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Vertical Transportation in Old Back Bay, a Museum Case Study: The Acquisition of a Small Residential Hydraulic Elevator

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ABSTRACT

Vogel, Robert M. Vertical Transportation in Old Back Bay, a Museum Case Study: The Acquisition of a Small Residential Hydraulic Elevator. *Smithsonian Studies in History and Technology,* number 50, 41 pages, 28 figures, 1 table, 1988.—The National Museum of American History recently acquired a small elevator from a 19th century residence in Boston's Back Bay. The acquisition was one of unusual historical significance, for the elevator's means of propulsion—by hydraulic pressure derived from the city water mains—was that employed in the first elevator systems technically capable of the long runs and high speeds required in the service of tall buildings. The Boston elevator, complete and original in all details, thus was a perfect example of one of the two technologies (the other, the skeleton iron/steel structural frame) that had made the skyscraper possible, at a scale that a museum could accommodate. The mechanical basis of these hydraulic elevators evolved from a sequence of developments in vertical transportation that stretched from the first powered passenger elevators—in English textile mills, ca. 1830, to the final development of the electric traction elevator, ca. 1905.

The removal of the elevator was itself an undertaking of some interest, preceded by the complete documentation of the system in place. During the course of disassembly, it was discovered that the original installation (which was made some 35 years after the house was built), while for the most part an artful one, incorporated several mildly serious structural gaffes. A final aspect of the removal process was the attempt to discover just when the elevator had been installed, and by whom. That ultimately was revealed not by physcial evidence but through water department records.

OFFICIAL PUBLICATION DATE is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, *Smithsonian Year.* COVER: "Teagle" elevator in English cotton mill, ca. 1830 (see Figure 1).

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Introduction

Late in 1984 the National Museum of American History (NMAH) was offered a small hydraulic elevator by the new owner of a row house in Boston's celebrated Back Bay. The elevator, installed well after the house's completion in 1866, had not operated since the years of World War II, was not needed, and stood in the way of plans for major rehabilitation of the building. When a museum accepts an elevator it is quite unlike the acquisition of a tea cup, even if the saucer is included, for an elevator is, after all, less a conventional "object" than a "system." There is a more-or-less mobile car, relatively independent and simple to remove, but in addition are all the other of the system's elements that power the car and control its movements—every one of them firmly built-in but equally essential to the historical and technological story that the elevator is to tell.[1]

Consequently, a museum does not undertake acquisition of an elevator, even a small one, lightly. This particular one was accepted on the strength of its representing the type that had been the first to be built on a large-scale commercial basis, the type that, probably unwittingly in most instances, has been so widely cited by historians of architecture and urban design as "*the* elevator" that "made possible the tall building." Clearly the preservation of one of these historically crucial elevator systems from an actual tall building of the 1880s, either *in situ* on or in a museum setting, would be impossible for a dozen reasons, not the least being that none are known to exist.[2]

The following account describes the recording of the Boston elevator before its extraction from the house, the removal itself, and the documentation of the elevator and its builder based on the physical evidence and the verbal record.

It is hoped that in due time there will be a sequel describing the installation of the elevator in the National Museum of American History, restored to full operation.

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The Origins of the Hydraulic Elevator

> Smooth running and noiseless, starting and stopping easy and graceful; capable of running fast or slow, at the will of the operator, without any of the noise or annoyance of the steam machine, has given the Hydraulic Passenger Elevator the monopoly of popular favor. *From a catalog of L.S. Graves & Son, Manufacturers of Passenger and Freight Elevators, Rochester, New York, ca. 1890.*

The elevator is an ancient device for the raising of both goods and people. Its roots are intertwined with those of cranes and hoists used in the construction of buildings and the routine hoisting of materials and products in mills, factories, and warehouses. The true elevator—having a car (or platform) designed for the accommodation of passengers (or freight), operating among the floors of a multi-story building, guided by a system of vertical rails, raised by a dedicated, mechanically powered machine under the full control of an operator on the car—seems to have emerged by the early 1830s, in the cotton-spinning mills of Lancashire. These buildings, large for the time, by then had reached up to six stories, and handled cotton and yarn in such volume that it became impractical to hoist the bales and various goods to the upper floors by the traditional manual rope tackle outside a series of vertically ranged loading doors. It was a logical matter to devote a shaftway, within the building itself, to hoisting and to increase the efficiency of the process by powering it through belting from the mill's line shafting. Control was obtained by

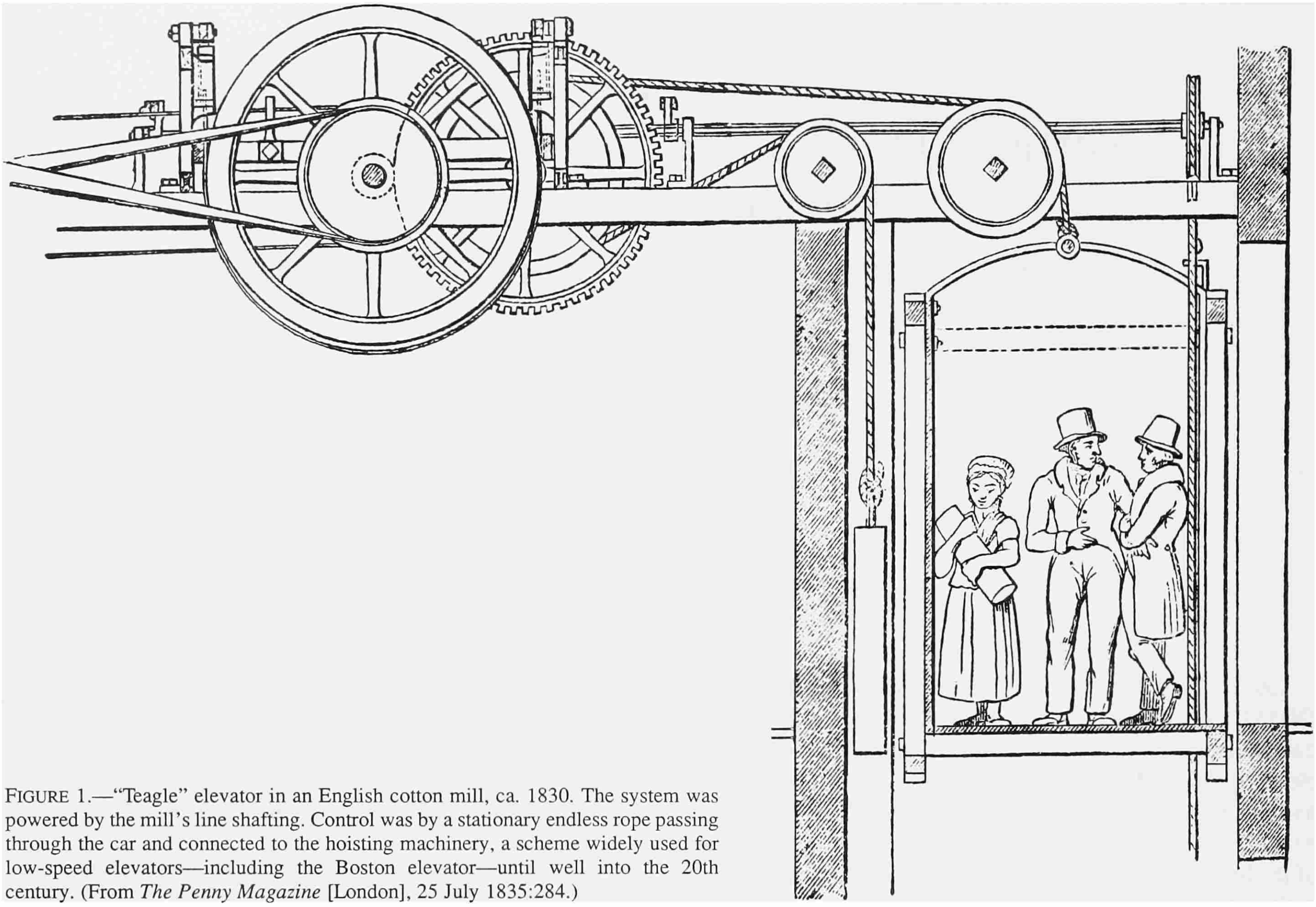


FIGURE 1.—"Teagle" elevator in an English cotton mill, ca. 1830. The system was powered by the mill's line shafting. Control was by a stationary endless rope passing through the car and connected to the hoisting machinery, a scheme widely used for low-speed elevators—including the Boston elevator—until well into the 20th century. (From *The Penny Magazine* [London], 25 July 1835:284.)

a stationary endless hand rope running the height of the shaft, which could be moved up or down by a man on the car to raise, lower, or stop. This basic arrangement of elements, then called the "teagle" (a variant of "tackle"), survived as a manufactured product until at least the 1920s in the United States, and in use until the present (Figure 1). As experiments had shown that a considerable amount of energy was expended by the hands in climbing the stairs of these mills—energy that could better be spent on productive tasks—the teagles were used for passengers as well.

The early development of an elevator expressly for passengers was based on a close interrelationship among several issues: the urging of property owners and architects for taller buildings; the need for absolute safety of the passengers—especially in the event of hoisting-rope failure; and the evolution of efficient, safe, and easily controllable hoisting machinery. It was the solution of the second of these factors that at a stroke permitted the elevator to evolve into a fully practical, commercial technology, and which has come to be indelibly set in the general lore of architectural and engineering history as "the invention of the elevator." This was the development by Elisha Graves Otis of a simple and nearly foolproof device to hold the car firmly in place should the hoisting rope(s) part. Otis demonstrated this at the New York Crystal Palace Exhibition in 1854, in effect opening the door to the development of all subsequent elevator technology.

Second in importance only to the introduction of a practical and dependable car safety in the history of the elevator was that of an independent hoisting machine. The teagle and its direct successors were perfectly adequate for use in factories and mills where a source of central mechanical power already was present, but they failed in the non-industrial, unpowered setting of the hotel, commercial structure, or residential building when increasing building height pressed for a means of mechanical ascension for the inmates. In the middle of the 19th century, in the middle of the large city, this could be accomplished by one means only: steam. The steam elevator machine by 1865 had evolved into a fully practical affair at the hands of several builders and was widely installed in buildings of all types.

It had, however, two serious limitations. The first was its capability of hoisting solely by means of a winding drum (turned by the steam engine), upon which the hoisting rope(s) was wound during ascent. There was a practical limit to the size of the drum, which acted as a collateral limit to the rise of the elevator and thus, effectively, the height of the building. The other problem was the inherent complication of a steam plant: boiler; chimney; fuel and ash storage and handling; and water supply. Further drawbacks were the expenditure of energy even when the system was not at work and the need for a nearly full-time attendant, usually licensed; not to mention the very real psychological disadvantage of having a potentially explosive boiler on the premises. This might do in a large commercial building with a steam plant for heating already necessarily in place; in a small building it would not, eliminating any possibility of an elevator.

The eventual solution was a third major class of elevator, the hydraulic, in which the rotary motion and winding drum of earlier hoisting systems were replaced by the linear motion of a hydraulic piston, indirectly translated to the linear motion of the elevator car. The concept initially was applied not to lifts but to cranes, appropriately enough by Joseph Bramah (1740–1814), the prolific English inventor of, among other things, the hydraulic press (1795) and thus the entire descendant family of hydrostatic machinery. It would have been a simple leap of imagination for as active a mind as Bramah's to consider applying the powerful forces available in his hydraulic press to the lifting of great weights. The principal problem was provision of some sort of multiplying mechanism to adapt the relatively short stroke of the press to the longer lift of a crane. From 1802 Bramah built several hydraulic factory and dock cranes, but rather than providing the multiplication with a purely linear mechanism—as in hindsight seems so obvious a solution—he employed what then must have appeared the logical element of any mechanical hoist: a winding drum. The drum was revolved by a pinion gear, turned by a rack that was an extension of the press piston rod (Figure 2). The relative diameters of pinion and drum provided the factor of needed linear multiplication. If the drum were twice the diameter of the pinion, for example, the crane hook would travel twice the distance of the piston (which conversely would have to exert twice the force represented by the load on the hook).

Although Bramah did apply a steam pumping engine to one of these cranes in his own works, the general idea, while practical, found only limited use, for in most instances the press water was furnished by hand pump, leaving the crane a hand-powered and thus slow, as well as clumsy, machine, not to say far more complex and expensive than an equivalent hand-operated crane of conventional form.

The hydraulic crane was moved a major step toward commercial praticality in 1846 with the invention by William Armstrong (later of ordnance fame) of a crane for his works at Newcastle upon Tyne, powered by water pressure derived from a reservoir on a hill 200 feet above. The principle was simple and far better adapted to the long linear motions of hoisting machinery than Bramah's awkward rack, pinion, and drum.

The pressurized water forced a piston *into* a cylinder (Figure 3). But now to the end of the piston rod was attached a sheave around which passed a chain. One end of the chain was fixed; the other passed over a multiplying sheave directly to a hoisting hook. As the piston moved into the cylinder the free end of the chain drew up the hook, raising the load (at three times the piston's speed and run). For lowering, a waste valve was opened, allowing the water to run from the cylinder, letting load and hook descend by gravity. The system was simple, effective, and ideally translatable to the raising of an elevator car.

In fact, Armstrong himself appears to have been the translator. Just contemporaneously with his crane, Jesse Hartley, the multitalented architect-engineer of most of Liverpool's extensive 19th century dock system, was designing the huge Albert Dock. Hearing of Armstrong's innovation, Hartley initially dismissed the notion of a "water crane," but nevertheless visited Newcastle to see for himself whether it held any promise at all for handling freight at the new dock. The device far surpassed any expectations he might have had and in 1848 he ordered from Armstrong two hydraulic cranes and two hydraulic hoists or lifts for the dock warehouses.[3] From a surviving drawing it is seen that the lifts—of five-ton capacity—were the direct precursors of the hydraulic elevator as it came to be developed, in all essential details.[4]

Although this application of the principle to elevators at Albert Dock by Armstrong and Hartley seems to have been a (presumably) successful fluke not widely copied, it did become the nearly universal method of operating cranes and other materials-handling equipment in the British Isles. But while the Armstrong crane itself never became widely popular in the United States, its influence on American elevator technology was profound.

Of itself it would have been useless for operating elevators in the absence of the necessary supply of water under pressure—the real source of energy. That appeared in the post-Civil War period in the form of the effective public water-supply systems possessed by most American cities. There, represented by the pressurized water in the mains, was a readily available, fairly cheap, clean, safe, and quite dependable source of energy, right at the doorstep of any building on the distribution network. It was an external power supply ideally matched to the Armstrong system of lifting.

By the early 1870s several builders had adopted and adapted the technology, resulting in an elevator that was compact, depended for its motive power only on a water main, was free of the problems of a steam plant, and could easily be controlled from the car by a hand rope running to a simple valve that controlled the passage of water to and from the power cylinder. It was, in basic terms, like a rope tackle in reverse: as the two pulley blocks were drawn apart (one fixed, the other hauled by the hydraulic piston) the free end of the rope raised the car. The height of the rise could be increased nearly without limit, yet keeping the cylinder of reasonable length, by increasing the

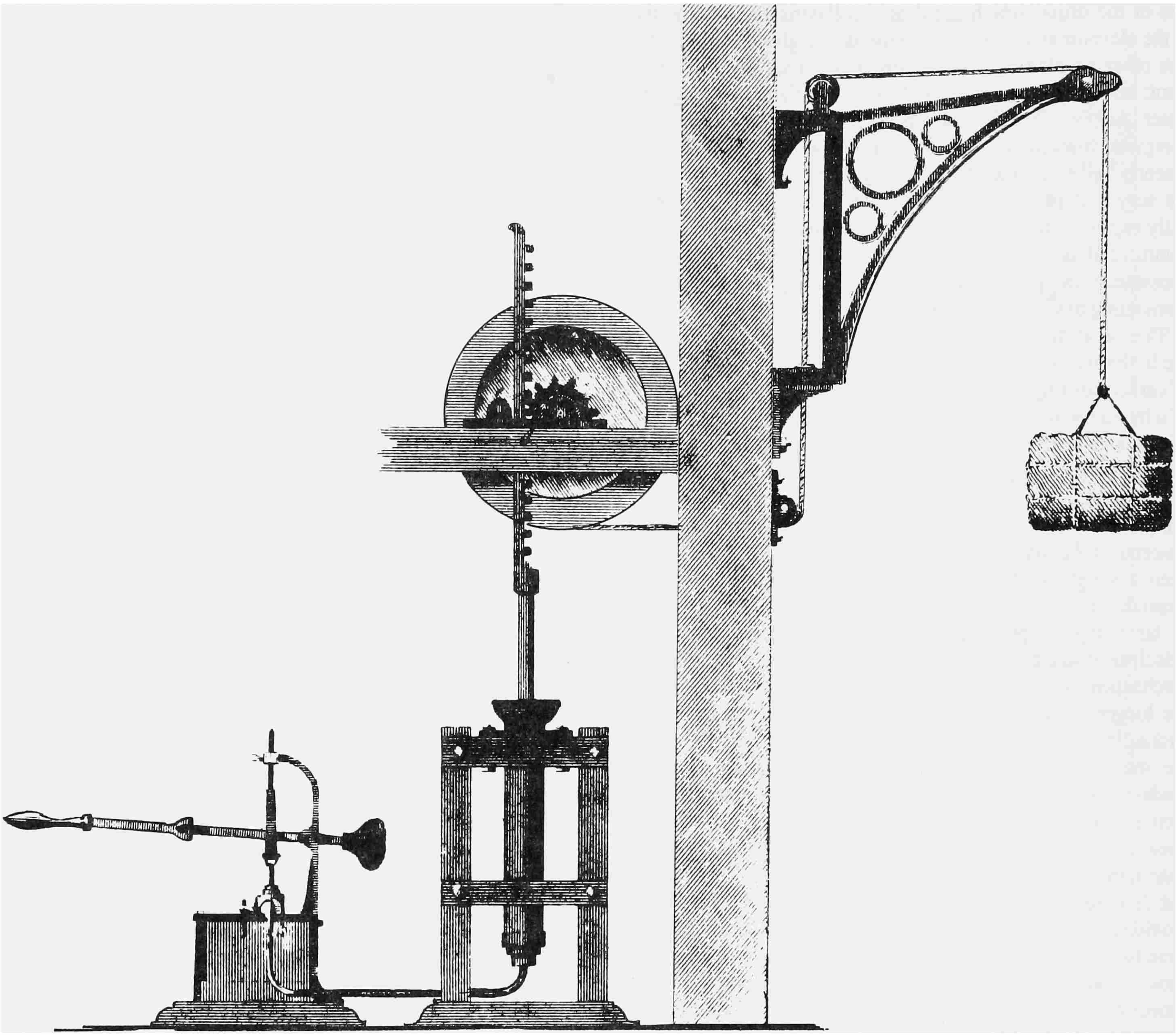


FIGURE 2.—Bramah's adaptation of his basic hydraulic press to the powering of the dock or warehouse crane by introducing a winding drum turned by a rack and pinion. The hydraulic pressure was furnished by a hand pump in most of the few installations mounted by Bramah, the net result being a clumsy and unduly complicated hand crane. (From David Brewster [compiler], *The American Edition of the Edinburgh Encyclopaedia* [Philadelphia, 1823], plate 215.)

number of fixed and moveable sheaves and thus the "multiplication" or the "gear" of the tackle. This, of course, meant that the piston was called on to exert proportionally greater force, but that was dealt with simply by increasing its cross-sectional area, in relationship to the available water pressure (Figure 4).

The system, which came to be known generically as the "rope-geared hydraulic" (Figure 5), was introduced to the United States in the early 1870s, improved principally by Charles Whittier and Cyrus Baldwin of Boston. On the basis of its elegant simplicity and effectiveness, within a short time it became literally the standard of the industry. It had achieved fully matured form by the mid-1870s and was being manufactured by numerous firms around the country. Because of its inherent capability of great rise and speed, and smoothness of operation as well, by that time there were installations in New York of up to 20 stories and, as has so often been related, the age of the skyscraper was upon us.

The basic rope-geared hydraulic was refined and improved during the remainder of the century. Rises and speeds were increased and control systems became increasingly responsive and complex (Figure 6). It followed naturally that power

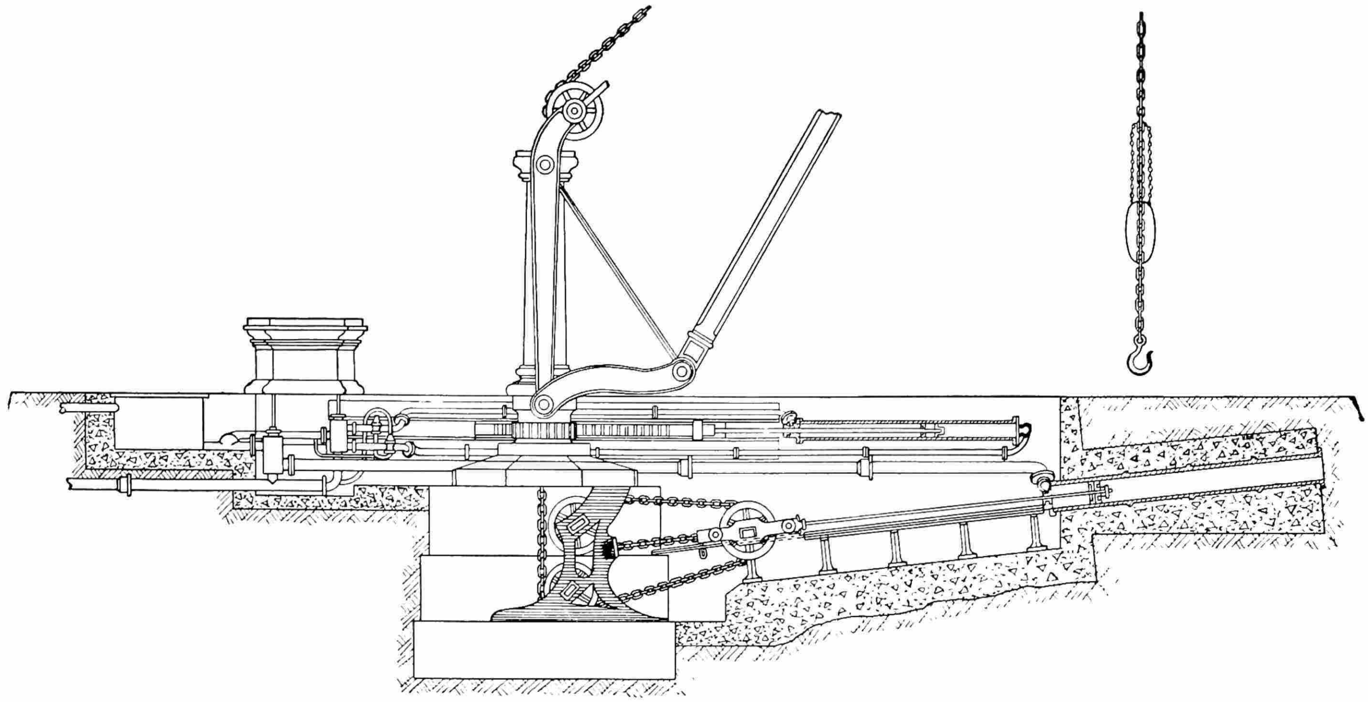


FIGURE 3.—The hydraulic crane was rationalized in 1846 by William Armstrong, who eliminated the winding drum and used the hydraulic piston to draw apart the two elements of an inverse rope tackle. As the sheaves were separated, the tackle's free end was drawn in raising the hook and its load, in the machine shown at three times the piston's travel and speed. The smaller hydraulic cylinder above drove a rack to slew (rotate) the crane. The main cylinder was slightly inclined, permitting gravity to assist in overhauling the hook. The ratio of multiplication could be varied, and the pressurized water supply could be provided by gravity from an elevated reservoir or by pumps. This "rope-gearing" principle was the basis of the first practical hydraulic elevator, as developed in the United States. (From John H. Jallings, *Elevators* [Chicago, 1916].)

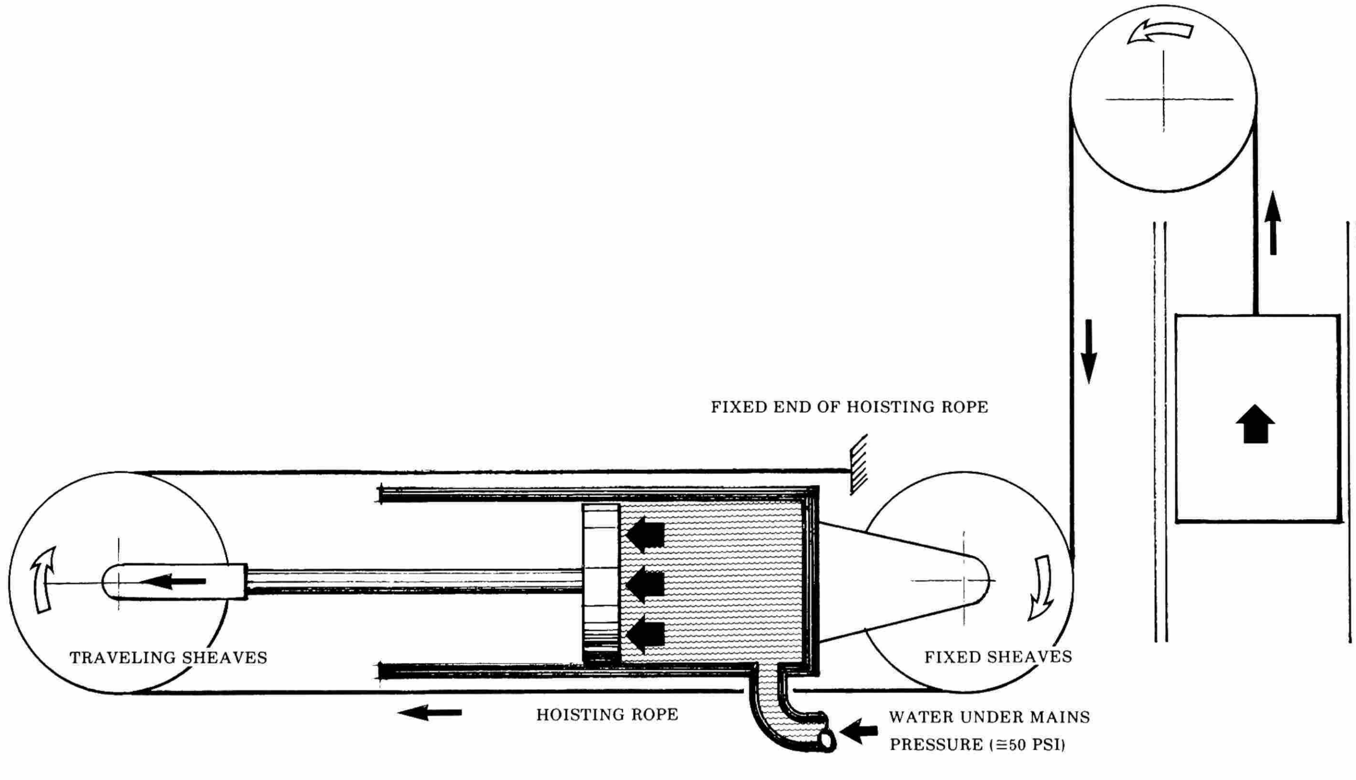


FIGURE 4.—The basic elements of the "pushing-type" rope-geared hydraulic elevator. The gear or ratio shown is 2:1—the car traveling two feet to the piston's one, and at double the piston's speed. The piston, correspondingly, must exert twice the force on the traveling sheave as that imposed by the weight of the car and its load. The gear could be made as high as 20:1 for very tall buildings by increasing the number of fixed and traveling sheave pairs, and the equivalent number of rope wraps around them, as a means of keeping the cylinder to a reasonable length.

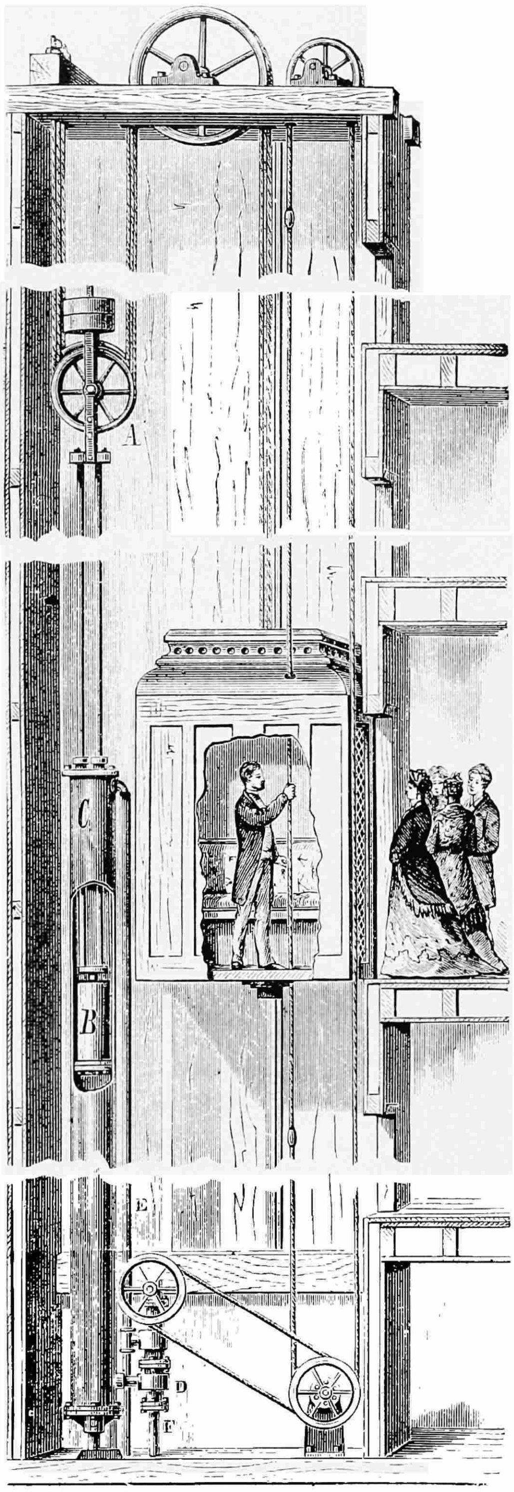


FIGURE 5.—The vertical-cylinder, pulling-type rope-geared hydraulic elevator in its initial mature commercial form, ca. 1875–1880. As in the teagle, control is by endless hand rope, here working the operating or control valve (at the base of the cylinder). For higher rises and speeds the rope was replaced by a lever or crank wheel. Although the basic arrangement was essentially the same for vertical- and horizontal-cylinder machines, with the vertical the dead load of the car was largely counterbalanced by the piston-and-traveling-sheave assembly with only a small amount of additional weight generally being needed. (From *The Builder & Wood-Worker* [New York], June 1880:iv.)

requirements eventually outstripped the energy available from the city mains with the consequence that dedicated steam pumping plants became an integral part of the elvator system of larger buildings, somewhat diminishing the advantage of the type. At just about the time that the rope-geared hydraulic had reached the limits of its capability, almost overnight it was superseded by a second generation of the electric elevator in the very form that we know it today: the traction type. This, like the rope-geared hydraulic and unlike the first generation forms of the electric in which a motor merely was substituted for the steam engine, was not based on a winding drum. The rise was therefore unlimited, permitting vertical transportation in the tallest structures that could—and can—be erected.[5]

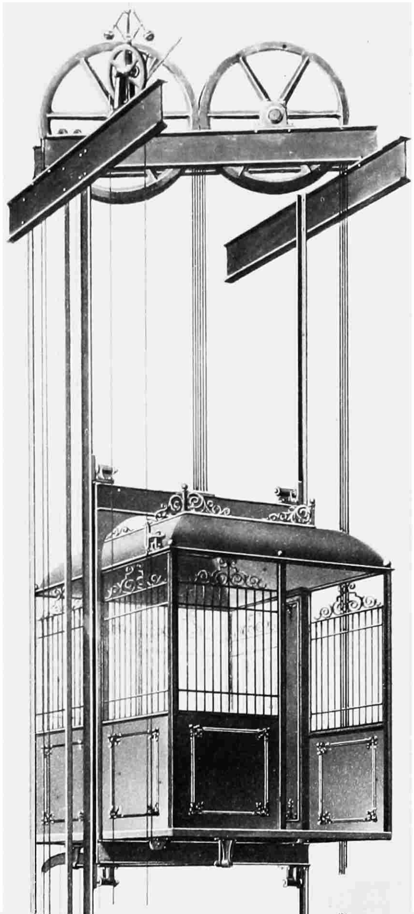
The Elevator in 19th Century Boston

There were many justifications for Boston's reference to its 19th century self as "The Hub of the Universe" for in an astonishing number of fields of human accomplishment the city can fairly be said to have been preeminent. Quite apart from musical, educational, ecclesiastical, medical, and legal attainment, in and around the "Athens of America" there was a considerable ferment in most of the fields of technology: instrument making; railway, civil, and mechanical engineering; hydraulic theory and practice; electrical theory and practice; and the engineering of public works, among others.

Many of the innovators in these areas were of the immediate region, and what with the notably robust Boston Society of Engineers (of all stripes) and the several other formal and informal means of intercommunication among the theoreticians and practical men there must have been a strongly synergistic atmosphere within which ideas were readily exchanged and the work of others was as readily observed.

Prominent in this hubbub of technological innovation was the elevator. At least as early as 1844 there was a steam elevator of sorts installed in the Bunker Hill Monument,[6] and George H. Fox & Co. was in commercial production of freight elevators by the mid-1850s, with considerable business outside Boston as well as local.[7] Fox was among the first to substitute wire hoisting ropes for hemp, in 1852, and the firm introduced a number of other improvements. It is Otis Tufts, however, who is regarded as the real father of the elevator in Boston. (It must be taken as bizarre coincidence that his given name—then a common one in New England—was the surname of the one man who is most prominent in elevator history and construction.[8])

In synopsizing the early history of the elevator in America, *Harper's* in 1882 noted that Tufts had graduated at the age of 21 (1825) "at the school of adversity" and then went on to post-graduate work at that great school of American mechanical technology, the machine shop of the Proprietors of Locks & Canals at Lowell. That experience seems to have launched him on his lifelong career as inventor.[9] Tufts entered the elevator field in 1858. The next year he installed what he termed a "vertical railway" in New York's Fifth Avenue Hotel.



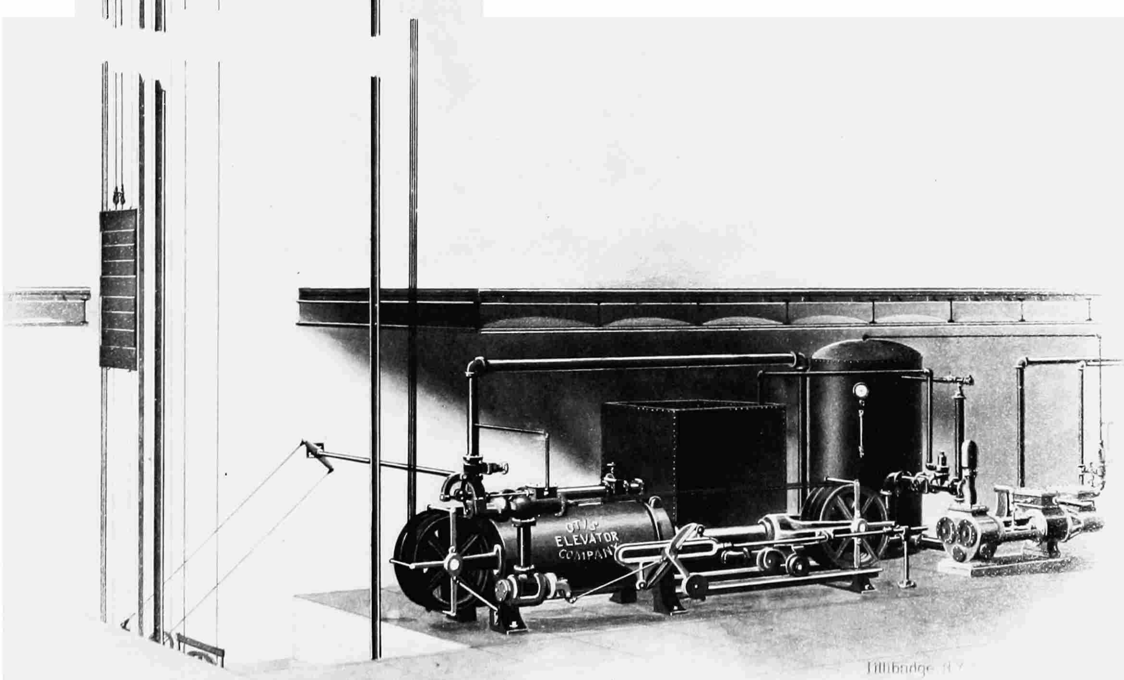


FIGURE 6.—With increasing building heights calling for higher elevator speeds and capacities, the rope-geared hydraulic became correspondingly complex. Mains-water pressure generally was inadequate for this high-duty service and the system energy typically was furnished by dedicated steam pumps or pumping engines on the premises. To provide the fine degree of control necessary for accurate car landing from high-speed runs (dependent entirely on operator skill), hydraulic controls became increasingly sophisticated. In the final days of the breed, about 1915, the valves commonly were electrically operated. Shown is a typical horizontal pushing-type installation of about 1910, a linear descendent of the Wheeler House elevator. Its steam pump and pressure tanks are at the right. (Courtesy of the Otis Elevator Company.)

In an apparent attempt at absolute safety—his near-namesake's device notwithstanding—he eschewed the "suspension" (rope-hung) elevator and embraced a principle that lured a number of elevator inventors at various times and places in the 19th century—the screw and nut. A nut cannot slide along a screw, of course, and in the minds of this group it followed that if a spiral shaft of some sort were erected in a building, around it were placed a platform or car having lugs that engaged the "thread" of the shaft, and the shaft were made to revolve, the car would be "screwed" up or down but would remain solidly and safely fixed in place when the shaft stopped turning. No ropes to break; no water to leak; inherently and absolutely safe, it would seem. This surely was an appealing feature in attracting a public not yet entirely confident about placing its life at the mercy of a hoisting rope or an unseen safety device.

The Tufts hotel installation was a success but was expensive, ponderous (the "screw" was a twenty-inch-diameter shaft of cast iron, driven presumably by a steam engine in the basement, although that isn't specified), and slow. It was repeated only once, in Philadelphia's Continental Hotel.

Tufts produced a number of other improvements to the elevator, including the logical and now-universal concept of multiple hoisting ropes (1861). The firm that succeeded Tufts' Elevator Works, Moore & Wyman, by the end of the century was a major Boston elevator builder that operated in a national market. Boston also was the home of Cyrus W. Baldwin, later improver of the rope-geared hydraulic and the inventor, about 1868, of the "water-balance" elevator. This anomaly, which enjoyed a mercifully brief tenure in the annals of elevator technology, employed water not under pressure to raise the car, but as sheer mass. The car was connected by overhead ropes to a large bucket operating in an adjacent shaft. Through control ropes the operator could fill the bucket with water from a roof tank or empty it. When the combined weight of the bucket and water became greater than that of the car and its passengers, the bucket would descend, causing the car to rise, its speed and stopping at intermediate floors controlled only by a car brake that gripped the guide rails. If the load were light and the operator filled the bucket well beyond the point of mere overbalance, the speed of ascent could be breathtaking and the operation appallingly dangerous; the same true in the descent if the car and bucket loadings were reversed. Although fast and efficient, the extra shaftway made the system expensive. It was that as much as its liability to misuse that brought about the system's rapid abandonment in favor of more rational ones.

The elevator thrived in Boston, a result of the city's importance as a commercial, as well as a cultural center. This gave rise to hundreds of multi-story warehouses, hotels, business blocks, and office buildings in the service of which, by the middle of the 1870s, the powered elevator was regarded as a necessity rather than an optional amenity. By 1877 twenty-one elevator manufacturers were doing business in the city, the most important of which, in terms of production on a nationwide scale, was the Whittier Machine Company, an old-line machine-building firm that entered the elevator business about 1872 and was absorbed by Otis in 1898 along with a number of others at the time of a reorganization that formed Otis Bros. & Co.

Perhaps most telling of Boston's elevator consciousness toward the end of the 19th century are the patent statistics, shown in Table 1 below. Between August 1880 and January 1886 the U.S. Patent Office issued 328 patents for elevators or directly related devices.[10] If the number of patents granted per capita in these leading "elevatored" cities can be taken as an index of general elevator usage and general level of absorption with the technology, we see that by a considerable factor Boston led the pack.

TABLE 1.—Elevator-Invention Prolificity Quotient (E-IPQ), by major city (based on U.S. elevator patents issued August 1880–January 1886).

City	Total patents issued to residents	Approx. average population, this period	E-IPQ (patents per capita $\times 10^{-6}$)
Boston	28	407,000	69
Chicago	25	804,000	31
New York	62	2,212,000	28
Philadelphia	15	905,000	17
All others	198		
Total	328		

The Back Bay

As Boston grew in commercial importance during the first half of the 19th century, business buildings gradually displaced residences in the old central city that occupied the small peninsula surrounded by the harbor, the Charles River, and the Back Bay immediately to the west. In 1852 the state undertook one of the first major municipal improvement schemes in the nation, to solve two problems simultaneously. By filling in the Back Bay, a useless, shallow, noisome tidal flat would be eliminated, and vitally needed new land for building would be created. The fill was brought by rail, largely from Needham, west of the city.[11]

The work progressed from the town westward. The cost was enormous but in time was more than compensated for by the sale of building lots, the state alone profiting more than $5 million. From the outset the new area, known as the Back Bay, was rigidly planned to become an asset to the city. The initial scheme incorporated several elegant, wide boulevards (Commonwealth Avenue; Boylston Street) and sites for churches and important public buildings as well as houses and commercial structures of distinction. It was intended that the area would be the residential center of the city's well-to-do, a goal met in the event and from which there has been only slight deviation.

The first structure erected was the Natural History Building (1864) to be followed two years later by the Institute of Technology—predecessor of the Massachusetts Institute of Technology—and the rush was on. Prominent architects and builders raised houses, churches, and additional public buildings at a pace matching the progressing fill, along principal and cross streets laid out in a precise grid that contrasted strangely with the haphazard European plan of the old town to the east of the Common (Figure 7). In 1866 Charles K. Kirby (?–1883), a speculative builder, erected a row of eight solid, five-story brick houses on the south side of Marlborough Street, numbers 66 to 80. Early in 1868, No. 72 was sold to Alexander S. Wheeler (1820–1907), a Boston attorney of some eminence. The house stayed in possession of Wheeler descendants until 1932 when it was sold to a family in whose hands it remained until purchased in late 1984 by Matthias B. Donelan, M.D. (Figures 8 and 9). It was Dr. Donelan's decision to undertake fairly extensive remodeling of the house—to which the only previous major alteration apparently had been installation of the elevator itself—that led him, at the suggestion of a colleague whose father had made a recent major donation to the National Museum of American History, to offer the elevator.

The Offer; The Inspection; The Decision

Offers of objects are made to museums in many ways. The last will and testament is a frequent one and perhaps the most deliberately formal. At the other end of the scale is the spur-of-the-moment, impulsive comment at a cocktail party. Not infrequently a donation results only after decades of negotiation with a firm or an individual. Nothing more gladdens the curatorial heart, however, than a phone call out of the blue offering something totally unexpected and (sounding as though) absolutely fitting. Dr. Donelan's call early in December of 1984 was such a one. What he seemed to be describing as no longer wanted was a horizontal-cylinder, rope-geared hydraulic elevator, just like the big ones but writ very small. This appeared to be an unlooked-for opportunity to collect the actual hardware of a vastly significant technology having national implications, created to museum scale.

Dr. Donelan does not, of course, speak elevator any more fluently than I speak plastic surgery, so while the gist seemed clear from our conversation it was necessary to confirm the details. I visited the house several days later, to find everything even better than described or imagined. Certainly the house was largely as built, the plan unaltered other than to accommodate the elevator. More importantly, the elevator itself conformed precisely to the picture drawn in my mind's eye: a perfect miniature installation of a rope-geared hydraulic seemingly of about the late 1880s or early 1890s.

The car, nicely finished in oak paneling with a spindle-work clerestory, could accommodate one person seated on a fold-down bench or two narrow people standing (Figures 10 and 11). The run was from the first floor to the third, suggesting installation for an invalid. Control was by an operating rope passing through the car and over small sheaves at the top and bottom of the shaft. The fitting of the system into the existing house had been done with considerable art, to a degree that it could have been taken by the unwary as original. The feature that made this possible was the perfect stacking of fairly roomy closets on the first three floors so that a shaft was produced merely by knocking out the two intermediate closet floors and slightly reworking the floor framing around the openings. The hoisting and counterweight sheaves at the top of the shaft were fitted simply into a low cabinet on the floor of a fourth-floor bathroom. The original closet doors became the three shaft doors, apparently with no modification needed.

Architecturally the job was masterful, although involving one or two minor structural gaffes that only revealed themselves later. The heart of the installation lay, of course, in the English basement. This floor, in the traditional manner, originally had been devoted to the service areas of the house, containing kitchen, laundry, furnace room, and so forth. What probably had been a small storage room partly beneath the basement stairs and directly under the closet stack had been converted to the elevator machine room. There were placed the two principal mechanical organs of the system: the hydraulic cylinder and the control valve (Figures 13 and 14).

Reeved above and below the cylinder—which was about four feet long and eighteen inches in diameter—was the single hoisting rope, passing over its two sets of sheaves: the fixed ones attached to the head of the cylinder and the movable ones opposite, traveling their course at the end of the piston rod. The ratio of increased travel of the hoisting rope's end compared to the piston's travel—the "gear"—was 8 to 1. Thus, the approximately 3½ feet of piston stroke produced about 28 feet of car travel, appropriate for a two-story run in a house with very high ceilings.

The operating rope was guided to and from the large sheave on the control valve by small sheaves on the ceiling of the machine room. The water-supply and waste pipes disappeared through the basement floor into a crawl space below.[12] The installation was absolutely textbook, a tiny exemplar of the late 19th century's primary elevator technology.

The *what* of the elevator had now been answered; its *why*

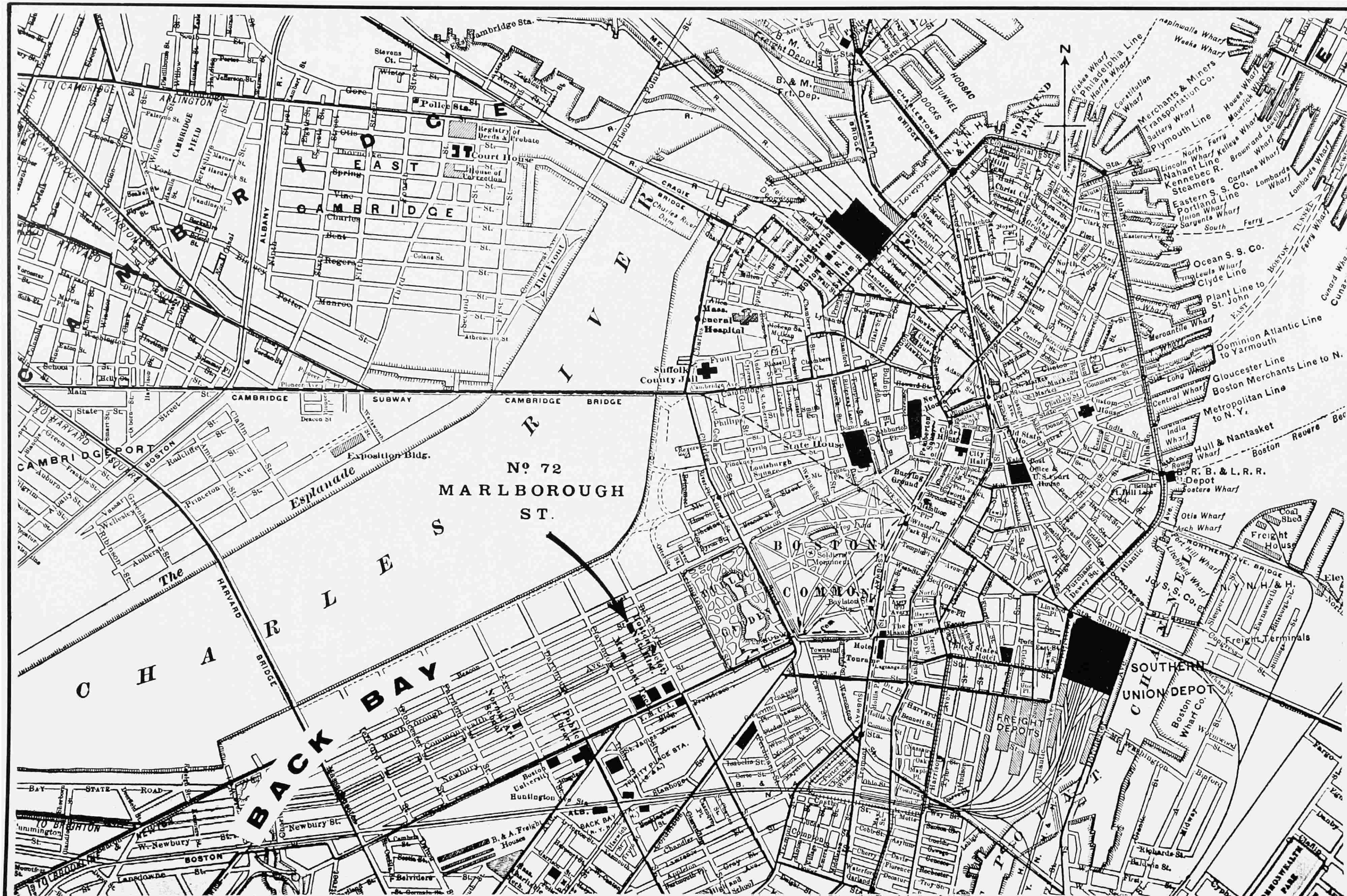


FIGURE 7.—Central Boston, ca. 1920. The rigid regularity of the Back Bay's street grid contrasts oddly with the random European city plan of the original city to the east.

FIGURE 8.—The Wheeler-Donelan House at 72 Marlborough Street, Back Bay. The snow-covered stairs lead to No. 72 in this 1985 photograph.

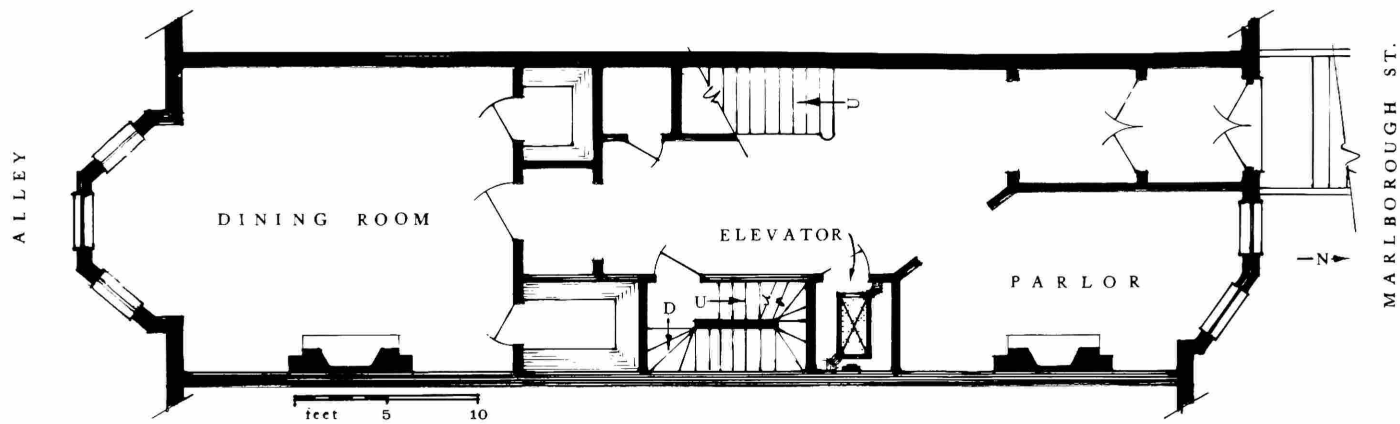


FIGURE 9.—First-floor plan of the Wheeler-Donelan House when purchased by Dr. Donelan. The original dining room—so designated here—by this time had been converted to a kitchen and general-purpose room. In the original plan the kitchen was in the basement, directly below the dining room, with service between the two areas by a dumb waiter in the large closet in the dining room's NW corner.

was a minor matter that most likely arose from invalidism or increasing infirmity on the part of the aging Wheelers. What was particularly troubling at this early stage was the inability to discover *when* or by *whom* it had been installed. Dr. Donelan had inherited almost no documents with the house and none concerning the elevator. There was no record of its history except a bit of lore passed on to him by the seller, who believed that it had ceased operating in 1942 when "something jammed, and what with the war on they felt that it would be unpatriotic to have it repaired." It hadn't run since. This was confirmed by the fact that the car reposed about two feet above its proper landing at the second-floor level (Figure 10).

Thus, there was no hard evidence as to the date of installation and nothing on which to base an estimate except the general ambiance of the car and machinery.

Most of all, we would have liked to know who had been the author of so wonderful a thing. There was not a mark on the cylinder or anywhere else about the installation accessible to the eye; not even a ghost image indicating the presence of a name plate that had been removed. There were not even pattern numbers in the castings or other incidental markings of any sort. The system was clean, the anonymity perfect.

On the assumption that the needed approval to collect the elevator would be forthcoming from the Museum's Collections Committee, I began to consider the means for removal. The diminutive scale of nearly all components suggested that the physical problems would be minor; the principal one would be cost at a time of thin budgets. The process of recording the system and its removal were of necessity undertaken sooner and a bit more frenetically than would normally have been the case, as Dr. Donelan was obliged to carry on the house rehabilitation project with all haste. Both projects were conducted during the first few months of 1985 in the rigors of a typical Boston winter. The recording was a relatively simple matter. In the course of a January weekend two NMAH curators and industrial historian Peter Stott (then of the Massachusetts Historical Commission) measured and drew all of the system's components and the contiguous, related elements of the house. On the following Monday Historic American Engineering Record photographer, Jet Lowe, covered everything with large-format (4×5) photography, his services generously contributed by HAER under its policy of having its photographers record worthy sites and structures when already in an area on a major project of its own. The resulting 18 negatives are incorporated into HAER's photographic holdings and provide a valuable addition to the Museum's documentary record of the elevator.[13] The field sketches made by the measuring party have not yet been translated into formal drawings but have been used to prepare a provisional sketch drawing showing the general arrangement of the elevator, reproduced as Figure 15. A final element of the elevator's graphic recording consists of about 200 35-mm photographs showing details and components, made during the measuring and removal work.

With the graphic documentation of the elevator *in situ* completed and formal permission to collect it granted by the Collections Committee, the way was cleared for removal. The Museum contracted for the work with Manitou Machine Works of Cold Spring, N.Y. Manitou, a small firm of historical millwrights, is one of the few in this rather esoteric line of work, having general practical expertise in and sensitivity for historic machinery to a degree that we felt confident about putting the job in their hands. The work was carried out over four days in mid-January 1985 with a crew of three. During its course a number of interesting details came to light, revealing a good bit about the conduct of the original installation.[14] The principal revelation was that despite the skillful job of architecturally blending the elevator into the house, the structural accommodation was somewhat less than scrupulous at several points. The first of these was in the support of the

FIGURE 10.—The Wheeler elevator in its final resting place just above the second-floor level, where it reposed, unmoving, from 1942 until its ultimate removal in February of 1985, having settled there as a result of the "jam." The small panel was fitted to prevent objects (and people) from falling down the shaft from the space beneath the car. The stacked closets on the house's first three floors seem to have been planned almost with a future elevator shaft in mind. As a result of this feature, minimal architectural modification was required when the elevator was installed some 36 years later. The original closet doors served readily as the elevator shaft doors. Against the right shaft-door jamb, mid-height of the car, is seen the gas cock to which was attached the flexible rubber hose that supplied gas for the car's ceiling light in the original installation. The hose and light fixture were removed, presumably when the house was wired sometime after the elevator was installed. (Jet Lowe photograph for the Historic American Engineering Record, 1985.)

FIGURE 11.—The car interior. All is original except the ceiling light, its switch, and the folding car gate which probably was added at the insistence of the city's elevator inspector. (Jet Lowe.)

FIGURE 12.—Looking down on the car from the third-floor level, showing the diagonally set guide rails; the attachment of the single hoisting rope to the Otis-type broken-rope safety within the hoisting beam; the part of the hoisting rope running between the basement and the overhead hoisting sheave (to the right of the rear guide rail); and the two parts of the operating-rope loop (at left). On the car roof are seen the armored cable for the electric light and adjacent to it the gas pipe for the original light, left in place when the modification was made. (Jet Lowe.)

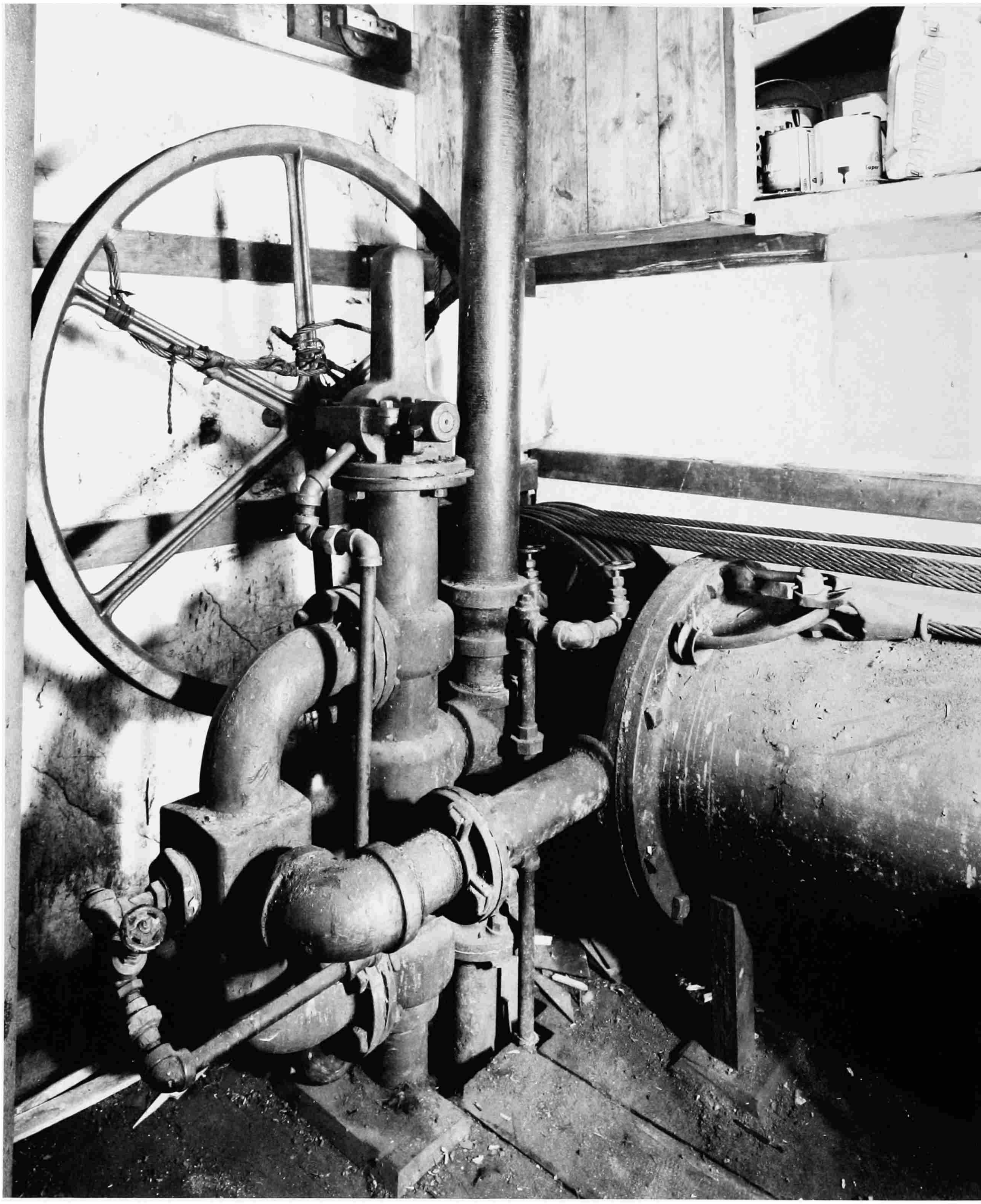


FIGURE 13.—The operating valve and head end of the power cylinder. The water supply and discharge lines pass through the floor below. The large pipe extending upward is the lower part of a closed air chamber to prevent water hammer if the valve were closed suddenly. The attachment of the hoisting rope's fixed end is seen on top of the cylinder. Above the operating valve is the home-made register that metered the travel of the piston and thus, by conversion, the water consumed by the elevator. There was no sign of its connection with the crosshead at the time of removal. (Jet Lowe.)

FIGURE 14.—The traveling sheaves and their inner guide rail, tucked neatly beneath the bottom run of the basement stairs. (Jet Lowe.)

overhead sheaves carrying the hoisting and counterweight ropes. Each sheave was borne by a floor pedestal resting directly on the floor of the bathroom above the elevator hoistway, the sheaves covered by a simple removable wood cabinet. As neither the flooring nor the plaster of the hoistway ceiling below apparently were disturbed during the installation, it seems that the four holes—to pass the two parts each of the single hoisting rope and the counterweight rope—were drilled up from the hoistway ceiling after having been located by plumbing down the shaft. Such situations then obviously were subject to the same laws of inevitability as they would be today: the part of the counterweight rope from the car was in direct alignment with a floor joist.

The installers did what any right-thinking mechanics working on a fixed-price contract would have done under the circumstances—they drilled a $1^1/_4$-inch hole for the rope right

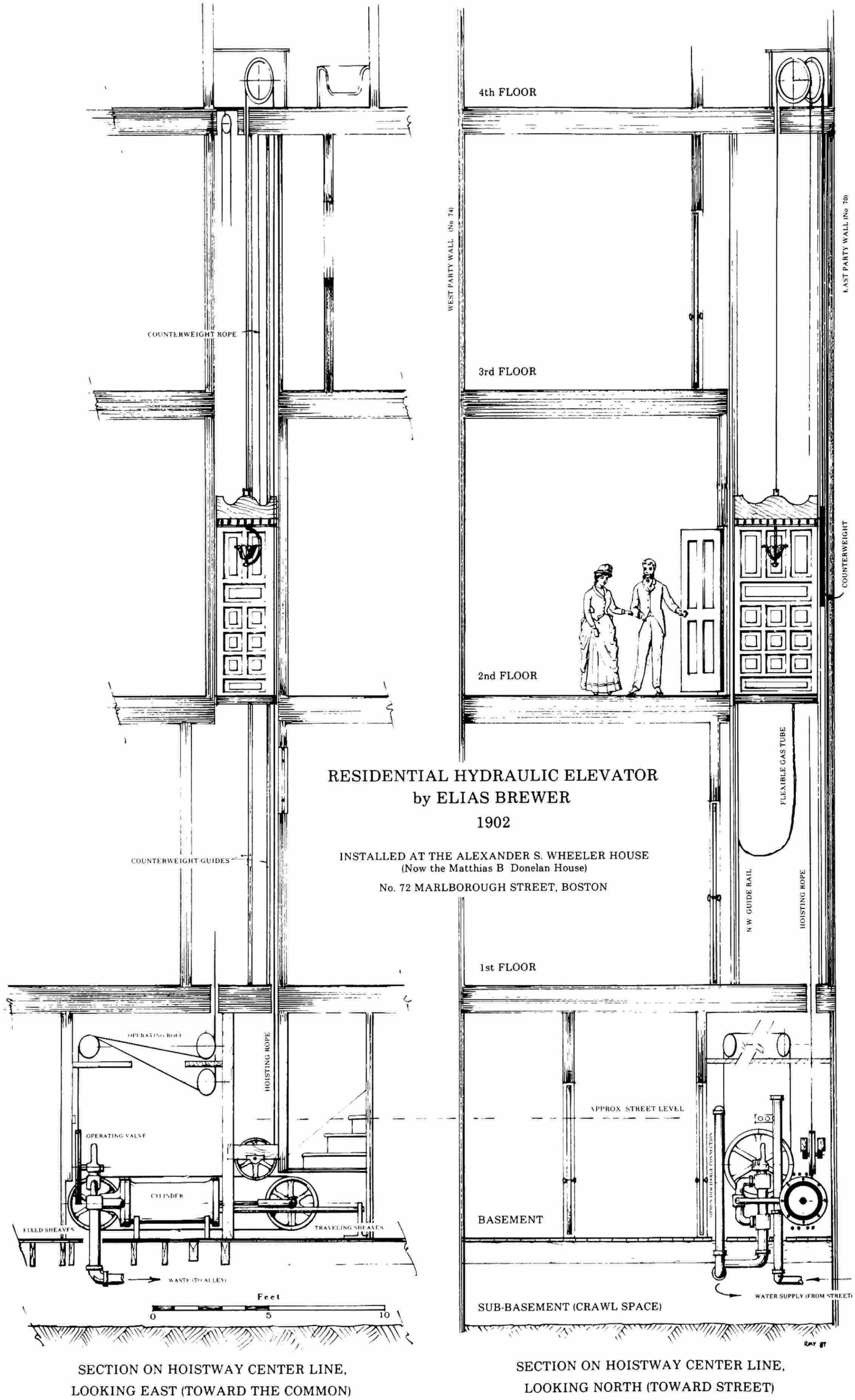


FIGURE 15.—General arrangement of the elevator in place, based on the sketches made before removal. Note: Car gas-fixture and flexible gas tube not present, 1985.

FIGURE 16.—Manitou Machine Works crew dismantling and removing the operating valve, February 1985.

through the joist. Given even the full two-inch scantling of the mid-19th century this left so little of the timber's substance that under the working load of the car and counterweight (some 1000 pounds) carried onto it through the sheave pedestals, it failed completely. If this didn't occur with the first use of the system it must have soon afterward. Plainly it was the legendary robustness of the American system of timber framing that saved the installation from disaster. The load of the pedestals simply was transferred to the adjacent joists through the layers of sub and finish flooring, and perhaps the floor bridging, although with an appreciable subsidence of the floor around this crucial spot.

Equally inelegant workmanship was evident at the system's lower reaches, the consequence of a similar condition. The same Law of Framing-Member Occurrence placed a floor joist precisely below the control valve in the basement machine room, interfering with the large-bore water supply and waste lines. The response was, naturally, the same as it had been upstairs. But here the elevator builders had added a curious twist. While the offending joist was completely cut through at the heavy head and control end of the cylinder, at the considerably lighter end opposite, where the movable-sheave carriage traveled on its guide rails, a pair of heavy, five-inch-wide joists had been laid into the floor framing. Compounding this curious state of structural imbalance, with the flooring of the machine room completely removed during the installation process to provide full access to the crawl space below, there was no agency for transferring the load from the disabled joist to the adjoining ones (nor was any diagonal bridging present). As an inevitable consequence the entire floor system at that end of the room had subsided two inches! Some of the weight of the control valve and cylinder (rigidly joined by their interconnecting piping) was carried by the pipe hangers that supported the supply and waste lines from other joists nearby, it is true, but taken together this aspect of the job was distinctly casual.

Nearly all else about the work was first-class, however. The alignment of the hoisting, counterweight, and control ropes (all of wire rope, not fiber) was perfect, and the architectural adaptation of the machinery to its basement room was on a par with the finer finish of the work above stairs. The machinery all had been neatly hidden within well-fitted cabinetry, with all critical parts accessible through doors or removable panels. (None of this work was preserved in the removal.)

FIGURE 17.—The power cylinder with its piston and piston rod being loaded. The fatal, final "jam" in the system lies here, for the piston defied all attempts to move it within the cylinder during the removal process.

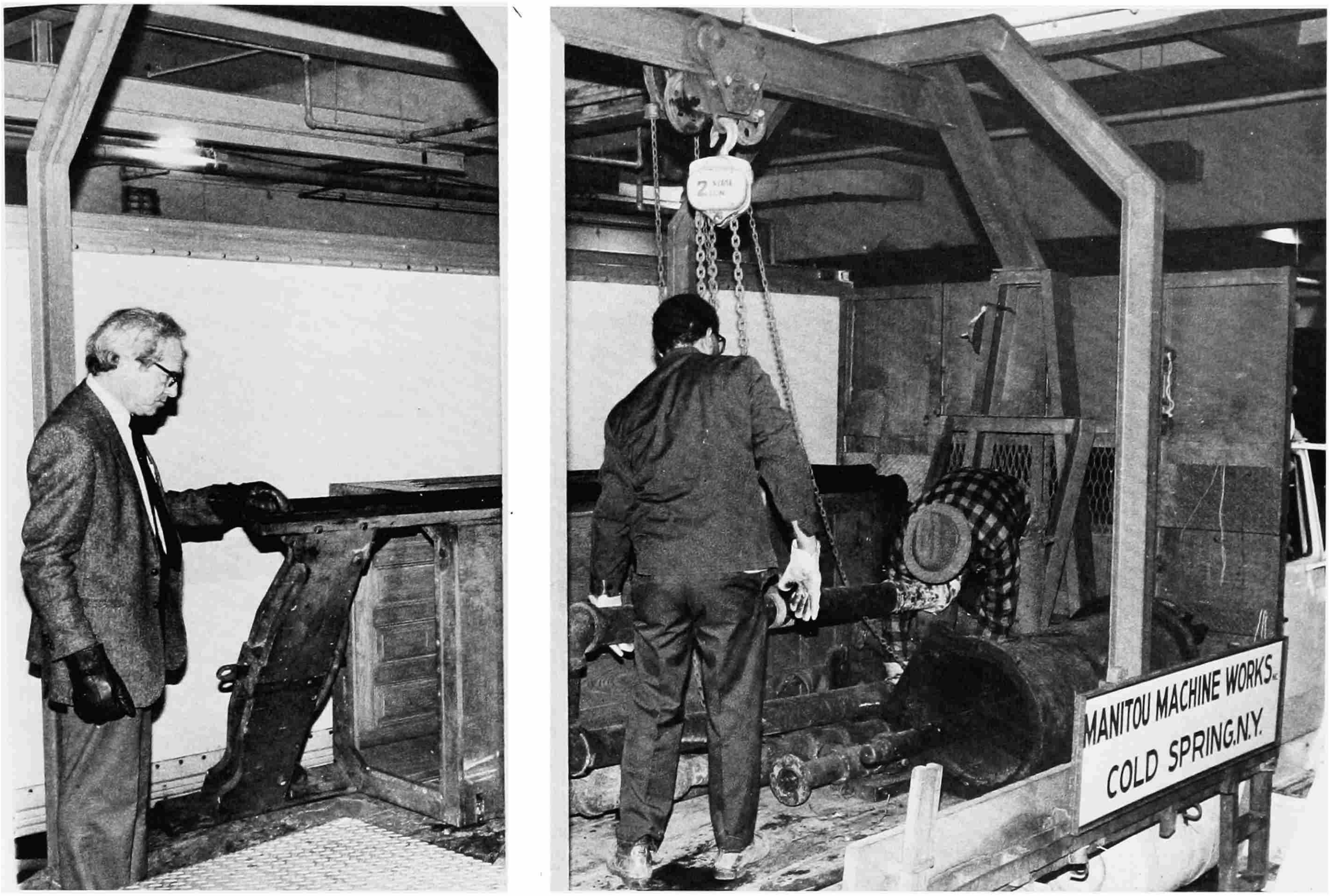


FIGURE 18.—Arrival of the elevator at the National Museum of American History, "knocked-down."

A final instance of curiously indifferent structural work revealed itself during removal of the car from the bottom of the hoistway at the job's end. It was our wish to preserve several short sections of the car guide-rails to serve as models when (if?) the system is installed as an exhibit in the Museum. These simple sections of $1^1/_2$-inch-square hard pine, which it might be expected would have been attached to the shaft walls quite solidiy, in fact came away with almost no effort, having been little more than nailed into the existing walls with no apparent reference to studs or other structural members. Of course, in normal service they carried none of the car's weight. Even any lateral force on them would have been minimal if the load in the car were more or less central. The rail sections thus would have done little more than bear their own weight as they were stacked up the height of the shaft. But recall their secondary function: that of sustaining the car and its load in the event of a hoisting-rope failure, the entire weight of the car thrown suddenly onto the rails as they were gripped by the "broken-rope" safety—as demonstrated with such celebrity by E.G. Otis those many years earlier at New York.

Had such an occurrence taken place with the car near the top of the run, it is easy to imagine that the lightly attached guide rails would have buckled, sending car and passengers to the bottom. We may assume that they never were tested in that fashion, and that if the installers had demonstrated the system's safety for their own and perhaps the Wheelers' satisfaction, the test was performed with the car scarcely above the bottom of the run at the first floor!

Although most of the removal job was routine—for such work—from the outset Manitou's proprietor, Tom Rick, was plagued by a concern that the elevator's water-supply line—of three-inch diameter and with the potential for very quickly conducting a Niagara into the crawl space and the basement—had been stopped off not at the main but at a quick-opening/quick-closing valve placed just upstream of the main control valve. This was part of a safeguard that prevented overtravel of the car at the top of its run, the normally open valve being closed by the traveling-sheave carriage if the regular stop system on the operating rope failed. As this valve was an important—if secondary—organ of the system we naturally wished to recover it. But if it turned out to be the sole barrier between the Donelan house and the water supply of Boston, its peremptory removal would have brought instantaneous disaster to the premises, to Manitou, and to the Museum.

To determine conditions in the supply line, Rick drilled a small test hole in the pipe just above the valve. This revealed that the line was neither dry, as hoped, nor under mains pressure, as feared. Rather, a small volume of 43-year-old residual water dribbled out, nevertheless giving assurance that the supply had indeed been stopped off well beyond the elevator, apparently at a large gate valve later discovered partly buried in the dirt under the front steps of the house.

Although the process of removing the elevator system turned up a number of interesting details about its own design and construction and its relationship to the house itself, the one thing we had hoped would be revealed as the previously hidden surfaces of its components were exposed to view remained obscure. Nowhere was there the slightest indication of the elevator's builder, a major disappointment.

The entire elevator system—cylinder, control valve, car, and all small parts were loaded on the Manitou truck and in due course arrived at the Museum where they currently are in storage pending future exhibition.

Post-Removal Investigations

With the Boston elevator securely preserved at the National Museum, there remained to be answered those questions of its paternity, its precise age, and its place in the history of vertical transportation in Boston, or at least in the Back Bay.

In the total absence of internal documentary or archeological evidence, the means for answering the vexing issues of the elevator's source and date of construction appeared to lie in local historical records, if anywhere. The point of departure was the city directory, one of the most useful resources for any inquiry on urban history. The Boston directory for 1888, selected as a time that seemed roughly consistent with the date of the installation, listed a good number of elevator builders, both well-known national firms with Boston branches or agents, and smaller, strictly local firms. As did most directories of the time, Boston's carried numerous ads for the firms listed in its classified section, these as useful historically as the personal and commercial listings themselves. Several of the elevator builders had advertised, but one large display ad drew the eye like a magnet (Figure 19). It had been placed by E. Brewer who billed himself as a manufacturer of "*hydraulic* and steam elevators, hand elevators, hydraulic dumb waiters, [and] *small passenger elevators for private residences,* [with] *invalid elevators a specialty...*" (my emphasis). It was the only ad with this particular message. Other builders offered their services

FIGURE 19.—Elias Brewer's city directory advertisement of 1888 that, before it had been confirmed, made his authorship of the Wheeler House elevator appear so strong a likelihood. Brewer's New York "office" was a short-lived venture, although he did do a modest amount of business there in the 1880s.

essentially for commercial installations: office buildings, apartment houses, stores, hotels, and factories.

Elias Brewer, with a downtown Boston address, was listed as an elevator builder first in the 1877 directory, advertised first in 1883, and with occasional address changes was carried well into the 20th century. Despite the complete lack of any evidence linking Brewer with the Wheeler-Donelan House elevator, the ad was compelling and the temptation to make the connection was powerful. Remember that name.

Investigation at literally all historical agencies in the city that might have shed light on the matter netted nothing. Especially disappointing was to find no references to the house in a large collection of 19th century building-permit files at the Boston Public Library. At the point when all leads seemed exhausted, it occurred to me—or was it to Peter Stott of the Historical Commission?—that perhaps the truth was to be found not in the architecture but the water. It was because the elevator drew far more water than could be supplied by the house's one-inch supply line that the special three-inch line had been run in from the eight-inch street main at the time of the installation. Clearly that would have required full collaboration by the water department and almost certainly a permit. Investigation by Stott at the Boston Water & Sewerage Commission (present-day successor to the Boston Water Department, as it then was) revealed that, indeed, records pertaining to individual buildings were kept in what were known as the "Premise Files," the earlier files retained in a warehouse in the near suburb of Forest Hills.

While it is likely that most—perhaps all—of the city's records had been destroyed in Boston's Great Fire of 1877, the Premise Files seemingly had escaped subsequent losses. And there, in the appropriate box for lower Marlborough Street, was the folder for No. 72. And there, *mirabile dictu,* did lie the original Elevator Service Application, requesting that the street main be tapped for a three-inch service pipe. The application, in the name of Alexander Wheeler, had been made by...*E. Brewer & Co!* It had been submitted on 28 May and approved on 26 June...*1902* (Figure 20); the two principal questions answered in a single document. Surprising was the fact that the installation had been made at least ten years later than we had supposed, leading a colleague to observe that we had miscalculated by not merely a decade, but a century.[15]

The application supplied not only the who and the when, but, by inference, the why of the elevator. By 1902 Alexander Wheeler would have been 82 years old and his wife presumably of about an age, suggesting that either it was invalidism or perhaps only a wish to avoid stair climbing that had prompted this major alteration to their house.

Elevators in Back Bay

Despite their considerable height and number of stories, Back Bay houses were not built incorporating elevators until the early 1880s, although Bunting reports that after 1895 rarely was a costly house built without one, regardless of its height.[16] From a fairly early period, however, presumably as made feasible by advancing elevator technology, post-construction installations were common. The first elevators in the area were installed in two apartment houses, apparently when built in 1871, but the first in a Back Bay residence did not appear until five years later, as a modification. In this early period the lift was viewed not as a substitute for stair climbing but as a purely utilitarian device for hoisting trunks and large furniture. Accordingly it was relegated to the rear areas of the house. But with the gradual erosion of the Puritan ethic, brought on, we may suppose, by the proliferation of passenger elevators in stores and other commercial buildings downtown, the attitude toward powered vertical transportation at home became more accepting. It is entirely possible, too, that as in the (later) case of the Wheelers, those householders who had moved into the initial sections of the district in the 1860s, by the 1880s were in their sixties and seventies and quite willing to recognize the benefits of mechanically assisted access to the sleeping floors.

Whatever the motivations—perhaps mere submission to fashion in some cases—the insertion of elevators into Back Bay's private houses proliferated during the last quarter of the century. Because the records of the building-inspection, elevator-inspection, and water departments all are extremely spotty for that period, it is impossible to fix any hard numbers, but it appears that there must have been something like a hundred residential elevators in Back Bay by the turn of the century, counting both original and supplemental installations. Introduction of many of the latter was eased by the same architectural factor that had rendered the Wheeler project so straightforward: the common existence of full-height light wells and tiered closets in the early row houses, providing ready-made or easily adapted hoistways.

The vast majority of these systems were hydraulic. Water remained the medium of choice for the propulsion of Boston's elevators until well into the new century. Although there is no breakdown of the few available statistics by district, a variety of evidence makes it clear that electricity's inroad into the elevatoring of the Back Bay was slow and uneasy. More will be said of this with particular regard to the Wheeler House installation.

The available figures on hydraulic elevators in the city as a whole, shown in graphic form (Figure 21), do not reveal anything about area, size of individual installation, type of system (rope-geared or plunger), or (particularly unfortunate) comparison with electric elevators. Hence, they are not terribly informative on the questions of hydraulic vs. electric installations over time, or on geographical distribution within the city. But it is possible to draw some speculative conclusions. As with almost all change, the transition from hydraulic to electric power for elevators was gradual, a consequence of the fact that the technical pros and cons of each with respect to the other were fairly evenly balanced until

GEN'L ... INCOME DIV. MAY 28 1902

CITY OF BOSTON.—WATER DEPARTMENT—INCOME DIVISION.

ELEVATOR ~~OR MOTOR~~ SERVICE APPLICATION. No. 602

Boston, May 28 1902

To the Water Commissioner:

SIR, — The undersigned hereby applies for a service pipe to supply water for Elevator — Motor — purposes at premises, owned by him situated on

STREET, COURT or PLACE Marlboro St. Ward X 5

Number or direction 72 for

Size of service pipe required 3 inch

Pipe to enter from No. 72 for Alexander S. Wheeler

BOSTON WATER DEP'T. JUN 23 1902 CITY HALL.

Deposit, No. 2893 Amount, $ 175.=

J. N. S.

REGULATIONS FOR SERVICE PIPES.

1. The desired point of entrance for the pipe must be designated within two days from the date of this application, otherwise the laying of the pipe will be delayed until such time as the desired information is received by the department.

2. No water shall be used through any water service pipe until the service pipe, the piping inside the building and the water fixtures have been approved by the Water Department, nor shall any water be used through any such pipe for experimental or testing purposes, or for any purposes other than those for which such pipe is installed, except by special permission of the Water Commissioner and under such restrictions and conditions as he may determine.

3. No alteration or extension of pipe inside the building shall be commenced until three hours after written notice thereof, giving description of the alteration or extension contemplated, has been left at the office of the Water Department.

4. No pipe or arrangement of pipes shall be made by which the high and low water service systems will be connected.

5. A registering apparatus satisfactory to the Water Commissioner shall be placed and maintained where approved by him, for the purposes of measuring the quantity of water used by the elevator or motor; said apparatus to be adjusted to accuracy before it is used.

6. Service pipes for supplying water to elevators or motors will be connected with the low pressure supply only.

This applicant is the owner of the estate and agrees — that he will pay all bills for the water supplied through the pipe applied for in this application; — that he will conform to all rules and regulations now or hereafter adopted by the Water Commissioner relating to pipes or the use of water; — that upon any violation of such rules or regulations the Commissioner may withhold the use of water at once, without further notice; and — that neither the City nor its agents or employees are to be held responsible for any damage resulting from pipes or the laying or placing thereof, or from water, or from any withholding of the water for any cause or reason.

A D Wheeler *Owner of Premises.*

Address. E Brewer & Co.

Notify E. Brewer
52 Sudbury St.

FIGURE 20.—The application for the Wheeler House elevator's water line, 1902, the sole evidence as to the builder and date of the elevator.

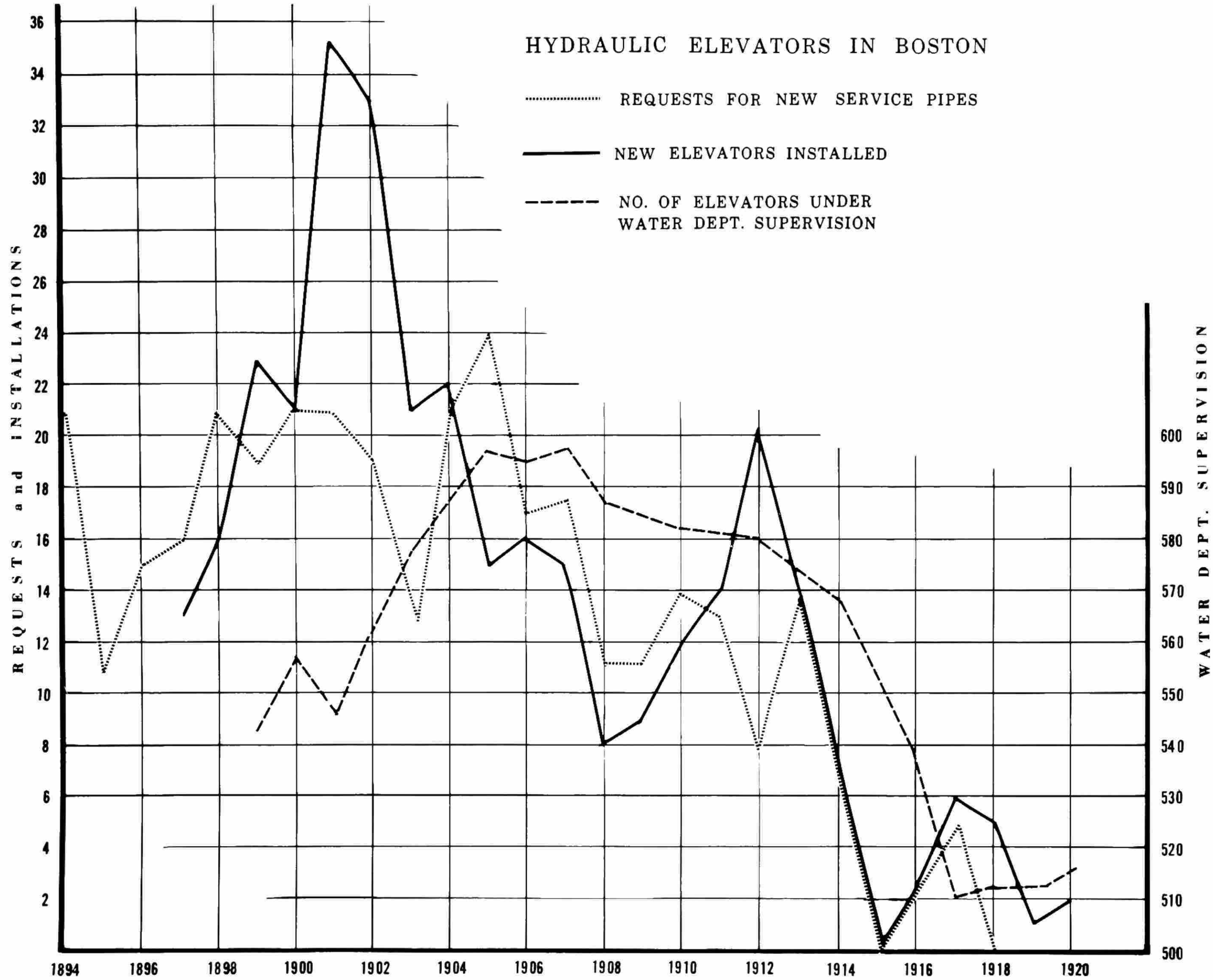
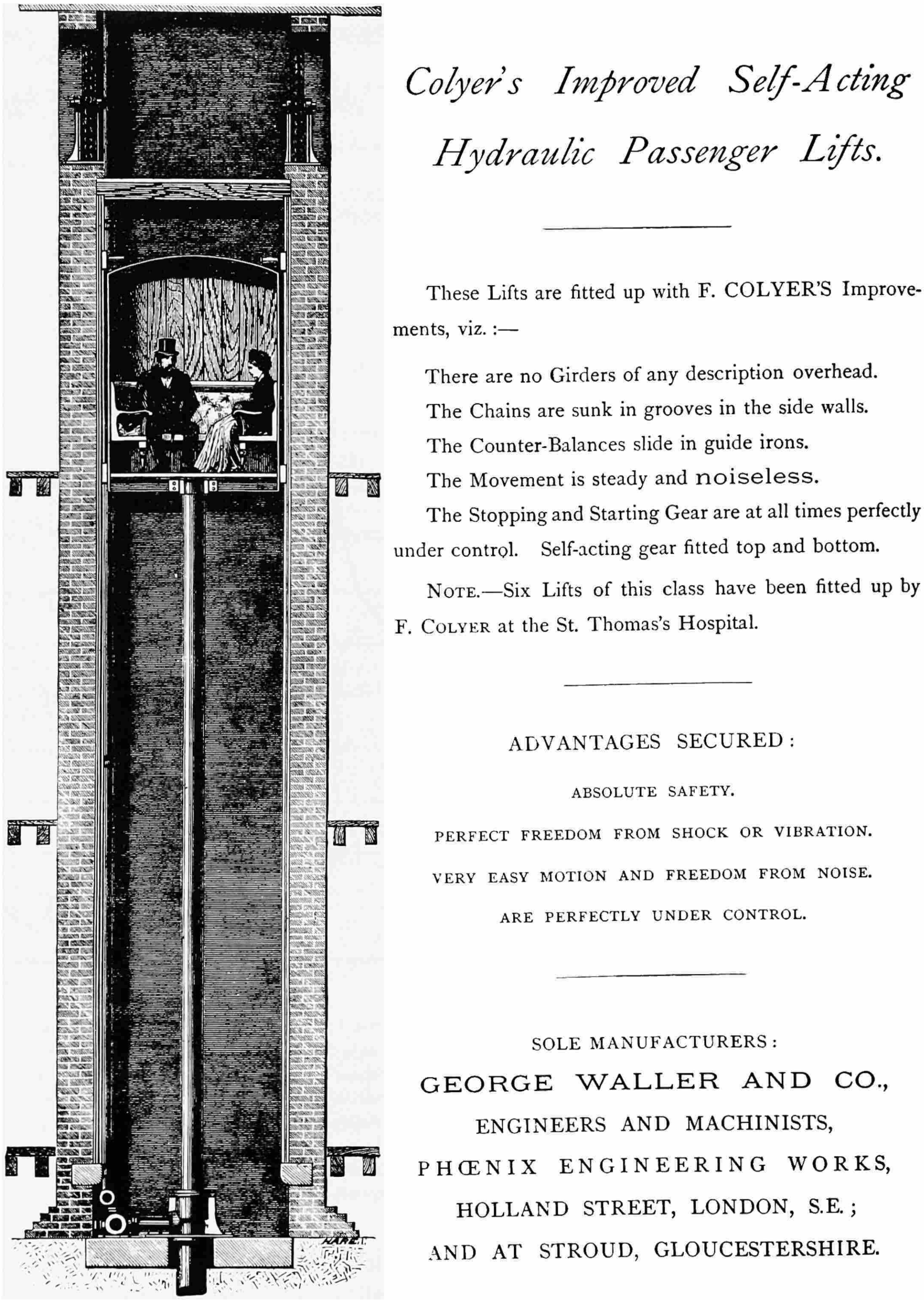


FIGURE 21.—The presence of the hydraulic elevator in Boston, 1894–1920. The three curves together provide a general qualitative sense of the gradual decline of the type, but only the figures for new installations reflect with any precision the state of affairs at a given time. The discrepancies among new installations, requests for service pipes (tappings into the mains), and water-department supervision (mains-water consumption and billing) arise from the fact that water under pressure for most large installations was supplied by house pumping equipment, not the city. The spurt of new installations around 1912 almost certainly resulted from a brief surge of interest in the large-scale direct-plunger hydraulic, the water elevator's last gasp before total dominance of the field by electricity. (From annual reports of the Water Commissioner and Inspector of Buildings.)

around the first world war. It will be seen that the number of hydraulics installed hit a spectacular peak in 1901–1902—coincidently the very time of the Wheeler House installation (Figure 21). The cause of this is unknown, but likely it was the result of a non-technological factor. The erection of just a few major office buildings, each having a large bank of elevators, would account for it, for example, as the actual increase in number of elevators over the previous and succeeding averages is on the order of only twelve or so. The 1911–1912 peak probably can be accounted for by several major direct-plunger installations, in office buildings, there being a distinct boom in popularity of the type just then.

The disparity between the number of elevator installations and the figures for service-pipe requests and number of elevators under water-department supervision certainly results from the fact that the large commercial systems, involving very high rises and heavy service, were of necessity furnished their water not by the city mains but by steam pumping plants on the premises.

Clearest of all is that by the post-war period the era of the



Colyer's Improved Self-Acting Hydraulic Passenger Lifts.

These Lifts are fitted up with F. COLYER'S Improvements, viz. :—

There are no Girders of any description overhead.

The Chains are sunk in grooves in the side walls.

The Counter-Balances slide in guide irons.

The Movement is steady and noiseless.

The Stopping and Starting Gear are at all times perfectly under control. Self-acting gear fitted top and bottom.

NOTE.—Six Lifts of this class have been fitted up by F. COLYER at the St. Thomas's Hospital.

ADVANTAGES SECURED:

ABSOLUTE SAFETY.

PERFECT FREEDOM FROM SHOCK OR VIBRATION.

VERY EASY MOTION AND FREEDOM FROM NOISE.

ARE PERFECTLY UNDER CONTROL.

SOLE MANUFACTURERS:

GEORGE WALLER AND CO.,

ENGINEERS AND MACHINISTS,

PHŒNIX ENGINEERING WORKS,

HOLLAND STREET, LONDON, S.E.;

AND AT STROUD, GLOUCESTERSHIRE.

FIGURE 22.—The direct-plunger hydraulic elevator, because of its inherent simplicity in low-rise applications, has been popular nearly since the introduction of hydraulic power for hoisting, continuing to the present (today invariably with oil rather than water as the medium). The direct plunger's clearly apparent safety also accounted for its appeal—especially in Europe, where the distrust of any form of suspended elevator remained a factor of selection until well into the 20th century ("Much safer to have the car pushed up from below than dangling at the end of a rope, wouldn't you say...?"). (From *Spons' Engineers' and Contractors' Illustrated Book of Prices of Machinery...for 1876* [London, 1876].)

hydraulic was essentially over. In 1919 (the year shown as 1920), new service-pipe requests were at zero, installations were at merely two (oddly, up from one the previous year), and the number of elevators under water-department supervision—i.e., being billed for mains-water—had leveled off at a bit above 510. This latter figure was well down from the high of 592 in 1904 (1905), a fourteen percent drop in fifteen years. The considerable significance of this is that existing hydraulics were being taken from service or converted to electric power in appreciable numbers.[17] It cannot be said what proportion of these were small residential lifts and what were larger ones in apartment and commercial buildings, but it is logical that it was the latter being converted as electric drive and control made possible self service, savings resulting from which could have been expected quickly to recover the conversion costs.

The Wheeler-Brewer Decision: Hydraulic or Electric?

Once the Wheelers had made the major decision to install vertical transportation in their house, they remained faced with a second decision nearly as daunting: what form of motive power for the lift? We have seen that at that time—just after the turn of the century—there were only two choices, seemingly on about a par. The electric elevator definitely had arrived and by no means could it be regarded as a mere novelty, untried and unreliable. If electricity for lighting had materialized on a commercial scale in the larger cities by the mid-1880s, the electric elevator wasn't far behind.

Edison's legendary Pearl Street (New York) generating station opened for business in September 1882, and in early 1886 the Edison Electric Illuminating Company of Boston energized its initial lines supplying customers in the immediate downtown area. By that autumn the mains had reached the Back Bay, including Marlborough St.[18] As though waiting in the wings for the magic moment, the electric elevator leapt forth almost immediately. *Electrical World* reported early in October—meaning that the installation had been made several months earlier—that Boston's Union Institution for Savings had installed a three-quarter ton electric freight elevator to serve its five or six stories, powered from the sparkling new Edison mains.[19] This actually was a proto-electric elevator—as was the case with many during that pioneer period—the hoisting mechanism consisting of a standard worm-gear-and-drum mechanical unit of the type (like the teagle) widely used in mills and factories, driven by belt from the line shafting. Here the role of the line shaft simply was taken by a five-horsepower Sprague motor. Even the control remained unchangedly mechanical, the operating rope in the car shifting the machine's drive belt among three pullies for raising, lowering, and holding, thus avoiding the vagaries of electric control (Figure 23).

In 1892 the Boston building department, in charge of inspecting elevators, made 12 inspections of electric passenger elevators (against 163 hydraulic and 59 steam). Only 11 years later the same numbers were 521, 646, and 74.[20] Now these figures may mislead, for they are numbers of *inspections,* not elevators, and it seems likely that certain elevators—say those in public buildings—were inspected more frequently than the once-annually minimum. (This would account, too, for the curious occurrence of more steam-elevator inspections at the later than the earlier date).

Perhaps most intriguing of all is that Elias Brewer, at least as early as 1895—seven years before the Wheeler House job—was advertising hydraulic and *electric* elevators.

Thus, from every practical and technological viewpoint it would appear that the project could have gone either way: by 1902 the electricity service was in place; the technology of the electric elevator was not only up to but well beyond a job of this scale in terms of capacity and control; and the contractor by his own declaration was involved in the line with a respectable period of experience behind him. Assuming that Brewer was unbiased in regard to motive power (actually, an unknown factor), let us examine the possible reasons for the choice of what could be viewed as a mildly *retardataire* system at the Wheeler's. First, despite the apparent availability of the technology, there may have been a practical problem that stood in the way of an electric elevator at No. 72. Although the Back Bay was served by the Edison Company, it is possible that the mains capacity—intended for a principally, if not exclusively, lighting load—simply was too low for power loading. The concept of selling electricity for power purposes came late to many of the pioneer lighting companies. It is perfectly believable that the illuminating company, recognizing the firmly established position of the hydraulic elevator in that residential part of the city, did not feel it worth the expense of upgrading its Back Bay mains to accommodate motor loads, and actually discouraged the installation of electric elevators.

In contrast, Boston's available water volume, mains pressure, pumping capacity, and reservoir capacity were the equal of any city in the world. As early as 1873 the Water Board held a special hearing on the subject of "Water Elevators" in recognition of the already widespread use of the devices. Among other things, the Board voted:

> That an independent indicator or register for determining the quantity of water used...shall be attached to each cylinder...and that the price for the water used for elevating purposes shall be at the rate of ten cents per hundred gallons.[21]

The City Solicitor immediately determined that the Board had exceeded its authority in setting the price, and reduced the figure to the maximum allowed for metered water: three cents per hundred gallons. At that rate the water cost for a full two-story round trip on the Wheeler elevator—using about 15 gallons of water, would have been barely half a cent, a bargain even then.

But even had there been parity of capacity between the two energy sources, and even had the price of electricity been as low as that of the water for an equivalent amount of supplied power—which it would not have been—there is good reason

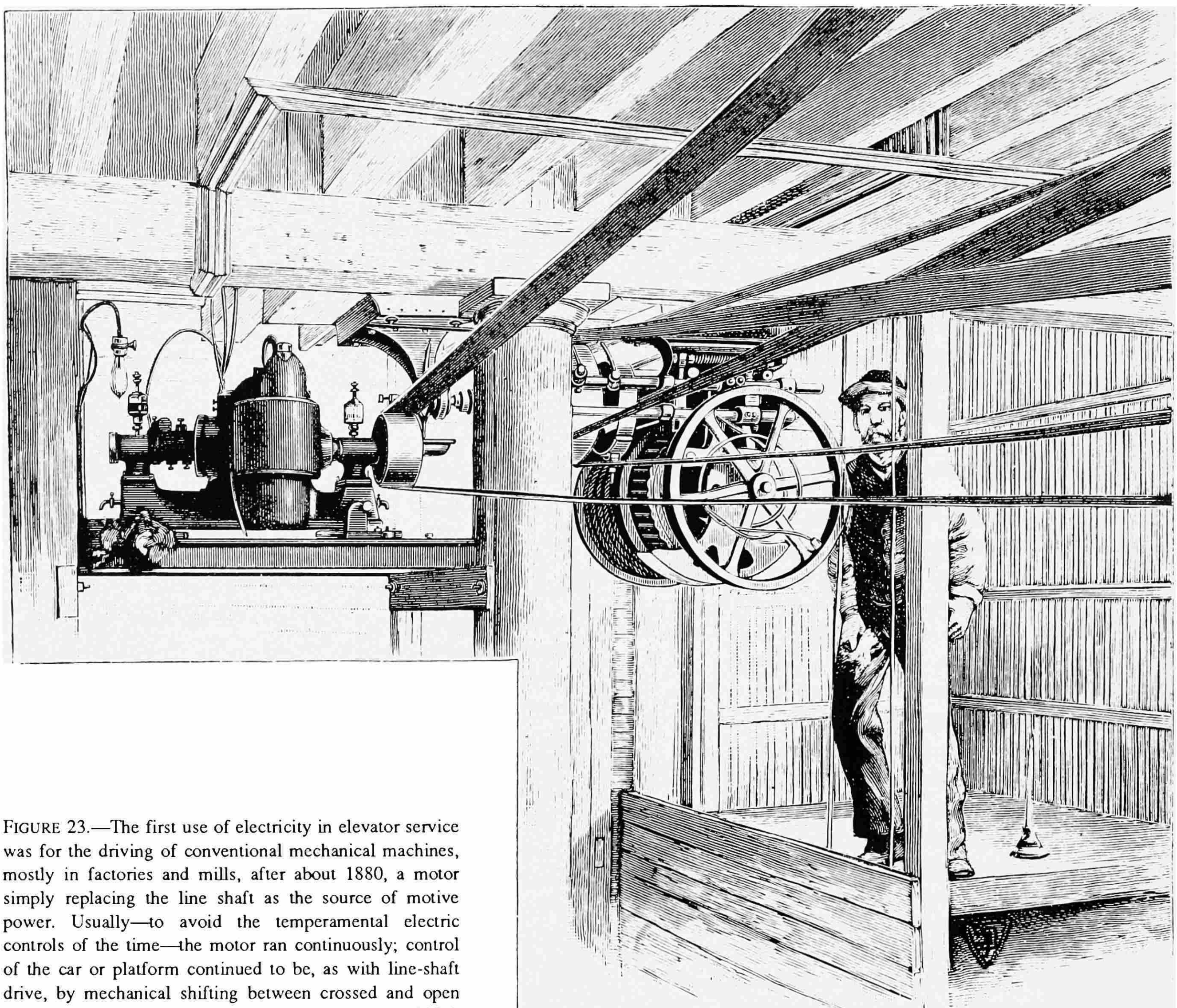


FIGURE 23.—The first use of electricity in elevator service was for the driving of conventional mechanical machines, mostly in factories and mills, after about 1880, a motor simply replacing the line shaft as the source of motive power. Usually—to avoid the temperamental electric controls of the time—the motor ran continuously; control of the car or platform continued to be, as with line-shaft drive, by mechanical shifting between crossed and open belts. (From Brackett et al., "Electricity in Everyday Life," *Scribner's Magazine*, 1891:127.)

to suppose that the Wheelers still would have opted for a hydraulic elevator rather than an electric, based on their own layman's comparative perceptions of the two technologies. Electricity, although commercially fully established by 1902 with a two-decade history of central municipal supply, still was seen by most people as a force of vast mystery. If present day experience with high technology can be taken as a guide, it would be fair to assume that the degree of bafflement over and distrust of electricity at that time would be in direct proportion to the age of the beholder. Bunting notes that the servant call bells at No. 72 never were electrified,[22] and although Marie Carden's HABS survey of the house reports that it was wired for electric lighting in the nineties, she gives no evidence for the date.[23] Inasmuch as the light in the elevator originally was gas, attested to by gas-pipe remnants in both the car and at the mid-point of the shaft where the flexible supply hose would have been attached, it can be inferred that the house was not wired until after the elevator installation, perhaps even following Wheeler's death in 1907.

But even supposing the house to have been wired for light by 1902, it is easy enough to imagine the Wheelers, in consultation with Elias Brewer, declaring that while electric lights might be one thing, an electric elevator was quite another! Water was, after all, a substance as common, familiar, and tangible as life itself. It was non-threatening, non-lethal, and its behavior was absolutely comprehensible. Furthermore, the hydraulic elevator, in widespread use all over the Back Bay, might reasonably have been taken to be as reliable as any mechanical device possibly could be.

Imagine the comparisons that might have been drawn by the

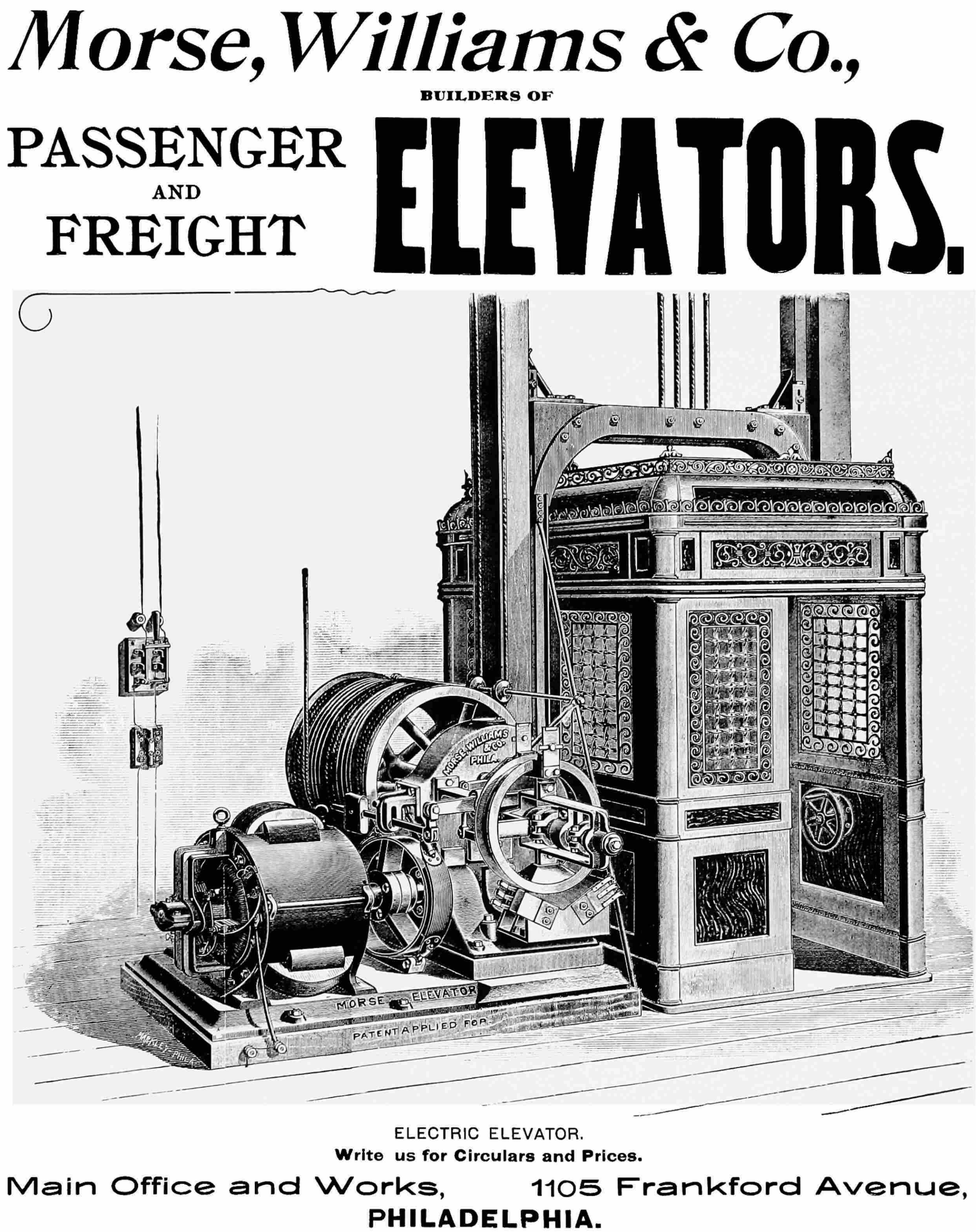


FIGURE 24.—The electric elevator in its first fully rational, "all-electric" form, about 1895. Because a winding drum remained the hoisting element, the run still was limited, but for stores, hotels, apartment houses, low commercial buildings, and residences the design was entirely suitable once a dependable central electricity supply had become available and the details of control been improved. The basic arrangement—the motor driving the drum through worm gearing—remains in wide use for installations in which the final form of the electric elevator—the gearless traction system—is not called for. (From *The Electrical World,* 2 January 1897:xcvii.)

Wheelers between these factors and the equivalencies of electicity, whose mysteries were due mainly to the fact that it was as intangible as water was palpable. Even illuminating gas, though invisible, was a fully detectable substance of long-standing common experience. Electricity, on the other hand, worked its wonders without benefit of pipes or other orthodox means of conveyance. It was ethereal. Moreover, it was anything but benign, for its tendency to arc violently and sputter menacingly, and its capacity for causing not only fire, but pain, injury, and even death were early and popularly recognized. It is easy to picture the feelings of the Wheelers if asked to consider the introduction into their house of this sinister element on what, in comparison to a few lighting circuits, would have been a massive scale.

But even if all of the above factors were disregarded, there remained one other that alone should well have been more than enough to remove electricity entirely from the running. That was the matter of reliability. Central electricity supply at the time was anything but dependable. Both generating and distribution systems were composed of numerous weakest links. Failures of service were frequent. Recall that until about the end of the century's first decade most incandescent lighting fixtures were of the combination type, incorporating gas jets equal in number to the bulb sockets so that in the event of electricity failure with only a momentary lapse light could be restored.

But if a collapse of the electric lighting system could be immediately side-stepped with only slight inconvenience, what of an electric elevator? With no possibility of falling back on gas (or anything else) a car stopped dead between floors due to power failure was a perfectly reasonable expectation. If the outage were protracted—as often they were—the consequences could be grim in the contemplation. In contrast, the supply of water in the mains was virtually foolproof, depending as it did on natural gravity flow from an elevated reservoir.

We may visualize, then, the decision being taken without a great deal of pondering on the part of the elderly and doubtless conservative Wheelers to adopt the tried and true, the utterly certain, the absolutely safe and easily controllable.

Elias Brewer, Elevator Builder

For reasons that will become clear, I have come to view Brewer not as an elevator manufacturer, but a builder. The more his work is examined the more it appears that he did less designing of equipment than of installations, and less manufacturing of machinery than specifying it, to be made by others—with the real possibility that he did no machine work at all.

Elias Brewer's professional career is obscure, the trail marked by no original paper and little enough secondary. He was born in Lachine, Quebec (near Montreal), on 24 December 1839, apparently moved to New York State, and is not again fixed in time or place until his initial appearance in the Boston city directory in 1874, listed as a carpenter. Although we will look at the few additional shreds of available information elucidating Brewer's work, these city directories may be taken as a fairly graphic indicator of his involvement in the elevator business. There is a startling jump in Boston's elevator industry about the year 1877, for whereas the 1874 directory lists 11 elevator firms and the 1876 directory 12, the volume for 1877 identifies 21, among whom, for the first time, is found "Brewer & Co." The directory through 1880 carried only the single classification "Elevators," but starting in 1881 subdivided the business into "Elevator Manufacturers" and "Elevators and Elevator Fixtures." The latter classification, which ought to have been the clear territory of installers and makers of such accessory products as safety devices and shaft gates, was in fact an indistinct one, for many of the large firms that clearly were manufacturers of elevator machinery and are so shown, appear also in the second group. Of pertinence here, though, is that Brewer invariably is listed only in the Elevators and Elevator Fixtures category. Nonetheless, equally invariably he styles himself as a "manufacturer" in all advertisements up to the year 1905.

I have found no clue as to the scale or scope of Brewer's activities in Boston's vigorous vertical-transportation community at this time of his jumping in, but that he aspired to be something more than a mere trooper is seen by his having obtained a patent on 10 April 1877, for an "Improvement in Hydraulic Elevators" (Figure 25). This is a curious device, embracing a minor mechanical modification of the conventional vertical-cylinder, rope-geared hydraulic. The patent specification is, in fact, uncharacteristically nebulous. The principal claim made by Brewer is the mechanical symmetry achieved by the arrangement of two power cylinders and two sets of rope sheaves, all working in conjunction with a common crosshead. The advantage claimed for this scheme was "very steady movement of the car" and security against the cables becoming unreeved in the event of the car becoming momentarily blocked during descent. It is difficult to see how either of these aims would be any better met than in a conventional system with appropriate guards for the ropes where they passed over the sheaves. But there is an even odder component to the patent. In Figure 25, the central cylinder (y) will be seen to be connected directly to the mains water supply line at (t), *before* the distribution or operating valve. The purpose of this feature was to act as a counterbalance—in place, presumably, of the conventional suspended counterweight used to balance the dead weight of the car. In Brewer's patent this was to be accomplished by the pressure of the supply water acting constantly on the central piston. When the car descended, the water in the cylinder simply would be forced back into the main; a plan noble in its simplicity, to be sure, eliminating the counterweight and its outfit of guide rails, overhead sheave, and ropes. But, strangely, the very same scheme had been patented by one Timothy Stebins (who, incidentally, also was a resident of Boston), a mere five months

E. BREWER.

HYDRAULIC ELEVATOR.

No. 189,424. Patented April 10, 1877.

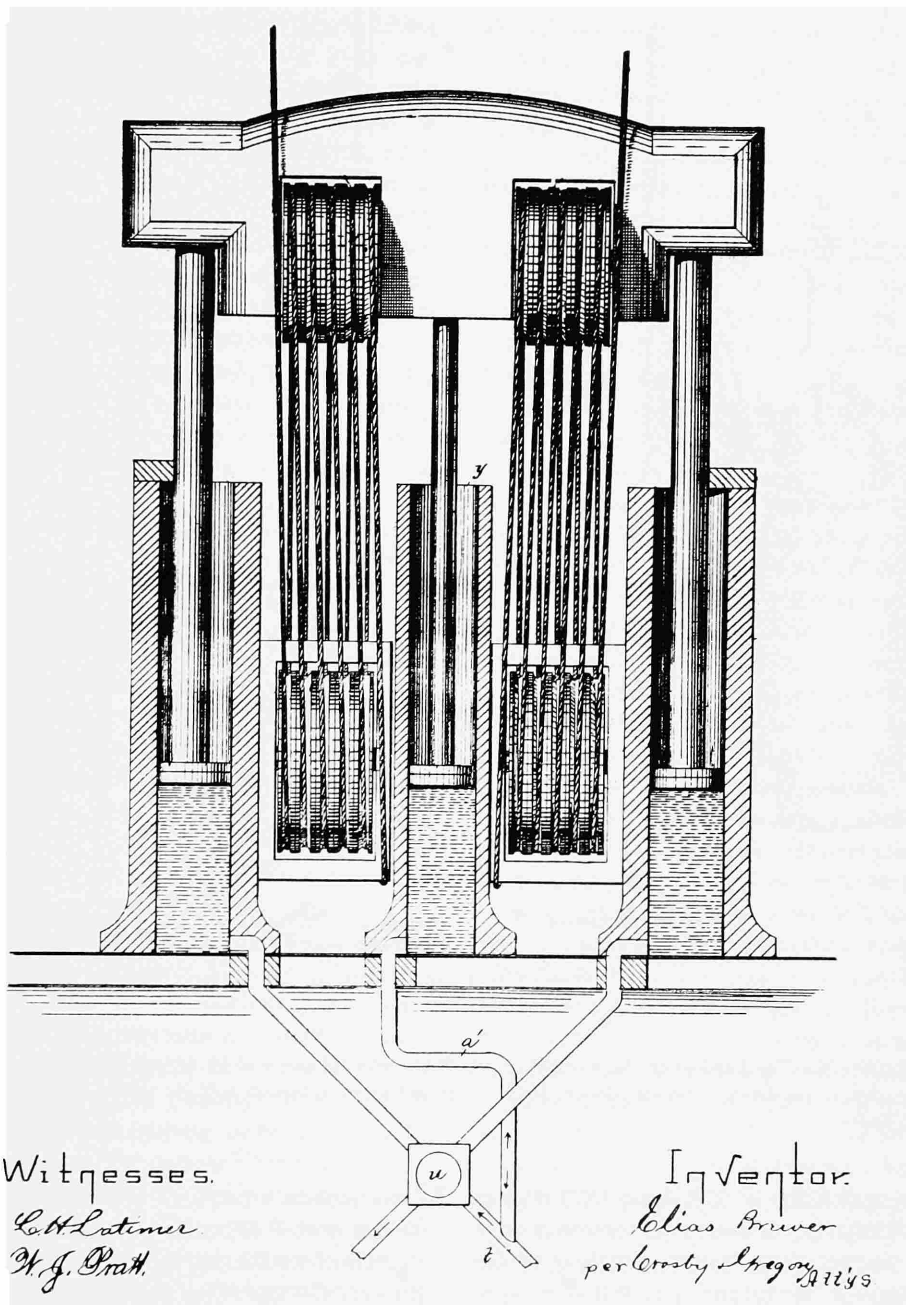


FIGURE 25.—The drawing accompanying Elias Brewer's (apparently) sole patent of 10 April 1877. Although the patent's claims of originality differed somewhat from those of Timothy Stebins's only slightly earlier patent, it is difficult to avoid the conclusion that Brewer was strongly influenced by the prior work of his fellow Bostonian. A principal Brewer claim was counterbalancing of the elevator's dead weight by constant application to the piston in the central cylinder (y) of pressurized water from the supply main—through pipe (a) which was connected to the main ahead of the control valve (u). When the car descended (by gravity), the water in the balance cylinder simply was forced back into the main.

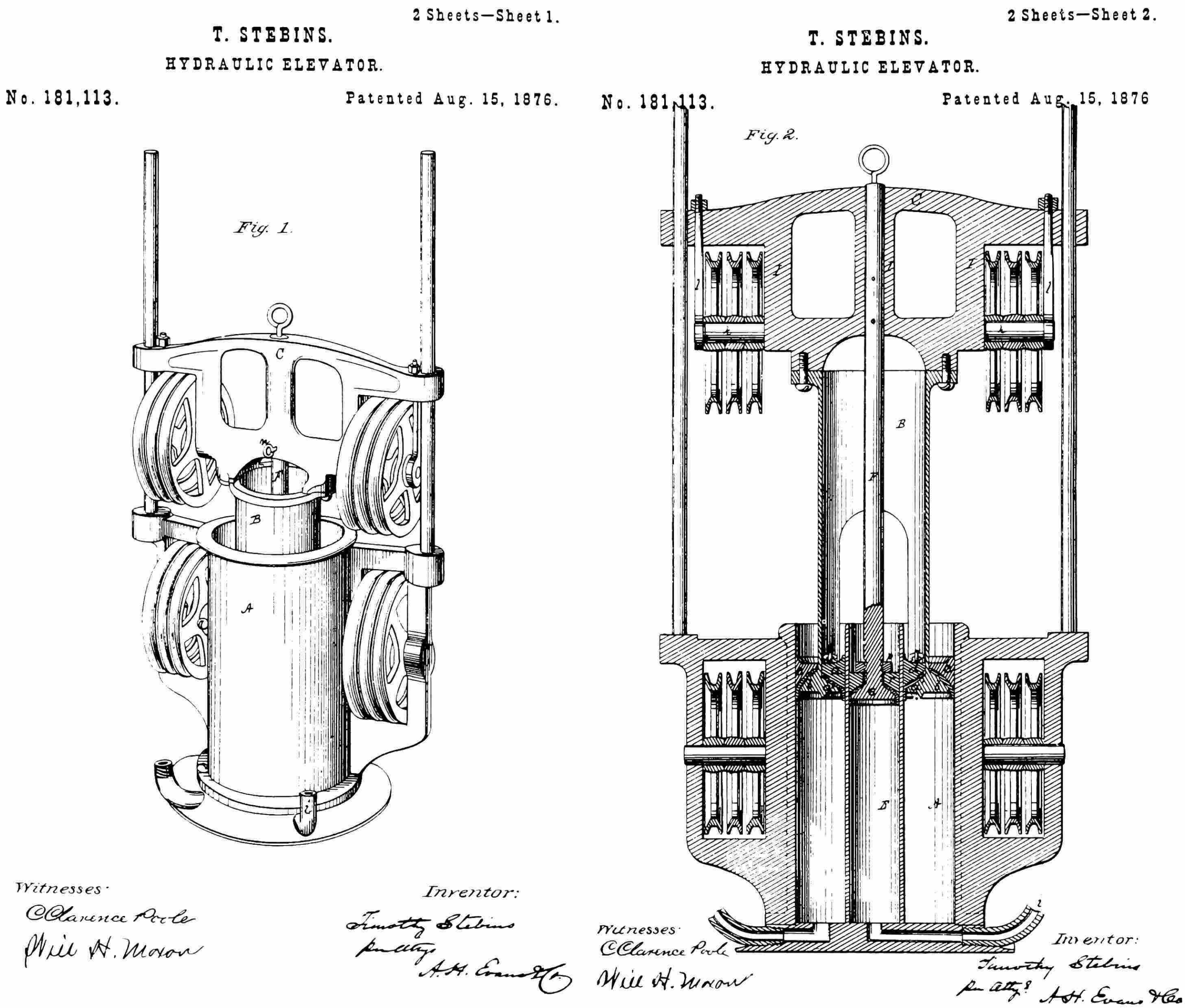


FIGURE 26.—The drawings of Timothy Stebins's hydraulic elevator patent of 15 August 1876, the apparent inspiration for Brewer's patented design. Stebins employed a central balance cylinder and an annular power cylinder.

before Brewer's patent application on 10 January 1877 (Figure 26). Clearly we have here a case of something other than eerie coincidence, and we should love to know something of the Brewer-Stebins relationship, for certain it is that they were known to one another. Timothy Stebins is listed in the directories through the mid-1870s as, simply, "foreman," with no affiliation. Then in 1879 he appears as "Supt. Hydraulic Elevator, S. Boston Iron Co." That firm was one of the city's large machine works, advertising as a specialty "Hydraulic Passenger and Freight Elevators Of Improved Design, by which the greatest possible economy in the use of water is effected."

As Stebins's patents were not assigned directly to South Boston Iron, is it possible that he was allowed to do a certain amount of freelancing and had some sort of association with Brewer? Or were they merely friendly rivals? Or were they bitter competitors?[24] Whatever the relative position of the two men with regard to their patents, that between the two patents is distinctly peculiar. In Brewer's initial application he explicitly claimed the use of the central piston and cylinder as a counterbalancing device. That claim, and the elongated crosshead with paired sheaves, initially were disallowed by the patent examiner as being covered by prior patents, of J.L. Clark and J. Standfield, and Stebins, respectively.[25] In this maze of curiosities, the examiner did not identify *Stebins's* use of the counterbalancing central cylinder. By a linguistic fiddle, his attorney was able to so adjust Brewer's claims as apparently to satisfy the examiner, leaving the patent to be issued in the following baffling form. In the body of the specification Brewer does "not claim the use of two cylinders, one lifting at each end of the cross-head, nor...the use of a car-counterbalancing cylinder containing water in connection with an elevator...," while in the summary of claims at the end of the specification he does claim the combination of the other elements of the device "with a central car-counterbalancing cylinder and piston...." It would seem that the patent finally was allowed on the basis of claiming a combination of the group of components, despite seeming to be in violation of the examiner's admonition that he would not allow the patent if it were "a mere aggregation" of previously patented details.

Whether Brewer and his attorney obtained a patent on a truly novel device or simply outran the examiner, an uncharitable eye might see in the patent the product of a man desperately anxious to make a visible splash in a new field in which he was attempting to gain a foothold.

There is no way to know whether Brewer actually built and installed any elevators based on his patent, although it is likely that he tried at least a few as a matter of pride (if not forestalled as an infringer by Stebins). But, to be sure, the patent did play a passive role in the next stage of his career. This was the placement in 1883 of his first advertisement in the city directory (there may have been earlier ones in other media). The ad (Figure 27) depicts an elevator machine clearly patterned after the patent, but with the notable absence of the central balance cylinder. The car is balanced by a traditional counterweight, the overhead sheave of which is seen in the cut. The ad copy ambiguously observes that what is illustrated is a "two-cylinder Hydraulic Machine with freight car in operation," going on to note that it has 30 percent less friction than any other in Boston and consumes 30 percent less water than any other elevator in operation (a response to the South Boston Iron Co. claim?). These assertions are patently absurd, for unless Brewer was constructing his sheaves with ball or roller anti-friction bearings—totally unlikely—two cylinders rather than one would only add rubbing surface area to the machine and raise, not reduce, the system's internal friction. As to water saving, if the supply was drawn from the main and discharged to the sewer, a given trip with a machine of a given lifting capacity would consume a given volume of water regardless of the load and the machine's configuration.

Hyperbole aside, Brewer does seem to have made modest progress in the elevator business. He continued to run large, illustrated ads in the city directory, but by 1886 had dropped the cut of his proprietary machine and was showing only a conventional hand-powered platform elevator of insignificant proportions—a trivial-seeming representative of a firm that billed itself as able to furnish hydraulic, steam, and belt-powered (and hand) elevators, for hotels, office buildings, and warehouses, as well as for private residences. It was, incidently, by 1886 that the ad prominently featured the "private residences and invalid elevators" notice that had first drawn my attention to Brewer.

The extent of Brewer's custom by this time is unknown. He still operated from the address (267 Federal Street) shown in his initial 1877 listing, but his ad in the 1888 directory introduces a distinct signal of expansion: a branch office at 135 Spring Street, New York. Obviously this was just that—an office—and quite likely signified no more than an agent who handled a stable of industrial accounts. This alliance appears to have been short-lived for the New York reference is gone from the ads by 1891, about which time Brewer also had moved the firm to 52 Sudbury Street. An anomaly is a small ad in an 1895 vanity publication on the city's building trades, to illustrate which the old cut of the double-cylinder hydraulic machine was dug out.

The only discovered hint as to the scale of the business is a short account in that same volume, describing Mr. Brewer as a man who has kept ahead of the times (with 18-year-old hydraulic machines of questionable merit?), and who has "introduced his elevators into about one hundred hotels and private residences in Boston and about fifty similar buildings in New York City...his trade [extending]...also into Canada."[26] A number of the Boston hotels are listed, as well as a theater and two office buildings. The account is also of interest in observing that the "elevators are all made under patents of Mr. Brewer's inventions, and his safety devices which are also patented, are peculiarly valuable." Unless Brewer held some Canadian (or other foreign) patents, this statement is an exaggeration, for a careful review of the U.S. patent records has failed to reveal any other Brewer patents.

But if this essay and the ad are to be believed, Brewer was, in fact, keeping, if not ahead of, at least up with the times as here for the first time he drops mention of steam elevators, and joins the van by stating that he can furnish electrics.

The attempt to assess the extent of Brewer's operations again raises the question of his being an actual manufacturer. His consistent directory listing under "Elevators and Elevator Fixtures" rather than "Manufacturers" would seem conclusive evidence that he actually built few or none of the components of his installations. This is supported by the fact that at none of the four premises Brewer is shown to have occupied between his start in 1877 and retirement about 1912 is he seen to be the sole occupant.[27] All of the immediate neighborhoods were occupied at that time by small loft and manufacturing buildings of up to five stories, few of them occupied by a single tenant. It would appear that at each of these locations Brewer operated from just a floor or two. There is nothing from which to draw even a sketchy picture of his plant, but we can speculate on a range of possibilities on the basis of the Wheeler elevator. At the minimal end of the scale would be an absolutely bare-bones operation, with Brewer himself and perhaps a draftsman designing each installation—which of course included new

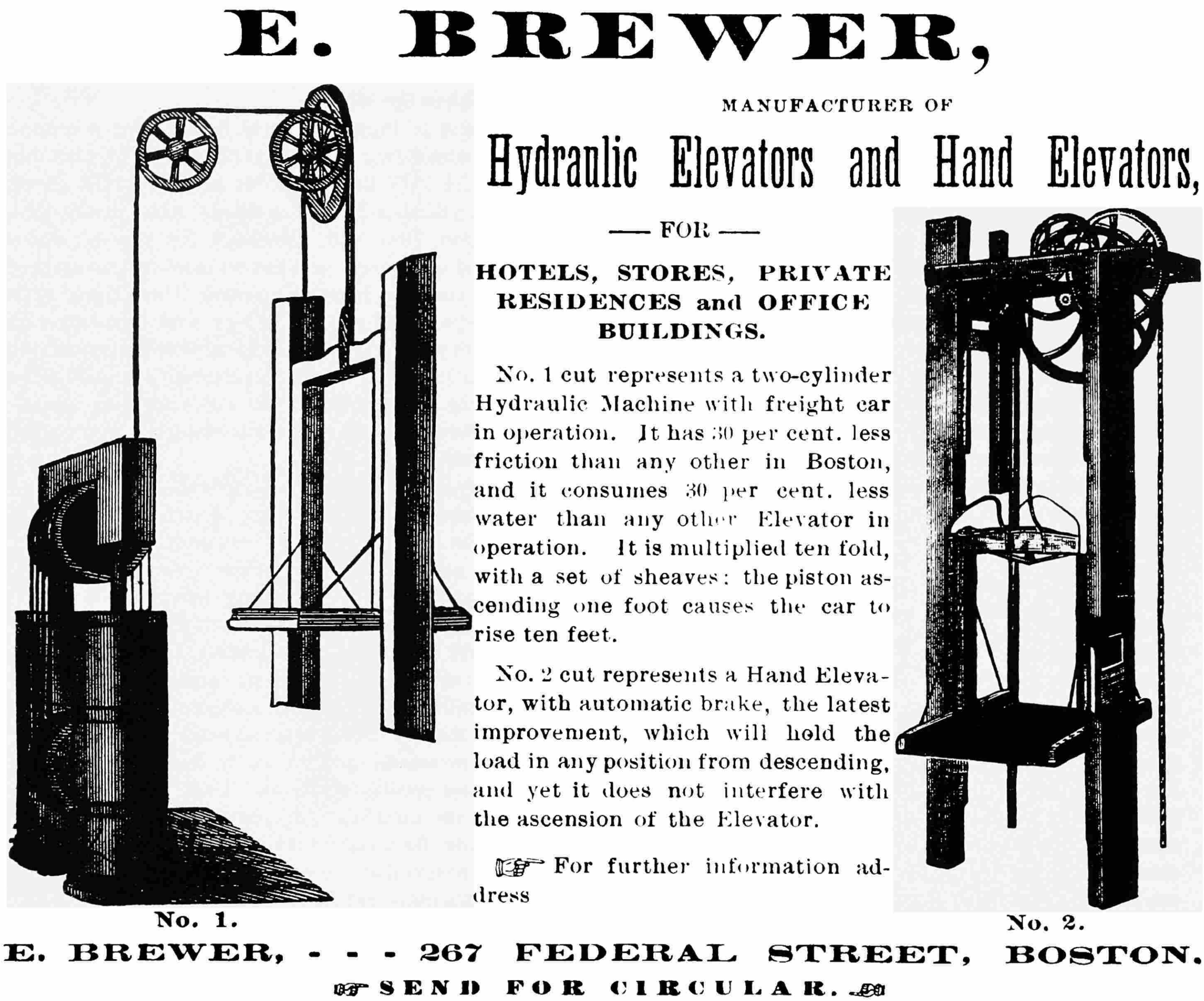


FIGURE 27.—Brewer's first advertisement in the Boston city directory, 1883, featuring his patented hydraulic elevator machine. Curiously, however, he had dropped the hydraulic counterbalancing feature in favor of a conventional counterweight as shown here. Perhaps Stebins had felt himself infringed upon and had persuaded Brewer to revert to counterbalancing orthodoxy.

buildings as well as insertions in old. In a city (and region) as industrially rich and diverse as Boston it would have been easily possible to have every detail of an elevator jobbed out: pattern and foundry work for the cylinders, operating valves, and other castings; all machine work for these; and, of course, the cabinet work of the cars. Many of the fittings such as large and small sheaves, hoisting and control rope, and all plumbing would have been available directly off the shelf from any number of mill and industrial supply houses.

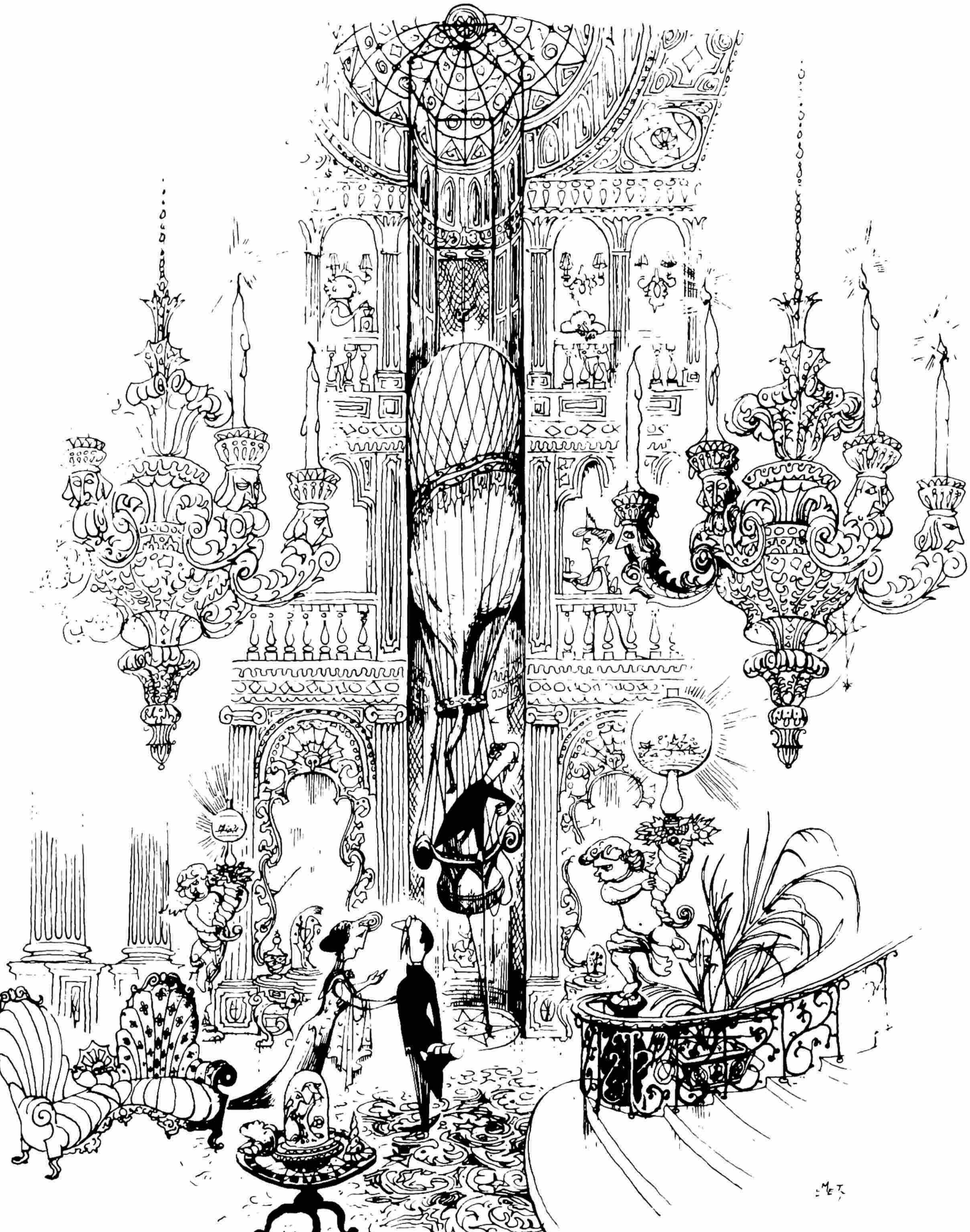
A certain amount of fitting and assembling could have been done in his own shop and the lot of parts carried to the job site where the major assembly would have had to be done in any case. At the other end of the scale, it would have been entirely possible for Brewer to have had a modest amount of metal-and wood-working machinery at his loft premises, enabling him to do the lighter machine work, all the wood pattern work, and the cabinetry of the cars. Arguing in favor of limited facilities, however, is the undoubted irregularity of elevator work, particularly in the case of a relatively small operator like Brewer, so that if he were half a business man he would have recognized the advantage of maintaining little or no plant of his own, farming out the bulk, or all, of his manufacturing work as jobs came his way. The same may be surmised about his field crews: that he picked them up and laid them off as the work demanded.

A final, indirect, clue to the generally modest level of Brewer's business may be taken from his life style, in turn implied by his residences. For most of his professional life in Boston he resided in Chelsea, an unpretentious near suburb, in a frame house (still standing) that could be described only as humble. Upon retirement he moved to Onset, an equally unimposing seaside community at the base of Cape Cod. That house now is gone, but on the assumption that it was on the order of its surviving near neighbors, it, too, was anything but grand.

Elias Brewer died (of senility) in February 1918, at the age of 78. He was hailed in local obituaries as the "inventor of the Brewer elevator," and eulogized in one as "a prominent manufacturer of elevators and...the dean of this business in Boston." The firm continued under his two sons until just before World War II, when it disappears from the directories.

A final, minor question remains concerning the Wheeler-Brewer elevator: how was the connection made between the two parties? In view of the number of residential hydraulics already installed in the Back Bay by the time the Wheelers had made their decision to go elevator, and the likelihood that a number of them were by Brewer, simple word-of-mouth reference may well have been the means. Otherwise, we may assume that it was Brewer's highly focused ads in the city directory—in 1902 essentially filling the role of today's telephone directory as a means of access to fellow residents and businesses—that drew the Wheelers' attention to his work.

> The elevator was invented in America, which also produced the aeroplane, the telphone and other time-savers and it has enabled man to colonize the air. Half a century ago nobody lived more than seventy feet above the ground. Now-a-days men do business happily 500 feet aloft, and discharge their office boys for stealing eagles' eggs off the fire escapes instead of attending to business. *M.A. O'Brien, Jr., 1915.*[28]



"We hesitated a long time before installing a lift, but fortunately it's Period . . ."

FIGURE 28.—(By Rowland Emett, reproduced from *Punch*, ca. 1950, by kind permission.)

Appendix

A Chronology of Elias Brewer

(From Boston city directories and obituaries in the *Wareham Courier*, 14 Feb 1918, the *Chelsea Gazette*, 16 Feb 1918, and the *Chelsea Evening Record*, 18 Feb 1918.)

1839 (24 Dec) Born, in Lachine, P.Q., Canada, of Canadian parents.

1874 First entry in Boston city directory, listed as "carpenter"; residence at 36 Lawrence St.

1877 First directory entry as elevator builder: BREWER &c CO., 267 Federal St. (residence at 54 Ellery St.) (Does "&c CO." imply a partner?)

1877 (10 April) Issued first, and apparently only, U.S. patent, for a hydraulic elevator: No. 189,424.

1879 Directory entry for BREWER & CO. at both 267 Federal St. and 158 Sumner St.

1880 BREWER & CO. now shown only at 267 Federal St.; residence at 267 E. 8th St. (Typo?)

1881 Directory entry now for ELIAS BREWER, elevator manufacturer. (A split from a partner?)

1883 First advertisement in the directory: E. BREWER, MANUFACTURER OF HAND AND HYDRAULIC ELEVATORS.

1886 Same as above, but ad now shows 267 Federal St. and 149 Broadway, New York, the latter presumably only an agency office.

1888 Same ad, but NY office now at 135 Spring St.

1891 E. BREWER's Boston premises now at 52 Sudbury St.; no mention of NY office.

1893 ELIAS BREWER, at 52 Sudbury St.

1895 ELIAS BREWER & CO. (this same ad, unchanged, to 1908). (Partner again?)

1902 Installation of small hydraulic passenger elevator for Alexander Wheeler, at 72 Marlborough Street, Back Bay.

1908 Address of firm now 19 Bowker St., with (son) John E. Brewer listed as clerk.

1909 Same listing as above, plus (son) Elias H. Brewer as mechanic.

1911 Firm now at 27 Bowker St.

1912 Shown now as BREWER ELEVATOR CO., INC., SUCCESSORS TO ELIAS BREWER & CO.; Elias Brewer, President; the sons still shown as clerk and mechanic.

1915 Same listing except that Brewer now residing at the seaside village of Onset, presumably in retirement (age 75 years).

1918 (13 Feb) Elias Brewer dies (of senility), age 78 yrs, 1 month, 19 days. No autopsy; interment at Long Neck Cemetery, Wareham. Hailed in obituaries as "Inventor of the Brewer Elevator" and "Dean of the elevator business in Boston." Surviving children: John E. of Malden; Elias H. of Revere; Amy; Mrs. Lillian McIsaac of Jamaica Plain; Mrs. Ella Van Patten of Chelsea; Mrs. Alice Macdonald.

1938 BREWER ELEVATOR CO. shown at 47 Bowker St., with John E. and Elias H.

1939 Firm shown at 14 Chardon St., with Paul E. only, residence at Malden. (Son of John E.?)

1940 No listing for Brewer Elevator Co; no individual listing for either John E. or Elias H. Paul E. still residing at Malden. The apparent end of the business.

Notes

1. The NMAH collections contain a modest number of elevator artifacts. The crown jewels of these holdings are an Otis double-cylinder steam elevator machine of ca. 1873 that powered the ballroom elevator of the celebrated Grand Union Hotel in Saratoga Springs, N.Y., and an Otis freight platform of the late 19th century, fitted with E.G. Otis's broken-rope safety stop of the original, classical "wagon-spring" type (see note 8). Both were donated to the Museum by the Otis company and at the time of writing are on display in the exhibition *1876*.

2. A small handful of horizontal-cylinder, rope-geared hydraulic elevators do survive *in situ,* both in service and more or less deliberately preserved on the strength of their historical value. Of those few in passenger service, all are in low buildings of, at the most, four or five stories, and thus cannot be viewed as truly representing the class in its role as the enabler of the tall building. Furthermore, none of these examples, even those "preserved," can be regarded as absolutely secure against future removal. The Smiths Clove Museum near Monroe, New York, has collected the machinery of one of these elevators but apparently not the car or the control gear. In the holdings of the Liftenmuseum near Amsterdam—one of two elevator museums in the world—is a rope-geared hydraulic freight elevator but with a configuration of elements rather different from the American pattern.

3. Nancy Ritchie-Noakes, *Liverpool's Historic Waterfront: the World's First Mercantile Dock System* (London: Her Majesty's Stationery Office, 1984), page 121.

4. Nancy Richie-Noakes, *Jesse Hartley: Dock Engineer to the Port of Liverpool, 1824-60* (Liverpool: Merseyside County Museums, 1980), page 58.

5. A transitional type between the rope-geared hydraulic and the electric traction elevator was the "direct-plunger" system, a collateral derivative of Bramah's hydraulic press. Funtionally it was, in fact, an even closer relative of the fundamental press than Bramah's own rack-and-pinion crane, for the elevator car was carried directly on the ram or plunger (piston) of the hydraulic cylinder, exactly like the platen of a press. The system's inherent simplicity was appealing, and by the 1860s inventors in all parts of the world were attempting to embrace the notion of an elevator with but a single moving part. The apparent great advantage of the type compared to the rope-geared hydraulic and the other suspended systems in addition to its simplicity—no ropes or sheaves in installations of low rise—was its fully evident safety: the car always was borne upon a column of water that, if by system failure were to escape from the cylinder, could do so only slowly, allowing the car to descend hardly faster than normally (Figure 22). A disadvantage was that in installation a bore hole to accommodate the cylinder had to be sunk beneath the elevator shaft equal in depth to the elevator's rise.

With the advance of well-drilling techniques by the end of the century, the problem of sinking even very long cylinders was essentially resolved. Direct-plunger hydraulics enjoyed a considerable use between about 1890 and 1920, built by two or three major firms. Employing nearly the same water-supply and control technologies as the large rope-geared systems, they were installed in some astonishingly tall buildings—up to 25 stories—largely in New York. When these systems are described for the first time to the mechanically oriented the question immediately is raised: what in the world prevents the buckling of a relatively thin plunger as much as 250 feet long, bearing at its upper end a loaded elevator car? In fact, in the highest rise direct-plunger installations, with the car in the upper reaches of its travel, the fully extended plunger could be seen to sway laterally several inches back and forth, a mildly unnerving effect. Why didn't the plunger, never more than eight inches in diameter, simply collapse like so much spaghetti under the weight of the car? The answer lay in the counterweight system always applied to those systems of more than five or six floors rise. When the car was at the top, the weight of the counterweight ropes, on the other side of the sheaves at the top of the shaftway, balanced the weight of the unsupported plunger so that for most of its length the plunger actually *hung* from the car and was in tension rather than compression. Hence the alarming but harmless swaying. As the car descended, the counterweight-rope weight gradually was transferred to the car-side of the sheaves and so balanced less and less of the plunger's weight. But simultaneously the plunger was retracting into its cylinder so that there was a steadily lessening length of unsupported column. The length of unsupported plunger in compression actually never extended very far above the top of the cylinder. As the car descended, a second effect took place: with more and more of the heavy counterweight ropes passing from the counterweight-side to the car-side of the overhead sheaves, the counterbalancing of the car was increasingly diminished. But at the same time more and more of the plunger's weight was being buoyed by the water in the cylinder,* reducing the car's virtual weight. Thus, the system's dead load was in nearly perfect balance regardless of the car's position.

*The plunger in a direct-plunger elevator was just that: a constant-diameter plunger passing through a stuffing box at the top of the cylinder and of somewhat less diameter than the cylinder bore—not a close-fitting piston. The effect of this was that when in the cylinder the hollow plunger was surrounded by water and thus buoyed in direct proportion to its retracted length.

6. An account of this elevator, certainly among the earliest for passengers in the United States, is found in a typescript from an unidentified source among the "papers of the Late Prof. Frank J. Roos, Jr." in the files of the Historic American Buildings Survey (National Park Service). The description, taken from "A Journal of a Voyage to New England Performed in the Year 1844, by S.S. Walker," reads, "[the Monument] is kept by a man who for a quarter will take you to the top in a steam car, or for a shilling you may have the privilege of walking up a never ending spiral staircase. The ascent by the car is pleasant. You step into a bird cage big enough for 6 persons to stand at once, and in 3 minutes you open the door of the cage and walk out upon a floor where you may look out...."I am not aware of any further description of this device nor of any illustrations of it. It probably was similar to a mine hoist, controlled from the machine itself at the

bottom.

7. "The Vertical Railway," *Harper's New Monthly Magazine* (November, 1882), pages 888–894.

8. E.G. Otis, commonly believed to have "invented the elevator," in fact was the inventor of the first practical safety device. It was of the "broken-rope" type, that arrested the car in the hoistway if, for any reason, the tension on the hoisting rope(s) was relaxed, in the event of rope breakage or failure of some other part of the hoisting mechanism. It was this elegantly simple device that largely was responsible for winning public confidence in the passenger elevator. There can be little doubt that Otis's spectacular and now legendary demonstration of his safety apparatus at the 1854 Crystal Palace exposition in New York was as instrumental as its own merits in both inspiring that confidence and fixing it in the popular mind.

9. "The Vertical Railway" (note 7).

10. John Albury Bryan, *Because of Iron: A Series of Brochures Dealing with the Use of Iron in our Modern Civilization* (published by the author, 1947). An interesting, brief history of the elevator, containing considerable obscure information gathered from a variety of sources. His cited patent statistics were obtained, presumably, from the Patent Office's figures for that classification.

11. Charles S. Damrell, *A Half Century of Boston's Building* (Boston: Louis P. Hager, 1895), pages 43ff.

12. All Back Bay structures, being on made ground, of necessity were built on pilings. In row houses the party, end, front, and rear walls, all of masonry, were thus piled. The pilings, of timber, had to be kept entirely below the water table to prevent their rotting. The interrelationship among the elevations of the water table, pile caps, granite footing blocks that bore on the piles, street, and house floors dictated the arrangement described. The Donelan house crawl space is about four feet in clear height, partially flagged with rough slates, and is used to pass all the house's supply and waste plumbing. The vertical relationship of the typical Back Bay row house to the topography is clearly described and illustrated by sectional drawings in Bainbridge Bunting's classic *Houses of Boston's Back Bay: An Architectural History, 1840–1917* (Cambridge, Mass.: Harvard University Press, 1967), pages 272–276.

13. The Historic American Engineering Record is a bureau of the National Park Service, charged with preparing graphic and verbal documentation of American engineering and industrial structures judged to be of historical importance. The drawings, photographs, and historical data generated by HAER projects—which can range in scale from a half-day photographic sortie such as that at the Donelan house to a summer-long survey of a major industrial site involving a dozen draftsmen, photographers, and historians—are deposited in and their distribution administered by the Division of Prints and Photographs, Library of Congress, Washington, D.C. 20540. A list of the HAER holdings from its start in 1969 up to 1985 is available from HAER, Box 37127, Washington, D.C. 20013-7127.

14. A full report on the removal process and its architectural-archeological revelations is in the files of the Division of Engineering and Industry, Room 5020, NMAH, Washington, D.C. 20560.

15. This points out once again the risk in attributing dates to things on the basis of their "typicality" or "suggestiveness" of a certain period. What so often is overlooked by historians in using this method is the "Factor of Temporal Inertia." This is, simply, that phenomenon whereby more craftsmen, builders, manufacturers, and others who produce things will tend to continue making what they know, than will innovate or change their product. Brewer seems to have been an exponent of this practice, for the Wheeler elevator—even to the style of the car—would have been entirely at home in a setting of the mid-1880s if not even somewhat earlier. It would be interesting to compare this installation with others of his—both earlier and later—but, alas, none are known.

16. Bunting (note 12), page 283.

17. The first electric passenger elevator in the United States was installed in Baltimore, by William Baxter, in 1887.

18. James V. Toner, *The Boston Edison Story, 1886–1951, 65 Years of Service!* (New York: The Newcomen Society in North America, 1951).

19. *Electrical World* (October 2, 1886), page 168.

20. Annual reports of the Inspector of Buildings, Boston, various years.

21. *History of the Boston Water Works from 1868 to 1876* (Boston: Rockwell & Churchill, 1876), page 43. The metering of elevator water was carried out as noted. The Wheeler House elevator was fitted with a register, cobbled up, oddly, from the clockwork register mechanism of a gas meter (Figure 13). Whether this was the convention or whether commercially manufacturered versions were available is not known. It was connected by string or wire (missing) to some part of the power-cylinder crosshead so as to register total piston/car travel. Multiplication of this figure by a conversion constant would give water consumption in gallons. Apparently the honor system prevailed for the register was neither enclosed nor sealed in any way.

22. Bunting (note 12), page 280.

23. Marie Carden, "Historic American Buildings Survey, 72 Marlborough Street, Boston, MA" (Boston: Boston University, spring, 1985), unpublished report for course AM 780: Problems in Historic Preservation, page 2.

24. Other than placing him at South Boston Iron Co., I have made no attempt to identify Stebins. His career certainly revolved around elevators, however, for he was issued at least four patents in the field. The first of which I am aware he obtained in 1873 while a resident of San Francisco. It was for a horizontal-cylinder "pulling-type" hydraulic in which the piston rod was dispensed with and the hoisting rope was attached directly to the piston, passing through a stuffing box in the cylinder head. There was no rope multiplication and the claimed object was to save the length normally required by the run of the rigid piston. Although the scheme appears dubious, such systems did find some commercial use. In December 1875 Stebins (by then in Boston) received a patent for a hydraulic elevator having the wildly unorthodox feature of an integral water turbine geared to a winding drum. In February, 1876 he was issued a patent for a "symmetrical" or "concentric" hydraulic having several co-axial cylinders working on a common crosshead, the apparent inspiration for his August patent and, thus by imputation, Brewer's.

25. Invention Patent Application File for Brewer's patent, issued as No. 189,424 on 10 April 1877. (Invention Patent as opposed to Design Patent.) These files, for all patents issued between 1836 and 1918, are at the National Archives and Record Service (Suitland, Maryland, repository). Each file contains the initial application and any subsequent correspondence between the examiner and the inventor (or his attorney) concerning prior art, anticipated rejections, rebuttals, and other matters concerning the invention's patentability. Clark and Standfield were Londoners, entirely fitting inasmuch as the field of hydrostatic engineering played a dramatically greater role in Britain's

technology than that of any other nation. (N.B. the account earlier in this article of English hydraulic cranage as hydraulic elevator prehistory.) Their extensive patent—No. 181,409 of 22 August 1876—covered a wide range of hydraulic lifting devices, most of them involving the balancing of a movable structure's dead weight by means of hydraulic pressure, provided in all cases by dead-weight accumulators rather than by mains pressure.

26. Damrell (note 11), pages 470–471; advertisement, page 117.

27. Sanborn Map Co., *Atlas Of Boston* (New York, various years). A large collection of these is in the Geography and Map Division, Library of Congress.

28. M.A. O'Brien, Jr., *A Treatise on the Elevator Industry* (Chicago: publisher unknown, 1915).

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