only US$250,000 per year. The proposed capital was US$1 million with US$150,000 in cash and the remainder to be raised from investors. The initial stock offering was US$500,000 at par with 10% paid upon subscribing with the remainder paid in installments after the company was officially organized. The date set for completion of the merger, assuming the stock sales met their goal, was July 1, 1873. The goal of the merger was simple. The prospectus stated that the united companies would reap higher profits, as they would no longer be in competition, and that combined they could "control the (elevator) business for years to come." This claim was supported by the fact that between them they had over 25 patents, which represented almost 10% of all elevator patents granted between 1850 and 1870. Thus, they could "effectively bar successful outside competition."

Surprising, this well-crafted prospectus failed to attract a sufficient number of investors to permit the merger. Its failure was surprising because the contemporary construction boom in New York and the rebuilding of Boston, as a result of the fire of 1872, created a strong demand for both passenger and freight elevators. However, as events unfolded in 1873 and beyond, the failed merger was a blessing in disguise for Otis Brothers and a disaster for Tufts' Elevator Works. In the fall of 1873, the stock market crashed, and the ensuing financial panic plunged the nation into a depression which lasted the remainder of the decade. As projects were completed, the demand for elevators dropped significantly.

In January 1875, the Tufts Elevator Works became embroiled in a patent infringement suit with the Boston Machine Co. The court ruled that the claims of originality for the use of shipper rods (from Otis Tufts' original 1859 patent), the use of multiple ropes and rocking device to equalize rope strain (1861), and the improvement in elevator guides (1866) were invalid for want of novelty. Although the company remained in business until the early 1880s, the Tufts Elevator Works never fully recovered, and they failed to recapture the initial status achieved by their founder. In 1884, their remaining patents were purchased by the Moore & Wyman Elevator & Machine Works of Boston; the following year Otis Tufts, Jr. died.

Steam Versus Water

The Western Union Telegraph Building, designed by George Post and completed in May 1875, was one of the first buildings to follow the Equitable paradigm. The building consisted of a below grade sub-cellar and cellar, an above grade basement, and 10 upper floors, with the three top floors incorporated into a large mansard roof. Originally intended to be divided evenly between Western Union offices and rental spaces, the continued growth of Western Union resulted in its occupying more than three quarters of the available office space. Although it followed Equitable's lead in building a tall office building with elevators, the Western Union Building differed substantially in its internal organization. The basement through the fifth floor housed the clerical or office core of the building and resembled the Equitable in much of its layout and finish. However above the fifth floor, six through 10 housed the working operations of Western Union:

battery rooms filled the sixth floor, the telegraph operating room occupied the entire seventh floor and a kitchen, employee lunch room and various storage rooms occupied floors eight through 10.

The elevator system reflected the building's size and its mixed use. Two passenger elevators were located along the main hallway and were intended to serve visitors, tenants and Western Union officers. A third passenger elevator was for the sole use of rank-and-file Western Union workers and operated in the well of a large iron stairway on the north side of the building. A freight elevator operated from the cellar to the top of the building. It was smaller than the passenger elevators, described in one account as a "cupboard elevator." The building also had several sidewalk hoists that provided access for deliveries to the Western Union supply room in the cellar. The two public passenger elevators and the freight elevator were designed by Otis Brothers. The passenger elevators, labeled "New York Safety Passenger Elevators," were powered by 30 hp steam engines. They reflected the high level of design found in earlier Otis steam elevators and featured additional refinements.

Among the latter were an improved safety brake attached to the winding drum which automatically released or engaged as the engine was started or stopped, a governor attached to the winding drum to activate the brake if the drum turned too fast, an improved steam valve for stopping and reversing the engine and modified guide rails aimed at producing a quieter ride. The new guide rails were almost identical to those designed by Tufts and provided clear evidence of the strong competition between the firms as they sought to bring the steam-powered elevator to a new level of performance. While the Western Union Building served to showcase Otis Brothers' latest efforts, the building also accommodated another passenger elevator that, through its unique design, challenged the primacy of steam power.

The elevator provided for Western Union employees was designed by Cyrus W. Baldwin (1820-1898). By the end of his distinguished career, Baldwin had been awarded over 35 elevator related patents, worked for most of the major elevator manufacturers and had played an important role in the development of the hydraulic elevator in the U.S. However, while his many technical innovations and contributions may be clearly traced, the precise nature of his relationship with his various employers is less clear. Although Baldwin was employed by the Whittier Machine Co. in the early 1870s, the elevator placed in the Western Union Building was constructed under the auspices of William E. Hale & Co. of Chicago. Baldwin had traveled to Chicago in 1871 to supervise the installation of a Whittier elevator in a new building located at the corner of State and Washington. The building was a speculative venture underwritten by William Ellery Hale (1836-1898). Hale had moved to Chicago in the late 1860s and became involved in real estate speculation and investments. He became acquainted with Baldwin during his stay in Chicago and through him developed an interest in elevators.

Hale's new found interest and business foresight led him to purchase the rights to an elevator design patented by Baldwin in 1870. Baldwin christened his invention the *Hydro-Atmospheric Elevator*; however, it eventually became known by a more descriptive, if less poetic name: the Water Balance Elevator. The latter title sums up the essence of his invention. The elevator relied solely on gravity for its operation with the weight of the car balanced by a large water-filled bucket. The elevator utilized two hoisting cables that passed over sheaves at the top of the shaft and connected the car to a large bucket located in a vertical metal standpipe. The elevator's movement, in terms of both direction and speed, determined the amount of water in the bucket and whether it, or the car, weighed the most.

With this single patent in hand, Hale founded, along with his brother George Wheelwright Hale, William E. Hale & Co. Since the new company did not have a factory, Hale contracted with established manufacturers to produce his elevators. While Hale's company received the commercial credit for the Western Union employees elevator, its actual manufacturer may have been Baldwin's employers, the Whittier Machine Co. The precise ownership of the various design aspects of this elevator presents an interesting puzzle. By 1875, Baldwin had received six elevator patents, four of which related directly to the elevator placed in the Western Union Telegraph Building. One of these was his initial 1870 patent, (#99,049, *Elevator for Hoisting Human Beings, Merchandise, etc.*, January 25, 1870). The remaining patents included Patent #70,941, *Improvement in Elevators* (November 19, 1867); Patent #109,169, *Improvement in Elevators* (November 15, 1870); and Patent #123,761, *Improvement in Elevators* (February 20, 1872).

The rights to Patent #99,049, which contained the conceptual basis for the Western Union elevator, were owned by William Hale. Baldwin apparently retained the rights to Patents #70,941 and #109,169 that concerned improved safety devices. The rights to Patent #123,761, which was essentially an elaboration on the elevator described in Patent #99,049, had been assigned to Charles Whittier and Henry McBurney of the Whittier Machine Co. when it was issued. Thus, it cannot be said with certainty who truly owned the full rights to this elevator which was marketed as Hale's Water Balance Elevator.

The elevator installed in the Western Union Building reflected both the simplicity of Baldwin's original idea and the impact of the features contained in the additional patents, with the end result being a surprisingly complex mechanical system (Figure 4.2). The operator controlled the elevator through a hand brake, a shipper rope, a shipper handle and a foot pedal brake release. The hand brake was connected to a spring mechanism attached to a set of clamps under the car that gripped two wrought-iron guide rails. The shipper rope controlled a valve located in an eighth floor water tank while the shipper handle controlled a valve in the bottom of the bucket.

To ascend, the operator first pulled on the shipper rope to open the valve in the upper water tank, allowing water to begin filling the bucket. When the operator felt that the weight of the bucket exceeded that of the car, he would pull on the shipper rope again, closing the valve. Next, he would depress the hand brake. As long as the brake was depressed, the car could move. When the required floor was reached, the handle was released, and the car stopped. To

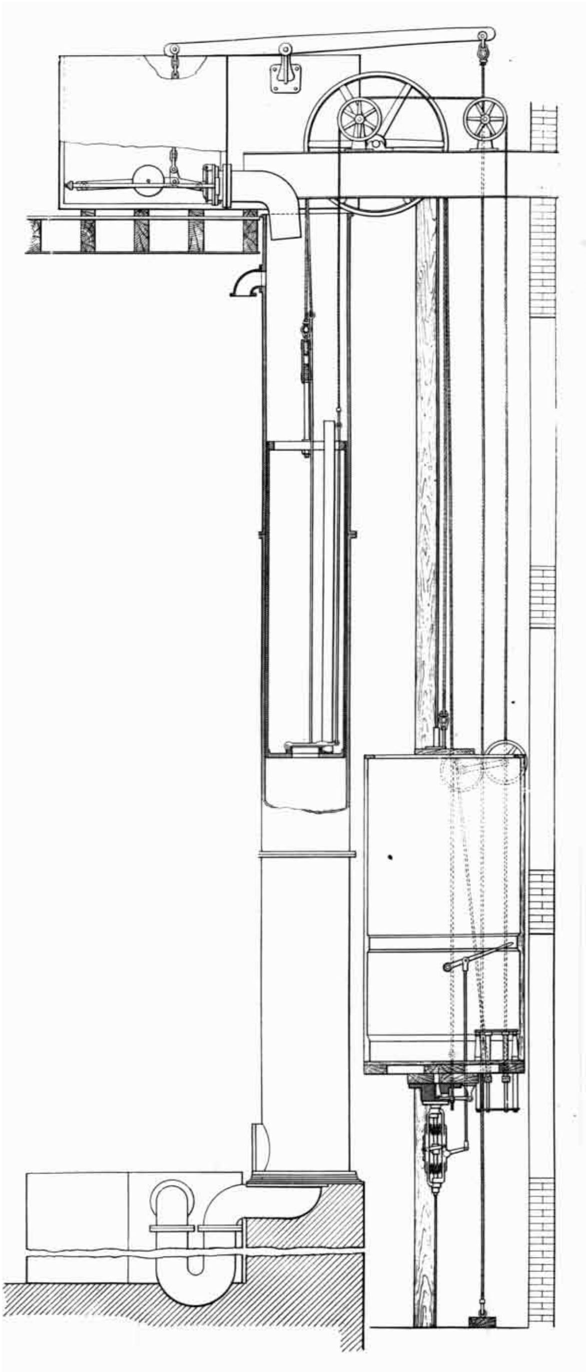

Figure 4.2: Cyrus Baldwin's Water Balance Elevator, 1875

descend, the operation was reversed. Now the shipper handle was moved opening the valve in the bucket, allowing the water to escape. The foot pedal was connected to the brake and served as an additional safety device. If the car ascended or descended too far, the brake would automatically engage, triggered by mechanisms in the shaft. The foot pedal released the brake allowing the car to move safely in the required direction.

The elevator was also equipped with what became known as Baldwin's Patent Safety Apparatus, or more commonly, the Baldwin Safety (Figure 4.3). This was yet another variation on an automatic mechanism that would grip the guide rails if the hoisting cables broke. Unlike its predecessors, this device was located under the car because the cables were attached to the bottom of the platform. Baldwin felt that attaching the hoisting cables to the top of a car simply added weight, since this would require heavy side posts to support a crossbeam. He also felt that this increased the possibility of the car falling due to the potential failure of the crossbeam.

The Baldwin Safety employed two fluted wrought-iron rollers, one located on each side of the car adjacent to the guide rails. The rollers were housed in brackets such that if a cable broke, they would move up into the bracket wedging themselves between the platform and the guide rail, stopping the car. Attaching the hoisting cables to the bottom of the platform also allowed Baldwin to construct his car with lighter materials than typical elevator cars. His initial concept proposed a car constructed of a simple frame covered with cloth or wire mesh. The illustration for patent #123,761 depicts a basket-like car atop the platform (Figure 4.4). However, the elevator car in the Western Union Building was fairly typical in its design, complete with a bench for passengers.

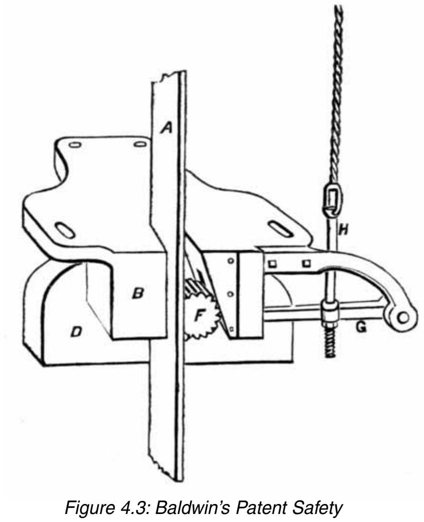

Figure 4.3: Baldwin's Patent Safety Apparatus, 1875

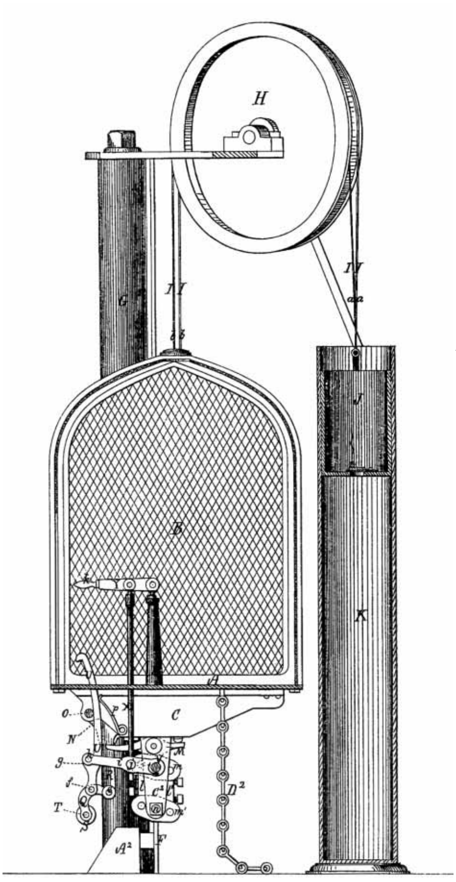

Figure 4.4: Cyrus Baldwin, Improvement in Elevators, Patent #123,761, February 20, 1872

Baldwin's elevator quickly established a reputation as being one of, if not the fastest, elevator in New York City with observers claiming that it occasionally reached speeds approaching 1,500 feet per minute. Considering its method of operation and the reliance on the hand brake to stop the car, the ride would have been exhilarating to say the least. When the building opened, it would have had to operate at only a fraction of its alleged top speed to claim the title of the fastest passenger elevator. Tufts' passenger elevators operated at a speed of 75 feet per minute, and Otis Brothers' elevators were only slightly faster, averaging speeds of 100 feet per minute. Regardless of their speed, it is doubtful whether any of the three elevators fully met the needs of the inhabitants of the Western Union Building.

Surprisingly in this massive building, the freight elevator was the only one which ran from the lowest to the highest floor, linking the Western Union supply room in the cellar with the attic store rooms. The Otis elevators only operated from the basement to the fifth floor. Although they were described as public elevators, they primarily transported Western Union officers, customers, visitors and the building's tenants. With a capacity of 18 passengers per car, these elevators served the clerical or office core of the building reasonably well.

Baldwin's elevator served the basement through the seventh floor, and although it operated in conjunction with the landings of the iron stairway, it primarily served to carry workers to the seventh floor. It seems unlikely that this single elevator, with a capacity of only 14 passengers, could have adequately served the more than 350 workers who occupied the upper floors. The seventh floor alone was home to 290 telegraph operators and various other staff.

Although these elevators may not have met peak traffic needs, they did offer a new usage model. Their design and placement marked the different zones of the building (clerical versus operational) and the recognition that elevators could serve different users. This was a subtle shift in thinking from the Equitable Building paradigm. This shift may have had more to do with the character of Western Union as a business than actual innovative thinking. The presence of the employees' elevator also permitted their effective segregation from Western Union officers and other building tenants.

The Tall Tower and the Unknown Engineer

Cyrus Baldwin was not alone in seeking innovative solutions to the technical problems represented by the passenger elevator. His ingenuity was matched by the little-known Boston engineer who designed the elevator system for the tallest office building constructed in New York City in the 1870s. In May 1875, the first phase of the *New York Tribune* Building was completed. Designed by Richard Morris Hunt, the building, at 260 feet from the sidewalk to the top of its clock tower, surpassed the Western Union Building by 30 feet and sent a clear signal regarding the future upward growth of the city.

The *New York Tribune* was one of the city's oldest papers, founded by Horace Greeley in 1841, and by the early 1870s, it also possessed a national reputation.

The new building was not a reflection of its pragmatic founder but rather of his energetic and youthful successor, Whitelaw Reid. He had succeeded Greeley in 1872, and at the age of 35, served as the paper's chief editor and principle stockholder. The new building was intended to provide a home for the *New York Tribune* that would reflect the importance of the newspaper and its youthful publisher.

The building consisted of a multi-level cellar, a basement level and nine upper stories with the top two housed in a large mansard roof. The paper occupied the entire cellar, a portion of the basement and first floor, and the entire eighth and ninth floors. The eighth floor housed the paper's editorial staff and offices for reporters. The ninth floor, in a similar fashion to the Western Union Building, consisted of a large open workspace used as the composing room. This space was where the paper was "put together." The lead type was placed by hand into large metal forms which were then transported to the printing rooms located in the cellar. The composing and printing rooms were always located at opposite ends in a newspaper building, one required proximity to light and the other to steam power. The need to transport the print forms between the two areas resulted in newspaper buildings utilizing freight hoists since the 1850s. The *New York Tribune* was the first newspaper to employ passenger elevators in their building, and in this, as in all matters related to the building, Reid played a key role.

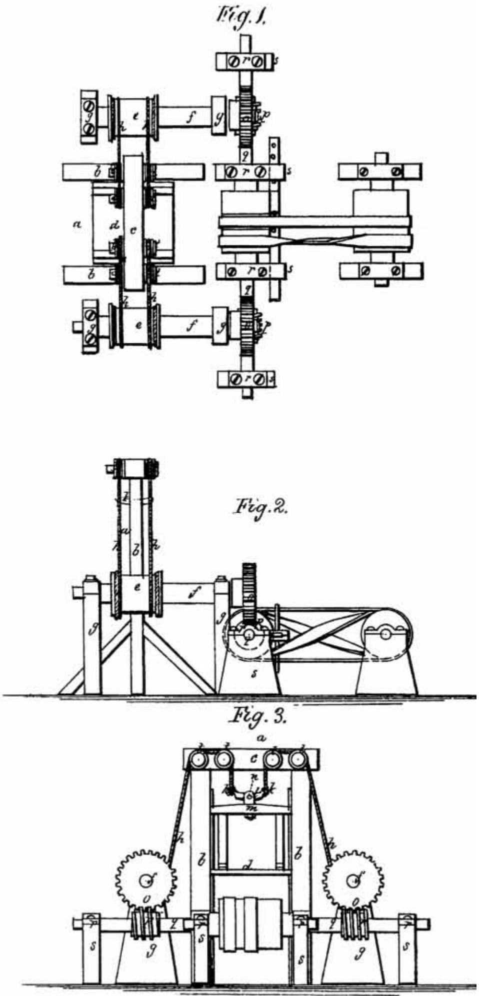

Figure 4.5: Melancthon Hanford, Improved Elevator, Patent #99,433, February 1, 1870

In July 1873, William Hale contacted Reid promoting Baldwin's water balance elevator. Although Reid stated that he was "favorably impressed" with the elevator, Hale was not awarded the contract.[9] Reid and Hunt instead choose Boston engineer Melancthon Hanford. Hanford was born in Red Bank, New Jersey in 1841. In 1851, his family moved to Boston where he attended school, and in 1857, he entered the blacksmith trade. Hanford moved to Brooklyn in 1862 where he worked as an apprentice machinist until 1865, when he returned to Boston to work for the Eagle Sugar Refinery. In 1870, he patented what eventually became known as his double screw and drum elevator and he left the refinery to pursue a career in the emerging elevator industry.[10]

Hanford's design was essentially a variation on the standard worm and gear drive and was popular in New England for over 15 years. The elevator employed two worm gears located at opposite ends of the drive shaft. Each gear turned a separate winding drum due to the different cuts (one left and one right) that rotated the drums in opposite directions. Each drum carried two hoisting cables which were connected to the top of the car via a modified rocking lever. Hanford claimed that the dual worms reduced the strain or end-thrust on the drive shaft, wear on the worms and the power needed to drive the elevator. The patent illustrations depict a belt-driven elevator with a pragmatic, if inelegant, arrangement of pulleys, shafts, drums and car (Figure 4.5).

By 1875, Hanford had substantially refined his elevator, using a more compact arrangement of working parts and incorporating a steam engine into the design (Figure 4.6). The presence of the engine may reflect the contributions of Hanford's brother, Clarence. Clarence was a well-known steam engineer in Boston and began assisting Melancthon in the mid-1870s in the construction of his elevators.

Prior to his work in the *New York Tribune* Building, Hanford received two additional patents.[11] The first concerned an improved cable connection to the top of the car. This employed oil-filled cylinders to equalize the strain between the cables and reduce the jarring or shaking of the car when the engine was engaged. The second patent provided one of the earliest designs for an alternative control mechanism in the car, replacing the shipper rope. Hanford felt that the ropes were not only unsightly but were a difficult means of controlling the elevator. He proposed placing the rope outside the car, adjacent to one side.

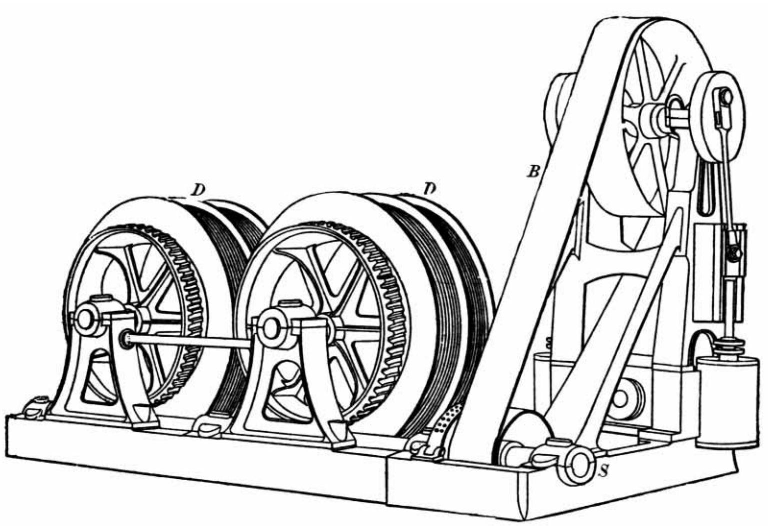

Figure 4.6: Hanford's Double Screw and Drum Elevator, 1875

The rope was wound one or more times around a pulley attached to a shaft connected to a hand wheel on the inside of the car. As the car moved, the pulley and hand wheel rotated. When the operator wished to stop the car, he would grasp the handle, stopping the wheel, which would in turn cause the shipper rope to move and stop the engine. To start the elevator, the operator simply turned the hand wheel clockwise to descend or counter clockwise to ascend. Hanford also incorporated an improvement not recorded in any of his patents. The sheaves at the top of the shaft were described by the *New York Tribune* as being of a "peculiar construction." They were lined with leather to deaden the noise of the wire ropes as they passed over the sheaves.

Like the Western Union Building, the *New York Tribune* Building was designed to accommodate three passenger elevators. Similarly, two of the elevators were intended for public use and one was reserved for employees. The two public elevators were placed side by side in a hall opposite the main entrance and were embraced on two sides by the main stairway (Figure 4.7). This miniature elevator bank was highlighted in news accounts of the new building:

> The elevators, however, which are built upon a greatly improved pattern, will be constantly running, and as there are two cars side by side, passengers are not likely to be kept waiting under any circumstance more than a few seconds. There are some large buildings in this city in which two elevators are placed at opposite ends of a long hall so far apart that the impatient passengers who miss one and go to the other are very apt to miss that one too.[12]

The employees' elevator was located adjacent to the inner party wall and was the first elevator to offer express service between floors (Figure 4.8). Unlike the

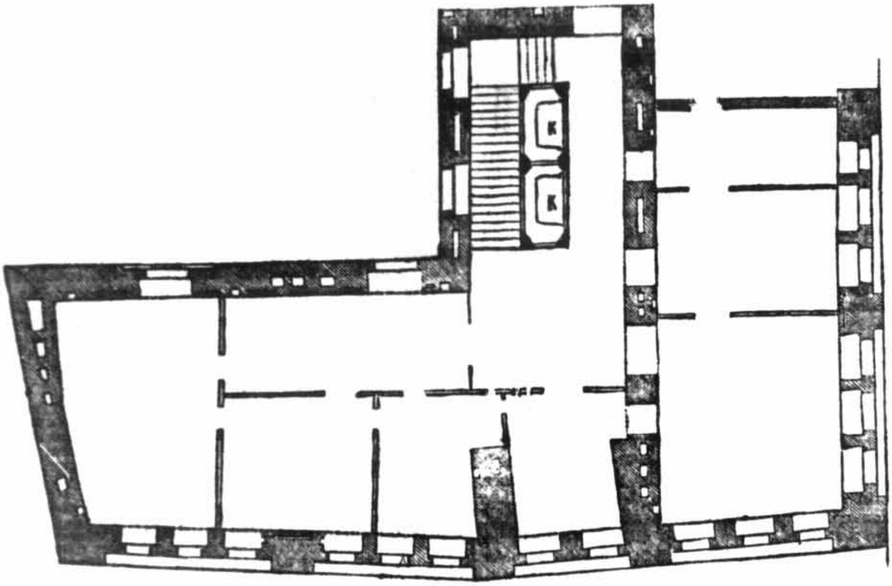

Figure 4.7: ***New York Tribune*** *Building, plan of first floor, Phase one, 1875*

Western Union employees' elevator, which served all floors from the basement to the eighth, the *New York Tribune* elevator provided access from the cellar, basement and first floor directly to the top two floors, bypassing the rental floors. The building followed earlier prototypes in its solution to moving freight throughout the building. One of the public elevators was fitted with a special baggage compartment beneath the car to carry the press forms between the composing room and the press room. A smaller steam hoist, similar to Western Union's cupboard elevator, also serviced the newspaper offices and operated in a cavity in one of the main walls.

The two public elevator cars were each 5 feet 6 inches by 9 feet and contained a bench along three sides. They were lighted by gas fixtures and skylights. The elevators also received light from the adjacent windows in the stairwell. Hanford's twin elevators were not housed in solid masonry shafts, they operated in an open iron framework enclosed by metal screens. The desire to use the stairwell as a means of lighting the cars, via their skylights, also had a pragmatic aspect. This meant that the operator would not have to burn the gas light during the day reducing the operating costs. In fact, the open nature of the elevator shafts proved quite useful when the building opened, since the gas lights did not properly work. Whitelaw Reid expressed both his displeasure and the magnitude of this problem in the following letter to the Building's architect:

> When Mr. Hanford was in today I mentioned to him that the gas arrangement for the elevators did not work at all. He said that is not his fault, but the fault of the man who put it in. Would you please put your hand on whoever is responsible, and see if the difficulty cannot be remedied at once. We are burning gas on eight stories of the building now in order to light one elevator a night, which is rather an expensive luxury.[13]

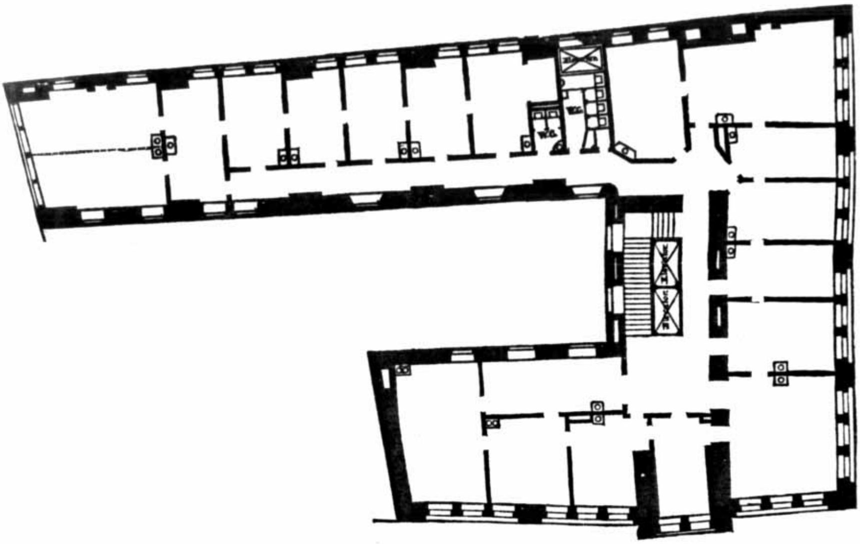

Figure 4.7: ***New York Tribune*** *Building, plan of typical office floor, 1881*

Although Reid may have exaggerated the problem slightly, since surely gas lights for the stairs would have been lit, it does serve as a reminder of the magnitude of the problem. Gas was supplied to the car by a small rubber tube which not only ran the length of the shaft, over 200 feet high, but also had to rise and fall with the car without catching, kinking or breaking.

Although the employees' elevator in the *New York Tribune* Building did not offer a contrast in technology as found in the Western Union Building, it did offer a different experience to its passengers. It ran in an essentially enclosed shaft, located behind the public restrooms on floors one through seven. The car would have received limited natural light from the windows in the party wall and from a skylight. The elevator was not available to employees when the building opened in 1875. It was located in a portion of the building scheduled to be built following completion of the first phase. Unfortunately, construction of the remainder of the building was delayed due to the financial panic of 1873 and the ensuing economic depression. When work finally began again in 1881, Reid awarded the commission to the Whittier Machine Co.

Criticism and Impact

The elevators placed into commercial office buildings of the early 1870s shared a common characteristic: the cars were considered elegant little rooms with cushioned benches for passengers. Although Tufts' elevators for an office building were mechanically different from his design for hotel elevators, they followed his initial conceptual vision. This conceptual vision was embraced by, or at least not challenged, by the popular press. More technically oriented publications were less enthusiastic. The *Manufacturer and Builder* noted that, even if these elevators could keep pace with passenger expectations, their very image would deter use:

> Perhaps, on an accurate computation, it would be found not really slower to pause at the elevator-door and wait for the return of the car in the required direction, then quietly sit down on its cushions, and patiently abide the stoppages at the successive landings until the right one is reached, than to bustle, as we do now, up and down ... with great expenditure of breath, muscle, and perspiration, with an imposing show of motion, but with very little net progress. But this demonstration would be in vain; for not one American in 10 would ever believe it.[14]

The lack of confidence in the efficiency of these elevators may also have been fueled by their actual operation. Prior to the opening of the Equitable Building, the company proposed to run the elevators "at stated intervals" for the convenience of passengers.[15] Although this proposal paralleled the operation of New York's streetcars, it did not offer a practical solution to the problem of traffic flow within the building. Equitable quickly abandoned this plan, and instead, simply assured building tenants and visitors that the elevators would "run at all hours of the day" and that "an interval of only two or three minutes (would) elapse between the periods of their ascent."[16]

However, the prospect of only a 30-second wait was perhaps overly optimistic due to another key issue: safety. The dangers of elevators were not limited to the possibility of mechanical failure during their operation. The 19th century is filled with stories of injuries and deaths resulting from unwary or careless individuals who fell down unguarded shafts. Not surprisingly, for the safety of their guests, most hotels strictly controlled access to their elevators. The shaft on each floor had a locked door, similar to the doors on individual rooms, which could only be opened by the elevator operator. While this eliminated the danger of a guest falling down an open shaft, it also slowed the elevator's operation. Tufts had experimented with automatically opening doors for his vertical railway of 1859, but in the Equitable Building, he employed ordinary doors at the shaft openings. This also reinforced the domestic image of the elevator and prompted calls for an elevator system designed for the railroad pace of business settings.

The editors of the *Manufacturer and Builder* called for the development of a new system that was a variation on the man-engine. They were convinced that the only elevator capable of meeting the needs of modern office buildings was one that delivered immediate access and transportation. Their "endless elevator" consisted of cars roughly six by six feet square made of light corrugated iron that passed up one side of an elongated shaft and down the other. The cars would be designed so that they remained right side up as they passed over pulleys at the top and bottom of the shaft. In spite of the desire for speed, they recognized the need for safety and proposed the following system of operation:

> Of course an automatic stop at each landing is necessary; or, what is probably better, an arrangement with a handle at each landing, by which the movement is brought to a stand as the car touches the landing, the door being thrown open at the same time in such a manner that the train can not start again until that door is closed ... and to prevent unnecessary detention of the train by thoughtless persons, the time during which a door will stand open may be limited automatically.[17]

This system, as outlined by the *Manufacturer and Builder,* retains the residential image of doors being "thrown open" and reveals the continued use of Tufts' metaphor for vertical transportation. Their proposed system would not have been much faster than the existing model, with the constant halts in operation as passengers boarded or exited the cars. The endless elevator, in this or any other guise, was never adopted in the U.S.

The questions raised concerning the operational character of these elevators were more than balanced by the prospect of a revolution in the economic character of office buildings. Traditionally, the lowest floors in a commercial building commanded the highest rents. The average commercial block in New York had three prime rental floors, the basement (typically not more than one half story below grade), the first floor and the second floor. These floors were easily accessible from the sidewalk and were ideal locations for lawyers, banks, insurance companies, etc. However, this immediate proximity to the street also had several drawbacks. The dust, foul air and noise were among the chief complaints by tenants and clients.

The elevator seemed to provide a solution to these problems rendering the upper floors, with their views and clean air, as accessible as the first floors. The anticipated revolution in use patterns and rental structure was slow in coming. Although Henry Hyde clearly believed that his elevators would render the highest floor of his building more desirable and easier to lease, he recognized that a hierarchy of spaces and rents did exist and would probably continue to exist for some time. In fact, Hyde said that his company, located on the second and third floors, occupied "for its own business a portion of the building much less valuable for renting purposes than the first floor."[18] While the Equitable Building clearly offered a new paradigm for the commercial office building, it was a paradigm whose promise was not fully realized until the early 1890s.

A glimpse of the elevator's initial impact on commercial rental structure is found in the Bennett Building, designed by Arthur Gilman and completed in May 1873. The building was designed for James Gordon Bennett, Jr., the editor and owner of the *New York Herald.* It was planned from the outset as a purely speculative office building and its plan was perhaps the best known in the city due to the extensive publicity campaign organized by Bennett. On December 17, 1872, a large advertisement, illustrated with plans of the basement, first floor and a typical upper floor, appeared in the *New York Times, New York Tribune, New York Post, New York Sun* and *New York World.*[19]

The plans were the first office building plans readily available to the general public that featured passenger elevators. Although they only presented the interior spaces as determined by the structural bearing walls, no sample office configurations were suggested. A prominent feature was a linear elevator/mechanical core with a central light court located in the rear of the building (Figure 4.9). This logical grouping of mechanical systems constitutes a possible first step in the evolution of the modern, centralized mechanical core.

The finished building consisted of a cellar, basement and six upper stories. It was to be heated by steam, and a janitor was to reside on the sixth floor to keep a "watchful eye" on the needs of tenants.[20] The rental spaces, by floor, were organized as follows: cellar – storage and mechanical spaces; basement – offices "especially adapted to insurance, money brokers, merchants, (and) sample merchandisers;" first floor – referred to as the Banking House Floor, contained offices for "banking businesses, life insurance, fire insurance, railroad companies, or large companies;" and the remaining upper floors contained offices "well adapted for professional men."[21] Serving this diverse clientele were two Tufts' No. 1 standard elevators, machines that were probably similar in type and operation to those used in the Equitable Building.

The proposed rent or tariff per floor clearly reflects the higher value attached to the lower floors:

Basement Floor	$22,500
First Floor	$40,000
Second Floor	$20,000
Third Floor	$15,000
Fourth Floor	$12,500
Fifth Floor	$10,000
Sixth Floor	$5,000[22]

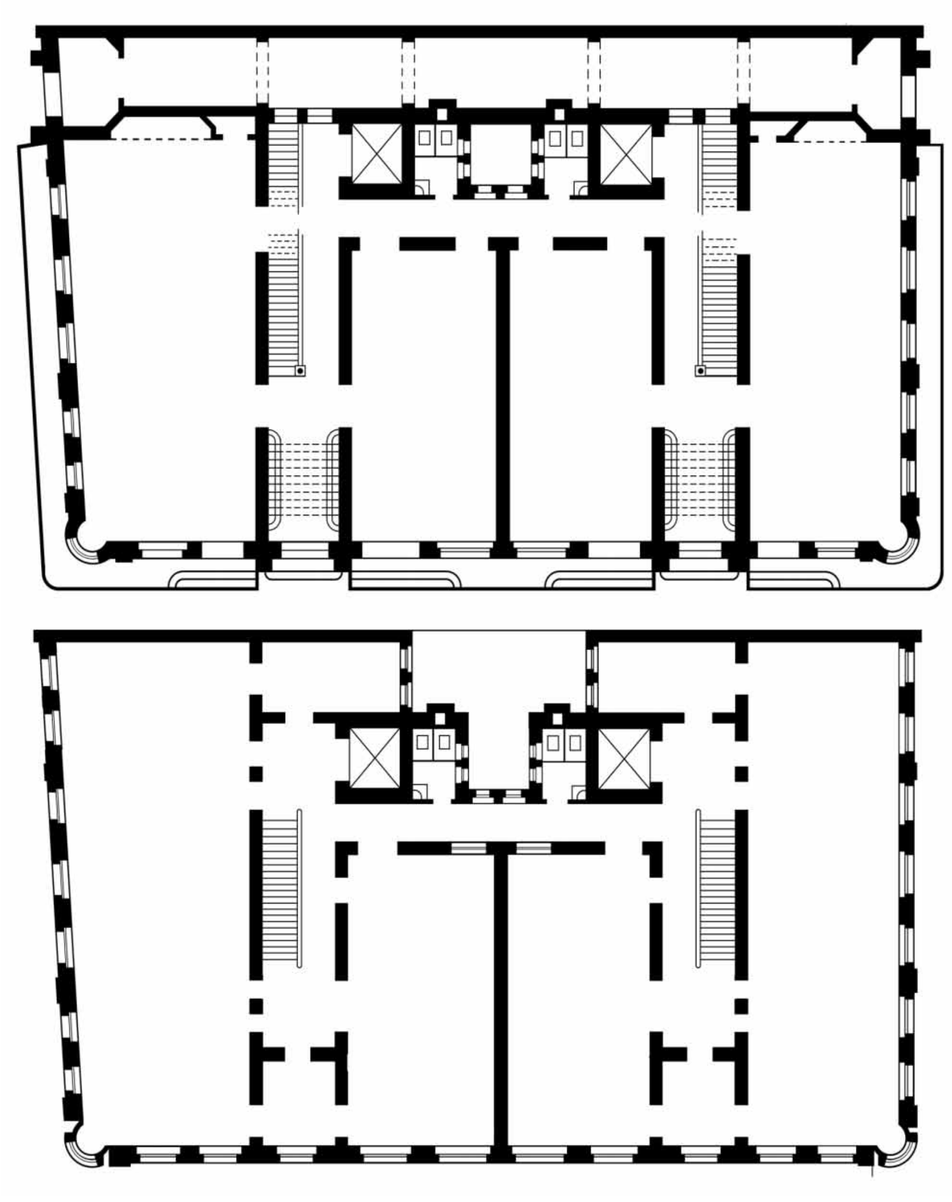

Figure 4.9: First and third floor plans, Bennett Building, New York City, 1873

These figures clearly indicate that the revolution in rents often ascribed to the advent of the passenger elevator did not occur immediately. The description of the target client groups for the various floors also indicates that the building retained a traditional hierarchy of uses.

That the elevator did not immediately revolutionize the commercial office building is not a surprise. Architects and owners, tenants and clients, first had to come to terms with the presence of this new machine in their buildings. The criticisms noted earlier regarding its domestic image and speed also required an appropriate response. This not only took time to formulate, when all was said and done, it was a long and complex answer. For, while the bench in the car remained a somewhat domestic fixture of elevators throughout the 1870s and 1880s, the desire for greater speed and efficiency, produced radical changes as the movable room began its gradual transformation into the express elevator. Many of these changes were predicated on the use of hydraulic power, which represented both an alternative to steam and the technological means to further distinguish the passenger elevator from its industrial counterpart.