The Great Bridge Study Guide

The Great Bridge by David McCullough

BOOKRAGS

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Plot Summary

The Great Bridge links politics, engineering and human drama in telling the epic story of the building of the Brooklyn Bridge, from 1869 to 1883.

Realizing each community stands to benefit from a land link between them, Brooklyn and Manhattan politicians obtain from the New York Assembly a charter for a private company to build a bridge. They appoint Henry Murphy, former mayor of Brooklyn, to President of the New York Bridge Company, and the renowned engineer, John A. Roebling of Trenton, NJ, as Chief Engineer. To win support for his plans, Roebling accompanies engineers and politicians on a train tour of his three previous triumphs at Pittsburgh, Cincinnati, and Niagara Falls. They are so impressive and so well illustrate the concepts he will use in Brooklyn, that work finally gets under way. Roebling again takes as his assistant his son, Washington, a graduate of America's premier engineering school. He was also a Civil War veteran, and supervisor of wire spinning on the Cincinnati job. Wash has also spent a year in Europe, studying the latest developments, including the use of pneumatic caissons as underwater footings for suspension bridges.

John A. Roebling dies of a job-related accident, leaving only Wash as a possible successor. He is appointed Chief Engineer, hires a staff, completes specifications and plans, and sets to work on the Brooklyn caisson, at the size of a city block, easily the largest yet attempted. The East River is highly irregular on the Brooklyn side, and many obstacles slow the work. When it is finally complete, the stone tower begins to rise, giving the public a sense of progress and hope.

The New York caisson incorporates features experience suggests will improve performance, but bottom conditions are far better and progress is brisk. Soon the caisson reaches a depth where workers suffer "the bends," a mysterious, debilitating, and occasionally fatal malady. Roebling, who contracts it twice, takes a calculated risk in settling for a sand-and-gravel footing short of bedrock, which doubtless saves lives. The New York tower soon begins rising towards the sky.

Roebling never recovers his health, and as the less challenging task of masonry goes forward, he retreats to Trenton. He continues directing work from his sickbed, largely through his remarkable wife Emily. After the towers and anchorages are built, it is expected John A. Roebling's Sons wire factory will provide materials for the next phases - spinning cables on-site. Politics, however, intervene as Boss Tweed falls in Manhattan and reveals the shady deeds that accompanied the original chartering of the Bridge Company. Reformers join the board, move to amend the charter to make it a public company run by trustees and subject to higher standards of accounting. Brooklyn leaders, however, want to keep profits in their county and finagle the $1 million wire contract going to J. Lloyd Haigh, who bilks $300,000 in illegitimate profits on defective wire delivered to the website. Roebling is targeted not only for conflict of interest but also for physical and mental inability to continue leading the project. Several times the recluse is angered to the point of resigning, but Murphy each time diverts a crisis. Brooklyn Mayor Seth Low narrowly loses a bid to fire Roebling, when he refuses to

resign and become a paid consultant. Emily's calm diplomacy and mastery of the engineering are a major factor in the ultimate success of the project. Fittingly, she drives the first carriage across the span and hosts the President and Governor at a gala reception on opening day, an event remembered by Brooklynites for as long as they live.

The Great Bridge is a triumph of engineering, an inspiring work of architecture perfectly fitted to its environment and task. It becomes part of American folklore. It lives up to all its founders' visions, even as Brooklyn and Manhattan changed radically.

Part 1, Chapter 1

Part 1, Chapter 1 Summary and Analysis

"The Plan" sketches the monumental structure John A. Roebling proposes to build across the East River between Manhattan and Brooklyn, suggests the promises it holds these communities, and hints at the political machinations that will accompany its building. The belief in human progress and technology that marks America around 1870, fills the pages.

In February of 1869, enigmatic John Augustus Roebling, bridge building's acknowledged giant, convinces seven eminent engineers to sanction plans for the crowning work of his career. Roebling wants to end public criticism and rumors and get to work. The consultants include his eldest son, Col. Washington Roebling, Horatio Allen, Col. Julius Adams, and William Jarvis McAlpine, the President of the American Society of Civil Engineers. Also included are Benjamin Henry Latrobe, John J. Serrell, J Dutton Steele, and James Pugh Kirkwood.

Talk about connecting Manhattan and Brooklyn goes back to 1800, and Thomas Pope's untried "Rainbow Bridge." Various engineers recommend solutions for spanning the turbulent tidal strait, one of the busiest stretches of navigable salt water on earth. In April of 1867, the New York Bridge Company is chartered in Albany as a private company to build a bridge by 1879 and operate it thereafter. The cities have no say about location or type. Roebling is named Chief Engineer and presents a master plan. Various names are given to the project, including Empire, New York, East River, Brooklyn, Roebling, and simply, Great Bridge.

The press in both cities takes an intense interest. New Yorkers see it as a valve to alleviate crime and overcrowding, while Brooklynites sees it accelerating growth and prosperity, which are severely limited by the danger, unreliability, and inconvenience of ferry crossings. Brooklyn sees an opportunity to become the biggest city in the world once New York is "full." Given to cosmic visions, Roebling sees the bridge as key to the mission of modern civilization, as important as the Union Pacific Railroad, Atlantic cable, and Suez Canal. The enthusiasm of Brooklyn's poet, Walt Whitman, singing of great achievements by engineers, is matched in Roebling's vision of a great work of art and engineering feat of the age that will bring prosperity to the community.

For years, people question whether Roebling's "advanced engineering" will work, whether the bridge is worth $6-$7 million, whether a tunnel or dam might serve better, whether this is not a wild experiment or exercise in vanity on Roebling's part, and whether this vast public work ought to be opened to no competitive bidding. To end such talk, Roebling explains everything to his consultants, patiently and candidly. The largest suspension bridge in the world must consist of one uninterrupted central span, held aloft by huge cables slung from colossal stone towers and secured to massive onshore anchorages. The distinctive towers, 268 feet high and set close to shore, not only bear

the enormous weight of four cables but also compensate for a lack of palisades to elevate the roadway above river traffic. Below water, the towers are limestone set on wooden foundations. Above the water, they are granite. Each tower is a shaft of solid masonry connected below the roadway by hollow walls and high overhead by Gothic arches, a heavy cornice, and three capstones. Each tower weighs 67,850 tons, and an iron superstructure adds 72,603 tons to each. Four cables, two outer and two inner, are 15 inches in diameter and hang in a catenary curve. The cables join the bridge floor at mid-span, and vertical suspenders link them all along, like harp strings. Across these run a network of diagonal stays, radiating from tower to deck. Roebling manufactures wire rope at his Trenton works like ordinary hemp ropes, twisting fine wires into cables the thickness of a pencil, which are "laid up" parallel by the thousands and wrapped with a skin of soft wire. Controversially, Roebling proposes to use steel, the still untried "metal of the future."

The 80-foot-wide avenue runs 1,600 feet tower-to- tower, and weighs 18,700 tons. It curves gently upward to a height of 130 feet above the water level at center span from a height of 119 feet at the towers. Sailing ships will soon vanish, Roebling predicts, but his bridge will not obstruct navigation in the meantime. Approaches must be long and gradual, so the lion's share of the project involves land construction. They extend the length to 5,862 feet. The route angles southeast from Chatham St., opposite New York's City Hall Park, to the Fulton Ferry slips in Brooklyn, accommodating turns in the river. Numerous streets at both ends are crossed. Roebling proposes railroad tracks run down the center to generate revenue from 40 million passengers a year. Commercial traffic crosses on either side of the trains, while pedestrians use a boardwalk 18 feet above the tracks, enjoying an inspiring view. Tolls and fares will pay for it in less than three years. Building it will take five years.

Allen and McAlpine challenge the length of the central span and tower foundations. Roebling allays fears over a repeat of the Wheeling Bridge collapse, assuring them his bridge is six times stronger than needed, and the incline stays offer a fail-safe even if all four cables snap. Roebling confesses he has never sunk timber caissons into a riverbed, but has worked out the engineering with his son, who has studied the technique in Europe. McAlpine vouches for the concept, which he has used on a smaller scale. Roebling's caissons will cover 17,000 square feet. Test borings on the Brooklyn side suggest they need go down only 50 feet and building it will take a year. On the New York side, he will go down to 110 feet. He explains how he will pack the timber structures with concrete and why the pine timbers will last forever.

Two days later, the public is assured renowned engineers approve Roebling's plan. Congress specifies the bridge must not "obstruct, impair, or injuriously modify" navigation or interfere with traffic to and from the Brooklyn Navy Yard. Gen. A. A. Humphrey appoints a review panel, the so-called "Bridge Party," including the Roeblings, the seven consultants, three Army engineers, and a mylange of businessmen, politicians, and journalists. William C. Kingsley, Brooklyn's leading contractor, driving political force, and largest stockholder, picks up the tab. Two prominent public figures do not make the trip. They are Democratic State Senator Henry Cruse Murphy, author of the charter and President of the New York Bridge Company,

and William Marcy Tweed, the "boss" of New York, who is intentionally excluded. They stop at Pittsburgh, Cincinnati, and Niagara Falls, sites of Roebling's great bridges, and the week on the rails helps everyone get acquainted. John A. Roebling is a mystery to the people who hire him and have dealt day-to-day with his son. He only leaves Trenton when necessary, keeps sessions short, and shuns small talk. People remember his fierce pale-blue eyes, which show dignity, determination, and the expectation of deference. He appears all knowing and unfriendly.

Part 1, Chapter 2

Part 1, Chapter 2 Summary and Analysis

"Man of Iron" introduces the roller coaster life of John A. Roebling up to the Bridge Tour. It hints his latter-day obsession with death proves prophetic. "Old Man Roebling" is quiet Trenton's first citizen. Since arriving in 1849, he has built a wire business from nothing, raised seven children, buried two and a wife, and remarried. At 63, he appears indestructible, thanks, he believes, to a regimen of scalding and freezing baths, vile health drinks, and copious fresh water. He regards illness a moral offense. The town knows him as an inventor, artist, writer, and freethinker. Since being widowed, he is said to host syances. Strong-willed, resourceful, stubborn, and self-assured - traits he tries to instill in his children -Roebling never squanders time and has never been known to take a day off throughout his working life.

Born on June 12, 1806 in M'hlhausen, Germany, to an unassuming tobacconist father and a determined, energetic mother, Roebling studies architecture, bridge construction, and hydraulics at the Berlin Polytechnic Institute. He becomes Hegel's favorite philosophy student, learning to think independently and to rely on the validity of his own conclusions. After three years building roads in Prussia, and after Hegel's death, John Roebling, older brother Karl, and 53 companions set off to become American farmers. John and Karl purchase 7,000 acres in Butler County, PA, to establish a German enclave, and through letters home attract industrious inhabitants to their earthly paradise. Within five years, Saxonburg is a going concern. In May of 1836, John marries Johanna Herting.

Farming quickly bores Roebling and he turns it over to Johanna to return to engineering. He builds dams and locks, surveys a railroad route east of Pittsburgh, and foresees prosperity for the village of Johnstown. There, he sees the iron ropes he is reading about in a German periodical replacing the heavy, expensive, short-lived hawsers used on inclined planes to lift canal boats over the summit. At his own risk and expense, Roebling fashions this new product in Saxonburg. His first 600-foot rope is sabotaged, but second works and Roebling's invention is adopted for inclined planes, dredging, construction, and mining operations. He hires villagers and farmers as needed to meet demand. In 1844, Roebling wins a prize for the best design for carrying the Pennsylvania Canal across the Allegheny River. Completed in nine months for $62,000, the aqueduct pioneers stringing wires in place and anchoring them in masonry, by comparison with later works is crude, small, and uninspiring, but it proves Roebling can build suspension bridges. When Pittsburgh burns to the ground, Roebling gets to build his first one - the first stop on the Bridge Tour. He builds four more suspension aqueducts, publishes his theories, and abandons Saxonburg for Trenton in 1848.

Roebling returns to Pittsburgh world-famous and worth over $1 million. During his most productive period as an engineer, Roebling has grown distant and is rarely home. Charles Swan, a Pittsburgh German, runs his mill. Roebling views slavery as an

affliction on an otherwise ideal land, and sends son Washington off to war. Johanna's death in 1864 devastates Roebling, who is working in Cincinnati and recalls her kindness and unselfishness, which he had failed to appreciate. His interest in the spirit world increases. He's most influenced by Andrew Jackson Davis, who views the abode of the departed as a geometrical hierarchy of life spheres. At a syance, Roebling uses a line of questioning designed to verify his set of beliefs. There is no trivial talk. Had the Great Bridge not become an overriding passion, Roebling might have done nothing but talk with the dead, because he has grown disillusioned with post-war America's surrender to greed, and is troubled his contributions are contributing to the degradation. He talks of washing his hands of Brooklyn, but joins the Bridge Party nevertheless.

Part 1, Chapter 3

Part 1, Chapter 3 Summary and Analysis

"The Genuine Language of America" follows the Bridge Party to Roebling's past projects, and reaches two conclusions. The first is that engineers are the true heroes of the Age of Progress. The second conclusion is that grand projects are worth the political and financial indiscretions and on-the-job fatalities that inevitably accompany them. Much will be said about this in later chapters.

Roebling plays tour guide from sunrise over the Alleghenies, across the Laurel Mountains, to the first world's first suspension bridge, built over Jacobs Creek by James Finley in 1801, in Greensburg, and into Pittsburgh. They settle into Monongahela House, at the end of his 1,500-foot Smithfield Street Bridge, which local papers in 1846 proclaim will overshadow all others. To the anchored cables Roebling pioneers on the aqueduct, this project adds a system of inclined stays, increasing strength and stability. Roebling builds it to prove his skill and the soundness of his techniques, but his showpiece is the Allegheny River Bridge, begun 11 years later. He and son Washington have a splendid time erecting one of the handsomest bridges in America, 1,030 feet long in four spans, supported by four cables hung from six highly ornamental iron towers decorated and braced by latticework and topped by spires. The owners do not bother to insure it and make money on it from the start - points the Bridge Party notes with interest. The cables are "spun" in place, unlike Roebling's earlier endeavors, by a traveling wheel that makes 1,400 trips over the towers shore-to-shore. Roebling proposes this technique for the Great Bridge.

The next stop is Cincinnati, where the "Biggest Bridge in the World" opened Dec. 1, 1866. It is a long, graceful arc, close in every aspect to the Great Bridge, but smaller. Roebling points out how the diagonal stays joining floor and towers form the hypotenuse of right triangles, which impart tremendous stability to the horizontal surface. Roebling first plans a Cincinnati bridge in 1846, but gets no farther than footings before steamboat interests and a terrible winter interrupt work. It is still in preliminary stages, when the New York *Tribune* publishes Roebling's first thoughts on the East River. The Panic of 1857 makes Roebling close the Cincinnati project with the towers half-finished, and a Confederate attack across a temporary pontoon bridge shows the strategic value of a bridge in wartime. Roebling resumes work to show his faith in the future political integrity of the nation. When Washington is discharged, he summons him to take charge of cable spinning as Assistant Engineer. The Cincinnati Bridge takes ten years and costs double the estimate, but no one complains, because it is a structural and architectural triumph.

The Bridge Party stops next in Niagara Falls, where Roebling's masterpiece spans the great gorge. Built before Cincinnati or Allegheny, the two-level International Suspension Bridge is saved for last because of its grandeur. At 825 feet, it is not exceptionally long, and its towers are half the height of Cincinnati's. The sad dangling remnants of an

earlier bridge, built downstream at Lewiston, NY, in 1851, by Edward Serrell, show the dangers of poor engineering. A second bridge, recently completed by Samuel Keefer, is already a tourist attraction. Roebling's bridge is shorter and unimpressive, until one looks down into the savage rapids and whirlpool and realizes what building it requires. Four plain 60-foot tours support four 10-inch cables with suspenders and stays, and two stacked a timber truss floors. It is perfect for its location.

Before 1855, suspension bridges have a bad reputation, particularly in Europe, and only one engineers of note besides Roebling, Charles Ellet, Jr., believes in them. The basic idea has been around in crude form for ages, but by the 19th century, they gain stiff level floors and are held to be as stable as any bridge type, and are no longer limited to foot traffic. The Scottish engineer, Thomas Telford, spans the 600-foot-wide Menai Strait of Wales in 1825, producing the prototype for everyone else. Swiss, Germans, and French build them, but when Roebling proposes a railroad bridge across Niagara Gorge in 1845, most experts declare it impossible. Serrell, Roebling and Keefer all build bridges, but flamboyant, impetuous Ellet succeeds first.

Born in 1810, Ellet grows up in Pennsylvania and is the first American to attend the elite Ycole Polytechnique in Paris. He proposes to Congress a 1,000-foot suspension bridge over the Potomac and another over the Mississippi at St. Louis. He actually builds one over the Schuylkill near Philadelphia in 1842. His greatest work, crossing the Ohio River at Wheeling, WV, is, at 1,020 feet, the world's first truly long suspension bridge. The showman in Ellet comes out, when he offers $5 to the first boy who can fly a kite to the Canadian side. He then ties to its string successively heavier cords, ropes, wires and cables. Ellet hangs an iron basket on the cable and pulls himself across the gorge and back to prove its safety, drawing great crowds on both sides. Weeks later, he drives a horse carriage across the first crude plank catwalk, and establishes his legend for bravado. He opens the catwalk to the public in the summer of 1848 and tolls bring in $5,000 by year's end. When his clients refuse to share the revenues, Ellet draws up cannons at both ends to claim the bridge. Eventually, he walks away and never returns.

Two years later, Roebling starts his bridge at the same spot, sans drama. He works carefully and steadily for four years, demonstrating a thesis many have stated -the stiffer and heavier the roadbed, the more stable the bridge - which some experts still debate. Roebling crosses the gorge with what amounts to an enormous "hollow straight beam." When Ellet's Ohio River Bridge twists apart in May of 1854, Roebling explains to the press that it had not been trussed strongly enough. Ellet rebuilds it using Roebling's inclined stays and it stands, but fear of suspension bridges is reinforced. Shortly after Roebling finishes his cables at Niagara and begins the deck structure, it survives a tremendous gale. When completed in March of 1855, it bears a 28-ton locomotive pushing 20 double-loaded cars without vibration, and plush passenger trains soon begin hourly crossings problem-free.

Bridges provide magnificent proof of man's capacity to master the forces of nature, the theme of the Age of Progress, shown in the Suez Canal and other massive projects. Stock fraud, political jobbery, kickbacks, and intense human suffering seem to

accompany them, but the price seems justifiable. Man the killer gives way to man the builder, and engineers are society's heroes.

Part 1, Chapter 4

Part 1, Chapter 4 Summary and Analysis

"Father and Son" portrays the transition of power from John to Washington Roebling. Long planned by the old man, it occurs in a dramatic and tragic manner, leaving questions whether Washington will be up to dealing with the greedy politicians that back the Great Bridge.

The amiable Bridge Party ends Apr. 20, 1869, and preparation for building picks up. John Roebling hires Col. William Paine, who is self-taught in engineering and the Union Army's leading topographical engineer. With "Wash" Roebling, Paine marks the route steadily inland from the river, noting how traffic will have to be routed and what buildings will have to come down. John leaves Trenton rarely, but is kept posted by Wash, who feels at liberty to speak for his father on nearly everything.

On June 12, John Roebling meets his consultants a last time and Wash prints 500 copies of their formal approval. Congressman Henry Slocum uses contacts with fellow Civil War greats to benefit the project. Secretary of War John A. Rawlings gives carte blanche and clears the way with Army Engineers Chief Humphreys, who specifies a seemingly small change of increasing the height of center span by five feet. This requires strengthening the superstructure and extending the length. It also adds $300,000 to the cost. They decide to widen the bridge floor by five feet to allow double roadways for vehicles. The newspapers carry the final report and announce work can commence. Demas Barnes, the strongest voice in Congress for the bridge, lectures ardently at the Brooklyn Athenaeum about what this monument to progress will mean for the city.

The day of that speech, June 28, 1869, the Roeblings are finalizing the location of the Brooklyn tower, when an inbound ferry crushes John's right foot. He continues shouting directions, until he topples over in pain. He is rushed to a doctor who amputates the toes, at Roebling's insistence, without anesthesia. Tetanus develops and Roebling suffers intensely for eight days from restlessness and savage headaches. His facial muscles grow rigid, creating a terrible grimace and preventing him from eating or talking. When convulsions begin, alternating with coma, the deathwatch begins. On July 21, Roebling surprisingly rallies and scribbles notes and sketches. Shortly after 3 AM, however, he is dead. The *Eagle* calls Roebling a martyr, whose blood has baptized the Brooklyn Bridge and assured its success.

Trenton cannot accept the news, until the body arrives. Eulogies begin at a special town meeting and crowds form outside the tall iron fence surrounding the comfortable 27-room home the deceased designed. Wash is now head of the family, married to Emily, her father-in-law's favorite. Ferdinand, 27, had been kept out of the war to help with the wire business. Charles, 20, silent and thoughtful, is a student at the Rensselaer Polytechnic Institute (RPI) in Troy, NY. Edmund (Eddie), 15, is shy and uncertain-

looking. Laura has married a "good German," Mr. Methfessel of Staten Island. They have eight children and depend on checks from the late John Roebling. Josephine is the wife of pianist Charles H. Jarvis. Playful, high-spirited Elvira has been Mrs. John Stewart for only a few weeks. Her expensive wedding took place in the parlor now occupied by Roebling's casket. The widow is the former Lucia Cooper of Trenton. She wed John in February of 1867, but is still not fully accepted by the family, and never will be. Also present is dependable Charles Swan, whom John Roebling includes in his will and wants brought into the business as a full partner. Roebling leaves $20,000 to Swan, $80,000 to distant relatives and charities, and splits the bulk of his estate among his wife and children, docking each for whatever expenditures they have received. The sons inherit the wire business.

The house opens to the public at 11 AM sharp and closes again at 1 PM, when a large delegation of prominent Brooklynites and New Yorkers arrive. Services begin at 2 PM, in stifling heat, with four ministers preaching. Some 1,500 people join the procession to Mercer Cemetery for the 4 PM burial. The notables go home, presumably discussing what to do now about the Great Bridge. John Roebling has long told Henry Murphy his son will take charge, and Thomas Kinsella editorializes in the *Eagle* that no one could be better equipped.

Years later, Wash gives three justifications for taking charge. First, he has more practical experience building cables than anyone alive. Next, he has studied caissons in Europe for a year. Lastly, he has helped prepare the designs and knows his father's ideas. Wash will, however, have no backup should something happen to him. The public has less confidence in him than the father, who had needed experts to testify to his judgment. Many ask if Wash will understand the role money plays in getting things done in Brooklyn. John Roebling had never concentrated on making money but had understood human nature. In the *Eagle*, Kinsella exalts Roebling above the politicians, who work "tricks and dodges," but the Great Bridge will now depend largely on them.

Part 1, Chapter 5

Part 1, Chapter 5 Summary and Analysis

"Brooklyn" describes America's third-largest city whose life the Great Bridge will transform, and barely hints at the corruption that will be involved in putting it in place. In the summer of 1869, Brooklyn is a fiercely proud and independent metropolis on the western tip of Long Island, where life has changed little since its founding by Dutch farmers in the early 17th century. However, now its population has increased a hundredfold in less than a lifetime to 400,000 people. That is half the number of New Yorkers, who regard Brooklyn as a backwater hinterland. In fact, Brooklyn is the third-largest city in America, a major manufacturing center, a seaport larger than New York, and growing faster than New York. Brooklyn covers 25,000 square miles.

Lead by foulmouthed, hard-drinking Mayor Martin Kalbfleisch, Democrats control Kings County. Fulton St. slopes from City Hall to the river, where the *Eagle* and the Republican paper, the *Union,* have offices. Banks, insurance offices, and up-to-date stores line the street. The Fulton Ferry is the sole "Gateway to Brooklyn" in 1869. Thirteen boats cross day and night, carrying masses of workers and business. Upstream are more ferries, the Navy Yard, sugar refineries, and the famous shipyards. The East River is considered the best part of the harbor of New York, deeper than the Hudson River and less troubled by bad weather. Downstream run the Heights, eight miles of piers, dry docks, grain elevators, and warehouses. From its high points, Brooklyn offers magnificent panoramas of land and ocean. The ages of sail and steam travel overlap, so the harbor is a ceaseless pageant of schooners, packets, yachts, and steamers.

Brooklyn is touted as a healthful place in all seasons and all respects. The Heights, left over by the glaciers, provide some of the stateliest houses in America for gentlemen obliged to work in Manhattan. The Heights are the social, cultural and moral center of Brooklyn life. Wealthy, charitable families live there, but summer elsewhere. Many New Yorkers of comparable station may move here once the bridge is complete. Cultural centers and events abound. Brooklyn is America's "City of Churches," with Plymouth Church foremost, because it is the pulpit of Henry Ward Beecher, "the Hercules of American Protestantism," famed and adored for his oratory and showmanship. His printed thoughts on every conceivable topic are in the papers almost daily. His intelligent, well-to-do parishioners enjoy the worldly comforts they have earned. Gas rates, taxes and schools are better than in New York, and the local government is less dishonest. The streets are lighted, there is little crime, and the drinking water is delicious. Jobs are plentiful and two-thirds of Brooklynites do not commute to New York, considered for all its enticements a cold, monstrous, overcrowded, overpriced, bewildering and unwholesome place. Brooklyn's restaurants and shops are second-rate, and the "flats" are as foul as any tenements across the river. Brooklyn is generally optimistic about what the Great Bridge will bring.

A plaque in Owl's Head Park commemorates the place where supposedly the bridge scheme is hatched in the winter of 1866-67. Ice closes ferry service, the papers tout Roebling's triumph in Cincinnati, and Brooklynites demand a bridge. On Dec. 21, 1866, young William Kingsley and Judge Alexander McCue call on Henry Murphy to change his mind about a bridge. Kingsley has been discussing the engineering with Julius Adams, and has facts and figures to answer all objections. Murphy is converted and shows unwavering devotion to the bridge thereafter. Kingsley undoubtedly has the greatest stake in the project after Wash Roebling. Kingsley and Murphy are the two most powerful, influential Democrats in Brooklyn.

Kingsley is 34 in 1867, hard, resourceful, ambitious, and worth close to $1 million. He has lived in Brooklyn ten years after a hard life in the Midwest. He has paved streets, installed sewers, built a reservoir, much of the parks, and branched out into construction-related businesses and real estate. Hugh McLaughlin, "Boss" of Brooklyn, takes an immediate liking to Kingsley, and while Murphy is out of the country gives Kingsley paving and later water contracts. Kingsley proves himself an effective money raiser and natural politician with no yearning for public office. He prefers to work behind the scenes.

By contrast, Murphy is Old Brooklyn, gracious, learned, cautious, subtle, earnest, and incorrupt. After Columbia Law School, he quickly makes a name for himself, writing, and forming a partnership with John A. Lott and John Vanderbilt, which attracts wealthy, conservative property holders - and runs the Democratic Party. In 1841, Murphy founds the *Eagle* and next year is elected mayor. He goes on to serve two terms in Congress and six in the State Senate. He fails in three runs for the U.S. Senate and once for Governor through the opposition of William Tweed. In 1852, Murphy loses the Democratic nomination for President by one vote, and admirers insist he would have been better than Franklin Pierce. Five years later President Buchanan names Murphy Minister to The Hague, and in his absence, McLaughlin takes control of Brooklyn, just as Tweed consolidates New York. Murphy returns in 1861, and takes an interest in various local ventures. He still has immense influence in Albany, which is a great asset for Brooklyn.

Kingsley and Murphy complement one another superbly. Murphy drafts the charter, enlists friends, and talks up the project at every opportunity. The *Eagle* supports him fully. His bill is submitted Jan. 25, 1867, and passes Apr. 16. The private New York Bridge Company is authorized to buy real estate and fix tolls. Capital stock is fixed at $5 million, with Brooklyn and New York authorized to subscribe as heavily as their councils allow at $500 per share. The President is elected annually. No one at this stage regards Murphy's charter as a license to steal. Kingsley lines up private money and convinces Julius Adams he will be Chief Engineer to get him to produce a cost estimate so low Roebling will have to trim his price. Adams comes in at $2 million, and Kingsley and Murphy use this to arrive at their $5 million stock figure.

In May of 1867, the Bridge Company elects Murphy President and appoints Roebling Chief Engineer with full design authority, even though he has no plan. In October, the Committee on Plans and Surveys, formed by the Board of Directors, recommends work

begin immediately, but nothing happens for a year, because New York City cannot decide what kind of bridge it wants. This ends with Roebling's death and the emergence of William Tweed.

Part 1, Chapter 6

Part 1, Chapter 6 Summary and Analysis

"The Proper Person to See" is how Murphy describes his crooked colleague, Boss William Tweed, whose story this chapter tells and begins revealing illegalities earlier suggested. New York is the country's financial capital, and the home of mighty newspapers, fashion, and high society. Every piece of real estate has been built up and traffic and noise are terrible. Self-interest and the almighty dollar reign on Broadway and Wall St. Contrasts are sharp and appalling, with some streets worse kept than anywhere on earth. Thousands of homeless children roam loose among beggars, drifters, thieves, and prostitutes. New York attracts the young, talented, ambitious, lucky, and unscrupulous. Since the war, it has been *the* place to scheme, promote, invent, pitch, and steal, and major figures like Mark Twain, Andrew Carnegie, and Thomas Edison have abandoned the west for opportunity in the east.

Tweed is born near City Hall in a respectable neighborhood, proves good at mathematics, and begins work as a bookkeeper, before going on to serve as a volunteer fireman before, in 1851, discovering politics and joining the "Forty Thieves," as New York's aldermen are called. By 1869, Tweed is near his zenith, the Grand Sachem of Tammany Hall. He is one of New York's principal landowners, on speaking terms with the rich and powerful, advertises generously, employs thousands, and controls judges, legislators, Mayor A. Oakey Hall, and Gov. John T. Hoffman. In 1869, however, *Harper's Weekly* cartoonist Thomas Nast begins a brave, brilliant attack, depicting Tweed as corruption incarnate. Constituents cannot read but understand the deft caricatures. They do not want to believe there is an evil side to this father of eight, tall, obese, genial, buoyant, non-smoking, moderately drinking, generous man who loves to dance, is never arrogant and always loyal to his friends. In truth, Tweed has at least two mistresses and a genius for organizing and making politics pay, and personally bilks $30 million from taxpayers before being deposed, while his cohorts take in $75-$200 million.

On Sep. 17, 1869, Tweed takes the Fulton Ferry to the first meeting of the Bridge Company's six-man Executive Committee, of which he is a member. It is charged with making all arrangements and controlling all business appointments, acquisitions, supplies, auditing and finances. Tweed's interest in the bridge is not new, but his name first emerges after Roebling's funeral, when death and resignation create vacancies for Tweed, his dear friend, Republican Police Commissioner Hugh Smith, and Peter ("Brains") Sweeny, a sneak thief. Tweed wants Horatio Allen named consulting engineer, gets his way, and goes home. Having unimpeachable Allen as Roebling's backup removes a potential flaw in Tweed's plan. Tweed's first entry into the Brooklyn scene brings no stir, because it is done in broad daylight and good faith. He will serve vocally for two years, despite Murphy's contention he plays no role.

Tweed and Murphy both serve in the State Senate, opposite sides of the same political coin, and detest one another. Tweed later recalls reminding Murphy he cannot make New York make good on his pledge it will buy $1.5 million of bridge stock (half the size of Brooklyn's subscription, leaving $500,000 open to private purchasers), Murphy asking Tweed to convince aldermen to lend their support to the bridge. Tweed suggests $55,00-$65,000 will help and, receiving it, gets the bonds passed by Thomas Coman, a Tammany hack. Kingsley apparently carries the carpetbag full of money from Brooklyn. By this point in his career, Tweed is a visionary, looking to control the bridge project. Stock is not selling well in Brooklyn, so Tweed offers to invest, along with Smith and Sweeny. An earlier Tweed construction project, the County Courthouse, is put out to bid at $250,000, and earns his people over $13 million by the time it is finished in 1871.

The act authorizing the New York Bridge Company stipulates no ceiling or even a rough estimate, so Tweed can count on at least $6-$7 million in unexpected developments. Kingsley, General Superintendent of construction work, has a say in all contracts, and receives a percentage of money spent on materials. Tweed claims Kingsley agrees to pay the balance after he, Smith, and Sweeny pay 20% in installments. Together they take 1,260 shares at $100 per share, split equally at 420 shares/$42,000 per man, for which each puts out just $8,400. As finally worked out, Kingsley & Keeney take 1,600 shares while Murphy is in for only 100. Tweed details this under oath Sep. 18, 1877, eight years after the fact, sick, deserted, jailed, and wanting to clear his conscience. His data shows only nine of the 38 directors invest in the project, and Tweed, Smith and Sweeny are the only New Yorkers. Murphy and Kingsley deny Tweed's claims, but Murphy admits hearing about a pay-off. If straight-as-string Murphy cooperates with Tweed, it is, because there is no other choice. Perhaps, Murphy figures the Tweed Ring will not last to see the bridge finished, and Tweed will not collect his due. Perhaps, he figures Brooklyn is getting off cheap compared to what Tweed could demand in Albany.

At the same time comes proof the Boss cannot be bypassed on a project as visible as the Great Bridge. The editor/publisher of *Scientific American,* Alfred Ely Beach, proposes New York's first subway, while Tweed promotes a grand, lucrative elevated railroad. Beach gets permission for a pneumatic prototype past Tweed in an innocuous bill and secretively digs a one-block tube, fitting it with cars and station so elaborate the public will embrace it, despite Tweed's wrath, but Tweed has Beach's charter vetoed, leaving Beach with nothing to show for his $350,000.

The fall of 1869, when work starts on the bridge, is an unsettling time. A mine fire in Avondale, PA, kills hundreds, and the company is held culpable. Stock gamblers Jay Gould and Jim Fisk, companions of Tweed, set off "Black Friday," Sep. 22, ruining brokers, requiring the calling up o the National Guard, and a government infusion of $4 million in gold to prop up investors' confidence. President Grant is said to be involved but proves only Gould's dupe. In October, a charlatan creates the "Cardiff Giant," a hoax that so alienates voters from government, that they turn out the Republicans for the first time in 20 years. Tweed, too, is on his way out, as American workers concentrate on the great projects of the Age of Progress.

Part 1, Chapter 7

Part 1, Chapter 7 Summary and Analysis

"The Chief Engineer" concludes Part 1 by portraying Washington Roebling, whose fate is to carry out his father's half-developed plans. McCullough shows how father and son differ and why Wash is as prepared to lead the project as anyone in America. Between being named Chief Engineer in August of 1869 and launching his custom-designed caissons in March of 1870, Wash works behind the scenes, specifying supplies, equipment, and machinery, making personal inspections, and interviewing job applicants. The awarding of contracts is put in the hands of the experienced General Superintendent, Kingsley.

Roebling's youthful staff of six (average age, 31) includes Paine and two Kingsley men, Sam Probasco and C. C. Martin, and three men of Roebling's choosing. Martin, an RPI graduate and veteran of three Kingsley-planned reservoirs, concentrates on supplies and hiring and is Roebling's *de facto* second-in-command. Francis Collingwood, Jr., another RPI friend, as yet inexperienced, helps Paine plan the caisson. George McNulty, barely 20, a University of Virginia graduate, has done only a little surveying but impresses Washington with an offer to serve gratis. He is assigned (with pay) to assist Martin. Finally, Wilhelm Hildenbrand, an exceptional draftsman recently arrived from Germany, who has done some finished sketches for John Roebling and designed a great arched roof at Grand Central Depot, is sent to Maine to supervise cutting granite for the towers. He proves to be a most valuable worker. At the start of the project, only the Chief Engineer has any experience with suspension bridges, and even he has no exposure to some of the problems this bridge presents. Roebling has the final say on every important decision and, aided by Horatio Allen, deal with the directors, the powerful Executive committee, and public officials in both cities. Roebling wastes much time responding to criticism from overnight "experts" the press deigns to cover.

Roebling must request from the Executive Committee permission to depart from the original plan in any way and must keep it abreast of every step taken. He writes thoroughly and candidly in non-technical language, knowing his reports will become public documents. Father leaves him only a general plan and Wash has been in full charge of only two military bridges. He has done nothing to earn the confidence of subordinates or others connected with the project. Wash senses he will be measured by what father *might* have done, be forever compared with him, and held accountable for anything he had promised. If successful, it will be John A. Roebling's bridge, while any failures will be uniquely Wash's.

John Roebling had been a European intellectual, perfectionist, and aristocrat. He was a proper, vile-tempered genius. On the other hand, Washington August Roebling is even mannered, informal, kindly, possibly lazy (by John's standards), patient, and calm like his mother. He was bright, but no genius. The biggest difference is that he lacks John's creative vision. Wash is a classicist, a linguist and musician. He's articulate and open-

minded, but lacks John's commanding presence. Professionally, Wash is good at mathematics and drafting, is thorough about details, a perfectionist, and courageous. His lack of vanity reduces his chances of attaining John's fame. Wash is unassuming, unimpressive, but confident he can do the job at hand. He exhibits "Dutch" stubbornness and accepts little advice. He believes in heredity - but not in any credit derived from it. He has grown up an American in rural privation and has experienced war. Above all, he has grown up with John A. Roebling as his father.

Wash is named after a surveyor with whom his father works, not for George Washington as is commonly believed. Born May 26, 1837, in Saxonburg, Wash grows up in farm country, enjoying plays, parties, and dances. He plays the flute and clavier. Neighbors inspire him with stories of Waterloo, Valley Forge, and Indian raids. Wash is twelve, when he moves to Trenton. With brother Ferdinand, he attends Trenton Academy. He enjoys the violin, astronomy and mineralogy, before settling on an engineering career. At 17, Wash is sent to RPI, America's first school of "theoretical and practical science," whose curriculum demands the memorization of unusable knowledge. Many students suffer break downs. One young man, whose love Wash cannot reciprocate, kills himself. Wash's thesis is entitled "Design for a Suspension Aqueduct."

After graduating in 1857, Wash runs the mill before going to work on the Allegheny River Bridge. He spends two years in Pittsburgh and develops an attachment to the city. He returns to the wire mill briefly before being ordered by John to enlist as a private in the New Jersey State Militia. Transferring to New York, he is promoted to sergeant and assigned to artillery. Elected lieutenant, Wash puts up his first bridge at Fredericksburg, a span longer than at Niagara, accomplished without proper tools by contraband Black workers who he trains on the fly. After almost dying at Antietam, Wash puts up a suspension bridge at Harpers Ferry. It's his last before Brooklyn. Assigned to Gen. G. K. Warren's staff in 1863, Wash makes daily reconnaissance flights by balloon and goes to Trenton for the best maps available on Maryland and southern Pennsylvania. Gen. Warren describes him as brave at Little Round Top, the turning point in the war, helping engineer a tunnel under enemy lines. As the fight drags on, Wash grows despondent over the senseless loss of life and has sympathy for the Southerners' gallantry.

Wash meets Emily Warren, the general's sister, at an officers' ball Feb. 22, 1864, and falls in love at first sight. They correspond and meet several times. John Roebling hears from daughter Elvira rumors Wash plans to marry, and writes from Cincinnati with rare affection and confidence in his son's judgment. He cautions a "matrimonial union without love is no better than suicide," assumes Emily is worthy of Wash, and assures him they are welcome in Trenton. He wants Wash back in the family business. Bored in camp, Wash worries about his ailing mother and forgetting everything he has known about engineering. He considers not following in his father's footsteps. When Johanna dies in November of 1864, Wash hurries to Trenton for the funeral, is promoted for gallantry to lieutenant colonel, and discharged.

Wash and Emily marry in January of 1865, settle in Trenton, but soon relocate to Cincinnati for two years. John then sends them to Europe so Wash can study pneumatic caissons. Emily is pregnant, when they sail, and the baby is born in Germany. Wash

explains in letters to his father, why he is unimpressed by Telford or Brunel's bridges and the Paris Exposition. They visit Manchester, Birmingham, Sheffield and Newcastle. In Essen, the notoriously secretive Krupp Works welcomes Wash, management knowing about the East River project. Wash fills notebooks and letters with observations and sketches on bridge builders, wire manufacturers and iron works. He appears to pay only casual attention while touring, but records everything in great detail afterwards, apparently with no special effort. By the time they return in March of 1868, Wash knows more than any American engineer about pneumatic caissons, upon which the success of John's vision depends. When word comes from Brooklyn that the bridge is set to go, Wash and Emily move to a house on Hicks St.

After John Roebling's death, Wash settles his estate and looks after the wire business. Ferdinand and Charles will head it eventually, but the big decisions are now Wash's. The family fights over John's request that Charles Swan be made a partner. Wash sends troubled Eddie to Emily, while he travels widely, examining dredging gear and quarries. In mid-August, Wash hands Collingwood, Paine and Hildenbrand rough drawings for the caissons with orders to finalize them. On Oct. 25, 1869, Webb & Bell shipbuilders are contracted to build the massive structure.

Part 2, Chapter 8

Part 2, Chapter 8 Summary and Analysis

"All According to Plan" examines the building, launching, and placement of the Brooklyn caisson, the foundations for the tower. The spirit of the Age of Progress is discussed in terms of competition with a rival bridge builder in St. Louis and suggests the human suffering inevitably attends grand projects. Still, this first phase in constructions goes smoothly for Washington Roebling and his team.

Caissons are gigantic boxes filled with compressed air, sunk to the bottom of a river, and anchored by stone. They serve as diving bells for construction crews to dig out the riverbed, until a firm footing is reached. The working space is then filled with concrete and a foundation for building. It has been used in Europe for a generation. Air locks, invented in 1831 by Lord Thomas Cochrane, allow the transfer of workers without loss of pressure. The Brooklyn caisson is the biggest yet attempted, and the New York caisson will go deeper than anyone has tried. The Brooklyn caisson measures 168 X 102 X 14.5 feet, offers 9.5 feet of headroom, and is topped by five-foot thick solid timers. The sides' thickness tapers from nine feet at the top to eight inches on the bottom cutting edge. A "shoe" of iron boilerplate and three feet of sheathing inside and out protect the oak. Bolts, irons, and straps hold it together. Seams are caulked with oakum to make the box airtight and sheets of tin, pine sheathing, hot pitch, and varnish offer additional protection. Once the caisson is launched, ten more courses of timbers will be added to the roof to produce a solid timber platform 15 feet thick to carry and distribute the tower load.

Two air locks, two supply shafts, and two water shafts are built into the ungainly structure. The cylindrical air locks, 7 feet high and 5.6 feet in diameter, are made of ?-in. boilerplate. Half a dozen men can enter at a time between iron hatches top and bottom that are both closed to allow air pressure to equalize with minimal loss. The water shafts are 7-foot squares of boilerplate open top and bottom and extending two feet below the caisson's bottom edge. They "lock in" the compressed air below, like huge barometers. Clamshell dredge buckets are lowered through them to remove materials workers shovel out. It is a neat, efficient system, provided the water stays at the proper level. Otherwise, flooding of the workroom or "blowouts" from below could result. The supply shafts come into play after excavation, to fill the caisson with concrete. John Roebling intends an open workspace, but Wash gives the massive structure additional support during launching and before it is permanently "righted down" under hundreds of tons of stone by subdividing it into six 28 X 102-foot chambers. Seven launch ways are required for the 6-million pound structure. There is a danger during launching of one end may sliding faster than the other and the whole thing getting wedged in, or that it will not attain enough speed to sink properly. Protecting against sea worms causes the greatest anxiety. Bystanders come to Noble St. daily to watch. Reporters, Tweed's people, and engineers (including Eads) visit regularly. Webb & Bell demands payment in advance of $100,274.51.

Once the caisson is in the water, it is towed downriver, the waterfront where it will dock is cleared, and the riverbed dredged. This begins Jan. 3, 1870, and goes smoothly during an abnormally mild winter. An enormous steam crane, "The Ox," pulls out the old piles, found to be uniformly infested with sea worms from the low-water mark to the mud line - 16-in. diameters shrinking to 3-in., proving the caisson must buried entirely but also that it will be safe once buried. A large basin is dredged, open to the river but bounded on three sides by new pilings. The dredges slow, when they hit hardpan and boulders, and nighttime blasting begins. This costs six times more than normal dredging, but reveals useful things about the strata.

James Buchanan Eads, a difficult genius, runs a lucrative underwater salvage business on the Mississippi before the Civil War, and organizes the building of early ironclad gunboats. This experience, self-confidence, and a reputation for getting things done, outweighs a want of formal training or experience with bridge building, when he proposes one at St. Louis. Ellet and John Roebling also prepare plans for a suspension bridge there in the 1850s, but are turned down. St. Louis needs a bridge that can carry railway and highway traffic without interfering with steamboat traffic. Eads proposes a series of three steel arches set on stone pillars, rather than the usual iron trestle construction. The center span will set a new record by several hundred feet. Temporary support for the arches, as they grow towards one another, comes from overhead cables attached to temporary wooden towers, rather than by "falsework" below. Everything about Eads' proposal is unorthodox and untried.

Approached about providing financing, bridge enthusiast Andrew Carnegie sends J. H. Linville to review the plans. The President/Chief Engineer of the Keystone Bridge Company (wrongly) finds Eads' proposal "entirely unsafe and impracticable." The project nevertheless goes forward in the summer of 1867, requiring $10 million and seven years. Roebling follows progress in St. Louis, particularly sinking the caissons, which Eads is convinced to use during a trip to Europe. With his caisson in the water, Eads is ahead of Roebling, when he visits Brooklyn. Roebling, however, has studied caissons more carefully and talked with engineers in French and German. Roebling's caissons will be three times the size of Eads', which are bigger than any in Europe. Eads' progress is encouraging until 40 feet, when 10% of the workers first show symptoms of caisson disease, or "the bends." As depth increases, the symptoms and numbers worsen, men adopt ointments and zinc/silver bands as charmed protective armor. Eads shortens shifts to four hours and then three. The first hospitalization is needed at 70 feet, where air pressure is more than double normal atmospheric pressure. Doctors find no explanation. The first death occurs on Mar. 19, 1870, the day the Brooklyn caisson is launched.

About 3,000 watch the Brooklyn launching, many expecting it to fail. Politicians orate. The caisson deck is strewed with tackle and strange machinery. A temporary airtight compartment has been built into the forward wall to buoy it as it hits the water. The last block is split out and the caisson moves straight and evenly, with no need for nudging by wooden rams. The caisson floats, without wetting the deck. The work chambers are tested for airtightness and then pumped out and the caisson settles at 17 inches above water level, precisely where Roebling has calculated. Dredging is behind schedule,

however, so Roebling and Horatio Allen visit St. Louis to see how Eads is doing. They get a briefing and descend into the caisson. Eads is courteous and helpful, and Roebling returns confident he is on the right track. Tragically, neither man knows about contemporary bends research, including a fast, sure remedy. Intense competition and little communication among engineers is the rule, minding one's own business is a rule of business, and trade secrets are jealously guarded. The only exceptions occur when sharing knowledge benefits the sharer financially. Eads is proud and guarded, and convinced his bridge is the engineering event of the century - as Roebling believes his own is. Eads views Roebling as a nuisance or a threat and will not stand in anyone's shadow.

The Brooklyn caisson is inflated, towed to the Fulton Ferry slip, positioned inside the new basin, and over the next several weeks, additional courses are built on its roof. Roebling reports on the progress 40 men are making under Charles Young's direction leveling the bottom and removing boulders. It is unpleasant work, requiring skill and perseverance. Work is possible only at low tide, when the chambers are free of water. As the center of gravity rises, the caisson no longer rides evenly and terrifying blowouts shoot columns of water 60 feet into the air. It is determined the blowouts have no serious consequences. There is no ceremony, when the cornerstone is laid. Work goes slowly, until the caisson is righted down and permanent derricks can be mounted.

Part 2, Chapter 9

Part 2, Chapter 9 Summary and Analysis

"Down in the Caisson" looks below-water as the Brooklyn caisson is dug into the bottom of the East River. Roebling and his assistants learn what looks good on paper is hard in reality and consider starting over somewhere else and in some other way, but the public gets no hint of trouble. Thousands of commuters every day see activity that resembles other massive projects, and are fascinated by the terrifying nether world worked by super humans or fools. Master Mechanic E. F. Farrington provides a description replete with allusions to Revelation, Sisyphus rolling his stone, and Dante's *Inferno*. Passing through the air lock is unnerving for novices and makes the head feel like it will explode. People want to flee back into the open air as soon as possible. The six work chambers are covered with muck water. Limelights are chosen as a safer light source than candles or kerosene. The air is heavy, dank, and hot, and visitors are amazed anyone can work in such a place.

Bottom materials differ, making it impossible to lower the caisson uniformly. Roebling keeps careful track of the kinds of rock uncovered. The caisson's growing weight overhead is supposed to drive the cutting edge steadily into the bottom, but it cannot do so, until boulders are cleared by hand. The caisson's full bearing surface is 1,050 linear feet, and every inch must be probed by each shift and the previous shift debriefed. The frames bear greater weight than expected. A simple solution fails and they settle on wedging wooden blocks beneath each partition and knocking them out frame-by-frame once obstructions have been cleared. The caisson then settles naturally at 3-4 inches per 24 hours. Boulders increase as they descend, work slows. Roebling warns it will take two years to sink the caisson. Boulders confined to individual work chambers can be broken into manageable pieces in comparative comfort, but those extending under the shoe or spanning frames are each major undertakings, holding up progress for 3-4 days each. The clamshell buckets that under normal conditions dredge over 1,000 yards a day break down and get caught under the bottom edges of the water shafts. They cannot bite into the material as designed and workers must "stir the pool" and feed the buckets. When the trouble occurs in the water-shaft pools, work stops for 1-2 days while it is capped off, the water is drained, and the bottom deepened by hand by 6-8 feet. Rarely are both shafts in operation. When delays stop the caisson's settling, earth compacts around it, and resuming movement is erratic, unpredictable, and uncontrollable.

Blowouts continue by changes in the tide and the wake of passing steamers. At ten feet below the river bottom, water ceases to flow in, as the outer sides seal tight. Experience shows adjusting the air pressure in the work chamber can help the caissons settle better. At the 20-foot mark, or halfway to the planned depth, boulders become so frequent, that Roebling must accept the risk of blasting. His greatest fear is the effect this might have on the water shafts, which must be closely balanced. A blowout could cause the caisson to implode. Roebling experiments, firing a revolver with successively

heavier charges, and then trying blasting powder, gradually building up to the magnitude needed for real work. The work moves forward as never before, 20 blasts being fired in a single watch. Nasty taprock breaks up nicely, and the caisson descends at 12-18 inches a week, instead of six. The shoe has been by this point been completely deformed, so boulders lodged beneath it are drilled through and blown bodily into the caisson.

Onlookers cannot understand what is going on beneath the waves and consider the workers a mythical breed apart. As the caisson sinks, the workers begin feeling discomforts. Eight-hour shifts run around the clock (except Sundays) and men remain in the caisson the full time. The day shifts are composed of 112 men each, while the night shift consists of 40 select workers. The full caisson work force is 264 men. On the surface, about 100 men in two shifts handle dredging gear, compressors, mechanical systems, lighting, carpentry and masonry. Amenities are customary and include sheds and washtubs. In the caisson, dry spots to eat are few, and the pools are an open toilet, until Roebling installs a pneumatic water closet that blasts waste over the river in a fine mist. Ordinary, laborers earn $2 a day. Their pay is raised to $2.25, when the caisson reaches 28 feet. All told, 2,500 individuals take part, with turnover often running one in three. However, for everyone who quits, dozens of immigrants, desperate for work, line up to take their places.

There is much talk about caisson sickness even before many experience it. For every two feet the caisson is lowered, one pound of pressure is added to the atmosphere. The highest pressure at Brooklyn is 23 psi. This is ten less than in St. Louis, when Riley dies. Like Eads, Roebling believes novices are most susceptible and sends them out at the first discomfort. By the time the New York caisson reaches critical depth, Roebling has spent as much time under compression as anyone. He believes shorter hours will help. Eads stations a hospital ship nearby, prescribes special diets, and lays down the rules on rest. In Brooklyn, men find the work more exhausting than anything they have experienced. Colds and bronchitis become common, as men "locking out" hit air 40? colder than in the caisson. Candle smoke and blasting contribute to hacking coughs. All fear being drowned like rats, suffocating, or being crushed in the event of an accident.

"The Great Blowout" occurs at 6 AM on a Sunday, when few workers are. There is a terrific roar and the river explores, sending water, mud, and stones 500 feet into the air. No one is inside the caisson and only three are atop it. Roebling, Collingwood, and others arrive, turn hoses into the water shaft, close the air locks, and restore pressure to the work chambers. Roebling leads the damage assessment, which is less than imagined. Settling 10 inches, the caisson withstands a staggering 17,675 tons, but the structure holds. Roebling calculates the caisson is carrying a total weight of 23 tons per square foot - over four times the amount it will bear as a finished support. He determines the cause lies in the density in the two idle water shafts as fine silt settles out at different rates. Normal procedure calls for keeping a trickle of water playing in, but this day it is accidentally turned off. Sounding like his father, Roebling talks about carelessness brought on by overconfidence, and thereafter comes down hard on those who violate safety precautions.

Part 2, Chapter 10

Part 2, Chapter 10 Summary and Analysis

"Fire" shows Roebling with the courage of a Civil War commander dealing with the second disaster to befall the Brooklyn project and hints at the resistance some are giving it. In October 1870, Web & Bell are contracted to build a caisson for the New York side. Roebling enlarges it slightly, modifies the water shafts and air locks, and orders the fireproofed. *Harper's Weekly* publishes a spectacular double-page aerial view of lower Manhattan and Brooklyn spanned by the finished bridge and acknowledges Washington Roebling's competence to execute this great engineering feat - implying earlier doubt. As the caisson reaches 43 feet, plans are made for brick piers to offer support while it is being filled with concrete. A fire breaks out Dec. 2, 1870.

Fire is discovered at 9:30 PM, in a seam where two chambers join the roof and the caulking has not been pointed with cement. A workman, McDonald, brings a candle too near his hanging dinner pail and ignites the flammable oakum. Workers, using the river water at their feet, have controlled four or five earlier fires at lower air pressure, and Roebling has installed steam pipes, fire extinguishers, and 1.5-inch hoses, but this accident long goes undetected, until the frame bursts into flame. Foreman Young gets the panicked workers under control and directs packing wet clothes, rags, and mud into the fist-sized cavity. Roebling arrives and orders the aperture stopped with cement and Farrington drills holes into the roof to determine the fire's penetration. Roebling knows every hole acts like a bellows. A few men are reserved as firefighters and the rest returned to their normal tasks, lest a night's work be wasted.

Roebling considers flooding the caisson but first tries less desperate measures for stopping the hidden cancer from eating through the roof, knowing the weight overhead is 28,000 tons. Flooding could cause problems like a blowout and weaken the caisson's support. Water and air pressures must be carefully balanced, and one shaft, sitting atop a boulder, could be permanently damaged by flooding the caisson. By 3 AM, the fire appears to be out, and at 5 AM, physically exhausted, Roebling and Young are carried up through the air lock. Driven home, massaged with salt and whiskey to restore circulation, Roebling rallies but remains weak. When word comes at 8 AM fire has been detected deep inside the roof, Roebling returns and within minutes orders the caisson evacuated and flooded. The Brooklyn fire department is alerted, and hundreds chase the trucks to the river. New York dispatches a fireboat and two tugs. Police control the crowd, which wonders at this unseen mystery, so like a mine disaster - except there is no anguish over human suffering. By 10 AM, fireboats, tugs, and fire engines are pumping water down the shafts, raising the interior level so gradually it will take five hours for it to reach where it is needed. Meanwhile, compressed air feeds the flames. By 3:30 PM the caisson has consumed 1.35 million gallons of water but prospects look dim.

The caisson stays flooded for two days, while New York newspapers question how management could allow such an accident, speculate on a cost of $25,000, and imply sabotage by the ferry company. The *Eagle* ridicules this but wonders about the fire's effect it on morale. Roebling testifies the caisson has settled two inches - less than the average daily rate - and may benefit from having its dry timbers saturated. Air pressure is restored, the water is pushed out, and Roebling inspects. The fire marshal passes the worksite, and work resumes. The brick piers are completed and the caisson is lowered the last two feet to rest on them. The work chamber is filled with concrete, mixed inside the caisson, because the Christmastime weather is too cold outside. The supply shafts are designed to allow materials to be dumped through smoothly and safely, so long as the attendants keep their heads. Once, workers topside clear a jammed load of bricks by dumping another load on top, which forces the bottom door to open explosively, air pressure to drop, water to flood in, and electricity to fail. The caisson crew should have simply closed the door, but panics. Roebling, who is on-site, hurries to the supply shaft, and helps remove debris, until the door can be shut. Disaster is averted. He assures the directors enough air would have been trapped to allow all hands to survive, until they could be rescued.

An inquest reveals pressure inside the chamber drops from 17 psi to four, and for several minutes the pillars bear 12 tons per square foot, but emerge with no signs of strain. The subsoil also withstands this pressure. With masonry work above suspended because of weather, deposits of phylogenic acid (wood vinegar) are discovered, indicating fire has damage is extensive. Roebling orders Farrington to drill 200 more holes, which reveal lateral damage far more extensive than believed and compressed air rushes out of every borehole. Some 600 cubic feet of cement are pumped into the holes and the air leaks end, but this is a costly error, because the cement coats brittle charcoal that must be scraped away to assure maximum solidity. Three months of what someone calls "gigantic dentistry" begins revealing erratic patterns of damage. After the burned channels are gouged out, timbers cleaned and squared, and new cement rammed in, bolts and iron straps secure the structure, which is covered with blocks of taprock and concrete. Roebling declares the repaired areas stronger than the original. Work is set back by months, $50,000 of payroll are wasted, and skeptics have new ammunition. Worst of all, Roebling, whose strength never returns after his collapse, is a different man.

By mid-March the Brooklyn caisson is permanently in place. No lives have been lost and no one seriously injured. None of Roebling's engineers has quit. Spectators now have something to see. Grandeur on the scale of the pyramids and European cathedrals and castles is years off, because Brooklyn 's low shores mean the footings must rise a long way even to reach the level of the roadbed. The *Eagle* publishes in full Roebling's annual report and people read it with interest. Roebling is praised for modesty and personal heroism. An English translation of Jules Verne's *Twenty Thousand Leagues under the Sea* has appeared, and Roebling and crew appear to fit the part of great underwater adventurers.

Part 2, Chapter 11

Part 2, Chapter 11 Summary and Analysis

"The Past Catches Up" tells how the Tweed Ring collapses and begins the story of the Great Bridge becoming embroiled in scandal and politics. The rather offhand way in which the Bridge Company is chartered and has operated come under scrutiny as Tweed's part in the project comes to light. On May 8, 1871, The New York caisson slides smoothly into the river, and. Kinsella hails Kingsley as the founder who risked more fortune and reputation than anyone. Kingsley toasts Roebling, who refuses to speak. It takes seven months to fit out, tow, position, and sink the caisson, and by then the Tweed Ring has collapsed.

Tweed greets 1871 at the annual Americus Club Ball expecting a very good year. His men, Hall and Hoffman, mayor and Governor respectively, are expected to advance to Governor and President, and Tweed to the U.S. Senate in 1872. On Jan. 24, however, a key henchman, James Watson, dies, creating a vacancy in the County Auditor's office. The press is too occupied with the Franco-Prussian War and grisly Paris Commune murders to take note of this passing, but covers the diamond-studded wedding Tweed gives his daughter on May 31. The *Herald*, estimating the cash value of the gifts at $700,000, wonders how public officials can live in such style. Other papers join the *Times,* which has long railed at political corruption, in demanding disclosures. These come as the Tweed people amazingly fail to vet Watson's successor, Matthew J. O'Rourke, and he reveals the "magic" of the Ring. Watson has every city contractor pad their bills by 50%-65%, paid the face amount, received overcharges in cash, and distributed the profits within the Ring to the tune of $75 million since 1869.

A former newspaperman, O'Rourke copies samples from account books and delivers them to the *Times,* and William Copeland also forwards unguarded figures. Tweed tries to bribe publisher George Jones to kill the story, but even $5 million is insufficient. Nast is also approached unsuccessfully, with $100,000, to end his campaign. The *Times* begins printing O'Rourke's figures and issues a special supplement on courthouse swindles. Greeley in the *Tribune* says Hall and Connolly should be breaking rocks in a state prison. On July 12, Hall forbids Protestant Irish Orangemen from marching, to forestall the violence that marked last year's parade. Hoffman comes from Albany calling for a peaceful march and offering police and military protection. However, two soldiers, one policeman, and 46 civilians die in the rioting. Fortunately for the Boss, anyone who might organize against him are out of town for the summer, but in September, a so-called "Committee of Seventy" organizes, led by a wealthy, ambitious Democrat, Samuel J. Tilden, and demands reforms. More evidence of fraud is seized, Nast intensifies his attacks, and the upright Andrew Green temporarily replaces Connolly. Tweed transfers real estate holdings to his son, but defiantly stands for reelection- and bribers himself into office one last time.

Most Americans feel New York has gotten what it deserves, and some see Jefferson's view that cities inevitably corrupt is vindicated. Even Whitman talks of "deep disease" and "hollowness at heart." Reform groups come into vogue everywhere, including Brooklyn. That Kallbfleisch is mayor through fraud is common knowledge, but even he denounces the Democratic machine and runs for reelection as an independent. Many call for the city to have a say in how the Bridge Company is run. The Brooklyn tower stands 70 feet tall and is topped by three boom derricks for hauling up 8-ton granite blocks. On Oct. 23, one of these breaks loose and kills two workers and injures five others, destroying the project's perfect safety record and further degrades public confidence. An investigation exonerates the company, but a few days later, several hundred reform-minded citizens meet in the Brooklyn Skating Rink to form a "Committee of Fifty," known popularly as the "Rink Committee," which targets the Bridge Committee. As expected, the Democrats win in Brooklyn, but narrowly and fraudulently. In New York, reformers sweep out all but two Tammany aldermen. The New York *World* sends a reporter to Brooklyn to interview Kingsley, who points out the differences between his allies and Tweed. Kingsley states he would be richer by $250,000 if he had never had anything to do with politics.

Failing to find corruption elsewhere, the Rink Committee focuses on Tweed, Smith, Connolly, Sweeny, and Kingsley. Kingsley seems a force for civic progress, a devoted family man, churchgoer, and philanthropist. No one, however, can find where his business interests end and political interests begin. None of the New York directors appears after Tweed's troubles begin, and no one can recall their contributing earlier. Tweed appears on only rare occasions - six of the 58 meetings during his tenure, and while records are mere synopses, it appears he finds the time and makes the effort to attend, only when something will directly benefit Kingsley. On Oct.27, 1869, Kingsley's company is paid back for lumber purchases. On July 5, 1870, Kingsley is allotted 15% on all expenditures on building the towers to the high-water mark - roughly $175,000. Why Tweed takes Kingsley's interests to heart is unknown, and such arrangements are common at the time. Five days after the elections, Tweed is removed from the Board and Kingsley is assigned payment of $125,000 for services rendered. The public learns none of this. In December 1871, someone discovers an erasure in the record book, changing Kingsley's 15% to 5%, and Kingsley's business practices and "connections" come under scrutiny. By the time the Rink Committee issues its conclusions, Tweed is in ruins, indicted on 120 counts but out on bail. He resigns from the Public Works Department and is fired as Grand Sachem of Tammany Hall. Before he can face trial, close friend Jim Fisk is shot and dies in Tweed's arms. Rev. Beecher preaches about God's providence towards society. The newspapers are too filled with stories about museum openings and presidential elections to care about the bridge's steady progress.

Part 2, Chapter 12

Part 2, Chapter 12 Summary and Analysis

"How Natural, Right, and Proper" details how Murphy's 1867 charter is the "license to steal" earlier suggested in the book and fulfills John Roebling's skepticism about the spirit of the age. As the Rink Committee concentrates on Kingsley's relationship with the Saw Mill & Lumber Company, the *Eagle* reminds readers he has been the only man willing and able to get the bridge project started and justifies his dealings with the Tweed Ring as unavoidable. It prints Kingsley's angry tirade against the "vagabonds and scoundrels," who would hold up progress to protect the interests of the landed gentry. Kingsley claims to have laid out $250,000, but the committee wonders in the *Eagle* what Kingsley has been doing and how he could spend $250,000 - twice the amount he has received to date without itemizing costs. Perhaps he has spent liberally in Albany to gain control of the Bridge Company? Kingsley's reply is calm and factual, and public interest in the Rink Committee fades, leaving much unanswered. The public demands to know why Roebling and the prominent original directors own no stock. The *Tribune* connects Kingsley with eight companies furnishing materials for the bridge. James Stranahan restores public confidence by nominating four New Yorkers to replace the Tammany directors. These include William H. Vanderbilt, Lloyd Aspinwall, William H. Appleton, and Abram N. Hewitt. Murphy is re-elected President and Andrew Green, Comptroller of New York joins the Finance Committee.

Replacing Tweed on the Executive Committee, Hewitt demands Roebling report on the fairness of expenditures and explain why his father's cost estimates are being exceeded. Roebling complies in just four days, and Hewitt chairs a special meeting on July 1. He breaks precedent by reviewing minutes of the previous meeting and considering admitting the press. Roebling reminds them Murphy had excluded him from making contracts or purchasing supplies, but admits being "personally cognizant" of nearly all transactions, which he feels have served the Company's best interests. Employment has not been politically motivated and wages are customary - perhaps low, considering the hazards. Roebling does not deliver the report in person for reasons we will see in Chapter 22. The concise accounting attached suggests Roebling has expected - perhaps hoped for - a summons to report. Father had not anticipated the increased size and elevation of the bridge (costing $113,000), buying land for the approaches ($330,000), difficulties with the New York caisson ($375,000), and other non-engineering "contingencies" ($165,771.65). Nor had he or father expected Kingsley would cost so much. The bridge will cost $9.5 million. That's $3 million more than foreseen. The directors are generally encouraged, but some want a Committee of Investigation, which Demas Barnes chairs. The *Eagle* condemns this as a political scheme intended to restrain Brooklyn's economic progress. Barnes, a vocal proponent of the bridge in Congress, is now labeled a demagogue, ass, and quack. Kinsella expands coverage of the bridge and Roebling. Kinsella is a tough, undisciplined, ambitious man who has weathered a public scandal, and New York papers consider him a paid propagandist for the bridge and the Kingsley-McLaughlin machine. Kinsella's

turnaround, described in later chapters, will come as a surprise after reading his paean to "The Engineer." The New Yorkers suggest Roebling is concealing the truth so as not to defame his father. *Scientific American* predicts $40 million will be spent and reminds readers it favors a tunnel. In November, Hewitt announces Kingsley's salary is ended, but he keeps his job. Adultery charges against Henry Ward Beecher, brought by the notorious Victoria Woodhull, distract attention.

The committee releases a six-page majority report on Dec. 1, 172, signed by Hewitt and Schroeder, which questions only Kingsley's receiving $125,000. Chairman Barnes dissents and blames the managers for not protecting the public against fraud, acting in secret, and benefiting personally. He calls for an independent inquiry and charter amendments to make the Executive Board's activities more transparent. Colleagues charge Barns is spinning data to fit an agenda, defend Kingsley as the ideal choice to oversee the project - and his right to earn a profit. Kingsley voluntarily returns $50,000 in exchange for being relieved of the stock holdings for which he is obligated - netting him $50,000. The Bridge Company is run according to the accepted practices and ethical standards for *private* corporations. When the Board of Directors meets Jan. 11, 1873, and names a committee to consider charter amendments, Murphy (author of the original charter) and Barnes (the severest critic) are omitted. Hewitt, Schroeder, Marshall, McCue, and Stranahan serve. Kingsley is assigned a $10,000 salary, effective July 12, which he accepts gratefully - and immediately asks for and receives a six-week leave of absence.

How had Kingsley spent $125,000 before construction even began? Why is the agreement changed so quickly after Tweed's fall? What about the erasure? What are Kingsley's duties? Why is Roebling always quoted as the authority? How much has Saw Mill & Lumber Company profited. In how many other firms doing business with the Company does Kingsley have interests? How much stock owned by Executive Committee members does he control? No answers to such obvious questions are ever given, but Hewitt affirms nothing improper has occurred. Could Roebling not know about everything that is going on? Is that why he holds no stock - to keep him away from the directors' meetings? John Roebling had always invested in his projects, and cash-strapped Brooklyn must surely have approached him - unless they recognize he is too honest to deal with. To think Kingsley would fail to spread money around in Albany to get a charter giving him a license to steal is napve, and Murphy may represent a large part of the $125,000 "investment." Kingsley has doubtless calculated he will get rich on the Great Bridge and is on his way, when Tweed unexpectedly crumbles. Now any political active building contractor is suspect. It takes Albany two years to change the 1867 charter, during which time the directors know they are no longer seen as leading a noble, heroic endeavor. Some papers are openly hostile, and the people are skeptical. Tweed's departure provides a rich opportunity for dishonesty, and John Roebling's fears venality will cloud his triumph come true.

Part 2, Chapter 13

Part 2, Chapter 13 Summary and Analysis

"The Mysterious Disorder" delves deeper into "caisson disease," as the New York caisson goes deep enough to cause problems. Roebling hires a doctor to care for victims and to determine a cause. He very nearly does, but prevailing wisdom stands in his way, and this confusing malady has a marked effect on the building of the Great Bridge. By June 1, 1872, the Brooklyn tower looms 100 feet over the East River, and the New York caisson sits 78.5 feet below water. Some 14,500 cubic yards of masonry have gone into the Brooklyn structure and 13,075 into New York. Progress in Brooklyn is so obvious, that it counteracts news reports and gossip, making it appear petty. The tower stands lengthwise against the shore, 140 X 59 feet. It is but a third its eventual height and still 19 feet short of road level. It's growing daily, but undetectably. It looks more like a battlement, medieval war machine, astronomical observatory, or monument than part of a bridge. Everyone knows it purpose, however, and it already dwarfs the wharves and stores. The *Eagle* equates it with the pyramids. Now, Roebling has told the public, underwater work on the New York side is just as impressive. It should be finished in a month, and another tower will arise. The first stage, the one presenting fundamental engineering challenges, will be over. Towers, cables, and superstructures have been built scores of times, albeit always on a smaller scale. There will be risk and uncertainty, but no more ventures into the unknown.

Piers 29 and 30 are demolished, the riverbed dredged to 37 feet, and a square enclosure protects the caisson from stronger tidal currents. Bedrock appears to lie 77-92 feet down, but it is not certain they must go that deep before attaining stability. The underwater terrain differs from Brooklyn's. The caisson is towed into place on Sep. 11, 1872, and ten more courses reinforce its roof before it is sunk. This caisson is treated against microscopic sea worms - teredos - that attack any crevice water can permeate. It must bear twice the weight as Brooklyn's, since it sits twice as deep. It is slightly longer, and the inside is lined with iron as fire protection and whitewashed to improve visibility. The water shafts are round to add strength, and some fifty 4-in. iron pipes are installed to remove sand. Paine comes up with a simple mechanical signaling system. The airlocks are modified, to accommodate a full 120-man shift in a single locking, and built into the roof of the work chamber, so workers climb under pressure.

The first stone is set Oct. 31, and by Dec. 12, enough are laid on to hold the caisson on the bottom at high tide. Digging begins and proceeds far more easily than in Brooklyn, but with greater discomfort for workers, because the site has been Manhattan's main sewer. The caisson floor is kept flooded, until clean sand and gravel are reached. The box descends rapidly, hitting few boulders, and the sand pipes work so well they keep 60 men busy feeding them. Controlling the blast of sand at the surface challenges engineers and several passing boaters are injured. When encountered, boulders are handled as at Brooklyn, but the communication system helps coordinate steps. As the caisson descends 6-11 inches per day, limestone is heaped on its roof.

The caisson grounds in 37 feet of water, generating 17 psi inside. Brooklyn never exceeds 21 psi. Within a month, they reach 45 feet and workers feel discomfort and pain. Work shifts are limited to four hours with a two-hour rest between. Roebling installs a steam elevator and hires Andrew H. Smith as "Surgeon to the New York Bridge Company." Smith issues a set of nine rules for workers and excludes anyone from taking a physical examination that he suggests may have abnormal difficulties. Most workers do not heed his advice on caffeine vs. alcohol or on quiet rest periods, and most live in cheap tenements crawling with disease. Smith enters the caisson, confirms others' findings, and observes effects on his own breathing and blood pressure. He notes pallor and shriveling of fingers that last about 20 minutes after returning to the surface, and nearly all workers run a fever. He links increased appetite with increased tissue waste and oxygen absorption, and comes close to discovering the true cause of the bends by conducting experiments on pigeons and dogs. Theory is secondary to his care of victims, to whom he attends daily. Future author Frank Harris sketches life in the caissons, which he leaves after seeing a worker writhe on the floor, spurting blood from his nose and mouth.

Smith's service runs Jan. 25-May 31, 1872, during which he handles 110 cases. Martin and Collingwood both suffer attacks, and Young transfers topside. Smith's notebooks describe leg cramps as usually the first sign, followed by severe joint pain. Victims look leaden and perspire. One in four develops dizziness, double vision, and vomiting, and many feel numbness instead of pain. Treatments include ergot, whiskey, atropine, and morphine. Smith advises some victims to seek different work and refers others to Walter Reed, a young intern at the Brooklyn City Hospital. Smith never uses the term "bends," preferring the formal designation, "caisson disease." He advocates slower decompression, but the New York airlock makes this more difficult, and workers resist safer "locking out" procedures. Smith calls for lock tenders to enforce his policy. He rightly identifies a predisposition of some physical types - fat people and heavy drinkers - to the bends but fails to figure out why.

Part 2, Chapter 14

Part 2, Chapter 14 Summary and Analysis

"The Heroic Mode" refers to the best method for alleviating the pain of bends, only rarely carried out. Chapter 14 examines further how the malady affects the Great Bridge, including striking down the Chief Engineer. No longer a demigod, Roebling remains unchallenged as project head, but his sickness tempts politicians to sweep him aside, as we will see throughout Part 3. Part 2 here ends with towers rising in Brooklyn and New York, showing clearly the Great Bridge is coming.

Smith perceives high pressure affects the circulatory system, which returns to normal gradually as pressure declines. Slower decompression minimizes suffering. It will later be shown nitrogen absorbed in the bloodstream under pressure form bubbles that keep oxygen from reaching tissues resulting in agonizing ischemia, usually limited to heart attacks, in the limbs and joints. Smith's locking-out policies, even if obeyed, fall short of modern standards by a magnitude of five or six. Smith recognizes how to relieve the agony by restoring pressure, but only twice applies this "heroic mode" of treatment, too impractical and feared by sufferers, who just hold on and wait.

At 68 feet, they hit material too hard for the clamshell buckets to remove and progress slows. At 70 feet, Roebling begins sounding for bedrock, but there is talk of going down another 30 feet. On Apr. 22, 1872, John Myers passes his physical exam and enters the caisson at 34 psi. Half an hour after surfacing, he feels poorly and dies before he can be carried to his room. An autopsy shows congested lungs. Patrick McKay, a four-month veteran, dies of Bright's disease, unrelated to the job. A meningitis victim is linked with these cases in wild rumors, and when a worker named Heffner begins vomiting, the work force goes on strike, telling reporters about terrifying conditions, and demanding $3 for a four-hour day. The Company agrees to $2.75 and threatens to fire anyone who does not return immediately. Roebling works 12-18-hour days, making many trips between the surface and the caisson, considering whether to blast the ridge and continue downward or stop where the sand and gravel appear rock hard. If he stops and is wrong, the tower may lean or slip. On May 18, 1872, with the caisson at 78.5 feet, Roebling orders a halt. He nearly dies of a second case of the bends, never reported in the press, and painful attacks recur, but nothing is said about them, even as a defense for not reading his report to the Executive Board. The New York caisson is filled in on July 12, and the Roeblings take a two-week vacation. When work wraps up for the winter, the Brooklyn tower stands 145 feet tall with the archways resembling gigantic teeth. The New York tower is nearly 64 feet tall.

Emily visits Murphy to talk about Roebling's desire to remain as Chief Engineer, although his doctor gives little hope of recovery. He spends the winter preparing minute directions for building the cables and superstructure. He cannot endure long conversations, his eyesight fails, and rumors spread that he will not return in the spring. Roebling requests a leave of absence and goes with Emily to take the water cure in

Wiesbaden. In the spring of 1872, Smith includes in his formal report, suggestions for aboveground decompression facilities- the "hospital lock" used today. Had he installed one on the project, Roebling and others might not have suffered, and the following history of conflict with the project's political overlords might be much different.

Part 3, Chapter 15

Part 3, Chapter 15 Summary and Analysis

"At the Halfway Mark" picks up the story in America's centennial year, summarizing how the towers and anchorages are competed and emphasizing Roebling's absent presence as mason work gives way to stringing wire. The biggest surprise is awarding the wire contract not to the Roeblings, but for purely political reasons to an obscure and incompetent Brooklyn firm. The Brooklyn tower is finished in June of 1875 and New York's in July of 1876. Times have changed. The Panic of 1873 wipes out businesses and fills the streets with unemployed drifters. Europe sends its poor and hopeful. Simple, ingenious inventions make life simpler. Big corporations get bigger. Railroad tunnels and bridges are constructed. New York boasts the nation's tallest office building, the ten-story Western Union Telegraph Building, which is 50 feet shorter than the bridge tower. Havemeyer is dead, and Tweed is on the run. Brooklyn's new ferry house is a costly expression of confidence in the future and is surrounded by new businesses and industries. The sensational Beecher-Tilton Trial ends in a hung jury, leaving people divided about Victorian hypocrisy. Brooklyn has lost its cherished reputation and looks to its bridge as a source of pride.

Roebling's plans are so clear and thorough and the task of laying stone so routine, the project can proceed without him on site. The towers end up taller than John Roebling plans, at 275.5 feet. Roebling's able assistants are loyal to the work and to him. Martin is Roebling's stand-in, Paine supervises the New York tower, and Collingwood the Brooklyn one through completion and then takes charge of the New York anchorage, 900 feet inland from the tower and filling most of a block. At the base 119 X 129 feet and at the top 104 X 117 feet, it stands eight stories high. At street level four great cast-iron anchor plates are embedded in granite and chains of huge iron bars connect it with the surface. To them four great cables will be secured, linking the anchorage with the tower, forming the "inland span." The final weight of each anchorage is 60,000 tons. Derricks and other apparatus lift stone towards a roadway level. The towers attract public attention, but the anchorages are the vital engineering features.

Each anchorage has four anchor plates, one per cable, set in place early in construction. They are immense oval spiders weighing 23 tons apiece. Each has two parallel rows of nine oblong apertures into which 18 iron eye bars are set, creating identical upright rows of nine anchor bars, each twice as tall as a man and forged in a single piece - no easy trick in those days. On the underside of each plate, steel pins fit through the eyes of a row, creating a double-tiered link of a gigantic chain that extends through the masonry in a gradual arc surfacing on top. (Consult illustration on pg. 418). The anchor bars differ slightly in size, depending on their relative position in the chain. Roebling spends months working out the optimum arrangement of size and number of bars. Pins run through the eyes forming joints like door hinges, allowing formation of a steady curve to a point 25 feet back from the edge, where the cable will join. By the summer of 1876, the huge iron bars look like clutching fingers embedded in stone.

Hildenbrand designs the approaches, requiring a series of structures half a mile long, to bridge the intervening streets. McNulty supervises the Brooklyn anchorage and prepares for cable making. Preventing costly mistakes are the two factors of Roebling's written communications and Farrington's experience, as he trains the crew. Hildebrand and Farrington design a footbridge to link the towers and a scale model showing every planned detail of the finished project. The stonework proceeds on schedule and smoothly, despite delays, shortages of funds, and accidents. Stone comes from 20 quarries to Red Hook, whence individual blocks are loaded as needed on scows, delivered to a tower, and hoisted by iron pulleys fitted to a continuous loop of steel rope with hooks that engage iron bolts in the blocks of granite. Only one shakes loose and falls. Once on top, blocks are moved by flatcar and derrick into place. The 11-ton keystone to the Brooklyn tower needs no trimming. Up to 80 men work atop each tower in stiff breezes and fog. Despite precautions, there are a dozen deaths and many close escapes before the truly dangerous part of the work begins - a notice that doubles the public interest, which has always been high.

Shipping interests claim the bridge will obstruct river traffic, and warehouse owners join the protest during public hearings, but the towers lend psychological momentum to the project. Since June 5 1874, the cities of Brooklyn and New York have owned the renamed "New York and Brooklyn Bridge" and pick trustees, including their mayors and comptrollers *ex officio*. The old company is dissolved, and the project is redefined as a public work. Brooklyn bears two-thirds of the cost and New York one-third. Private stockholders are reimbursed with interest, and their titles are extinguished. The old management survives. Business continues behind closed doors. In July, the *Eagle* writes optimistically about a contract for 120 tons of wire to be filled by the Chrome Steel Company of Brooklyn and predicts completion in three years. The engineers are praised as peerless, but Roebling is not mentioned. Paine announces eight 13-ton "saddle plates" are positioned atop the towers to accommodate the cables. They work like expansion joints to alleviate lateral strain on the towers. When the first wire crosses the East River, the halfway point in the Great Bridge's building is passed.

Part 3, Chapter 16

Part 3, Chapter 16 Summary and Analysis

"Spirits of '76" looks at Roebling's frustrating life and indecision over whether he can remain in charge of the bridge. The newly incorporated John A. Roebling's Sons participate in the Philadelphia Exhibition, anticipating the next phase of the project. After six months on the Rhine, they buy a house on Columbia Heights a half mile from the bridge, but on doctors' advice, they spend nearly three years in Trenton. Letters and reports flow in from the engineers and Roebling issues detailed orders on every aspect of the stonework, and the tower saddles. He is on top of every detail, recommending pay raises for his assistants, and hires Theodore Cooper, a St. Louis veteran, to inspect iron for the superstructure. When Murphy economizes by furloughing men, Roebling protests, "To build *now* is to save money!"

After Europe, Roebling suffers stomach, limb, joint, and head pain, but is not paralyzed as is often said. His nervous system is shattered and noise upsets him. He is hounded by visions of his own death and of incompetent subordinates ruining the bridge. He feels imprisoned in his body, can no longer read or write, and is extremely short-tempered. Overwork and anxiety succeed the bends in making him a victim of "nervous prostration." He tells people his agony is of his own making and knows he must rest, but has no time. Collingwood is also nearing collapse, and Roebling advises him against being taken in by "fake ambition." Grey-faced, Roebling dictates correspondence to Emily, his constant attendant, who learns to write a lot about the engineering of a wire suspension bridge. Roebling returns to childhood hobbies of geology and mineralogy.

Roebling is upset by suggestions of collusion with Carnegie's Keystone Bridge Company over anchor bars, and announces to Murphy he will no longer be responsible for low-bid supplies. He is aggravated by the Eads' lawsuit begun in 1871, claiming $5,000 for infringing on airlock design. They feud in *Engineering* in an unprecedented manner. Eads is also embroiled with the Secretary of War and Army engineers over whether his bridge is a hazard to navigation. G. K. Warren, Roebling's brother-in-law, calls for tearing it down in phrases suggesting a personal motive. Eads' old friend, President Grant, says only Congress can pull down a bridge it has authorized. In a few years, the St. Louis bridge is finished, and he is hailed as "the noble engineer." In May of 1876, Roebling settles out of court.

Roebling dictates a resignation that is ignored or never mailed. His powers of concentration and gift for recall remain sharp. He puts newly graduated Charles, 27, in charge of production and Ferdinand ("F.W.") in charge of commercial concerns. Wash is bitter his brothers get everything handed to them including health and wealth, while he is broken in both regards. His $10,000 salary meets only half of his expenses. The European trip and Brooklyn house are costly, and he is educating Eddie and his own son. When John A. Roeblings' Sons incorporates, Wash is President and F.W. secretary/treasurer. Swan is induced to retire.

The Roeblings benefit from identification of their name with the Bridge. Their 350 workers in five rolling mills produce 75% of U.S. wire rope- some 450 miles a day, and everyone assumes they will supply the East River project. Roebling specifies 3,400 tons of "superior quality steel" wire, double the strength of the Niagara and Cincinnati projects, and galvanized to withstand salt air. Sealed bids are due Dec. 1, 1876. F.W. and Charles are pleased by public response to their exhibit at the Centennial Exhibition, showing every stage, including strands, bundles and cables. Wash only hears about the grand opening by U.S. President Grant, Brazilian Emperor Dom Pedro, and inventor George H. Corliss, whose engine powers the electric displays. He perhaps questions if civilization is truly progressing, since it coincides with the massacre at Little Big Horn. By July, Wash talks of returning to supervise the stage he knows best. However, things go too well, and the first wires are in place before he can leave the house to witness the event.

Part 3, Chapter 17

Part 3, Chapter 17 Summary and Analysis

"A Perfect Pandemonium" is how the New York *Times* describes the welcome given the first man to cross the East River by cable. The chapter describes both colorful events and the engineering behind them. On Monday, Aug. 14, 1876, 6,000 spectators await the first rope to cross the river. Scheduled for Sunday or overnight, when water traffic is light, it somehow becomes a public event. Working ropes have been hauled up the Brooklyn tower, attached to 3,000 feet of the ?-in. twisted steel strands, and the tower and anchorage are connected. At 9 AM, a scow sets off trailing wire rope that sinks as it is played out. The trip takes under 10 minutes, and the arrival is loudly applauded. The rope is hauled up and over the tower, and when a break occurs in river traffic, the submerged wire is lifted to 200 feet over the water. A second rope is fetched by scow, and the two are spliced to form a loop or "traveler" 6,800 feet long. The *Eagle's* headline is "Wedded," but the *Herald* insists it is merely an engagement. The public waits for a man to be sent across, and over 100 volunteer, including a 12-year-old boy and a Long Island acrobat.

The machinery for running the rope stands on the Brooklyn anchorage, while the framework on the New York anchorage is adjustable to keep the rope at the correct deflection (or sag). No one is surprised, when Farrington is selected for the first crossing. He appears cool and collected on Aug. 25. The rope is run over the river for an hour to eliminate twists and kinks before the "daring voyager" is tied into a boatswain's chair on the rim of the anchorage. People shout and wave as he passes over the housetops and stands on the seat to wave. The sling is moved to the riverside of the tower, Farrington sits down and has a glorious time during the seven-minute ride to New York. He descends from the tower to the ringing of church bells, whistles, horns, and a "perfect pandemonium." Farrington later speaks of the magnificent view and pleasing sensations but decries the fuss and publicity. His goal is to prove workmen will be safe doing their work.

Two more wire ropes are taken across and spliced to form a second endless traveler, then a heavier rope, the "carrier" follows to hold the weight of even heavier 2?-in. ropes to support "cradles" on which men stand to bind the wires of the great cables. A footbridge, handrails, and storm cables are strung. New Yorkers are treated to high-flying excitement as Harry Supple slides down, unlashing 20 temporary connections in ten minutes. On the Brooklyn side, William Kohnrner, nervous and awkward, takes an hour. Timbs and Carroll do the same task on the river span, but Supple has to rescue both from repeated tangles and an engine breakdown, giving the papers a field day. Monday, William Miller breaks Supple's speed record, Arnold and O'Neil plummet towards one another over the river, but O'Neil becomes stranded. In Brooklyn, Farrington seeks to make up for Kohrner's poor showing. After all the theatrics, continuous loops, at 27 feet apart, cross the river.

Part 3, Chapter 18

Part 3, Chapter 18 Summary and Analysis

"Number 8, Birmingham Gauge" replaces high-wire antics with nasty politicking over who will supply wire for the Great Bridge. Brusque, hardworking Congressman Hewitt is campaign manager for his friend, Gov. Tilden, the Democratic candidate for President, whose chances look good against unknown Rutherford B. Hayes. On Sep. 7, 1876, Hewitt moves anyone connected with the Board should be excluded from bidding on the $1 million contract for wire. He removes his own wire business from contention and threatens to resign if Roebling is allowed to bid. John Riley asks whether infirm Roebling should be removed before he makes mistakes. News from Spain that Tweed has been arrested reminds the public of his connections with the Bridge, making Hewitt's resolution seem all the more praiseworthy.

Roebling cites health and other pious reasons for resigning before coming to the heart of the matter. Hewitt, with transparent designs on bridge contracts, has impugned his and his family's integrity, and can resign as trustee to avoid his own resolution. Murphy says he lacks authority to accept the resignation and infuriates Roebling by defending Hewitt's noble intentions. Roebling, warns Cooper & Hewitt lack production facilities and will bid through J. Lloyd Haigh of South Brooklyn, a proven bigamist. With no quorum, the crisis passes. Roebling moves to New York and sells his shares in John A. Roebling's Sons to eliminate the conflict of interest. Several trustees suggest an assistant be hired, and a committee is formed to evaluate candidates. Hewitt is absent through March of 1877, trying to keep the Republicans from stealing in the Electoral College Tilden's popular victory. Roebling warns bluntly the Bridge is his pride and honor and he will hear no more about a consultant.

Specifications call for 6.8 million pounds of "Number 8, Birmingham Gauge" steel wire with a breaking strength of not less than 3,400 pounds, medium quality, and straight. The Chief Engineer is sole arbiter of disputes between inspectors and manufacturers, but Paine and Martin stand in. The trustees open nine sealed bids on Dec. 4, 1876. The highest is for 14? per pound, and the lowest - Roeblings' - is for 6.75? per pound on *Bessemer* steel. A separate bid for *crucible* steel is higher than Haigh's. The New York *Herald* publishes unflattering remarks about specifications and testing made by a Brooklyn engineer, Albert Hill, who cannot imagine why crucible steel has not been specified and demands engineers not connected with Trenton conduct the testing. Roebling says there are no guarantees test wire and production wire will match. Hill claims Roebling's mathematics are wrong and proposes other figures that impress newspaper editors and trustees, who know nothing about engineering. Hill has never built a suspension bridge and is unknown, but the *Herald* sticks by him. The trustees grow edgy. Wire manufacturer Hewitt finds nothing wrong with Roebling's calculations. Extraneous personal remarks by Hill provoke F.W. to withdraw the Roebling bid, but Murphy talks him out of it.

At a private meeting of the Executive Committee, Murphy presents the Chief Engineer's report and Paine's explanation of why, on engineering grounds, Hill's charges are false. The best wire comes from England. Those from Cleveland are good but not galvanized. A German wire is excellent. Roebling's Bessemer wire is good but cast steel samples do not stand up. The committee unanimously recommends the contract go to the Roeblings and Murphy is to convene a special board meeting to award it. Behind the scenes, Kinsella plays for time, as the *Eagle* demolishes Hill's attack and suggests Bessemer steel is not the answer. He asks whether they should they go with the cheapest steel or the best at the cheapest rate. Never before has the *Eagle* criticized Roebling, but Kinsella is now motivated. He wants the contract to go to Brooklyn's Haigh. Nineteen trustees attend the Jan. 11, 1877, meeting (Hewitt is detained in Washington,) and Haigh attends as a guest. Slocum calls for Army engineers to inspect wire before it leaves the Roebling works to remove public suspicion. The chair reads Hewitt's bombshell letter that questions allowing Bessemer wire - after he had earlier urged Roebling not to specify crucible. Murphy reads extracts from engineering papers comparing the processes and they discuss how the current specifications had come about. A "test vote" on using crucible steel loses 8 to 7 with four abstentions, but within hours, a secret meeting of the Executive Committee awards the contract to Haigh. There is no record of how this happened.

Haigh posts a $50,000 surety his crucible steel will match the quality of his samples and receives the contract, over Marshall's protest. The *Union* calls for naming an eminent consulting engineer to aid the disabled Chief Engineer, to which "Tripod," perhaps a Roebling pseudonym, points out in the *Eagle* consulting engineers do little but sign their checks. If the "invalid" is to be put aside, one of the hardworking assistants should be advanced. Tripod dares the *Union* to name any engineer who can compete with Roebling's familiarity and devotion, and the paper calls for the mystery engineer's removal. Roebling is galvanized to fight for his job. He determines Hewitt holds Haigh's mortgage and agrees not to foreclose in exchange for 10% of Haigh's profits. Hill may be a Hewitt mouthpiece. Roebling never speculates on why Kinsella turns on him, but it may be to ingratiate Hewitt in case Tilden becomes President.

Part 3, Chapter 19

Part 3, Chapter 19 Summary and Analysis

"The Gigantic Spinning Machine" is a Brooklyn *Eagle* description of the cabling of the Bridge described in Chapter 19. Farrington races cold weather to secure a temporary footbridge for workers, which reporters find disheartening. Four-feet wide and angles down from the tower at 35°, it has handrails at hip level but nothing to prevent slipping through and spaces between the slats to improve stability in the wind. Five cradles hang at right angles, allowing men to position the wires and bind them into strands. The anchorages bristle with activity. Wire coils are galvanized, dried, dipped in linseed oil, and spliced together onto drums that will play out like fishing line across the river. Every splice has to be as strong and weather-tight as the wire itself. Full drums contain 10 miles of wire, but the cable-making machinery consumes four drums a day, so crews "drum up" for months. On May 29, 1877, a first experimental wire crosses the river, uneventfully. On June 11, spinning commences. The two downstream cables are built simultaneously, laid parallel for strength, rather than twisted, as the public supposes. They will be compacted into essentially a curved bar of solid steel.

A great skein of wire is built up between the anchorages, over the towers, like yarn held between one's thumbs. In Brooklyn two wires are drawn off the drums, affixed to "carriers," great bicycle-wheel like structures attached to the working rope, trundled over both towers to the New York anchorage, where they are slipped off, pulled taut around a shoe, and secured to the anchor bars. The continual loop brings back to Brooklyn an empty carrier, ready to be refilled. Hundreds of wires are hung in unbroken continuity, with uniform tension and exact parallelism. Each trip takes ten minutes. Along the way, "regulators" on the towers and cradles watch sag and tension, and mark the wires with red paint to help spot and fix any problems that occur. After a strand is completed, pairs of workers ride "buggies" down from the towers to compress the wires and apply temporary "seizings" of soft wire every 15 inches. Wires that break must be hauled in and spliced, causing only a few minutes' delay. High winds and fog make aligning wires impossible, and extreme temperatures affect deflection. The *Eagle* calls the bridge "The Gigantic Spinning Machine" as up to 50 wires are laid a day, slowed only by slow deliveries from the manufacturer.

Nineteen strands constitute a cable, which is clamped into a compact unit and permanently set into the tower saddles and the anchor chains, in a "difficult and delicate" operation that doubles the tension. The strain exerted is 70 tons, and the danger is a strand will get away. On July 2, it is carried out successfully on two downstream strands, and later on two upstream cables. Four carriers now shuttle back and forth like clockwork, and Roebling watches with field classes from his Columbia Heights home. The summer violence in Baltimore and Pittsburgh during the Great Railroad Strike stands in contrast with the optimism here, where the footbridge is a tourist attraction. Foreigners, journalists, engineers, politicians, and preachers are routinely given access, while others must give a good reason for wanting to go up.

Thousands cross without accidents gut numerous freeze-ups. Press fuss about an epileptic makes Murphy end the fun.

In September, Tweed talks under oath in exchange for immunity, as earlier described. October brings jokes about Captain Kidd's treasure and predictions the Bridge will be an excellent venue for suicides. On behalf of the Council of Political Reform, Henry Beers tries to close the project down as a waste of money, and is joined by Abraham Miller, a warehouse owner. Buildings inland from the New York anchorage are being demolished as the spinning moves faster than ever. On Thanksgiving Day, a wire snaps, injuring no one, but Roebling examines a sample and finds it brittle as glass. He wonders how much brittle wire is already strung and suggests Murphy find a way of prevent any more from being used. Engineers ought not to have to be detectives he writes, and takes a swipe at Kinsella, with whom he is soon feuding again over specifications for the "suspenders" that hang from the cables to the future roadway - a contract that goes to the Roeblings as low bidders. The *Union and Argus* joins the anti-Roebling chorus.

An arch behind the Brooklyn anchorage gives way, killing a worker, and while rumors others are trapped prove false, the public outcry is great. Roebling is upset with McNulty, who has ignored his warning. Wild rumors about Roebling's physical and mental condition circulate, while he obsesses over the adequacy of his father's planned trusses for the roadway. He fees his way towards a decision. His concern for communicating details to assistants is shown in a memo to Farrington about planking for the bridge floor. In January, Haigh tries to maneuver out of financial obligations under his contract, and the papers raise no questions. Murphy as Board President hiring himself and his sons as lawyers is noticed, however, and questioned.

Part 3, Chapter 20

Part 3, Chapter 20 Summary and Analysis

"Wire Fraud" reveals how Roebling had been correct about Haigh as a supplier - and in building safety margins into his specifications. Political machinations are now rampant, and the Great Bridge could yet be a monument to futility. The workers, however, continue to be shown as heroic. Crews brave 65-mph winds and ice to lash the cable strands together as protection during a gale that punishes the half-finished bridge in January, but come spring, spinning goes faster than every and Murphy predicts work will be finished by 1880. Roebling tells the trustees his father's plans for trains will be followed. Cars will be hauled at 20-40 mph by an endless cable powered by a steam engine, like the San Francisco streetcars. Kinsella has been calling for a system compatible with New York railroads should be substituted. Tweed dies Apr. 12, 1878, still hounded by the press, and the Bridge's old links to Tammany Hall are dredged up.

On June 14, a bridge cable snaps, killing two workers, and scaring the people in Tweed's old neighborhood by the loud report and scraping noises. Farrington has been supervising the "easing off" of the 60th strand. Everything goes nominally, until the "fall rope" snaps with a deafening report. Blake is killed instantly, and McGrath and Arberg are in pain. Supple, of high-wire fame, is mortally wounded and thrown into the yard. The weight of the strand midstream shoots the free end over the tower and into the river with a massive splash. Papers correctly claim that the failed rope is Bessemer steel manufactured by the Roeblings. It has been used 15 times for this purpose and is tested at six times the load it is carrying. The Company is open with reporters, and eventually it is determined the sharp edge of a pulley has damaged the rope and Blake had failed to see it. People do not soon forget this episode and skepticism, already considerable, spreads. "Honest John" Kelly of New York announces his city is done paying. Only after three missed monthly payments do the trustees take him seriously. Murphy shuts down everything but stand making and furloughs 600 workers. Saying the foolish bridge will do New Yorkers little good, Kelly declares his city no longer legally bound to pay and happy to settle the issue in court.

On July 22, Roebling delivers to Murphy privately the devastating news Haigh has been committing massive fraud. After failing to bribe inspectors outright to pass inferior wire, Haigh has been removing certificates from good rings of wire and placing it on rejects while being stored in his warehouse overnight. Haigh receives a warning, but the pile of reject wire continues to shrink rather than growing as it should, and spies discover wagonloads are being switched en route. The next delivery is tested closely and only five of 80 rings pass. Haigh evades additional safeguards, and Roebling calculates up to 500 tons of bad wire have gone into cables and cannot be removed. He demands the Board accept responsibility for any future problems with Haigh's wire, but Murphy answers with a lawyer's evasiveness. Roebling suggests an alternative provider and demands a committee assess damages to be collected from Haigh's security. Instead, the trustees sweep it under the carpet and allow Haigh to continue. Record of the

meeting is expunged from the Company archives. Roebling assures them the margin of safety he designed into the specifications mean the cables are still five times stronger than needed. By selling the Company Bessemer steel at crucible price, Haigh makes $300,000 in illegitimate profits.

Knowing none of this, the *Eagle* sings of accomplishments as time comes for the roadbed to be hung. The 19 strands making up a cable are laid out in four tiers according to Roebling's ingenious plan. Cincinnati cables had only seven. The length of individual strands has to vary with their position in the bundle, and their cure has to be precise to be properly bound together. Temperature and exposure to sunlight can cause a 6-in. difference in length in a given day. Once perfectly aligned, the strands of a cable are tightly wrapped in iron wire by machines beginning at the towers and working towards the center. Men, riding a "buggy," hand-crank the wrapper. The cable is then oiled and painted white. The process is hurried to finish before winter. The Roeblings' are quietly given the contract for wrapping wire. This breaks the contract with Haigh. Work ends Oct. 5, 1878, four months ahead of schedule, the carrier wheel has made 23,000 passages. Wrapping is not finished before Murphy announces it must stop, because Kelly is withholding funds, and the Company is broke.

Part 3, Chapter 21

Part 3, Chapter 21 Summary and Analysis

"Emily" focuses on the Chief Engineer's wife and reveals her as a major force in getting the Great Bridge finished during times of intense political infighting. Emily Warren grows up in the maritime atmosphere of the upper Hudson Valley at Cold Spring near West Point. As an adult, she looks out her window to see the Hudson empty into the bay. One hundred ten Columbia Heights is half a mile from the Bridge. Neighbors include Moses Beech, Henry Bowen, and Beecher in the next block. Nothing like her reclusive husband, Emily keeps his life tranquil and runs his errands. She is 35, married 14 years, half of that time tending an invalid. Their son is an adolescent, and a fall during the pregnancy has left her unable to bear others. The trip home from Germany had been agonizing, but since she has enjoyed perfect health. Everyone notes her grace and scientific mind. Wash had written his sister Emily's beauty is greater than the sum of her features and is never satisfied with any photograph taken of her. They are engaged six weeks after meeting and neither has second thoughts. They exchange affectionate letters, all of which he destroys and which she collects. She meets the M'lhausens on Staten Island and is happy to learn they are the only "Dutch" relatives, when she visits the "home circle" in Trenton.

The Warrens are one of the most prominent and virtuous families in the county and invest in the West Point Foundry before steam boats put Post Road businesses like her grandfather's tavern out of business. The mot notable Warren is her older brother Gouverneur Kemble (G. K.), who graduates West Point second in his class, and spends ten years out west fighting the Sioux and mapping Nebraska and the Dakotas. He returns to teach mathematics at the Academy and raises his siblings, when their father dies in 1859. He seems too gentle and kindhearted to be a soldier. Emily, 16, picks up his orderly ways, interest in botany. She must have seen much of his fearless brother in his aide, Wash Roebling, when they meet at the officer's ball. The Warrens are gentry, but not wealthy. Cold Spring is an artists' colony, and Roebling likes it from first meeting. The couple is married Jan. 18, 1865, and looked forward to a life long forgotten in 1879. Not only has her husband has been destroyed before her eyes, but so has G.K., after Gen. Sheridan relieves him of command at Five Forks. He remains in the Army after the war, working as an engineer. Building the new Rock Island Bridge in 1869 breaks his health, and this is complicated by frustration trying to get his name cleared by the people at the top, who will not oppose Grant and Sheridan. G.K. is penniless and has to be helped financially, as well as morally, by the Roeblings. Emily cannot stand to see two such decent men tormented, while the corrupt prosper as never before during the "Gilded Age." Nonetheless, she never lets it get her down.

Emily is remarkable, quick and retentive. It is not hard to see how trustees and journalists could believe she took over running the Great Bridge. To shield Wash, she grows adept at handling technical questions well enough that some correspond with her directly. Wash relies on his "amanuensis" in everything, and the more he does, the more

gossips' tongues wag. She reads him the newspapers from which the Bridge is rarely absent, and clips relevant articles. Her letter books, which survive, only rarely reveal emotion. Outbursts are inevitably Wash's. Emily provides ballast. The worst time comes after the courts force Kelly to pay New York's six-month debt, allowing work on the approaches and cable wrapping to resume. The State Committee on Commerce and Navigation also finds in favor of the Company after hearing waterfront opponents led by Abraham Miller, intent on closing the project down. Finally, in May, when Roebling concludes he must shift to an all-steel bridge, rumors arise that his assistants are taking bribes from steel interests. Slocum claims he has evidence on Marshall P. Davidson of the Chrome Steel Company, and suggests it is "indelicate" for the Chief Engineer's brothers to be furnishing materials. Kingsley admonishes Slocum for impugning the Roeblings' honor, but allows a special committee to investigate. F.W. comes up from Trenton to clear the record and hires a lawyer to sue "somebody" for libel. Wash dictates an indignant letter to Slocum, saying that no gentleman would spread Davidson's lies without first verifying them, and link his family name with fraud while allowing a rascal caught red-handed to repeatedly continue his contract. The committee exonerates the engineers and the Roebling Company. The bribery stories had grown out of a mission by Paine to study steel processes in Pittsburgh with metallurgist Andrew Kloman. Slocum never apologizes, and Roebling never forgives.

The trustees receive an influx of new members. Kinsella steps down. Entering the picture are Brooklyn's new Republican comptroller, William G. Steinmetz (an engineer), and Mayor, Alfred C. Barnes. From New York come Mayor Edward Cooper (Hewitt's brother-in-law) and Robert B. Roosevelt, a wealthy lawyer and political crusader. These wealthy, urbane, public-spirited, politically ambitious young men have little in common with their new colleagues, who are self-made men patient with human failings. Steinmetz blames Kingsley for the length of time it is taking to build the bridge and wants him removed. Brooklyn mayor Howell demands he stay, and Murphy is removed instead. Another trustee resigns, so Murphy can be reappointed, and he and Kingsley are elected President and Vice-President, respectively. Infuriated, Steinmetz opposes using Bessemer steel for the superstructure, awarding the contract to the low bidder, and generally becomes so silly and tiresome the other newcomers side with the opposition. In December, the Tay Bridge in Scotland fails in a gale, killing seventy-five. While it is an iron bridge and an inquest determines the engineer had miscalculated wind loads, the disaster stirs Brooklyn and New York. Haigh goes bankrupt, and a "noted engineer" claims that the Great Bridge will not hold a fifth of the weight it must.

In February, Ferdinand de Lesseps, the "Great Engineer" of the Suez Canal visits New York, seeking support for a new project in Panama. Emily accompanies him to a banquet at Delmonico's, and the grandfatherly Frenchman tells reporters the bridge impresses him. Installation of the suspenders and attachment of the first planks is covered in *Frank Leslie's Illustrated Newspaper,* and soon Emily is able to walk out on a steel deck to make inspections for her husband. Emily's scrapbook shows historic St. Ann's Church torn down to make way for the approaches, wrangling over finances, minor accidents, and Haigh's imprisonment for passing bad checks. At the October trustees' meeting, Steinmetz distributes a lengthy report, which Kingsley refuses to consider, saying Steinmetz has never done anything positive and now dares bring ward

politics into the boardroom. Word of their quarreling spreads rapidly, and the papers print Steinmetz's letter, filled with wild and unsubstantiated accusations about steel contracts. Tactful Emily must play peacemaker, and she becomes trusted in an industry from which women are excluded. There are no formal records on her activities, but clearly she is invaluable. After Collingwood lectures about the bridge at a gathering of RPI alumni, the Chief Engineer and Emily are discussed. The assistant engineers idolize her.

As steel floor beams go up the structure begins looking like a bridge. The New York skyline is changing but the bridge tower still commands attention. Roebling watches progress from his window, but rumors he peers through a telescope continually are overblown. By the time snow flies, there is continual planking across the span, and Emily leads the mayors, assistant engineers, and some reporters on a stroll to New York, where Emily is toasted with champagne.

Part 3, Chapter 22

Part 3, Chapter 22 Summary and Analysis

"The Man in the Window" brings the question of Roebling's health and physical absence from the project to a vote of confidence by the politically motivated Board of Trustees. Animosity among the trustees rises, when plans are changed to accommodate Pullman cars and freight trains on the bridge. No one can say who authorizes this, and Stranahan turns uncharacteristically adamant. Mayor Grace of New York admits to discussing a linkup with the New York Central Railroad for a decade and wonders why Brooklyn should not appreciate what this can mean to them. The argument ends abruptly as time comes to meet Emily for the first stroll across the bridge. The change would not matter much had it not come so close to the end of the expensive project.

In October of 1881, Roebling asks to add 1,000 tons of steel to strengthen the trusses enough to bear heavy locomotives. Opponents use it as an opportunity to question whether the Chief Engineer knows what he is doing any more. As of the New Year, expenditures will total $13,377,055.67, and Murphy refuses to guarantee $600,000, more will suffice. Tweed's machinations are recalled. Few trustees understand engineering questions, and fewer still have even met Roebling. They find him a nuisance, when they communicate with him in writing. Roebling explains for Roosevelt how the additional steel will benefit the bridge, but does not explain who asked for heavy trains, which he had earlier opposed. Roebling says the bridge must serve every possible use to justify the expense. No one at this point foresees automobiles will sweep away other forms of transportation, but the bridge will be strong enough to handle them. The bridge is now virtually complete. The footbridge is coming down. Roebling can relax for the first time since his father's death, but the young trustees are frustrated with the old timers, and Brooklyn's new Republican mayor, Seth Low, stirs them to action.

Low, 32, listens, alertly, during his first meeting in January of 1882 before asking ex-mayor Murphy when work will end. Low has grown up with "all the advantages" as the son of a silk merchant. After graduating Columbia College and marrying a Supreme Court justice's daughter, Low organizes a puritanical Young Republican Club in Brooklyn and helps elect Presidents Garfield and Arthur. He runs for mayor as "the people's candidate" on a platform of home rule for Brooklyn. Professional politicians do not care for him, but he trounces Boss McLaughlin's candidate. On the Bridge Board, he aligns with A. C. Barnes and the New Yorkers to "clean the stables" rapidly. On June 12, Low demands monthly progress reports and an appearance by Roebling at a special meeting. Roosevelt resigns, angry at a lack of leadership by the trustees in allowing an absentee Chief Engineer. The papers give Roosevelt much play, and Murphy defends the system for keeping the assistant engineers fully abreast of Roebling's plans. Trustee John T. Agnew testifies to Roebling's clarity of mind and provisions to supervise everything from home. Without checking, Agnew promises Roebling will attend a future meeting. Low chairs an investigative committee looking into Edge Moor Iron Company's

failure to deliver, which leads to a figure named Sellers at Cambria Iron Company in Johnstown, PA - the same name as a character in Mark Twain's hit play, *The Gilded Age,* leading to sarcastic humor. Sellers is to be discussed with Roebling on June 26, but Roebling is in Newport, RI, without explanation. Even supporters find this rude behavior by an employee. Low criticizes him at every opportunity, and the press is full of contradicting rumors - about Roebling being kept away, because he knows too much or is so ill Emily has been de facto in charge for months. Roebling declines a second request to appear, citing medical advice, but assures the trustees his assistants enjoy full access to him. The only thing holding up work is slow delivery of Sellers' steel, which will put off completion to 1883.

The Roeblings rent a cottage on the quite side of Newport, away from the social scene. G. K. Warren is stationed here as regional head of the Corps of Engineers. Roebling sees no reason to remain in Brooklyn, with work moving relatively smoothly towards completion, and he is too proud to "dance attendance on the Trustees." If they are irritated, so is he. The Bridge may determine who will be the next Governor, and Democrat Slocum, backed by Kingsley, wants the job. Roebling has had his fill with politicians, especially those two. Notes prepared for a never-sent letter to Comptroller Campbell show Roebling has seen much mismanagement of funds but held his tongue to date. Low goes to Newport to ask for his honorable resignation, and returns to Brooklyn threatening to fire him. A few days later G. K. Warren dies suddenly at 52, shaking the Roeblings. Months later, he is vindicated by a military court investigating Five Forks.

Low summons the Brooklyn trustees to an important business meeting Aug. 22. Low gives a little speech about weak management and the handicap of having the Chief Engineer in Newport. Roebling has refused to resign, so Low moves he be named "Consulting Engineer" and replaced by C. C. Martin, his current first assistant. The board regrets having to do this and testifies to Roebling's past services. Mayor Grace seconds the motion, but Brooklyn Comptroller Ludwig Sempler, new to the Board, protests the injustice of making Roebling a scapegoat for non-performing suppliers. Stranahan backs Sempler and calls on the older trustees to understand Roebling has done too much to fire him now. Nevertheless, the motion passes. The two cities begin debating this action, and the whole project, heatedly. The *Star* says it is time for a new Chief Engineer and says his fate would be different if he had done his job rather than becoming the cat's paw of the Bridge Ring. This cost the cities millions. The *Daily Graphic* coldly observes any engineer can now finish the job. *The Iron Age* objects to Martin taking over, and says that an outsider is needed to redeem the project. Only the Trenton *Daily State Gazette* and Brooklyn's *Eagle* defend Roebling's honor, integrity, skill, devotion, and sacrifice of his health. Several trustees fear this is a death sentence for a man who has been kept alive only by his desire to see the bridge finished properly. Kinsella shakes lose of Kingsley's control to write from his conscience about Roebling.

Sempler receives a letter from Roebling thanking him for his unexpected defense, and goes to Newport to gain a clear vision of what ought to be done. He notes de Lesseps had been in Paris while the Suez Canal was built, but wants to act justly rather than sentimentally. Sempler will be the swing vote among the trustees. Committed to the

gubernatorial race, Slocum will vote with powerful Kingsley, who logically should back Murphy (and Roebling), but the reformers (Low and Grace) have muddied the waters. Roebling knows his fate hangs from Kingsley. Sempler returns to City Hall and gives a press conference about his full, frank talk with Roebling, whose infirmities are obvious but whose mind is astonishing. To fire him would be shameful. Before the crucial trustees' meeting, a New York *World* somehow talks his way into the Roeblings' Newport home and gets the first interview with Wash in ten years. The only condition is no direct quotes be used. Wash speaks candidly about several trustees' political ambitions, and when the reporter reneges and quotes him, Roebling's stock in Brooklyn declines. Emily is shattered by her husband's political napvety.

Murphy presides at the meeting of 17 of the 20 trustees attended by a dozen journalists. Martin leaves the room, when discussion of Low's motion begins. Low pledges to go along with the majority whether it agrees with him or finds Roebling has done an adequate job of managing. The public deserves to know nothing will hold up completion. Low does not intend to criticize Roebling or past actions by trustees. Refusing to yield the floor to Murphy to read a letter from Roebling, Low notes Martin had been unaware of his plan, but this is not a question of personalities. This body is responsible for $3,000 a day in expenses and $1.25 million in interest, which demands a live Chief Engineer.

When Low sits down, Murphy has Secretary Otto Witte read Roebling's brief letter aloud. He refuses to become a consultant and demands a vote up-or-down on his record. Mayor Grace reiterates his second for Low's motion. Marshall expresses sorrow over the resolution and denies its premise that Roebling is a liability. Marshall points to Niagara and Cincinnati, where Roebling bridges stand and others have fallen. Roebling is unblemished in character and ability. Marshall admonishes Low for going to Newport to demand a resignation without authority, and declares fellow trustees too honorable to do as Low wishes. A. C. Barnes observes that had Roebling remained in the Army he would have retired by now on half-pay and have nothing to do, so Low's offer is generous. Seeing the meeting going against Roebling, Sempler tries to refer the question to a special committee, but Kingsley demands an immediate vote. Roebling retains his office by a 10 - 7 vote and fills the headlines. Low tells reporters that he is content and had hoped it would go this way. Roebling suffers a nervous affliction that keeps him from mingling comfortably with numbers of people.

Part 3, Chapter 23

Part 3, Chapter 23 Summary and Analysis

"And Yet the Bridge is Beautiful" describes the final months of bridge construction and how the project helps determine the New York gubernatorial race. Once it is decided, all the controversy vanishes and planning for dedicating the bridge come to the fore. The "final touches" at Cincinnati had dragged on for months after the official opening, and Roebling knows this will probably happen here too. He will soon be 46 and has spent a third of his life on the Great Bridge - the time his father had given to all his major bridges combined. His health is much improved. He can get about the house and even go into the garden. He can read newspapers again, to learn about social gatherings, inventions like the telephone and electric light that would have made work in the caissons much easier, five transcontinental railroads, extermination of the buffalo, modern plumbing in the White House, and a new generation of national leaders. His son will enter RPI in the fall. The bridge has taken three times longer than father predicted and cost $15 million, twice father's estimate. Slocum has lost the governorship, thanks to the Bridge, and Murphy lies buried in Greenwood Cemetery.

Last fall, the Republicans had picked a lackluster candidate, Charles Folger, giving the Democrats confidence their man will become Governor. Slocum is the forerunner, opposed only by Roswell P. Flower, who is linked with "bridge frauds" in the Tweed manner. People are saying Kingsley and Stranahan are common crooks. Kinsella says this is just Jay Gould trying to control the Democrats as he has the Republicans. Convention leaders block seating of the Tammany delegates, and Kelly begs Brooklyn colleagues to help. Eventually, they do and are double-crossed. Finally, Grover Cleveland comes in to break the deadlock. Cleveland wins in November, and Slocum is elected to Congress. After the election, the papers say little more about bridge fraud, showing it had been pure politics. Mirror clerical errors are all that is found in the Company's "honestly and neatly kept" books. Murphy, 72, catches a cold, which progresses to pneumonia, and he dies, the last holdover from a golden age. Kingsley takes Murphy's chair and declares the Bridge will be a memorial to him.

Electric lighting is installed, and iron terminal buildings at either end will not be ready for opening day. Roebling's assistants all remain on the job. The bridge looks like Hildenbrand's drawing, except John Roebling's crowning capstones are omitted to save money. The towers have for seven years been part of the landscape, but the Gothic gateways are first appreciated, when all the timber falsework is removed. Close-up and at a distance, every detail of the bridge is thrilling. It looks different at different times of day and from different vantage points. The shabby neighborhood makes it look even more majestic, like medieval cathedrals rising among hovels. The archways from street level look like vast, vacant windows on the sky. The roadway is closed off by a high board fence at Chatham St., and piles of rubbish wait to be carted off.

Few New Yorkers want to go to Brooklyn, but are still drawn by this highway into the open air. It offers escape from smelly streets and stuffy shops, without having to endure the crowded ferries. The bridge dominates the imagination, as much as it does the skyline. The view from the water below is interesting, but the arc of the entire structure from a distance is what impresses most. From Brooklyn Heights it is clear the bridge belongs to them. The scale is perfect from that perspective, which Roebling sees before the two cities build upward and obscure it. The bridge's function of linking Brooklyn and Manhattan is obvious. It appears to fix the two shores and keep the cities from drifting apart. The East River is busier and faster moving than when work began. Perceptions of the building process will differ in decades ahead, with some seeing greed and deception, torture and grief.

In April, Roebling is taken by carriage to see the Brooklyn terminal building, the only element he cannot see from his window. Designed by McNulty, it is half-built and noisy. Commuters will eventually buy tickets in ornamental iron booths, climb a broad iron stairway to a cavernous, ornate platform. The cars will be the newest available and appear to be self-propelled, bulled by hidden steel traction cables. The smokestack for its massive boiler house will become a landmark. Crossing the river will take five minutes and cost 5?. Horse riders will pay the same to use the roadway, as will cattle drivers. Sheep and hog drivers will pay 2?, and pedestrians on the promenade will pay 1?. However, Kingsley is lobbying in Albany to make it free. Roebling does not get out of his carriage. Not once in 14 years does he set foot on the bridge.

Roebling gives full attention to details of the terminal buildings. The United States Illuminating Company gets the $18,000 contract for 70 arc lamps, cheaper and superior to Edison's product, Roebling believes. The dynamos powering the lamps are housed in the Brooklyn terminal, and frighten reporters by their size and speed. The Great Bridge is the first use of electric light over a river. Emily visits the bridge regularly, communicating between the Chief Engineer and his assistants. She settles some questions on the spot and no one doubts her judgment. The roadway is complete in May, and Emily is allowed to make the first coach ride across, cheered by workers who pause to watch her pass.

A week before the formal opening, Roebling gives another interview, figuring little damage can come of it at this point. Emily receives the *Union* reporter and explains preparations for the festivities and advises him Wash is healthier than he probably supposes. He cannot, however, talk for too long without being debilitated. The Colonel will not take part in the ceremonies, which will be too exciting, but will take part in a reception at the home. She hands him Tiffany invitations that depict Roebling as victor and the bridge "in perfect detail." Emily doubts Wash will undertake any other great works, and he has earned a rest. Emily then escorts the reporter upstairs to meet her husband. He finds Wash dressed and surrounded by medical phials. He appears to have put on weight, but is pale, and his hair and beard streaked with gray. His steps are uncertain, but he looks robust. Only around the eyes is suffering evident. The trio speaks about locomotives and Pullman cars. Roebling tires, and the reporter prepares to leave. Roebling says there is much big work to do in the world, and does not rule out taking part in it.

New York prepares for the biggest celebration since the opening of the Erie Canal. In Brooklyn, it is known as "The People's Day," with Mayor Low asking schools and businesses to close. The trustees issue 13,000 tickets, 7,000 in pale blue, granting admittance to the bridge, and the rest in white admitting people to ceremonies in the Brooklyn terminal. The itinerary calls for President Arthur, Governor Cleveland, and their parties to walk across from New York, escorted by Mayor Edson. Once over, they'll meet the Brooklyn delegation on the bridge and proceed to the terminal for ceremonies presided over by Stranahan. Kingsley will then present the bridge to the two mayors, Hewitt and Reverend Storrs deliver speeches, and Roebling gives a private reception at his home. Low will give a dinner for the President and Governor. Fireworks and a public reception at the Brooklyn Academy of Music will complete the day. The six battleships of the North Atlantic Squadron anchor off the Battery. All boatmen plan on participating in the festivities. Wharf- and building-owners offer choice space for onlookers. Only militant Irish immigrants are displeased, because the opening falls on Queen Victoria's birthday. Rumors spread they may blow up the bridge.

Roebling favors less hoopla, such as a sign that says, "The Bridge is Open," but the trustees want something grand and begin planning in March. Fireworks worry Roebling, as do soldiers marching in step. A mob out of control after the ceremonies concerns him. Despite precautions, people have been wandering onto the structure for months, including gangs of young toughs. Hewitt dares ask Roebling for help with his speech - examples of great projects in history, tables of wages, and other technical information. Hewitt wants to present the bridge as a symbol of progress. Roebling obliges with tongue-in-cheek remarks about Cheops building his pyramid, which the politicians does not understand, and uses literally in his text. Roebling is happy to send him the names of all the workers and an explanation of their contributions.

Emily is busy with her reception, inviting guests, commissioning a bust and oil painting of her husband, and decorating the house lavishly with flowers and flags. They plan to return to Newport immediately afterwards. The reception is her idea - if the Colonel cannot go to the President and other dignitaries, they can come to him. She books 25 carriages for her entourage, including the Roebling relatives and friends. The mail brings responses to her invitations and a letter from Hewitt (probably) declining to attend, because he is obligated to dine with the mayor. He asks for Mrs. Roebling's full name. On May 19, the dynamos are turned on and riders of the Brooklyn ferry are amazed from 11 PM until midnight to see the bridge illumined.

Part 3, Chapter 24

Part 3, Chapter 24 Summary and Analysis

"The People's Day" chronicles the day they opened the Brooklyn Bridge, ending with story of how a very old lady recalls it in 1969, as two astronauts walk on the moon. The event is also compared with the opening of the Erie Canal in 1825, America's last great engineering accomplishment to achieve such notoriety. We see the Roeblings given their public due, all the battles buried, and most people pleased with this symbol of modernity.

Cloudless skies greet the opening of the bridge. Trains bring 50,000 people from out of town, and many more come by boat. Hotels are sold out. Fifth Ave. and Broadway are festooned in red, white, and blue, for the President's passage. The Chatham St. fence is torn down and the entrance policed. Masses of "rural swains" mix with sophisticated New Yorkers, myriads of children, vendors, pamphleteers, and ticket scalpers. New York municipal institutions do not close officially, but are abandoned. The *Times* sniffs at all the fuss, for no New York will want to go to Brooklyn. No one knows who begins the urban legend of selling the Brooklyn Bridge. Fulton St. too is decked out for celebration and resurrects old boasts of the bridge being the modern hanging garden, pyramid, Acropolis, and Athenaeum. The Low and Roebling homes, the two places the President will visit, are elaborately decorated. The river is filled with diverse watercraft. The ferries run regularly, with people apparently figuring they offer the best vantage point and ride endlessly. Police control 10,000 people crowding the streets near the terminal. At 12:40, troops form up to lead 200 officials, trustees, and special guests onto the bridge.

Four living ex-Presidents had attended the opening of the Erie Canal in 1825, but on May 24, 1883, Chester A. Arthur is the sole attraction. Gov. Cleveland and Congressman Hewitt are there, but are no real rivals. Arthur is a New Yorker and fully presidential-looking, striding along on Edson's arm. Carriages convey the dignitaries to City Hall, whence they walk across the bridge promenade. Thousands of ticket-holders watch from the bridge surface. A lone photographer records events from the New York tower. Troops halt and part for the President just before the tower, and Kinsey greets him to the tune of "Hail to the Chief." Guns boom across the harbor as the walk resumes. Low and his welcoming committee wait beneath the opposite tower. Because of the bridge's arc, the dignitaries come gradually into view, from the head down. As Low welcomes the President, the *Tennessee*, and the whole fleet fires a salute, bells ring, people cheer, and the band plays the presidential anthem repeatedly. In the terminal, 6,000 people greet Arthur enthusiastically. Stranahan calls for order, and Bp. An. N. Littlejohn offers a prayer. All afternoon speeches drag on as ordinary people walk back and forth across the bridge in a holiday spirit. What everyone is celebrating is variously interpreted, but the key words are science, commerce, and courage. Acoustics are so bad few hear the speeches by Kinsley, Low, and Edson. Jules Levy, a cornet player refuses to quit performing for a long while. Hewitt addresses a tired, restless audience, before Rev. Storrs takes the stage for nearly an hour. The President and

Governor are guests, not expected or allowed to speak. Hewitt's speech is the best of his life, and he later publishes it as a pamphlet to use in a campaign for mayor. He acknowledges the genius of John and Washington Roebling, praises the assistant engineers and others involved, and talks about the bridge being a vindication of industrialism, labor, capital, and democracy. Low extols its beauty, which offers hope for the future of mankind.

Roebling watches from his window, until the procession disappears. He rests, until Emily arrives to get things ready. Arthur arrives, congratulates his hosts, and stays an hour, enjoying himself immensely. Roebling needs to rest, when the President leaves, and the 1,000 guests trickle out within hours. People watch the sun set over New York, and the bridge lights come on. The streets look like a great carnival. A solitary rocket shoots up from the mayor's house, where the President is dining, signaling the bridge lights should be extinguished, before 14 tons of fireworks, or 10,000 individual pieces, are set off. Every boat joins in the noisemaking. When the manmade illumination ends, the moon rises slowly in a dramatic benediction. Arthur remains in top form, enduring the long public reception line, admitting Brooklyn is "quite a town." Huge crowds gather at both ends of the bridge for a midnight stroll. Police need clubs to control the violent rush on the tollbooths. Many "firsts" are recorded. No one knows how late the Roeblings watch, or what goes through their minds

Epilogue

Epilogue Summary and Analysis

The epilogue summarizes fifty years of bridge craze. There were the strollers, the deadly Memorial Day stampede that Roebling had feared inevitable, and the jumpers, including Steve Brodie, who later stars in the play, *On the Bowery,* that features a leap. Martin becomes Chief Engineer in 1883 and remains on the job until 1902, managing 201 full-time employees. The ferries continue to run until 1942. The Bridge becomes a world-famous symbol of faith that mountains can be moved. Generations grow up in New York and Brooklyn loving the Bridge from childhood through courtship. Tourists have to photograph it. It is featured in novels, paintings, and lithographs, films, advertising, poetry, and songs. Its place in architecture, engineering, and sociology are debated for decades. It marks the beginning of modern New York, and the end of old Brooklyn, delivering the hoped-for economic stimulation.

Additional bridges are built across the East River and more than a dozen tunnels are dug below it. In 1898, Brooklyn becomes a borough of New York, and by 1930 surpasses it in population. Most move in from elsewhere, and Brooklyn becomes synonymous with things the Roeblings would not recognize. The George Washington Bridge across the Hudson is twice as long as the Brooklyn Bridge, and the Golden Gate Bridge in San Francisco greater still. There is talk of tearing down the antique Brooklyn Bridge. In 1944, elevated trains stop running across it, and the terminals are dismantled. After two years of studies on what to do with it, the Brooklyn Bridge is painted.

Wash Roebling lives incredibly until 1926. He keeps in touch with his former assistants as they go on to other projects. While son John studies at RPI, Wash and Emily live in Troy, and while Wash suffers relapses of pain and cramps, his health generally improves. Emily plans a Tudor mansion for them in Trenton, where John goes to work in the mill. Emily becomes a socialite, earns a degree, writes a book, and travels widely, including Russia where she attends the tsar's coronation. Roebling remains in semi-seclusion, absorbed in his hobbies, writing a biography of his father (unfortunately lost), sometimes travels with Emily, reads, invests wisely in the stock market, and keeps an eye on the wire business. Relations with his brothers sour, when Wash blocks sale of the corporation to U.S. Steel. He is close to John, who does not measure up on the job and is retired, as Eddie had been years before. Emily's eyes begin to fail, and in 1902 is confined to bed ostensibly for ulcers, while Wash recuperates from surgery. She plans on taking the cure at Sharon Springs, NY, but dies at home of cancer on Feb. 28, 1903. She is buried at Cold Spring. Wash is too weak to make the trip.

Wash lives alone for five years as a widower and watches the wire business supply the great projects of the world. His estate grows to $29 million. He plans and supervises building of Kinkora, NJ, a new mill complex that extends John Roebling's ideals at Saxonburg. Father's memory looms large, and he comes to terms with people who cannot figure out which of them build the Brooklyn Bridge. To everyone's surprise, Wash

remarries a young widow, Cornelia Witsell Farrow, of Charleston, SC, and she helps him take a less gloomy view of things. He loses his nephew and namesake on the *Titanic* in 1912, riles at the passage of income tax in 1913, and shudders at the fate of mankind as World War I begins in 1914. He continues writing John and taking solitary walks. Trenton relishes in his "oddities." People stop him to talk, uncomfortably, on the street, and he becomes known as a soft touch. A disreputable-looking Airdale, "Billy Sunday," becomes his walking companion. F.W. dies in 1917 and Charles a year later, Within three years, F.W.'s son, Karl, dies. The corporation turns to its 84-year-old founder to take over. He runs it for five prosperous years, learning every facet of the business and new technologies. He tells a reporter one cannot desert one's job or slink out of what life lays on you. In 1924, he writes a detailed account of Saxonburg. Trenton modernizes, to Wash's disappointment. By the spring of 1926, Wash's health is declining. He is again wracked with pain and longs for peace. His brain stays active to the end. He dies peacefully on July 21, 1926.

Only the Cincinnati Bridge and an aqueduct at Port Jervis, NY, survive to show John A. Roebling's legacy. His Saxonburg house and church stand. John A. Roebling's Sons has been sold. Wash's homes in Trenton and Brooklyn are torn down, his mineral collection is in the Smithsonian, and his body lies beside Emily in Cold Spring, with no statues. The Brooklyn Bridge is remodeled several times to accommodate cars but has changed visually very little. In 1964, it is put on the National Historic Landmark lit, and still carries enormous traffic. Bronze plaques on the towers list the male builders. Emily is later honored with plagues, as well. Manhattan now dwarfs the tower, but they remain unique. Engineers believe the bridge will last another hundred years if properly maintained, Perhaps it will last forever.

Characters

John Augustus Roebling

Col. Washington ("Wash") Roebling

Emily Warren Roebling

Col. Julius Adams

Horatio Allen

Demas Barnes

Francis Collingwood, Jr.

James Buchanan Eads

Charles Ellet, Jr.

E. F. Farrington

J. Lloyd Haigh

Abram N. Hewitt

Wilhelm Hildenbrand

William C. Kingsley

Thomas Kinsella

James Pugh Kirkwood

Benjamin Henry Latrobe

Seth Low

Charles Cyril ("C. C.") Martin

William Jarvis McAlpine

George McNulty

Henry Murphy

William Paine

Thomas Pope

Charles Roebling

Ferdinand ("F.W.") Roebling

Henry Slocum

Andrew H. Smith

William Tweed

Gouverneur Kemble (G. K.) Warren

Charles Young

Objects/Places

Allegheny River Bridge

John A. Roebling's first real bridge and great showpiece, one of the handsomest bridges in America, is completed in 1860, 11 years after his first aqueduct project in Pittsburgh. PA. The opportunity comes, when much of the city burns to the ground. His son, Washington, just graduated from college, assists on the 1,030 feet long structure, consisting of four spans supported by four cables hung from six highly ornamental iron towers decorated and braced by latticework and topped by spires. The cables are "spun" in place, unlike Roebling's previous endeavors, the technique he proposes for the Great Bridge. The Allegheny River Bridge is the first stop on the Bridge Tour.

New York Bridge Company

The New York Bridge Company is a private company, chartered by the New York Assembly in 1867. It calls for spanning the East River by 1879, and operating it thereafter. The cities have no say in where it will be located or what form it will take. Roebling is named engineer, by whom or on what criteria is unknown, and in September, he presents a master plan. On June 5 1874, the New York Assembly dissolves the old company and turns the project into a public work. Brooklyn bears two-thirds of the cost and New York one-third. Private stockholders are reimbursed with interest, and their title extinguished. The old management survives. The two cities own the "New York and Brooklyn Bridge" and pick the trustees, including their mayors and comptrollers *ex officio*.

Niagara Falls Bridge

Roebling's masterpiece, the Niagara Falls Bridge spanning the great gorge precedes the Cincinnati and Allegheny bridges, but is saved for last on the Bridge Tour because of its grandeur. The two-level International Suspension Bridge trembles terrifyingly in heavy traffic. At 825 feet, it is not exceptional in length, and its towers are half the height of Cincinnati's.

Ohio River Bridge

John A. Roebling's graceful arc across the Ohio River from Cincinnati, OH, to Covington, KY, is close in every way to the Great Bridge, but smaller. The "Biggest Bridge in the World," when it opens in 1866, the Ohio version employs diagonal stays joining the floor and towers to improve stability of the horizontal roadbed. Roebling plans it in 1846, but is forced to close down work by the Panic of 1857, leaving the towers half-finished. Roebling resumes work after the Civil War as a sign of his faith in the future political integrity of the nation, and names son Washington Assistant Engineer

after his discharge from the Union Army. The ten-year project costs double the original estimate, but no one complains, as it is a structural and architectural triumph. Cincinnati is the second stop on the Bridge Tour.

Pneumatic Caissons

Caisson in French means "chest," and pneumatic refers to the use of compressed air to maintain buoyancy against the weight of the enormous structures. Europeans pioneer sinking them into river bottoms to serve as the foundations for bridge superstructures. During excavation, they serve as diving bells for construction crews who burrow the structures ever deeper, until they hit a firm footing. Excavations then stop, the interior is filled with concrete, and building the superstructure commences. Components include the air lock, invented in 1831 by Lord Thomas Cochrane, to transfer workers. James Eads in St. Louis is using caissons far larger than the Europeans have dared and is ahead of Roebling in getting one into the water, but Roebling's will be triple the size he is using, and the New York one will have to go far deeper than ever attempted. The Brooklyn caisson that begins being built at Web & Bell in 1869, is 168 X 102 X 14.5 feet. Caisson users everywhere discover that as depth increases workers develop perplexing and occasionally fatal maladies called "caisson fever," or "the bends."

Rensselaer Polytechnic Institute (RPI)

America's first school of "theoretical and practical science," founded in Troy, NY, by Stephen Van Rensselaer, is the alma mater of Washington (and Charles) Roebling and his top aids, Francis Collingwood, Jr., and C. C. Martin. It offers a full range of demanding courses in civil engineering emphasizing rote memorization of unusable knowledge.

Rink Committee

A body of several hundred reform-minded Brooklynites that organizes in the autumn of 1872 to look into corruption, as New York's Committee of Fifty already has successfully. It is so called, because they first organize in the Brooklyn Skating Rink. Failing to find corruption in several institutions, the Rink Committee focuses on Tweed, Smith, Connolly, and Sweeny's presence on the Bridge Board and on Kingsley's business practices and "connections." Kingsley says the Tweed Ring is infinitely better than the scoundrels sitting on the Rink Committee, seeking to hold back the people's bridge to benefit the landed gentry of Brooklyn.

John A. Roebling's Sons

The Trenton-based wire rope company left to Washington and Ferdinand and Charles Swan upon John's death, John A. Roeblings' Sons incorporates in 1876, with Washington as President, Ferdinand as secretary/treasure, and Swan convinced to

retire. Their grounds cover 14 acres, where 350 workers in five rolling mills produce 75% of the wire rope made in the U.S. - some 450 miles a day. It is naturally expected they will provide the wire for the Great Bridge. When Hewitt gets the trustees to exclude anyone connected with the project from bidding on materials, Roebling in sells his 300 shares of stock in John A. Roebling's Sons to eliminate the conflict of interest. Murphy acknowledges the company may bid.

Web & Bell Company

The shipbuilding firm contracted to build the great caissons that serve as foundations for the Great Bridge, Web & Bell are located upstream at Greenpoint, NY.

Themes

Progress

The Great Bridge is set in the Age of Progress and throughout its pages is woven the conviction that after the senseless suffering and destruction of the Civil War, the United States must dedicate itself to peaceful pursuits for the good of mankind. We see antebellum precedents in the Erie Canal, the beginnings of a transcontinental railroad, the slow development of the theories and methods of suspension building. John A. Augustus has his roots in German engineering and Hegel's emphasis on thinking independently and relying on the validity of one's own conclusions. He discovers a better way of hauling canal boats over the Alleghenies, begins growing a fortune on metal wire, and repeatedly shows he is the master of building long, beautiful bridges. Brooklyn sees its proximity to Manhattan as a means to great economic and population progress, if a Great Bridge can be built.

There are people who more conservative solutions are not better and cheaper, and Roebling's solid reputation does not exempt him from criticism, but he convinces engineers and politicians that he can make it work. His sudden death throws his technically prepared but politically inexperienced son, Washington, into the Chief Engineer's seat. He has seen caissons used in Europe but has never built or used one. He does both.

Being crippled by "the bends," Wash nearly loses the job, and politics come close to leaving the towers monuments to human folly rather than progress, but Wash will not give in. He advances his father's designs for cables and superstructure, whose value are repeatedly demonstrated by the deadly failure of poorly engineered bridges worldwide, and the Great Bridge is completed. The Roeblings display their wire at the Centennial Exposition in Philadelphia in 1876, and the pages given to the event (counterbalanced by the massacre at Little Bighorn) point out the spirit of the Age of Progress. The grand opening celebration, including turning on electrical lights along the length of the span, demonstrates that human beings in the late 19th century have learned not just to conquer nature, but also to enhance its beauty. People are willing to pay the frightful cost in money and lives that progress seems to demand.

Fraud

Brooklyn and New York are eager to see a bridge between them, because they see economic benefits accruing. Albany is run by money and no one would expect that politicians and financiers would not expect to make a profit on their endeavors. In New York, William Tweed and his cronies make a fortune on municipal construction projects, drawing them out, over billing on manpower and material, and Brooklyn's bosses, Murphy and McLaughlin, if less dramatic, are adept at controlling things to their benefit.

Murphy's charter for the New York Bridge Company is not seen at the time as an invitation to steal, but it turns out to be, once honest John A. Roebling dies and is succeeded by his son as Chief Engineer. Boss Tweed begins showing at least limited interest in his job on the board of directors, notably when Kingsley's financial well being is at stake. Tweed's sudden fall ushers in an era of moralistic reform, which concentrates on changing the Bridge Company from a private company to a public one, subject to strict due diligence. At this point, Brooklyn politicians want the local economy to profit on the sale of wire for the cables rather than Trenton, NJ, where the Roeblings are located. Reform-minded Congressman Hewitt threatens to foreclose on J. Lloyd Haigh's mortgage, unless he bids on the contract. Behind closed doors and with no records kept, after failing to make conflict-of-interest charges Roeblings stick, the Executive Committee gives Haigh a contract that yields $300,000 in illegitimate profits (Hewitt is supposed get 10% of Haigh's earnings) by shipping defective steel to the worksite. Press attitudes are linked to the prevailing political atmosphere at a given time, and are generally ineffectual.

Ingenuity

The Great Bridge repeatedly emphasizes the value of individual ingenuity. Many of the major characters enjoy top-notch technical educations, John A. Roebling at the Berlin Polytechnic Institute and Washington Roebling at the Rensselaer Polytechnic Institute (RPI) America's first school of "theoretical and practical science," which offers a full range of demanding courses in civil engineering but stultifies students' minds by demanding the rote memorization of unusable knowledge. Nevertheless, Wash draws his top aids, Francis Collingwood, Jr., and C. C. Martin from among its alumni. Without formal training in engineering, however, men of ingenuity can build bridges in the late 19th century, best shown by Roebling's rival in St. Louis, James Eads. Engineers are jealous of one another, hoarding their discoveries rather than publishing (and licensing) them as in later times.

Before John Roebling only small-scale use of suspension construction has been tried, and he must figure out and try every major aspect. Europeans have been experimenting with pneumatic caissons as bridge footings before Eads and Roebling, but they work out the myriad practical problems on the job, including treating "the bends" other than by waiting for symptoms to go away. No one has laid up cables as complex as Wash Roebling's design or build an all-steel superstructure. The Chief Engineer repeatedly weighs arguments and makes decisions that could prove disastrous. His inexperienced assistant engineers learn to cope with a variety of situations. Perhaps the most remarkable example of ingenuity is Wash trusting his wife Emily to serve as his intermediary with the project and the world, after he is crippled with the bends. In a completely male-dominated business and era, Emily masters suspension construction and earns professionals' respect, and is rightfully honored as the Great Bridge comes to completion.

Style

Perspective

Pittsburgh-born, Yale-educated David McCullough is fond of the writing about the Age of Progress following the American Civil War. He is attracted to the great persons who dream up massive projects for the benefit of humanity and of the common people who work, suffer, and die making the dreams come true. John, Washington, and Emily Roebling, to whom the Great Bridge owes its existence, live in Brooklyn myth but have never before been studied systematically.

Having lived in Brooklyn, McCullough is sentimental about the great landmark, whose construction overlaps the period of another project to which he devotes a monograph, the Panama Canal. In his "Author's Note," McCullough admits he has no engineering background but says he does not shy away from dealing with technological matters, and the portions require several readings. In this book, as in general, McCullough writes history for everyday readers, helping them hear, taste, and feel what it is like to live and work in a given period. In *The Great Bridge,* McCullough succeeds admirably in bringing out the seesaw of enthusiasm and doubt, the political ins and outs, and the courage, compassion, and heartlessness that all lie behind the Great Bridge.

Tone

The Great Bridge presents history in an objective manner, but so obviously identifies with the idealism and sufferings of the chief characters, Chief Engineers John A. and Washington Roebling, and the younger Roebling's engaging wife Emily, that the reader, too, is drawn to them emotionally and pulls for them in their adversities. The two Roebling males are quite different personalities, and this is brought out in such a way that neither is idealized nor demonized, but they are set into a tension with a constant undertone of "what if?" Politicians and lawyers abound, but all - even Boss Tweed - are given redeeming features, even if the net effect is to be put off by greed and scheming. The laborers' lives are brought out a bit less vividly and individually than in most McCullough histories, but their situation is engaging. McCullough pauses several times to help us see our modern world taking shape. Steam and electricity come of age, and petroleum is just over the horizon. Bridges and railroads are remaking America. The frontier is gone, faith and doubt are coming into conflict, but moralism runs high. Machine politics fall on bad days, but even reformers understand self-interest. Journalists are fickle cheerleaders. Engineers just do their jobs, overcoming unexpected difficulties. Readers of *The Great Bridge* gets the feeling of an intriguing age.

Structure

The Great Bridge consists of 24 chapters, divided into three parts, an Epilogue and a brief Author's Note. Part 1, in seven chapters sets up why Brooklyn and Manhattan

would want a bridge built between them, how the Roeblings are brought in to direct the project, who they are and how they differ. Chapter 1 begins at the end of the planning phase. The following chapters fill in rich details on people, places and events. In seven chapters, Part 2 deals with sinking pneumatic caissons to serve as platforms for the great Gothic towers that make the Brooklyn Bridge distinctive. "The bends" are brought up several times, tantalizingly, with the last discussion being the definitive one. The fall of Boss Tweed in New York creates an atmosphere of political distrust that plays out in the next two parts.

The five chapters of Part 3 concentrate on stringing the cables that support the bridge's weight. It includes both technical material and dramatic high wire performances. Political pressure continues to rise over Washington Roebling's absentee management. Part 4 in five chapters brings the conflicts to a climax, finally turns Emily Roebling into a living character, and helps the reader feel part of the crowds that celebrate the Great Bridge's opening day. The Epilogue ties up loose ends on the Bridge's later history and the fates of the major characters. The Appendix, providing vital statistics and a chronology are useful, and some of the illustrations are vitally important in understanding technical discussions. A few more would have been useful, and readers may want to query the Internet about spinning suspension bridges. Except for Chapter 1, intended to set the mood dramatically, and 2, 7, and 21, dedicated to the early lives of John, Washington, and Emily Roebling, the story unfolds chronologically. McCullough is adept at segueing between subjects to tell an easy-flowing story.

Quotes

"At an earlier stage it had been referred to occasionally as the Empire Bridge, but the organization incorporated to build it was called the New York Bridge Company, because the Brooklyn people behind the idea saw it as just that - a bridge to New York. Roebling, on the other hand, had referred to it as the East River Bridge in his proposal, and the newspapers and magazines had picked up the name. But it was also commonly called the Roebling Bridge or the Brooklyn Bridge or simply the Great Bridge, which looked the most impressive in print and to many seemed the most fitting name of all, once they grasped what exactly Roebling was planning to do." Part 1, Chapter 1, pg. 25.

"But the bridge seemed to make the whole breath-taking panorama all the more terrifying, all the more magnificent. It was one of those occasions when the hand of man had enhanced that already wrought by the hand of God." Part 1, Chapter 3, pg. 73.

"At first he had become extremely restless, complaining of savage headaches. But presently he began having trouble swallowing. After that there was no mistaking what was wrong with him. The muscles around his face, neck, and jaws grew rigid as iron. Within a day or so his eyebrows were permanently fixed in a raised position and his mouth was pulled back in a terrible grimace, the teeth all showing and locked tight. He was unable to eat anything solid, or to talk, but he kept scribbling notes to Washington and the others attending him, instructing them on his proper care." Part 1, Chapter 4, pg. 92.

"'Now, how did you expect to be benefited by becoming one of the subscribers to this bridge?' Tweeds interrogator asked. Tweed answered with two sentences, the second of which is a classic sample of his gift for understatement. "'I expected,' Tweed said, 'that when the bridge was built by the citizens of New York and Brooklyn, and with their money, it would be a well-paying dividend stock. Then we expected to get employment for a great many laborers and an expenditure of the money for the different articles required to build the bridge.'" Part 1, Chapter 6, pgs. 132-133.

"The question of flooding the caisson came up. To put the fire out some less drastic, simpler way would be immensely preferable, Roebling said, but If they were to find that the fire was not out, as it appeared to be, then, he said, it was only a matter of time, until the entire foundation would be destroyed. The fire would at through the immense pine roof like a hidden cancer, destroying one course of timber after another, until the structure was so weakened that the vast weight overhead (now at 28,000 tons, Roebling calculated) would come crashing through." Part 2, Chapter 10, pg. 234.

"But since such arrangements had been shown to be the common practice of the Tweed Ring, a great many people, rightly or not, would conclude that that was just what Kingsley had agreed to. Moreover, it would also be pointed out that buying bridge stock by installments, 10 per cent at a time, which was all that was required and what Kingsley and most stockholders were doing, then drawing 15 per cent on several million

dollars in expenditures, was a most attractive proposition from a business point of view." Part 2, Chapter 11, pg. 265.

"Attached to this initial statement was a long accounting of expenses to date and a detailed explanation of why the bridge was costing more than had been anticipated - and could not therefore be completed for the sum John Roebling had set. The presentation was so very thorough, so concise and solid, hat it was obvious that more than four days had gone into its preparation. Clearly Roebling had been ready in advance for just such an accounting. Quite likely he had even welcomed the opportunity." Part 2, Chapter 12, pg. 274.

"The massive, freestanding masonry tower rising at the edge of Brooklyn was still the only part of the bridge conspicuously on display. Through the whole of that spring, as charges of fraud and jobbery filled the papers and Brooklyn gossiped of bridge scandals, work on the tower had proceeded exactly according to schedule and the immense granite shaft was looked upon popularly as an irrefutable affirmation of all that had been promised and anticipated over the past several years. One look at something like this was enough to restore a person's faith in what man could do and to make crooked bookkeeping and the life seem both terribly petty and no more than a temporary nuisance." Part 2, Chapter 13, pg. 290.

"Since McNulty, along with each of the other assistant engineers had had no previous experience building suspension bridges, every step after the stonework was a new one and there might have been costly delays or mistakes had it not been for Roebling's extraordinary written communications and for Master Mechanic E. F. Farrington, the one and only man among them who had ever worked with wire before." Part 3, Chapter 15, pg. 332.

"His knowledge of everything happening at the bridge, his total confidence about how each successive step ought to be taken, the infinite, painstaking care he took, seemed absolutely uncanny to the others back in Brooklyn. Had his communications on technical matters alone been written by a healthy man who was regularly on the scene, they would have been regarded as exceptional. But the idea that they were emanating from a sickroom sixty miles away seemed almost beyond belief." Part 3, Chapter 16, pg. 341.

"Then he wrote: 'In conclusion I beg to assure Captain Eads that I feel perfectly competent to take care of the East River Bridge, and to overcome dangers and difficulties of which he has but little conception. ... all of the St. Louis caissons together can find room in one of the East River caissons, with space enough left for several more like them. ... And where would you go to find an easier material to sink through than at St. Louis, or a more difficult one than in the East River?" Part 3, Chapter 16, pg. 345.

"No sooner was the footbridge in operation than the newspapers sent reporters to make the crossing, which a few of them managed to do, with Farrington going along each time as an escort. His own men were never bothered by great heights, he was quoted as saying, 'No sir, no man can be a bridgebuilder who must educated his nerves. It must be

a constitutional gift. He cannot when 200 feet in the air, use his brain to keep his hand steady. He needs it all to make his delicate and difficult work secure. They must plant their feet by instinct.'" Part 3, Chapter 19, pg. 397.

"It was all over in an instant. Farrington, who had been knocked down by something, but not hurt, looked about to find that only the jagged ends of the fall rope remained. Blake was dead. McGrath and Arberg were bleeding badly and clearly in terrible pain. The remainder of the rope, the pulleys, and the strand had disappeared. And so had Harry Supple." Part 3, Chapter 20, pg. 439.

"All kinds of intriguing stories were going about. It was said Roebling had been shipped off to Newport against his will, that he himself had nothing to hide but Stranahan, Murphy, and Kingsley dared not let him be questioned by the others. Roebling knew too much about the original contracts, it was said. He was the one man who could tell the story from beginning to end. "There was another rumor that he had become hopelessly paralyzed by this time and that the trustees certainly did not want this known. It was said that he lost all control over his mind, that he was raving mad, that he was 'really as one dead,' that his wife, without anybody knowing it, had been deciding everything, directing the entire work for months. Soon most of the papers were saying as much." Part 3, Chapter 22, pg. 486.

"But it was the finished span between them that made the towers seem so much more important and purposeful than ever before. It was the finished roadway, arching slowly, gracefully upward over the river to meet at the center with the great downward swoop of the cables, that made it a suspension bridge at last - and the greatest on earth. And finally, now, the diagonal stays were in place, hundreds of them, radiating down from the tower tops, angling across the vertical harp-strung pattern of the suspenders, and forming what, at close range, looked like a powerful steel net, or, from a distance, as Roebling saw it, like a vast, finespun web. The bridge now, as never before, was a thrilling thing to see." Part 3, Chapter 23, pg. 511.

"There were busts of both the Chief engineer and his father standing on one drawing -room mantle. On the elder Roebling's white marble head Emily had placed a wreath of immortelles, while the one of her husband wore a laurel wreath decorated with tiny American flags and a white satin ribbon on which she had printed in red and blue: 'Chief Engineer Washington a. Roebling, May 24, 1883. Brooklyn Bridge. Let him who has won it bear the palm.'" Part 3, Chapter 24, pg. 537.

Topics for Discussion

Which Roebling is most responsible for the success of the Great Bridge? Why?

How do John A. Roebling's mystical beliefs affect the Great Bridge?

What Civil War event most affects Washington Roebling?

How might things have been different if Washington Roebling had not gotten the bends?

What most inspires Brooklynites about the Great Bridge?

How does Boss Tweed affect the Great Bridge?

Why is the New York Bridge Company charter so liable to corruption?

Why is the Brooklyn Bridge so iconic in American life?