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OF

HENRY LARCOM ABBOT

1831-1927

BY

CHARLES GREELEY ABBOT

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Henry L. Abbot

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Chapter I

Ancestry

Henry Larcom Abbot, Brigadier General, Corps of Engineers, U. S. Army, member of the National Academy of Sciences, was born at Beverly, Essex County, Massachusetts, August 13, 1831. He died on October 1, 1927, at Cambridge, Massachusetts, aged 96 years. He traced his descent in the male line from George Abbot, said to be a native of Yorkshire, England, who settled at Andover, Massachusetts, in the year 1642. Through early intermarriage, this line is closely connected with that of the descendants of George Abbott of Rowley, Essex County, Massachusetts.

The Abbots of Andover were farmers, highly respected by their townsmen, and often intrusted with elective office in town, church, and school affairs. In the fifth generation, descended through John, eldest son of George Abbot of Andover,[1] Abiel Abbot, a great-grandfather of General Abbot, removed from Andover to settle in Wilton, Hillsborough County, New Hampshire, in the year 1763. He made his farm from the wilderness on "Abbot Hill" in the southern part of the township. Having cleared two acres and built a two-story house and barn, he married Dorcas Abbot and moved into the house with his bride before the doors were hung, in November, 1764. They had thirteen children, of whom the fourth, Ezra Abbot, born February 8, 1772, was grandfather to our propositus. Among other children were:

Reverend Abiel[2] Abbot of Peterborough, New Hampshire,

[1] The eminent family of authors, clergymen, and lawyers which includes Rev. Jacob Abbott, John S. C. Abbott, Rev. Lyman Abbott, Benjamin Vaughan Abbot, and others, descends through Nathaniel, twelfth child of George Abbot of Andover.

[2] Without vouching for the authority, which is that of a newspaper question corner, I venture to insert the following:

Q. Where is the oldest free public library in this country?

A. The town library of Peterborough, N. H., formed through the efforts of the Rev. Abiel Abbot in 1833, appears to have been the first free library which has continued to the present day.

of whom his grandson says that at ninety-three years old "he made it a point to read every day two chapters of the New Testament, critically, in the original Greek," and of whom a biographer says "it would be difficult to say what his faults in life were, he was so pure and upright in everything";

Reverend Jacob Abbot of Hampton Falls, New Hampshire, for many years a trustee of Phillips Exeter Academy and of the Adams Female Academy of Derry, New Hampshire;

Rhoda Abbot, who married Ephraim Peabody of Wilton, whose son, the Reverend Ephraim Peabody, was for eleven years pastor of King's Chapel, Boston, and whose granddaughter, Ellen Derby Peabody, married President Charles William Eliot of Harvard University;

Samuel Abbot, who, as a partner with his brother Ezra, invented the machinery for the manufacture of potato starch, in which they developed a large business;

Phebe Abbot, who married Ezra Abbot of Jackson, Maine, whose son Reverend Ezra Abbot of Cambridge, Massachusetts, attained so great distinction as a biblical student that the New York "Nation" says of him: "By the death of Ezra Abbot, the science of the New Testament criticism has lost one of the foremost scholars of this generation. . . . His loss is a national one, for no scholar ever shed more lustre on the American name."

Abiel Abbot was in continuous public service for the town of Wilton in many elective offices from 1765 to 1805. He was commissioned Captain, New Hampshire Royal Militia, in 1769, but later adhering to the Revolution, reached the rank of 1st Major in the New Hampshire continental militia. Though an officer, yet on emergency he enlisted as a private in a volunteer company of cavalry. He was always spoken of as "Major Abiel Abbot." He served sixteen years as a deacon of the Congregational Church.

Ezra Abbot, son of Major Abiel Abbot, succeeded to the ownership of the farm. He married, October 6, 1799, Rebekah, daughter of Lieutenant Joseph and Rebekah (Harris) Hale of Coventry, Connecticut. She was the niece of Captain

Nathan Hale, "the martyr spy of the Revolution." They had thirteen children, of whom the third, Joseph Hale Abbot, born September 25, 1802, was the father of General Abbot. The eighth child, Harris Abbot, born September 19, 1812, succeeded to the larger part of the farm on which his son, Stanley Harris Abbot, his grandson, Howard Stanley Abbot, and his great-grandson, Richard Hale Abbot, are now living.[3] The tenth, a son, Nelson Abbot, born November 17, 1816, inherited a smaller part of the farm, including the site of the original house, and his daughter Kate Abbot now resides there.

Ezra Abbot, like his father, was constantly engaged in town, school, and church business, serving in many elective offices for forty years. He was always spoken of as "Deacon Ezra Abbot." Becoming financially interested in the manufacture of potato starch for which his brother Samuel invented machinery, they built first a small mill on Deacon Abbot's farm, and later a larger one in connection with a water power about a mile distant in the town of Mason. Through the efforts of Ezra a considerable demand for the product as sizing was built up among the textile mills, so that, starting from nothing in the year 1813, they manufactured 23,000 pounds in 1820, and reached 238,500 pounds in 1829. The business was continued by Deacon Ezra Abbot and by his sons, Harris and Abiel, until about 1852.

Rebekah (Hale) Abbot, the wife of Deacon Ezra Abbot, was a very notable woman. She developed in all her children the love of reading and scholarly attainment. Her daughter, Abby Ann (Abbot) Rockwood, who also was a woman of remarkable character, has often spoken of the family custom of having one member read aloud for the edification of the others while engaged in household tasks. At his death, Deacon Ezra Abbot willed to his wife his library in addition to a sum of money and support during her lifetime from her son, Harris, who inherited the larger part of the farm. She survived her husband thirteen years, dying in 1860, aged 79 years.

[3] The author of this memoir, Charles Greeley Abbot, is the fourth child of Harris Abbot.

Reverend Edward Everett Hale, the eloquent preacher and gifted writer, was closely related to Mrs. Rebekah (Hale) Abbot, she being the niece, he the grand-nephew of Nathan Hale of Revolutionary fame.

Joseph Hale Abbot (1802-1873) father of General Henry Larcom Abbot, studied for college with Reverend Thomas Beede, minister at Wilton, expecting to enter Harvard College. But as accident would have it, a relative, Mr. John Abbott, called at the Abbot home with two sisters on the way to Brunswick, Maine. Having two chaises, another driver was needed, and it was decided that Joseph should go, attend Bowdoin College one year, and go to Cambridge later. He, however, remained and graduated at Bowdoin, standing near the head of his class. After taking graduate work at Harvard, he entered the teaching profession, which he followed with great success almost all of the remainder of his life, sometimes taking private pupils, sometimes teaching in public schools and academies.

Being exceedingly interested in natural philosophy, Professor Abbot was elected, in 1838, Resident Fellow of the American Academy of Arts and Sciences, which he served as secretary, 1850 to 1852. He published several articles on scientific subjects, including one in Silliman's Journal, October, 1840, describing original experiments and explaining the "Pneumatic Paradox" so called. In June, 1848, in Littell's Living Age and in the Atlantic Monthly of June, 1868, he contributed important articles on the controversy relating to the discovery and use of ether as an anesthetic. During the last fifteen years of his life he was laboriously preparing an original work embodying a lifetime of experience in the teaching and study of English grammar, but he did not live to complete it.

As a teacher he won the love, respect, even veneration of his pupils. Of his high character no truer record can be given than the words of his widow, who said: "Intellectual superiority and moral purity—these were the qualities I first required in my maiden ideal of a life companion; and, looking for these in your father, I was never disappointed."

Joseph Hale Abbot married, May 13, 1830, Fanny Ellingwood Larcom (1807-1883) of Beverly, Essex County, Massachusetts. She was the daughter of Captain Henry Larcom, and a granddaughter of Nathan Dane, LL. D., of the Continental Congress 1785-1788, framer of the famous "Ordinance of 1787" and founder of the Dane Professorship of Law at Harvard University.

Mrs. Abbot was a woman of rare charm and a brilliant conversationalist. The present author remembers her visits to his father's home as great occasions in his boyish mind. As in all New England farmsteads of that period it was customary not only for the family and visitors but the farm help as well to sit at table together. On one such occasion, the conversation in which Mrs. Joseph Hale Abbot was carrying her interesting part was much interrupted by a farm-hand named Jackson, who had seen war service, and had traveled with Barnum's circus. The unusual flow of wit spurred him to exalt his experiences which he dilated upon with what is called "the long bow." At last, to quiet him, Uncle Abiel Abbot turned suddenly upon him and said, "Jackson, did you ever see a Gyasticuticus?" Jackson hesitated but an instant and replied, "They had a big one in the circus—" but he got no further for the shout of laughter silenced him for the remainder of the meal, and left the conversation of "Aunt Fanny" its proper opportunity.

In the Atlantic Monthly for August, 1871, Mrs. Abbot published a thrilling account of the shipwreck of her father, Captain Henry Larcom. As it throws much light on the qualities of General Abbot's forbears and of the people they lived among, I quote freely from this account.

In the year 1809, under the First Empire, the French Government confiscated 29 American vessels lying in the harbor of Naples, and among them that which Captain Henry Larcom commanded. After long and fruitless attempts at release, through the efforts of the American consul one ship, with a crew of 15 and 31 passengers, comprising the captains and

others from the seized ships, was permitted to sail from Naples April 10, 1810, on her return home.

All went well till May 20, when, being ten days' sail from American ports, the vessel was capsized in a heavy wind, and the long-boat and yawl both damaged. After cutting away the masts the ship was righted, and one of the captains at great risk succeeded in mending with canvas and lead the hole in the bottom of the long-boat. The vessel's captain and crew got into it, partly provisioned it, took on all the tools, and, as it seemed to the others, in a heartless and cruel way abandoned the ship and left the thirty survivors to perish.

Captain Larcom and another were elected to command those left behind, and they succeeded in getting out food, and in building some protection on the after part of the ship. But heavy weather coming on, all their salvaging operations were stopped, their food was washed away, the vessel partly broken up, and only with great difficulty and danger did they save themselves on the forepart of the ship.

Having no water, fourteen died in one day from the effects of trying to quench their raging thirst with brandy. We continue in the words of Captain Henry Larcom and of Mrs. Fanny (Larcom) Abbot, recalling only that on June 6, 1810, there remained but fifteen of the survivors, of whom five were beyond hope, five preferred to run their chances on the ship, and five formed the company of Captain Larcom. He says:

" 'On the 6th of June the whole of the upper deck was gone, and everything that was between decks had floated out, leaving us without any subsistence, excepting some pork and beef, which it was impossible to eat for want of water. On the 7th of June, finding we could be of no use to those on the wreck, having nothing but brandy to subsist upon, and being then in lat. 39° 12′ N., thinking that too far south for the track of Europeans, we decided, five of us, to trust ourselves to the yawl, and endeavor to stretch northward.

" 'The morning we left the wreck we went under the bowsprit, and joined in prayer with Captain J—— for our deliver-

ance. At ten we bade them a final adieu, taking in the boat about two and one-half gallons of brandy and a little pork. . . .

" '. . . For sixteen days after we left the wreck we had no sustenance, excepting the brandy, of which we took a gill in the course of twenty-four hours. On the night of the 22d of June we had considerable rain, and we caught water enough, by holding up our handkerchiefs and wringing them, to quench our thirst partially, and to save two quarts. On the 23d T——, overcome with fatigue, hunger, and thirst, breathed his last, without a groan. On the same day we observed a number of rudder-fish round the boat, and making a dip-net out of a hoop and some twine, caught plenty, and, after drying them, we ate some of them, being the first food we had taken since leaving the wreck. From this time to the 27th we had several showers, and caught water sufficient nearly to quench our thirst; in which time I had eaten a small quantity of salt pork with some of the fish. But as soon as our water was gone I could eat no more. On the 28th of June L—— died of hunger, thirst, and fatigue. He went out of the world without a struggle or a groan. On the 29th, the boat still leaking so badly as to keep one man constantly baling, there being a heavy sea running, we had the misfortune to lose all our oars and the boat's mast. Having nothing left to steer the boat with, she lying in the trough of the sea, and being in great danger of filling every moment, we lost nearly all our remaining courage. However, we went to work to make a paddle to steer the boat with; by taking the yard from our boat's sail, which was made of the blade of an oar split in two, and seizing it together in its former place, and lashing a strip of board to it for a handle, by this means we kept the boat before the sea.

" 'On the 30th of June, about 3 P. M., the boat being half full of water, I was looking round between hope and despair, and, to my unspeakable joy, espied a sail to the southeast, which, after looking some time, I thought was standing from us. In about ten minutes I observed she was standing on the wind to the north-northwest, and that she would not fetch within two miles of us, we being to windward.

" 'We were now almost in despair, having neither oars nor boat's mast, and Mr. V—— so lame that he could scarcely move himself, but being in the stern of the boat, he took the paddle and kept her before the wind, while Mr. E—— baled the boat, which was leaking very badly. I went to work to rig a sail, and for that purpose took one of the boat's thwarts; and the Lord giving me strength for that effort,—I had very little natural strength left,—I split the thwart over the stern of the boat, seized it together, and made a mast six feet long; with a piece of board I made a yard; and in about ten minutes got a sail set, and was running before the wind to forelay the vessel. About four o'clock P. M., having run about two miles to leeward, we came alongside the vessel, which proved to be the General J—— of G——, from Lisbon, commanded by Captain S—— L. D——, who received us on board, and treated us with the tenderness of a brother while we remained with him. . . .' "

"My father lived fifty-two years after these events occurred, but he never could discuss them without an effort. Indeed, after he was eighty years of age, I have known him to lose a meal if this subject became a topic of conversation at table.

. . .

"I remember hearing that, after the long-boat left them, my father was one day attempting to take an observation, when one of the men, suddenly becoming deranged, as several of them did before death ended their sufferings, rushed at him and knocked off his hat into the water. At this time the heat of the sun was very oppressive, and for a few hours he felt the loss very painfully; but at length it so happened that his own trunk, with the lid off, was 'washed up from the hold, and floated within reach.' It contained many valuable things carefully collected by him, but he said he thought only of securing something to protect his head. As it floated past him he caught at a bright-colored cashmere shawl lying upon the top; this he folded in a way to answer his purpose, and this he kept on his head until he was taken from the boat.

"I have this shawl in my possession now; faded with its exposure then to the sun and salt water, and stained where the

beloved head rested on the salt pork, which, when the parched mouths could no longer eat it, was used as a pillow in the boat. I have also a portion of a blue bandanna handkerchief which he held up to catch the precious drops of rain, and wrung into a small wooden box, with which they baled the boat, to slake his thirst. Of this handkerchief he finally made the 'signal,' which caught the eye of the sailor, who had been 'sent to the masthead to look out,' and who reported to Captain D—— upon the deck, 'I see a sail, sir, at a great distance,' and being ordered to 'look again,' shouted, 'it is something almost alongside now.' I have also a piece of tarred line, knotted at the ends, just twenty-one inches long, which was the exact measure of my father about his waist, taken carefully by Captain D—— the day he was received on board his vessel. He was a man rather above ordinary height, and of good proportions when in health. These, to me, precious relics I would have my children preserve after me, as tokens of suffering and privations so manfully borne more than half a century ago, by one who yet lived long enough to gain the love and veneration of them all. . . .

"The account given by Captain D——, of their appearance and condition when first rescued, I have often heard my mother repeat. This kind and good man, looking through his spy-glass from the deck of the vessel, saw *nothing,* but, at the sailor's second report, the mate, looking over the side, saw, almost close to them, an indescribable object. So embrowned and emaciated were these men, almost divested of clothing, which had 'been used strip by strip to calk the boat,' that they had almost lost the semblance of humanity, as they lay,

'With throats unslaked,
With black lips baked,'

unable from debility and emotion to make audible replies to the questions proposed to them. My father attempted to rise and stand *upright* but in so doing lost his balance, and fell between the boat and vessel, but the mate, who was then preparing to leap down to them, caught him, as he touched the water, and

carefully passing a rope around his body, had him tenderly raised and placed safely on the deck of the vessel; and finally, after rescuing E—— in the same manner, the entire boat, with V—— lying in it, was hoisted on board the General J—— by the sympathizing sailors.

"Captain D—— said my father *'asked for nothing,* but at once seemed desirous to attempt *to give an account of himself,* which he did, in a hoarse whisper, but with a mind perfectly collected, and in a very direct and intelligible manner.' . . . I have heard my father say: 'I had *then* no hope of reaching home, and for twenty-four hours did not even inquire if the vessel were *homeward bound;* but I wished my friends to know my story, thanked God devoutly for giving me this chance of sending it to them, and thought, this being done, I could then lie down and die in peace, for I felt that I was *still at the gate of death.*'

"By Captain D——'s unceasing and extremely judicious kindness, however, they were surprisingly recovered in the twenty-one days they passed on board his vessel. . . . They anchored at G—— toward nightfall; and he was so desirous of going home *at once,* that Mr. L——, for many years a well-remembered driver of the stage-coach, then running only twice in a week between G—— and Boston, where several trains of cars now pass and repass daily, offered to drive him, in the most comfortable manner which could then be devised, to B——, and used years afterward to speak of it to the family as 'a peculiar privilege' that he had been allowed to do so. Strength, however, was not yet sufficiently restored to my father's wasted frame to enable him to perform at one effort the whole journey of fourteen miles; and about nine o'clock in the evening he was brought to his mother's house at W—— Beach, being still distant five miles from his own home, and was there received by her and her family 'as one arisen from the grave.'"

Meanwhile what of the home? Already the long-boat survivors had arrived and told their story. Of its effect we learn in Mrs. Abbot's words:

"It was a lovely June morning; its atmosphere comes back to me with all its balmy freshness; so does its midday heat, and its evening shadows; it is the first day I wholly remember.

. . .

"Presently a knock at the street door aroused my mother, and listening a few moments, she distinctly heard a lady who opened it say, 'do let her alone till evening!' 'No,' was a gentleman's reply, 'the children in the street would tell her before she could get ten rods from this door.' While they talked my mother descended the stairs, and with a face like marble, laying her hand firmly on Deacon L——'s arm, said in a strange, hollow voice, 'yes, tell me *now;* I can bear anything, if you do not say *he is dead!*'

"She was then quietly seated in an adjoining parlor, and very gently told that my father had taken passage in the ship M——, for S——, with thirty others, on the 10th of April; that on the 20th of May she had been wrecked in a squall within ten days' sail of home. That fifteen men—but he was not with them—escaped in the long-boat, had been taken up, and brought to Salem, having no hope that any other return could ever be made from the wreck.

"I had slipped into the room, and stood close beside my mother; I did not at all comprehend what had happened, but I was thrilled with the mournful quiet of the scene; and that room, with much of its furniture, and the faces in it, were so engraven on my memory in a few minutes, that though I never entered it again until one year ago, I found a distinct picture of it in my mind with which to compare its altered appearance. My mother uttered not one word, but suffered herself to be dressed and placed in a carriage, and with me seated beside her was driven home. This was about ten o'clock in the morning. She was placed in an easy-chair in her own chamber, where she sat nearly in one position, uttering no word or moan, nor in any way taking notice of the friends who passed in and out or gathered around her until about three o'clock in the afternoon.

. . . . . .

"At sunset her minister and very intimate friend, the good

J—— E——, who had been out of town all day, came in and sat down at her side.

"Being a man of strong sympathies, now deeply moved, he sat for some time, like the friends of Job, and 'spake no word, because he saw that her grief was very great.' Then as he afterward said, 'feeling that her condition was becoming dangerous,' he 'tried this experiment to arouse her.' Taking her hand, he said in a low, distinct voice: 'Sister L——, will you come to the church on Sunday and hear me offer prayer to God for you as a widow, and address the people?' She instantly startled him and all in the chamber by raising her tearless face and exclaiming, 'I have not yet heard that Henry is dead!' And when one near her whispered, 'Poor Child! she has gone crazy!' she added, almost cheerfully, 'God may have prepared a plank to save him, and he may be taken from some rock in the ocean.' And 'at that moment,' as she afterward often said, 'my first ray of hope dawned upon me.'

. . . . . .

"Toward the close of her term of sorrow, having once thrown herself down, as usual toward morning for rest, she dreamed that she was standing at a door of my grandmother's house, from which a wide view of the harbor could be seen; a heavy shower of rain was falling which suddenly ceased, and at once the setting sun lighted up the whole bay. Presently she discovered a plank, with three men upon it, approaching the land; while she looked it 'came ashore,' and the first man who leaped upon the beach was my father. She started to her feet, with a wide-awake assurance that he *was safe*. . . .

". . . In about a week after this time my father was brought to his mother's house, as you may remember, about nine o'clock in the evening. After the first shock of the arrival was over, it was my grandmother's first care to endeavor to have my mother and myself brought to them as soon as possible. And forgetting the hour, on a lonely road, my uncle's wife, with my eldest cousin, then a little girl, ran directly to the house of Captain M——, their nearest neighbor, who yet lived at a considerable distance; knowing that, as he owned a carriage, he would be only too happy to start immediately on this 'errand

of mercy.' Nor did they underrate his kindness. As soon as his chaise could be got in readiness, he set off at once, feeling, as he afterwards said, that he 'could consider what to do when he arrived, as he went along.'

". . . But unfortunately the door was opened to them by a well-meaning but injudicious woman, who acted in the capacity of a servant in the house; and while the gentlemen were communicating to one who followed her some of their facts, she rushed over those stairs, and before Mr. P——, who saw what she aimed at, could overtake her, she had seized the latch of my mother's chamber door, which was locked, and shaking it violently, shouted, 'Miss L——, Miss L——, get up. Your husband's down at the door, alive and well!'

"My poor mother had thrown herself face downward across the foot of her bed in a despairing mood a short time before, and thus had fallen into a troubled sleep. . . . She shrieked, and gathering the bed-cover in her hands, drew it tightly over her head, declaring afterward that, if she had heard that sound again, she must have instantly gone distracted. But in a moment the mild voice of Mr. P—— was heard, saying in a low, soothing, yet perfectly distinct tone, which fell on her ear 'like oil on the troubled waves,' 'No, no, dear. If you could presently open your door, here is Captain M——, who can tell you there is good reason to hope there is some real news of your husband.' This calmed her in an instant, *so much* she could bear to listen to; and in a little time, taking me on her lap, she was seated and quietly listening, while Captain M——, cautiously beginning with the fact that news had arrived of my father, after much suffering, having been taken on board a vessel from a small boat, gradually announced that the vessel was bound to G——, and at length, that it had arrived; that he had been taken to his mother's house that evening; and now, could she prepare herself and me to go to my grandmother's to meet him there?

"She listened like one in a dream, and at last said slowly and mournfully, 'Have you seen him? Are you sure he is living, and can live till I get there?' He replied, 'I have not myself seen him; your mother sent to me, and I came for you without

any delay; but I fully believe him to be living, though probably in a very exhausted condition; he sent for you to come to him.' . . . And now we go out into the open air, and are carefully placed in the chaise. It was near the middle of a hot night in July, and there was a very clear moonlight. . . .

"Not a word was spoken by any one until we came to that remarkable bend in the road, at the top of the hill near M—— Beach where the wide and beautiful ocean view bursts so suddenly upon the gaze; then my mother gently laid her hand on the reins, and said in an imploring tone, 'O Captain M——, do stop here, and turn your horse to carry me home! This *is only a dream;* it must be so; I cannot bear to go on!' With true tact, he instantly stopped the horse, and quietly settling himself into a posture for discussion, replied, 'I do not at all wonder at your doubts; I myself stopped my horse as I was going to your house, and it was just at this turn of the road too, and asked myself, "Am I not dreaming? Am I not on my way to excite hopes in that poor suffering young woman that cannot be realized?" Then I paused and reflected some time, and finally said to myself, "No, I cannot be mistaken; so many persons cannot all have been dreaming; our neighbor and her little niece certainly came to my house at a very late hour for them, and waking my wife and myself, told their story, and returned; then we called up our son, who harnessed the horse, my wife helping me to get ready; we could not all have dreamed."' Still he saw doubt resting on my mother's face; still humoring her mood, he said, 'I think we had better go on till we come toward "Sandy Way," where you know we can see your mother's house at a considerable distance; if it is lighted up at this hour, we will go on; if it is all dark, we will return.' To this she consented, though still unbelieving, saying not another word, until turning a corner they came in full view, though still at a distance, of the western end of the dear old homestead, illuminated even to the garret window. 'Then,' she afterward said, 'I felt assured.' And imagination busied itself, during the remainder of the ride, in picturing 'a wasted form, scarcely able to recognize her, bolstered up in the bed, which it would never again quit alive.' As the chaise drove up the ample green

yard to the front door, my father stood at it, extending his arms to his wife and child. As they received me, my mother fell senseless to the ground, before any one could prevent her fall.

. . . . . .

"We remained a few days at W—— Beach, until my father felt able to return to our own home. Even here . . . for weeks after his return, my mother said that, though he carefully avoided all voluntary allusion to the subject during the day, yet at night, as soon as his eyes were closed in sleep, he would startle her with such ejaculations as 'For God's sake, hail the boat, E——!'

"In after life I often heard persons say to him, 'How could you ever dare to trust yourself at sea again?' To which he would reply, 'I felt ten times more confidence than ever, after being rescued from such dangers.'

"And so it was that, in six months after his return, he sailed for the West Indies."

To Joseph Hale and Fanny E. (Larcom) Abbot was born in Beverly, August 13, 1831, the eldest of seven children, Henry Larcom Abbot. Other progeny of Joseph Hale and Fanny (Larcom) Abbot also showed good parts. The other children were:

Edwin Hale Abbot, 1834-1927
Francis Ellingwood Abbot, 1836-1893
Emily Frances (Abbot) Vaughan, 1839-1899
Captain Edward Stanley Abbot, born 1841, mortally wounded at Gettysburg, July 2, 1863, while leading his company near Little Round Top.
Son, born and died 1844.
William Fitzhale Abbot, 1853-1922

Edwin Hale Abbot, late of Cambridge, Massachusetts; A. M., 1858, and LL.B., 1861, of Harvard University; practiced law in Boston, Milwaukee, and New York; was President of the Wisconsin Central Railway, and director of other railway corporations. He was a man of wide reading and culture as well as of

great business success. His elder son, Philip Stanley Abbot, A.M., LL.B., 1867-1896, was a man of exceptional charm, who took high honors in all activities, social, athletic, and scholastic at Harvard University, but being an expert mountain climber lost his life untimely in the attempted first ascent of Mount Lefroy, Alberta, Canada. The younger son, Edwin Hale Abbot, A.M., LL.B., 1881- ——, is an eminent lawyer.

Francis Ellingwood Abbot, late of Cambridge, Massachusetts, A.M., Ph.D. Harvard, graduated from Meadville (Pennsylvania) Theological School. His researches in philosophy and religion were very profound. Editor of "The Index," 1870-1880, he later taught private pupils and published numerous philosophical articles, and especially two books, the embodiment of his system, entitled "Scientific Theism" (1885), and "The Way Out of Agnosticism" (1890). Of his seven children but three reached adult years. One, Edward Stanley Abbot, A.M., M.D. Harvard, is an eminent specialist in mental diseases.

Emily Frances Abbot married Abiel Abbot Vaughan, a merchant of Cambridge, Massachusetts. She was active in social and church enterprises, and a fine amateur water-color artist.

William Fitzhale Abbot was an able teacher, who for many years had charge of the college preparatory department of the Worcester (Massachusetts) High School. He was Secretary of the American Antiquarian Society, 1885-1891.

Such was the ancestry and immediate family of General Abbot. In his own countenance and character shone out the quiet scholarly life. Though not in the least lacking in social charm, he went little in society, preferring the study, where throughout his life he engaged in research after research, and in the preparation of papers, giving both to the technical and the lay public the results of his investigations. Medium in height and weight, he measured about 5 feet 7 inches, and weighed in health approximately 170 pounds. Considering the following table, his longevity may well be regarded as an inheritance.

Name	*Age at Death*	*Relation to Propositus*
Henry L. Abbot	96	Propositus
Joseph H. Abbot	71	Father
Fanny E. L. Abbot	76	Mother
Henry Larcom	85	Grandfather
Ezra Abbot	75	Grandfather
Rebekah H. Abbot	79	Grandmother
Abiel Abbot	68	Great-grandfather
Dorcas Abbot	85	Great-grandmother
John Abbot	89	Great-great-grandfather
Phebe F. Abbot	90	Great-great-grandmother

Average 83.4 years

Chapter 2

Early Life. Pacific Survey

In the fortunate circle of a happy family of moderate means, shared with a sister and several brothers; frequently spending an active out-of-doors summer at the ancestral Wilton homestead, Henry L. Abbot passed his perfectly normal childhood and youth. He left the Boston Latin School shortly before graduation in order to accept appointment to the U. S. Military Academy at West Point. Entering as a cadet July 1, 1850, he graduated, standing number two in his class, June, 1854.

This high standing, of course, entitled Abbot to ask service in the Corps of Engineers, but under the mistaken notion that their assignments would keep him in the old, well-settled portions of the country, he applied for the Artillery which at that time was largely on western frontier posts. Fortunately his mistake was corrected by two curious coincidences. Being invited to spend the week after graduation on the estate of Professor H. R. Agnel, Cadet Abbot happened to meet there, while tramping in the forest, a West Point graduate of the

class of 1853. This young lieutenant inquired of Abbot which branch of service he would enter, and expressed surprise that with such high standing he had passed over the opportunity to join the Engineers. Learning the reason, he strongly advised a reconsideration, informing Abbot that the Topographical Engineers were at that very time engaged in pioneering surveys for railroads in the far West and were thus afforded the best of opportunities to see remote parts of the country.

Young Abbot regretted his choice, but feared it would make a bad impression to start his military career by asking a change of assignment. However, shortly afterward, and again by accident, he met on a hotel piazza the Adjutant of the Academy, Fitz John Porter, afterwards a corps commander of the Army of the Potomac, who said: "Abbot, I notice that you have not applied for the Engineers, though your rank entitles you to do so. I have not yet mailed the applications, and if you should wish to write a new one I will tear up the original." They went directly into the hotel office, and young Abbot made out on hotel paper an application for the Topographical Engineers. By this curious series of happenings his whole career was altered.

He soon received the following order:

"Office Pacific Surveys, Washington, May 1, 1855.

"SIR: By direction of the Secretary of War [then Jefferson Davis], you will report to Lieut. R. S. Williamson, Topographical Engineers, for duty on the explorations and surveys in California and Oregon, with which he is charged.

"It is understood that you are second in rank of the party, and that, if sickness or any accident should disable Lieutenant Williamson, so as to oblige him to relinquish the command, you will succeed to the charge and command of the party.

"Very respectfully, your obedient servant,

"A. A. HUMPHREYS,
"Captain Corps Top. Engineers,
"In charge of office for Pacific
"Railroad Survey.

"Lieut. Henry L. Abbot,
"Corps Topographical Engineers."

So much of their assignment as they were destined to finish is included in the following excerpt from Secretary Davis' order of May 1, 1855, to Lieutenant Williamson:

"1. To make such explorations and surveys as will determine the practicability, or otherwise, of connecting the Sacramento valley in California, with the Columbia river, Oregon Territory, by a railroad either by the Willamette valley, or (if this route should prove to be impracticable) by the valley of the Des Chutes river, near the foot slopes of the Cascade chain. Along Des Chutes river the character of the country is such as to render it improbable that a practicable route can be found."

Owing to the illness of Lieutenant Williamson, it fell to Lieutenant Abbot to prepare and transmit the report of their survey, which he did, with the promptness and thoroughness which ever characterized him, under date of May 6, 1857. The report, comprising 499 quarto pages, forms Volume 6 of "Explorations and Surveys for the Pacific Railroad." Of this volume, Part 1 and the Appendices are by Lieutenant Abbot, comprising 198 pages, the remainder on the geology, botany, and zoology of the region was contributed by the civilian assistants under his direction.

On May 5, 1855, Lieutenants Williamson and Abbot, with their civilian assistants sailed from New York, crossed the Isthmus of Panama (much later to be the scene of General Abbot's celebrated researches relating to the Panama Canal), and arrived at San Francisco, May 30. Organizing his party there, Lieutenant Williamson was in camp at Benicia ready to commence work on July 9, 1855.

The party included five civilian technical assistants, a pack master with large mule train in charge of eighteen packers, mostly Mexican. Later, when arrived at the dangerous Indian country, the expedition was reinforced by a military detail of eighty foot and twenty dragoons under command of Lieutenant H. G. Gibson, with Lieutenants George Crook and J. B. Hood, and additional packers and guides. Lieutenant Hood being later ordered to Washington, he was relieved by Lieutenant P. H. Sheridan. The reader will notice among the

small number of responsible names of those connected with this expedition the future President of the Southern Confederacy, and several general officers in high commands on one side or the other in the great Civil War, so soon to follow.

Although about to survey a mountain wilderness, known to be filled with a tangle of precipices, deep canyons, and fallen trees, and traversing a volcanic region almost impassably obstructed with soft and hard ejecta, the expedition took with it one light cart to carry the barometers, sextants, chronometers and other instruments, but primarily to serve as an odometer to measure distances. The narrative has frequent references to the "little cart," how it overturned and broke some of the instruments; or how after all the instruments were removed it took the united force to let the "little cart" down some precipice; and how the body of the "little cart" was finally totally smashed, but the wheels were kept and still retained the title. Finally, while lifting the wheels over an endless succession of fallen trees, in crossing the Cascade Mountains by a little-used pass near Mount Hood, the Indian guide said that if they were to reach water by sundown they must "mam-uk mam-a-loos-ten-as chik'-chik," which means, being interpreted, "kill the little cart." Lieutenant Abbot adds: "I also decided much against my will, to 'kill the little cart.' The men took the spokes for picket pins, and in this form our old friend continued to accompany us to the end of the journey."

Great care was taken to measure altitudes and latitudes. Owing to the disabling of the chronometers in one of the adventures of the "little cart," the observers were early prevented from determining longitude by time differences. This defect they remedied as far as possible by taking many bearings of the numerous high peaks of the region, so that their map is in close accord with modern surveys. Lieutenant Abbot devotes a whole chapter to the description of his means of correcting and reducing barometric readings for altitude, and shows by a long tabular comparison with actual levels that the results of his barometric method have a mean error of but 9 feet. Here we see a good example of that passion for precision that distinguished his work throughout his life.

After following up the Sacramento valley for a considerable distance, the expedition crossed over the Cascade range, and struggled on among lava beds, precipices, fallen trees, past the Klamath lakes to the upper canyon of the Des Chutes river. Here Lieutenant Williamson with the dragoons under Lieutenant Sheridan attempted to find a practicable pass over into the Willamette valley, while Lieutenant Abbot pushed on to the Columbia river and returned with supplies. Lieutenant Williamson then crossed over to the coast and returned by sea to San Francisco to prepare for the remainder of the survey, leaving Lieutenant Abbot to come down overland on the west side of the Cascade range.

Just after this separation of the party, a fierce Indian uprising broke out, so that the greatest doubt prevailed as to whether the party could be extricated at all. Settlers fled to the larger places and many families were murdered. Fortunately Lieutenant Abbot had been told by a half-breed of a rarely used pass south of Mount Hood. He was fortunate, through his own pleasant relations with the Indians and a working knowledge of their language, and also through the good offices of one of the last of the settlers to flee to safety, in getting the goodwill of a chief called Kok-kop. Although he did not himself know the pass, this chief assigned to the party a young Indian named Sam An-ax-shat who had once been through the pass. This was perhaps the last friendly act of Kok-kop or of Sam, but the latter with complete fidelity piloted the party through the often perfectly indistinguishable trail to the valley of the Willamette, recovered for them a mule that had strayed with valuable cargo, and then decamped in the night in fear of his life from the white settlers.

To show more vividly the character of this march, I quote from Lieutenant Abbot's diary of October 10 to October 14, 1855:

"October 10.—This morning the weather was clear. We started early, abandoning a horse that could travel no further. On leaving camp we ascended a steep hill about 400 feet high, and then gradually descended, for about a mile and a half, by

a succession of pitches connected by narrow terraces. They conducted to a small brook, flowing north through a ravine destitute of grass. Continuing a southerly course for about two miles further, we found ourselves in a small dry prairie, where the trail suddenly seemed to disappear. Thus far to-day we had been very little troubled by fallen timber. Our guide dismounted, and, directed by signs too slight for our eyes, led us across the open spot to a place where the Indians had blazed the trees for a few rods into the forest, but where no trail on the ground was visible. We had before occasionally seen blazing, and sometimes twigs broken in the direction of the trail. The blazing generally consisted of a simple cut, laying bare the wood; but sometimes we found a rude image of a man marked in the bark. This always indicated that much fallen timber was to be expected. The object of the blazing, in the present instance, was simply to indicate a direction, for it soon ceased, and even Sam could see no trail. By carefully preserving the course it had pointed out, however, he led us about a mile up a gentle slope, covered with much fallen timber, to the brink of an enormous precipice, which seemed vertical. There was a trail near the edge, which conducted us up a gradual ascent to the foot of a very steep mountain, composed of basalt and compact metamorphic slate, whose summit was bare of trees. After climbing it with much labor, and the loss of a mule that rolled down the precipitous side, a magnificent panorama burst upon our view. At an elevation of 5,000 feet above the sea, we stood upon the summit of the pass.[4] For days we had been struggling blindly through dense forests, but now the surrounding country lay spread out before us for more than a hundred miles. The five grand snow peaks, Mount St. Helens, Mount Rainier, Mount Adams, Mount Hood, and Mount Jefferson, rose majestically above a rolling sea of dark, fir-covered ridges, some of which the approaching winter had already begun to mark with white. A yawning ravine, into which we had gradually and unconsciously descended this morning, came from the north, near

[4] This is the summit by my trail. It is 500 feet higher than that of the proposed wagon road.

Mount Hood, and winding to the south round the mountain on which we stood was lost in the dim distance. Another, heading near us, wound out of sight towards the west. On every side, as far as the eye could reach, terrific convulsions of nature had recorded their fury, and not even a thread of blue smoke from the camp fire of a wandering savage, disturbed the solitude of the scene.

"Near this mountain we noticed an extraordinary local variation of the magnetic needle, which numerous bearings to well-known peaks enabled me to measure with considerable accuracy. At places about two miles from the mountain, both before reaching and after leaving it, the variation, as usual in this region, was about 18° east. At the top of the great precipice encountered about a mile before reaching the mountain, it was only 11° east, while on the summit it was 16° west. The needle was thus actually disturbed 34° by some abnormal cause. It, however, settled readily. The mountain was principally composed of slate and basalt, like those around it, and we could see no indication of iron or other local cause of disturbance in the vicinity.

"During the remainder of the day's march, the trail followed a knife-like ridge between two great cañons east and west of us, to avoid the fallen timber in them, and it was very mountainous in its character. After a steep descent we toiled up another peak, two miles distant from the first and very similar to it. From the summit we could look many miles down the great westerly ravine, and distinctly see the blue hills of the Willamette valley beyond its mouth. This peak was separated from the next one of the ridge by a cañon connecting the two great ravines. This we crossed with difficulty, and continued to follow the narrow ridge, toiling up and down several more steep peaks rising from it, until the sun was only a few minutes high. Some of our exhausted animals were far behind, and the Indian said that we were still a long way from the 'Stone House,' where he had expected to encamp. He knew, however, a spring not far off, where we could get water, but no grass. We reached it on the steep eastern side of the

ridge just as the sun set. Its bed was dry. We were all feverish from fatigue and thirst, and it was a bitter disappointment; still, to advance was impossible, and our animals were unpacked and tied to the trees as they gradually came in. Two had broken down entirely, and been abandoned on the way. In the meantime the Indian had disappeared. When he returned he quietly remarked that he had discovered water. We rushed to it, and found a little spring which flowed almost drop by drop from under a rock in the thick bushes. There was enough for the men, but none for most of the suffering animals, and their cries from hunger and thirst were incessant through the night.

"October 11.—This morning we took a westerly course, which led us over the ridge that we had been following, into a third great ravine heading near us and winding out of sight to the northwest. The descent was about seven hundred feet, and very abrupt. In the ravine we found a fine stream of water and a small lake, bordered by some good grass, which, however, had been eaten so short by Indian horses that our animals could get none. This place Sam called the 'Stone House.' The origin of its name I could not discover, but probably there is a cave in the vicinity. It is a great Indian whortleberry camp, and we found the bushes still loaded with berries. The lake is doubtless the source of a branch of Sandy river. Disappointed in not finding grass for the animals, we toiled up a steep precipice of compact slate, 1,000 feet in height, to the summit of the western side of the ravine, and obtained an extended view of the surrounding country. On every side nothing could be seen but fir-clad ridges and frightful cañons; most of our animals were on the point of giving out from fatigue and hunger; and, to crown our misfortunes, Sam quietly informed me that he had only travelled between the 'Stone House' and Willamette valley once, and that was when he was a child. He had a vague recollection of many mountains and a great scarcity of grass on the way. Under these happy auspices we pushed desperately on towards the west. After following a narrow ridge thinly covered with trees, until we had travelled a little more than six miles from

camp, we fortunately found a small opening, in which the ground was wet from numerous springs and thinly dotted with grass. We had hardly encamped, when a rain storm that had been threatening all the morning, suddenly burst upon us, causing great anxiety lest it should change into snow. Sam and I explored the vicinity on foot, and I was fortunate enough to obtain a good bearing to Mount Hood through the clouds. It was N. 40° E. We were on a narrow ridge, with an immense cañon on each side of us, and the supply of grass was very limited. The number of whortleberries was so great that we could strip them from the bushes by handfuls.

"October 12.—All last night and today, a cold and steady rain poured down, chilling our animals and rendering the trail slippery and dangerous. Although I greatly feared snow, I decided to remain in camp and recruit the animals, as many must have given out had we proceeded. To eke out their scanty supply of grass, I issued a small quantity of hard bread, which most of them ate eagerly. We collected heaps of pine knots and logs in different parts of the opening, in order to pack the mules by fire-light on the following morning, and thus get a very early start. In the night it cleared off, and Mr. Anderson and I left our beds, and obtained good observations for latitude.

"October 13.—We had reveillé at two o'clock this morning, and started as soon as it was light enough to see the trail. It followed a continuous ridge, varied by a succession of steep peaks, slippery from the rain. After slowly climbing over them for about three miles, we encountered one so steep that the ascent seemed impossible. We, however, carefully urged the animals along a narrow ledge, which wound up the face of the tremendous precipice, and at length gained the summit. The blue Willamette valley, marked by a line of fog rising from the river, lay below us, and the word 'settlements,' shouted down the line, inspired every one with new life. From this point we began a rapid descent to the level of the valley. At the foot of the mountain there was a small grassy swamp, around which the trail wound in nearly a semi-circle. Beyond

it we crossed a rocky pedregal, and then followed another ridge less mountainous than the former one. It gradually disappeared, and left us among thick fallen timber. A very few clumps of bunch grass again began to appear among the trees. This trail had been used by the Indians of the Willamette valley to reach the whortleberry patches, and they had cut through many of the logs. Still vast numbers were left, and we were obliged, in several places, to clear a path with axes. We slowly worked our way on, in this manner, until night overtook us, and compelled us to encamp in the dense forest without either water or grass. During the night the cries of the half starved animals were very distressing. We also suffered much ourselves from thirst, which a diet of musty hard bread did not tend to allay.

"October 14.—Yesterday, one of our best mules, with a valuable pack, was lost on the way, and I sent two men back this morning to search for him. The fallen timber diminished in quantity as we advanced, and the trail soon became excellent. Pressing rapidly forward we reached, about five miles from camp, a little log cabin on the edge of the forest, and, with a feeling of inexpressible satisfaction, found ourselves at last in the long wished for Willamette valley."

Though the War Department orders had specified a military escort of one hundred men, the commander of the forces in Oregon felt justified, owing to the exigency of the Indian uprising, in withdrawing the escort completely. Both Lieutenant Williamson and Lieutenant Abbot strongly urged the danger to the expedition and to its valuable records, but without being able to modify the commanding officer's decision. Hence, Lieutenant Abbot was obliged to march south through the hotbed of the Indian warfare with his train of 120 animals and 30 men, mostly unarmed civilians and Mexican packers. Fortunately he was able to follow for a considerable distance through the mountains a small detachment of volunteer militia, but he was forced to forego several side surveys which were necessary to fully accomplish his investigation. En route, the expedition passed by burned cabins and the bodies

of slaughtered settlers, and narrowly missed the scene of a fierce battle, but reached the headwaters of the Sacramento without loss.

Lieutenant Abbot's report points out the prohibitive expense of constructing a railroad through northern Oregon on the eastern side of the Cascades, although the eastern route was found practicable as far north as the Klamath lakes. On the western side of the Cascades he considers it practicable to follow the Willamette and its coast fork from the Columbia river, a distance of about 150 miles; thence by Pass creek, a branch of the Umpqua river, and across a small divide to Elk creek and up over Long's hills; thence following the path of his expedition to the North Umpqua river at Winchester and the route surveyed, or some small variation of it to Canyonville, some 60 miles farther. The Umpqua mountains would then be found a formidable obstacle, and he regrets that the lack of escort prevented him from more thorough explorations here. Yet he thinks the road practicable either through the Umpqua or the Cow Creek canyon though at considerable expense.

From the southern base of the Umpqua mountains to Wolf creek no serious obstacle was found, but from thence to Rogue river the route followed by his party was very unfavorable. He again regrets that he was forced by lack of escort to forego further exploration, but gives information he gathered as to alternatives, which on the whole seem practicable. Thence to the foot of the Siskiyou mountains on Stewart creek no great obstacles would be encountered.

But now the great obstacle of the Siskiyou mountains is encountered, and he admits that no practicable route over them was surveyed by his party. He thinks it might have been practicable, had the escort been available, to have found a route through the Cascade mountains to join the surveyed route east of them, and thus avoid great difficulties. On the other hand, his inquiries led him to think that some variations of his own route through the Siskiyou mountains might be found, leading

to the Klamath river, and thence to Yreka. From Yreka to the middle reaches of the Sacramento river he suggests several practicable routes, of which he inclines to prefer one striking the head-waters of the Sacramento river west of Mount Shasta, and thence following the course of the stream. He concludes by quoting a report on a preliminary survey of this route for a wagon road, as made by several local gentlemen.

It speaks well for the keenness of observation of this young lieutenant engaged on his first assignment, that the Southern Pacific railroad now follows exactly the course he recommends from Redding, California, all the way to the mouth of the Willamette near Portland, Oregon. On the other hand, only recently has a railroad been constructed north of the Klamath lakes on the eastern side of the Cascade range which he found impracticable.

Chapter 3

The Control of the Mississippi

The National Academy of Sciences was not organized until 1863. General Abbot owed his election to it in 1872 to the remarkable investigations which he made as a young man in his twenties, in the years 1857 to 1860, in cooperation with General (then Captain) A. A. Humphreys on the flow and control of the Mississippi river. Their report, originally printed as Professional Papers of the Corps of Topographical Engineers, No. 4, 1861, and reprinted as No. 13 of the Professional Papers of the Corps of Engineers, 1876, is a classic in river hydraulics. Although seventy years have elapsed, it is still very highly regarded, although naturally some modifications would now be made, both as regards measurements and theory. It is mainly since the comparatively recent establishment of hydraulic laboratories abroad—a move which our own country is very late in following—that new principles useful to the control of streams are being added to the sterling results of this research.

It is difficult to give an adequate idea of the comprehensive character of this extraordinary investigation. The geographical and geological conditions of the vast basin of the Mississippi and all its important tributaries are extensively described. The history of river hydraulics in the old as well as the new world is summarized, and the principal ideas and investigations of leading scientists as to the flow of rivers are critically examined. New methods of measuring cross sections and velocities of flow of streams are worked out with careful attention to the elimination of errors. Abundant observations of these quantities are made under all conditions of flood at numerous points on the Mississippi and its tributaries. Formulæ are deduced which accurately represent all these data. The histories of many crevasses in the levees during high floods, with determinations of their flow and the effect they produced on the flow of the main river, are traced. Changes in the bed of the river as influenced by levees, outlets, cut-offs, and the other modifications of the banks which are practicable in river control are quantitatively determined. The practicability and exact effect of all suggested means of flood protection are carefully examined, and mathematically derived directions are given to show what is necessary and sufficient as protection against any flood which history warns us to forecast. The clearance of the delta for navigation is considered in the same quantitative manner. In short, the authors aimed to accept no assumptions, but to satisfy every inquiry by exact measurements made under such a wide variety of conditions as to enable them to reduce the whole subject to accurate mathematical expression, so that estimates could be based with certainty thereon.

In order to supplement authoritatively this inadequate picture of what was attempted, I quote extensively from Captain Humphrey's letter of transmittal. Yet even this fails to give the impression of complete study of a tremendous problem which comes only from the full perusal of the great report itself.

"Office of the Mississippi Delta Survey,
"Washington, August 5, 1861.

"Major Hartman Bache,
"Corps of Topographical Engineers,
"In Charge of Bureau of Topographical Engineers,
"War Department, Washington.

"SIR: Under the act of Congress directing the Topographical and Hydrographical Survey of the Delta of the Mississippi river, with such Investigations as might lead to determine the most Practicable Plan for securing it from Inundation, a Board, consisting of Lieutenant-Colonel S. H. Long, Topographical Engineers, and myself, was organized in November, 1850, and directed to examine the river with a view to decide upon the character and extent of the surveys required. It was further ordered that, the duty of the Board being completed and a report thereon being made, I should take the direction of the work.

"In accordance with those instructions, the report of the Board was made from Napoleon, Arkansas, December 18, 1850. That report was communicated to Congress and printed in Senate Ex. Doc. No. 13, 31st Congress, 2d session. The field of survey and investigation by measurement, as enlarged by authority of the Bureau of Topographical Engineers in the following spring, extended from the head of the alluvial region at Cape Girardeau to the Gulf of Mexico. At a still later date, the investigations were authorized to include within their scope the best mode of deepening the channels at the mouths of the river, an object which had been likewise contemplated in the original appropriation act.

"That act required a topographical and hydrographical survey of the delta of the Mississippi to be made in connection with the investigations; and in execution of the plan of operations laid down in the report of the Board of December, 1850, three parties were at once organized to determine the topography, hydrography, and hydrometry of the alluvial region. Fortunately for the objects of the Survey, the succeeding high water proved to be a flood of a peculiar character.

"The topographical party in charge of Mr. James K. Ford, assisted by Mr. Joseph Bennett, Mr. W. Thornton Thompson, Mr. George F. Fuller, and Mr. Samuel Hill, made a minute topographical survey of the Mississippi river, extending from one mile above Routh's point to one mile below the Barataria-canal locks, just above New Orleans, collecting at the same time information concerning the crevasses of former years, old flood-marks, the history of levee construction, the dimensions of levees, well authenticated changes in the banks of the river, etc., etc. Owing to the high stage of the river, and the consequent inaccessibility of the east bank between the foot of the Raccourci cut-off and a point one mile above Baton Rouge, that portion was omitted. The survey included the mouth of the Red river, the heads of bayous Atchafalaya, Plaquemine, and La Fourche, and numerous off-set lines—among them one from Carrollton to the mouth of the new canal, lake Pontchartrain. . . .

"The hydrographical . . . operations included the measurement of sets of cross-sections of the Mississippi at Routh's point, at Red river landing, in the Raccourci cut-off, at Raccourci bend, at Baton Rouge, at site of Bonnet-Carré crevasse, at Carrollton and above and below that locality, and of sets of cross-sections of the mouth of Red river, of Old-Red river bend, and of the heads of bayous Atchafalaya, Plaquemine, and La Fourche. In each set of cross-sections, the velocity of the current was measured—in some instances, with great elaboration. The nature of the material pushed along at the bottom of the river was examined from time to time. . . .

". . . Gauge-rods were established in lakes Pontchartrain and Borgne, in the gulf bayou at Fort St. Philip, and—in the river—at Fort St. Philip, Carrollton, Donaldsonville, Baton Rouge, Red river landing, Natchez, New Carthage, and Lake Providence. Most of these observations were continued for two years, and some of them longer. The gauge-observations made under the Navy Department at the Memphis Navy Yard were relied upon for that position, and private gauge-observations at Napoleon and Cairo for those localities. Temporary gauge-rods were likewise observed at Berwick's bay, at Field's

Mills on bayou La Fourche, and at Indian Village on bayou Plaquemine.

"The chief labor of the hydrometrical party, however, was directed to the constant measurement of the velocity of the current of the Mississippi in all parts of the width and depth of the Carrollton section, in order to obtain the volume of discharge in every condition of the river throughout the period of a river year; and with a view to determine the law of change of velocity from the surface to the bottom, and from side to side; including the effect of wind; and thus to furnish the hydrometrical data for completing the determination of the laws governing the flow of water in natural channels. During a portion of the periods of high and low water, similar measurements were made upon a section of the river at Baton Rouge, in which vicinity the course of the river is nearly straight for several miles.

"In connection with these operations, the amount of sedimentary matter held in suspension by the river was measured daily for two years, together with the temperature of the river-water, and the air, etc. The character of the material pushed along the bottom was likewise examined from time to time.

"Detachments from this party measured the discharge of the crevasses in the vicinity of Carrollton, the cross-sections of Berwick's bay, and of the La Fourche, at Pain Court, Thibodeaux, and Field's Mills, and ran a line of levels from the high-water mark of the Mississippi, at McMaster's plantation, to the gauge-rod at Proctorsville on lake Borgne. Mr. Smith's lines of cross-section, at Carrollton, were likewise re-sounded by this party in low water, 1851.

"It also made experiments upon the velocities of the current from the surface to the bottom at the mouths of the Mississippi, both in the high and low states of the river, sounded the bars, and determined by measurement the advance of that of the Southwest pass.

"The results of the labors of all these parties enter into the most important deductions of the report; they will be found

embodied in the chapters devoted to the subjects for which they were designed to furnish the data.

. . . . . .

"While engaged in the field, in the summer of 1851, I was suddenly prostrated by sickness, which obliged me early in the following winter to relinquish the charge of the work to Lieutenant-Colonel Long, Topographical Engineers. The operations in the field were soon after entirely suspended, with the exception already stated in connection with the Carrollton work, and continued so until the fall of 1857, when, the charge of the work having been previously resumed by me, the surveys and investigations were again vigorously prosecuted.

"During the interval, while they were in abeyance, the state of my health still rendering me unfit for duty, I sought and obtained authority to visit Europe, with instructions to examine its delta rivers, and ascertain what the experience of many centuries had really proved as to the ultimate as well as immediate effects of the different methods of protection against inundation. Such of the results of that visit as have immediate application to the Mississippi river are briefly embodied in the text of the Report.

"Upon returning from Europe, in the summer of 1854, I was assigned to special service under the immediate orders of the War Department, and placed in charge of the Office organized in connection with the Explorations and Surveys, then in progress, for the determination of the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean. The duties thus devolved upon me prevented my giving sufficient attention to the Survey of the Delta of the Mississippi to admit of its active resumption until the autumn of 1857.

"At my request, Lieutenant Henry L. Abbot, Topographical Engineers, was then directed to report to me for duty on the Delta Survey. This request was made in order that Lieutenant Abbot might take the immediate charge of the parties of the Delta Survey under my direction, the office being estab-

lished at this place. An arrangement of this kind was rendered absolutely necessary by the nature of the duties then imposed upon me. . . .

"Previous to the resumption of the field work of the Survey, Lieutenant Abbot recomputed the volumes of discharge at Carrollton from the original notes. . . .

"As other important duties required my presence in Washington at that time, Lieutenant Abbot was directed by me in November, 1857, to proceed to the Mississippi river, organize the necessary parties, and prosecute the surveys and investigations. The completion of the Topographical and Hydrographical Survey of the Delta in the manner in which it was commenced in 1851 was not attempted; because the Investigations, the more important of the two classes of work called for by the appropriation acts, required the expenditure of the balance of the appropriation. It was extremely fortunate that they were resumed just at that time, for the flood of 1858 was one of a remarkable character, and furnished data which could not have been collected if the appropriation had been exhausted by the resumption of the Survey in a previous year, inasmuch as no Mississippi flood occurred between 1851 and 1858.

"In compliance with these instructions, gauge-rods were established at Columbus, Kentucky; Memphis, Tennessee; Napoleon, Arkansas; Vicksburg, and Natchez, Mississippi; and Red river landing and Carrollton, Louisiana. Donaldsonville, Louisiana, and Cairo, Illinois, were subsequently added to the list. A daily record of the height of the water upon the rod, the state of the weather, the direction and force of the wind, etc., was kept at these stations until January, 1859. The observations at Columbus, Memphis, and Vicksburg were continued until September, 1859, and those at Carrollton until April 30, 1861. From May 11, 1859, to June 5, 1860, a self-registering tide-gauge was maintained at the mouth of the Southwest pass, a portion of the corresponding Carrollton observations also being made with one of these instruments.

"A party . . . established at Columbus, Kentucky, 20 miles below the mouth of the Ohio, . . . measured daily the velocity of the current from bank to bank, and occasionally

from surface to bottom. To this duty were added the determination of the quantity of earthy matter held in suspension by the river-water, and a careful survey of the river above and below the base of current-observations, with lines of level to determine the slope of the river at high and low water. A survey across the low grounds between Cape Girardeau and the Commerce bluffs was likewise made by this party.

"A party with similar duties . . . was stationed at Natchez, Mississippi, but was subsequently moved to Vicksburg, Mississippi, . . . In addition to its regular duty of current-measurements, this party made a careful survey of the river for about eight miles at Vicksburg, including the site of the velocity sections, with exceedingly accurate lines of level to determine the slope of the water surface at various stages between high and low water, entirely around the abrupt bend above Vicksburg. The discharge of the Yazoo river was also measured by this party, whenever it could be done without interfering with the regular progress of the work of the Vicksburg station. . . .

"The observations at Columbus were continued until November 16, 1858, and those at Vicksburg until December 15, 1858. The summer of 1858 was remarkable for its intense heat and sickly character, notwithstanding which, the gentlemen composing these parties never relaxed their exertions.

"Similar but much less elaborate observations were made . . . to ascertain the daily discharge of the Arkansas river at Napoleon. These commenced on January 1, and continued until November 30, 1858.

"Aided by Mr. Pattison, and, at times, by others of the assistants . . . Lieutenant Abbot, besides establishing the parties at Columbus and Natchez, measured accurate cross-sections with corresponding velocities, of the following streams, to determine approximately their discharge during the flood; the Ohio, the Hatchee, the St. Francis, the White, the Arkansas, the cut-off between the Arkansas and White rivers, the Yazoo, the Red, the Black, the Atchafalaya bayou, Old river above Red-river landing, and Grand river at Berwick's bay, Louisiana. In addition, accurate measurements of the high-

water cross-sections of the Mississippi were made by him at Columbus, Kentucky; New Madrid, Missouri; a point two miles above Osceola, Arkansas; Randolph, Tennessee; Helena, Arkansas; Napoleon, Arkansas; Lake Providence, Louisiana; Vicksburg, Mississippi; New Carthage, Louisiana; Natchez, Mississippi; Baton Rouge, Louisiana; Bonnet-Carré, Louisiana, and Fort St. Philip, Louisiana.

"Mr. Pattison, assisted by Mr. J. D. Julian, measured in 1859 similar sections on the lines of survey of 1851 above and below the site of the Bonnet-Carré crevasse, and on two of those at Carrollton, Louisiana. He likewise re-sounded the bayous Plaquemine and La Fourche, on the lines of 1851, with some additions; and re-surveyed the heads of these bayous and of bayou Atchafalaya with a view to detect any changes which might have occurred since 1851.

"Aided by Mr. W. H. Williams, Lieutenant Abbot measured with great care the discharge of the Bell crevasse near New Orleans in May, 1858, and thus, in connection with the observations made by the parties in 1851, obtained the elements necessary to frame rules for ascertaining the discharge of crevasses. The locality of this crevasse and that of the La Branche were surveyed with minute accuracy by Mr. W. H. Williams during the following low water.

"As soon as the flood of 1858 subsided, a party . . . passed down the Mississippi, from Cairo to the mouth of Red river, in a yawl, measuring the dimensions of the various crevasses occasioned by that flood, and collecting all the information regarding date of occurrence, rate of increase, etc. . . .

"Great care was taken to obtain from every available source correct information respecting the dimensions, condition, and extent of the levees throughout the alluvial region, the history of their progress, etc.; respecting the height and date of the floods throughout the same region; the depth of overflow in the swamps bordering the river, the nature of the growth upon them and their geological character; and the seasons and dates of the floods, the range, etc., of the tributaries of the Mississippi.

"The intelligent and energetic labors of Lieutenant Abbot, faithfully aided by the gentlemen [of the party] accomplished a great amount of work.

"Series of detailed observations upon the currents at and near the bar of the Southwest pass, from the surface to the bottom, were made. . . .

"Various circumstances successively delayed my intended inspection of the operations in progress on the Mississippi in 1858, and the examination of particular localities, until the month of May. A short time after my arrival in Louisiana, a return of my former illness, induced by the excessive heat of the climate, rendered me unable to perform, without great suffering, any duty for the remainder of the summer.

"In the fall of 1859, measurements similar to those made at the permanent hydrometric stations of Carrollton, etc., were made upon a canal feeder of the Chesapeake and Ohio canal, at the Little Falls of the Potomac, by Lieutenant Abbot, assisted by Mr. Pattison and Mr. Vaughan, with a view to determine the laws governing variations in certain coefficients entering the new formulæ derived from the Mississippi observations.

"To complete the Delta Survey, every source from which reliable information connected with the question of Mississippi floods could be collected was examined. Wherever a record of the rise and fall of the Mississippi and its tributaries has been made, it was secured if possible.

. . . . . .

"As the surveys and investigations progressed, the great labor commenced of reducing the observations, of assembling the results, of combining and digesting them, of the development of the laws governing all the phenomena that were subjects of examination, and, finally, of the application of these laws to the solution of the great problem which formed the object of the Delta Survey.

"This work, which was in fact the preparation of the Report, was performed by myself and Lieutenant Abbot. It involved an amount of labor and study, which will not perhaps be fully appreciated even by professional persons. Devoted to the task,

Lieutenant Abbot brought to its performance great industry, energy, sagacity, and skill in analysis, the fruits of which, to be found in every part of the Report, are particularly exhibited by the chapters in which the flow of water in natural channels is treated. But a perusal of the Report will convey a more forcible impression of the extent and value of Lieutenant Abbot's labors than any terms of acknowledgment that I can use. In the mass of exceedingly intricate calculation necessarily attendant upon such a work, Lieutenant Abbot has been aided by Mr. F. W. Vaughan, a skilful computer, whose zeal, unwearied care, and industry in the performance of the duties he was employed upon, entitle him to more than the ordinary terms of acknowledgment.

"Some reference to the state of the question of protection against inundation, at the time when the Survey of the Mississippi Delta was begun, appears to be proper here, in order that the necessity of such extended and laborious investigations as were made may be appreciated, and that it may be understood how absolutely essential it was in every division of the subject to collect fact upon fact, until the assemblage of all revealed what were and what would be the true conditions of the river in every stage that it had passed through or could attain, and thus to substitute observed facts and the laws connecting them for assumed or imperfectly observed data and theoretical speculations.

"A wide discretion was necessarily entrusted to the officer in charge of the Mississippi Delta Survey. I entered upon the execution of that duty with an apprehension that the laws of flowing water in natural channels as enunciated in treatises upon the hydraulics of rivers, were not based upon sufficiently extended experiments upon natural streams, and, hence, that the formulæ found in them could not be relied upon for the solution of the questions upon which the plans of protection against inundation from overflow depended. The system of measurements and investigations carried on at Carrollton, Louisiana, Vicksburg, Mississippi, and Columbus, Kentucky, while it was intended to render the solution of the problem of the protection of the alluvial region of the Mississippi

against inundation independent of the laws and formulæ of the books, was at the same time designed, in connection with other parts of the survey, to afford the means of determining, by experiments on a far more extended scale than any ever before attempted, the laws governing the flow of water in natural channels, and of expressing them in formulæ that could be safely and readily used in practical applications. The success that has attended this part of the work has even exceeded my expectations. Laws have been revealed that were before unknown, new formulæ have been prepared, possessing far greater precision than the old; and improved methods of gauging streams have been devised.

"But the imperfect state of the science of hydraulics as applied to rivers was not the only difficulty to be encountered in the execution of the duty imposed upon the officer in charge of this work. The much-agitated question of the best method of protection against inundation had been always discussed upon assumed data, and the truth of the very ground-work upon which these discussions rested had to be experimentally investigated by this Survey. For instance, the Mississippi had always been regarded as flowing through a channel excavated in the alluvial soil formed by the deposition of its own sedimentary matter. So important an assumption was inadmissible; and great pains were accordingly taken to collect specimens of the bed wherever soundings were made, and by every means to ascertain the depth of the alluvial soil from Cape Girardeau to the gulf. This investigation has resulted in proving that the bed of the Mississippi is not formed in alluvial soil, but in a stiff tenacious clay of an older geological formation than the alluvion, and that the sides of the channel do not consist of homogeneous material; facts that have an important bearing upon all plans of protection.

"Further, it was held by the advocates of the exclusive use of artificial embankments that the levees of Louisiana had already lowered the bed and floods of the Mississippi river, and that their extension throughout the alluvial region above would still further lower the floods by deepening the bed and reducing the slope of the river. The advocates of outlets, on

the contrary, contended that the experience of many centuries, on the Po, proved that levees had raised the bed and floods of that river—to such an extent, indeed, that it was impracticable any longer to protect the country, except by opening new channels to the sea. This conclusion appeared to be sustained on the authority of two distinguished names, Cuvier and de Prony. While the investigations of the Delta Survey have rendered untenable that position of the advocates of the exclusive use of levees on the one hand, the investigations of the Chevalier Elia Lombardini have shown the supposed facts advanced by the latter class to be entirely erroneous, and their apprehensions to be unfounded.

"The effects of cut-offs were likewise the subjects of controversy among engineers, a controversy which the measurements of the Delta Survey must set at rest, since they demonstrate that cut-offs raise the floods below them, a conclusion sustained by the well-established effects of such works upon the Po and Adige.

"Outlets were advocated by some engineers because they were considered a ready and inexpensive means of reducing the floods. On the contrary, they were objected to by others because, as they claimed, outlets would raise the bed and floods of the river. The investigations of the Delta Survey prove that outlets, in the few localities where they are practicable, may be made to reduce the floods to any desired extent in certain divisions of the river; but that they would not be inexpensive, and would entail dangers and disasters which should not be risked. These conclusions, it is shown are sanctioned by the experience of Europe upon the Po, the Rhine, and the Vistula.

"The effect of a great swamp like that of the Yazoo upon the floods of the Mississippi, a subject that has formed the theme of speculation for at least thirty years, has also been established by the collection of facts; as likewise the law governing the rise, fall, and discharge of the river throughout the alluvial region; the manner in which the flood is propagated; the modifications introduced by tributaries; the succession of river stages; the drainage of its basin and that of its tribu-

taries; the proportion of drainage to downfall, and the discharge of outlets: in fact, every river phenomenon has been experimentally investigated and elucidated.

"Thus every important fact connected with the various physical conditions of the river and the laws uniting them being ascertained, the great problem of protection against inundation was solved.

"At the mouths of the river, a similar course has resulted in the development of the law under which the bars are formed, the depth upon them maintained, and the regular advance into the gulf continued; and, as a consequence, the principles upon which plans for deepening the channels over them should be based, and the best mode of applying them. The rate at which the river progresses into the gulf, and the extent, thickness, and relative level of the alluvial formation having been ascertained, its probable age has been estimated; and the ancient form of the coast, and the changes that have taken place in the present geological age, have been surmised.

"The Report exhibits in detail the investigation of each of these subjects, and many others not enumerated in this letter. Based upon extended survey and investigation in the field, made at times under circumstances of great exposure, it contains the results of many years' labor, comprising laborious office work, extended research, patient investigation, and exhaustive mental effort. The association of Lieutenant Abbot with me in this duty has been of such a character that the title of the Report should bear his name as well as mine. I beg leave therefore to submit it herewith to the Bureau of Topographical Engineers, as our joint Report upon the Survey of the Delta of the Mississippi river.

"Very respectfully, your obedient servant,

"A. A. HUMPHREYS,

"Captain Topographical Engineers, U. S. Army."

As remarked above, the investigations were highly comprehensive. The authors sum up their recommendations in the matter of the protection of the Mississippi valley in the following paragraphs:

"The preceding discussion of the different plans of protection has been so elaborate and the conclusions adopted have been so well established, that little remains to be said under the head of recommendations. It has been demonstrated that no advantage can be derived either from diverting tributaries or constructing reservoirs, and that the plans of cut-offs, and of new or enlarged outlets to the gulf, are too costly and too dangerous to be attempted. The plan of levees, on the contrary, which has always recommended itself by its simplicity and its direct repayment of investments, may be relied upon for protecting all the alluvial bottom lands liable to inundation below Cape Girardeau. The works, it is true, will be extensive and costly, and will exact much more unity of action than has thus far been attained. The recent legislation of Mississippi in organizing a judicious State system of operations, however, shows that the necessity of more concert is beginning to be understood. When each of the other States adopts a similar plan, and all unite in a general system so far as may be requisite for the perfection of each part, the alluvial valley of the Mississippi may be protected against inundation.

"To secure this end in the most economical manner, the operations of this Survey indicate that levees should be constructed. Near the mouth of the Ohio, they should be made about 3 feet above the actual high-water level of 1858, which has been selected as the plane of reference, because more unvarying than the surface of the ground. The height above this level should be gradually increased to about 7 feet at Osceola. Thence to Helena, the latter height should be maintained. Thence to Island 71, the height should be gradually increased to 10 feet. Thence to the vicinity of Napoleon, it may be gradually reduced to 8 feet. Thence to Lake Providence, it must be gradually increased to 11 feet. Thence to the mouth of the Yazoo, it may be gradually reduced to about 6 feet, and should be thus maintained to Red-river landing. Between that locality and Baton Rouge, it should be kept uniformly about 4 feet, and below Baton Rouge about 3 feet. If the water-mark of 1858 be unknown at any locality, it may be re-

duced to any well-determined local mark by the table in Chapter II. The above estimate is exclusive of settling, and allows about a foot for possible rise above the height necessary for restraining the flood of 1858.

"It should be remarked that these heights are based upon the supposition of *absolute security*, so far as its conditions can be ascertained. . . .

"It will be noticed that near Lake Providence the levees must be constructed of enormous height to restrain the floods. It may, therefore, be well to reduce them by constructing, near that town, an outlet leading to bayou Tensas and Black river. Its capacity should not exceed 100,000 cubic feet per second, a volume which might be made to pass off through the natural drains of the Tensas swamp without producing serious inundation. Those drains have always discharged a large amount of crevasse-water in the great flood years, and may be depended upon for sensibly relieving the river in that vicinity. Abstracting 100,000 cubic feet per second at that point would reduce the river flood three feet throughout that part of the region between Napoleon and Vicksburg which it is most difficult to protect, and would thus materially reduce the cost of the levees and the danger of crevasses. Before undertaking the project, however, extensive borings should be made to ascertain the character of the substrata. Unless a solid bed of clay should be found at a moderate depth, the outlet should not be undertaken, lest it might become too large for the safety of the region bordering upon bayou Tensas and Black river. Under any circumstances, it would be an injury rather than a benefit, to the country below Red-river landing (see discussion of flood of 1851), and in the event of coincident floods in the Mississippi and Red rivers, it would be disastrous to the lower part of the Tensas and to the Black river country."

While their solution of this important problem has not proved to be quite so absolute as Humphreys and Abbot very reasonably believed it to be, they laid a foundation on which

others may build up the complete edifice, correcting those faulty details which by the very completeness of this great pioneer work have come to test the sooner.

Chapter 4

Civil War Service and Subsequent Military Career

The great task of the preparation and printing of the Mississippi river report was still occupying Lieutenant Abbot when the Civil War broke out in 1861. He managed to drive the book through the press in season to take part in the first battle of Bull Run, where he was seriously wounded, and brevetted captain for "gallant and meritorious services." Soon recovering from his wound, he was continuously in service and rapidly promoted so that at the age of thirty-three years he commanded a brigade of troops in the field. A summary of his Civil War record and subsequent military assignments follows:

Chronology, Henry L. Abbot

June, 1850-June, 1854: Cadet, West Point.

Class standing: January, 1851, No. 1; June, 1851, No. 3; June, 1852, No. 4; June, 1853, No. 2; June, 1854, No. 2.

Cadet appointments: Corporal, sergeant, lieutenant.

July 1, 1854: Bvt. 2nd Lieut., Topographical Engineers, U. S. Army.

Oct. 12, 1854-May 19, 1857: Surveys for Pacific Railroad in Oregon and California.

Oct. 2, 1855: 2nd Lieut., Topographical Engineers, U. S. Army.

May 19, 1857-July 1, 1861: Survey Delta of Mississippi River.

July 1, 1857: 1st Lieutenant, Topographical Engineers, U. S. Army.

Civil War Service.

July 5-15, 1861: Topographical Engineer, Staff of General McDowell.

July, 1861: Chief Engineer, Tyler's Division in Manassas Campaign.

July 18, 1861: In action of Blackburn's Ford.

July 21, 1861: In action at Bull Run, seriously wounded; bvt. Captain for meritorious service at Battle of Bull Run.

July 23-Aug. 21, 1861: On staff of General McDowell, defenses of Washington.

Aug. 21, 1861-Mar. 10, 1862: Assistant to Gen. Barnard.

Mar. 10-July 24, 1862: Aide-de-camp to Gen. Barnard during Peninsular Campaign.

Apr. 5-May 4, 1862: In action Siege of Yorktown.

June 18, 1862: Captain, Topographical Engineers, U. S. Army.

June 26-July 2, 1862: In action in seven days' operations before Richmond.

July 24-Sept. 25, 1862: Sick leave, Chickahominy fever.

Sept. 25-Nov. 11, 1862: Aide-de-camp to General Barnard fortifying approaches to Alexandria, Va.

Nov. 11, 1862-Feb. 10, 1863: Chief Engineer, Banks expedition to the Gulf.

Jan. 19, 1863: Colonel of Volunteers commanding 1st Conn. Heavy Artillery.

Mar. 3, 1863: Captain, Corps of Engineers, U. S. Army.

Feb. 28, 1863-May 10, 1864: Command of regiment and brigade south of Washington.

Jan. 27-May 31, 1864: Member of Board revising system Coast Defense of U. S.

May 13-June 23, 1864: Command of Siege Artillery, Army of the James.

June 23, 1864-Jan. 5, 1865: Command of Siege Artillery of armies operating against Richmond.

July 30, 1864: Personally served in Mine Assault.

Aug. 1, 1864: Bvt. Brig. General, U. S. Volunteers for gallant and meritorious services in the operations before Richmond, and especially in the lines before Petersburg, Va.

Jan. 5-22, 1865: Chief of Artillery of expedition against Fort Fisher, N. C.

Jan. 22-July 13, 1865: Command of Siege Artillery of Armies operating against Richmond.

Mar. 13, 1865: Bvt. Lieut. Colonel, U. S. Army, for gallant and meritorious services during the Siege of Petersburg.

Mar. 13, 1865: Bvt. Colonel U. S. Army, for gallant and meritorious services during the Rebellion.

Mar. 13, 1865: Bvt. Maj. General U. S. Volunteers, for gallant and meritorious services during the Rebellion.

Mar. 25, 1865: Personally served in battle of Fort Steadman.

Apr. 2, 1865: Personally served in assault on Confederate intrenchments.

May 10-July 13, 1865: Chief of Engineers, Department of Virginia.

July 15-Sept. 25, 1865: Command of the Brigade in defenses of Washington.

Sept. 25, 1865: Mustered out of volunteer service.

Oct. 4-Nov. 23, 1865: Awaiting orders.

Nov. 11, 1865: Major, Corps of Engineers, U. S. Army.

Nov. 25-Dec. 12, 1865: Command Engineer Battalion, and constructing Fort Schuyler, N. Y.

Dec. 12, 1865-May 29, 1866: Assistant Engineer examining Mississippi levees.

June 1, 1866-March 15, 1886: Command Engineer Battalion and Engineer School at Willets Point; also Command of General Engineer Depots, and constructing Fort Schuyler, N. Y.

Sept. 11, 1866-May 18, 1867: Member of Board on use of iron in permanent defenses.

June 12, 1868-May 24, 1886: Constructing fort at Willets Point, N. Y.

Dec. 19, 1868-Nov. 15, 1869: Member of Board to revise Ponton Manual.

May 5, 1869-Aug. 13, 1895: Member of New York Board of Engineers for Fortifications.

June, 1869: Member of Board on Wallabout Channel to N. Y. Navy Yard.

Oct. 7, 1870-Jan. 20, 1871: On detached service under Secretary of the Treasury to observe solar eclipse in Sicily.

July 2-Oct. 13, 1873: On professional detail to learn all possible about the torpedo systems in Great Britain, Germany, Austria, and France, and to contract for large mileage of torpedo cable in London.

July 2, 1874-Jan. 18, 1875: Member of Board of Commissioners to devise a plan to reclaim the Mississippi River alluvial basin.

Feb., 1875: Member of Board on proposed Topolobambo Railroad in Mexico.

Apr. 5-June 13, 1877: Member of Board to examine contracts between United States and Moline Water Power Co.

June 1, 1879: Member of Board of Visitors to West Point Military Academy.

Mar. 31, 1880: Lieutenant Colonel Corps of Engineers, U. S. Army.

Apr. 3, 1883-Dec. 20, 1884: Member of Gun Foundry Board.

Apr. 10, 1886-Aug. 13, 1895: Drilling Engineer troops in Torpedo service.

Oct. 12, 1886: Colonel, Corps of Engineers, U. S. Army.

Oct. 25, 1888-Aug. 13, 1895: Member of Board of Ordnance and Fortifications.

Mar. 12, 1885-July 27, 1888: Member of Endicott Board to select sites for seaboard fortifications.

Aug. 13, 1886-Aug. 13, 1895: Member Boston Harbor Line Board.

Oct. 5, 1888-Aug. 13, 1895: Member of New York City Harbor Line Board.

Dec. 3, 1888-Aug. 13, 1895: Division Engineer North East Division.

Aug. 13, 1895: Retired for age.

Engagements After Retirement.

1895: Chairman Jury of Higher Awards, Atlanta Exposition.
1895-1896: Consulting Engineer Manitowoc harbor for Wisconsin Central Railroad.
1895-1896: President, Board on Lake Erie-Ohio River Ship Canal.
1895-1918: Member Board of Overseers, Thayer School of Engineering.
1896-1897: Member of Forestry Commission.
March 23, 1897-1900: Member of Comité technique de la Cie. Nouvelle du Canal de Panama. Living in Paris.
Feb. 1898-Feb. 1899: Member of Comité statutaire of same Company. In Paris.
Feb. 1899-May, 1904: Consulting Engineer of same Company. Living in the United States.
Apr. 23, 1904: Brig. General U. S. Army, Retired.
June, 1905-Feb. 1906: Member of Roosevelt Board of Consulting Engineers to report on type of canal.
May 1905-June 1910: Professor of Hydraulic Engineering, George Washington University.
Dec. 7, 1915-Jan. 1916: Member of Commission on slides in Culebra cut, visiting the Isthmus.

Shortly after the Civil War closed, General Abbot, then as always devoted to scientific aspects, prepared a paper entitled "Siege Artillery in the Campaign Against Richmond," which was published as No. 14 of the Professional Papers of the Corps of Engineers. In the Introduction he says:

"The rapid progress made of late in the science of artillery demands close attention from the Corps of Engineers. Indeed any facts bearing upon the capabilities, uses, and theory of modern ordnance possess an interest almost as great for engineers as for artillery officers. For these reasons I have devoted such time during the past year as my professional duties would allow, to preparing the following memoir, designed to place in a small space the most important results of the recent experience in Virginia. Incidentally, an analysis of the

problem of ricochet firing upon water has been attempted, based upon certain data collected before my volunteer command was disbanded at the end of the war.

. . . . . .

"The important batteries of siege guns in all these campaigns were served by the 1st regiment of Connecticut artillery, which was thus identified in a conspicuous manner with the history of the army of the Potomac. This paper is therefore in some sort a record of its labors, and especially of its contributions to the science of artillery.

Record of First Connecticut Artillery

"In May, 1861, this regiment was mustered into the United States service as infantry. On January 1st, 1862, it was changed to artillery. After a few months of drilling in the defenses of Washington, it went into the field under Colonel Tyler to serve the siege train of 1862. It there took rank as one of the best disciplined and most efficient regiments in the army, and became imbued with a spirit of enthusiasm for the duties of its special arm.

"In January, 1863, after the promotion of Colonel Tyler, his Excellency W. A. Buckingham, Governor of Connecticut, conferred upon me (then captain of engineers, United States army) the appointment of colonel of the regiment. From that date until its muster out of service in September, 1865, it remained under my command; constituting the basis of an artillery brigade which sometimes exceeded an aggregate of 3,500 men.

. . . . . .

"With a wise appreciation of the requirements of a good military organization, his excellency Governor Buckingham uniformly appointed its officers from the regiment, and never except upon the recommendation of its commanding officer. It is hardly possible to overstate the advantages conferred by this system. The *matériel,* like that of most of the volunteer regiments, was of an unusually good character; college graduates being by no means unknown to its ranks, while the majority were possessed of a good common-school education.

"The commanding officer had thus in his power, by making just and judicious recommendations to the governor, to offer to the members of the regiment a career open to merit, uninfluenced by political or other favoritism; and to secure to himself the aid of a body of officers in every way qualified for their duties. This was naturally considered a matter of primary importance; and whenever a few vacancies had occurred the following system was adopted in selecting the nominees. Each captain was called upon for the name of his non-commissioned officer best entitled by acquirements, character, and faithful performance of duty to receive a commission. Field officers added those personally known to themselves to the list, which thus usually contained from twenty to thirty names. An examining board, consisting of all the field officers, including the commanding officer, was then convened, and the candidates were thoroughly examined in artillery and infantry. All the non-commissioned officers were habitually required to recite to their company officers in the textbooks treating of those branches whenever the duties of the regiment would allow; and these examinations were consequently thorough, exceeding half an hour to each candidate. After carefully comparing his own notes of the examination with the lists of the other field-officers, due weight being given to the character of the candidate for soldierly qualities and energetic performance of duty, the commanding officer submitted his recommendations to his excellency the governor.

"At every promotion, up to captain inclusive, the senior in each grade passed a similar examination before the same board, so that if an unworthy appointment had been made no subsequent promotion would be obtained.

"The power of assignment and of transfer among the different companies being vested entirely in the hands of the regimental commander, he was enabled to promote non-commissioned officers into companies where they were strangers to the enlisted men; to give to officers failing in one company an opportunity of benefiting in another by their past experience; and to see that each company contained officers well qualified

for all varieties of duty. Great attention was always paid to this matter, which was judged to be of vital importance.

"The character of the officers of the regiment can be inferred from the method of their appointment. The jarring factions so common to most volunteer regiments were nearly unknown to the 1st Connecticut artillery. Its officers were a body of men who appreciated the dignity of their position, and who were well educated in their duties. The regimental record shows how those duties were performed." [5]

He then takes up the subject of mortars as follows:

"After a little experience in campaigning in Virginia, both armies adopted the expedient of immediately intrenching themselves upon taking up a position. This was chiefly caused by the murderous precision of the rifled small-arms with which both armies were supplied, but was also very useful in covering the troops from horizontal artillery fire. The rapidity was surprising with which the 'rifle pits,' so called, could be thrown up by the aid of a few axes for felling timber, and shovels, or even bayonets or tin cups in cases of necessity, for moving dirt. After a few hours' work, the men lay secure in their trenches, indifferent alike to artillery and musketry fire. Vertical fire alone could severely annoy them.

"Although at the siege of Yorktown we had placed heavy mortars in position, and had practically experienced the annoyance of receiving upon our approaches the constant fire of one 8-inch mortar from the Confederate lines, neither belligerent availed itself during the subsequent campaigns of this species of artillery, prior to the advance of the army of the Potomac from the Rapidan, in the spring of 1864. In preparing for this campaign, General Hunt, chief of artillery, had procured eight Coehorn mortars to accompany the movement, and had included in the composition of my siege train many 10-inch and 8-inch siege mortars and Coehorns. It was a new arm to the

[5] "The following extract from a letter from General Barry, dated July 27, 1865, speaks for itself:

" 'As chief of artillery successively of the two principal armies of the United States during the four years of war now happily ended, I have enjoyed unusual opportunities for observation. You will on this account value my opinion when I assure you that the 1st Connecticut artillery, in intelligence and the acquirements and services of its special arm, stands unrivalled in the armies of the United States.' "

troops, and excited much interest and attention from both officers and men. Owing to the peculiar character of the march from the Rapidan to Petersburg, but little use was made of the Coehorns; although they were placed in position and served on the lines at Cold Harbor. After the failure of the first assault upon the Confederate position on the heights of Petersburg, the siege train was called into active service, and then began for the first time in the experience of the armies operating in Virginia, a really heavy mortar fire.

"Having noticed the effect upon the morale of our troops produced by the indifferent practice of the single 8-inch mortar from the Confederate lines of Yorktown, I had paid great attention to training the gunners in the use of this arm while in the defences of Washington. They were familiar with all the minor but essential details upon which the effect of vertical fire depends; and, as I learned at the time from deserters, and subsequently from Confederate officers, the result of their sudden and unexpected opening on the Petersburg lines was appalling. Having no mortars wherewith to reply, and no bomb-proofs for cover, and yet being compelled by the proximity of the main lines (only two hundred yards distant in the nearest place) to keep their own fully manned in order to guard against an assault, the enemy suffered severely for the first few days, and the moral effect was extremely depressing. On one occasion which came under my personal observation, a Confederate soldier was blown entirely over his parapet by the explosion of one of our shells; and his body lay, the clothing consumed by fire, beyond the reach of his friends who were deterred from approaching by our sharpshooters. To thus deprive an opponent of the accustomed protection of the trenches is well calculated to shake his nerves preparatory to an assault, or to retard or prevent the pushing of siege approaches.

"As soon as the enemy could obtain mortars they placed them in position, and from that time until the evacuation the fire was frequent and severe on several points of the lines. Our expenditures amounted to over forty thousand rounds, and theirs were not much less. Having the benefit of previous

training, our gunners retained the advantage, and the precision of their practice was justly admired.

"Mortars were first introduced and multiplied upon the Petersburg front, with a view to preparing the way for an assault, and for keeping the artillery of the enemy quiet when it was delivered. This purpose they accomplished most effectually. When, after the Mine fiasco, the project of directly assaulting the Confederate position was abandoned, the fire was maintained to keep down picket firing and to compel the silence of certain very annoying batteries, which from the left bank of the Appomattox river, enfiladed the right of our line and caused much loss. Both parties ultimately constructed bomb-proofs, and remaining as much as possible under cover when the firing was going on, received little injury. For this reason it was gradually discontinued on this part of the line.

"At Dutch Gap, however, the Confederates had an opportunity to reap the full advantage of vertical fire, and they continued it there until the canal was essentially completed, sinking one of the dredges and greatly harassing our working parties. They placed their mortars in sunken batteries, provided with good bomb-proof cover, on the low ground on the right bank of James river, in front of the canal. Our return fire was so heavy that they fell into the error of concealing these batteries behind clumps of trees, and thus lost, what is really essential to success, a good view of the target from the battery itself. The result was that their range was faulty, and their shells fell chiefly from forty to one hundred yards to the eastward of the canal, where they literally ploughed up the ground. This error enabled our working parties to continue the excavation with comparatively little loss, but suffering greatly from the harassing nature of the fire.

"A second error, worse than the first, committed by the Confederates at Dutch Gap was in not sufficiently multiplying their fire. They never used more than four or five mortars, and these chiefly Coehorns. Not less than twenty, and these eight and ten inches in calibre, were required. I am confident that this number could have been placed in position in such a man-

ner that no efforts on our part could have compelled their silence; and that well served, they would have effectually prevented the digging of the canal.

"To check their fire as much as possible, 10-inch, 8-inch, and Coehorn mortars were used—advantage being taken of the high signal tower at Crow Nest to correct errors of direction—and also horizontal fire of shell and case shot from field guns, and, occasionally, from a 100-pounder rifle, to annoy the Confederate gunners in watching the effect of their shot. To compel, by such means, resolute soldiers like these Confederate artillerymen, to suspend fire from well-constructed mortar batteries was impossible; but the precision of their practice was so much impaired that the work on the canal could continue."

After this interesting introduction, General Abbot goes on with that careful attention to details so characteristic of him to give an exhaustive account of the construction, transportation, emplacement, ammunition, service, effectiveness, and possible improvements of mortars, smooth-bore and rifled guns, and the use of entrenchments. This account embodies the results of field service and experimentation extending over a period of several years of warfare. Naturally the progress of the science of artillery renders much of this treatise obsolete, but as indicating his constant passion for accurate research it takes a worthy place among General Abbot's writings.

Another subject which the war brought prominently forward greatly interested him, and became General Abbot's major field of research during many years after. It is the subject of submarine mining. He gave a most interesting account of it in a paper read January 10, 1880, before the Military Service Institution, and published in pages 203 to 224 of Volume I of its Journal. After referring to early suggestions, little followed up either in this country or in Europe, he traces the very considerable development, especially on the part of the Confederates, of this arm during the Civil War. Very interesting is a table which he compiled from official sources showing how disastrous submarine mines proved to the shipping, particularly of the Union forces:

STEAMERS DESTROYED OR CRIPPLED BY TORPEDOES, DURING THE CIVIL WAR

Date	Vessels					Injured		
	Name	Service	Class	Tons	No. of guns	Where	Extent	Torpedo
Dec. 12, 1862	Cairo	U. S. Navy	Armored	512	13	Yazoo River	Destroyed	Mine
Feb. 28, 1863	Montauk	"	Monitor	844	2	Ogeechee River	Seriously	"
July 22, "	Baron De Kalb	"	Armored	512	13	Yazoo River	Destroyed	"
Aug. 8, "	Com. Barney	"	Gunboat	513	4	James River	Disabled	"
Sept. —, "	John Farron	U. S. Army	Transport	...	..	"	Seriously	"
Oct. 5, "	Ironsides	U. S. Navy	Armored	3,486	18	Off Charleston	"	Spar
Unknown	Marion*	Confederate	Unarmored	...	..	"	Destroyed	Mine
"	Ettiwau	"	"	...	..	"	Seriously	"
Feb. 17, 1864	Housatonic	U. S. Navy	Sloop of war	1,240	13	"	Destroyed	Spar
Feb. 17, "	Fish Torp. Boat	Confederate	Torpedo boat	...	..	"	"	Own
April 1, "	Maple Leaf	U. S. Army	Transport	508	..	St. John's River	"	Mine
April 6, "	Gen. Hunter	"	"	460	..	"	"	"
April 9, "	Minnesota	U. S. Navy	Flag ship	3,307	52	Newport News	Internally	Spar
April 15, "	Eastport	"	Armored	800	8	Red River	Sunk	Mine
May 6, "	Com. Jones	"	Gunboat	542	6	James River	Destroyed	"
May 9, "	H. A. Weed	U. S. Army	Transport	290	..	St. John's River	"	"
June 19, "	Alice Price	"	"	320	..	"	"	"
Aug. 5, "	Tecumseh	U. S. Navy	Monitor	1,034	2	Mobile Bay	"	"
Oct. 27, "	Albemarle	Confederate	Armored	...	2	Plymouth	"	Spar
Nov. 27, "	Greyhound	U. S. Army	Transport	900	..	James River	"	Coal
Dec. 8, "	Narcissus	U. S. Navy	Gunboat	101	2	Mobile Bay	"	Mine
Dec. 9, "	Otsego	"	"	974	10	Roanoke River	"	"
Dec. 9, "	Bazley	"	Tug	...	..	"	"	"
Jan. 15, 1865	Patapsco	"	Monitor	844	2	Off Charleston	"	"
Feb. 20, "	Osceola	"	Gunboat	974	10	Cape Fear River	Crippled	Drifting
Unknown	Shultz†	Confederate	Transport	...	..	James River	Destroyed	Mine
Mar. 1, "	Harvest Moon	U. S. Navy	Gunboat	546	3	Georgetown	"	"
Mar. 4, "	Thorne	U. S. Army	Transport	403	..	Cape Fear River	"	"
Mar. 12, "	Althea	U. S. Navy	Gunboat	72	1	Blakely River	"	"
Mar. 28, "	Milwaukee	"	Monitor	970	4	"	"	"
Mar. 29, "	Osage	"	"	523	2	"	"	Drifting
April 1, "	Rodolph	"	Gunboat	217	6	"	"	Mine
April 13, "	Ida	"	"	104	1	"	"	"
April 14, "	Sciota	"	"	507	5	Mobile Bay	"	"
May 12, "	R. B. Hamilton	U. S. Army	Transport	400	..	"	"	"
June 6, "	Jonquil††	U. S. Navy	Gunboat	90	2	Ashley River	Seriously	"

* Blown up accidentally when planting mines (General Beauregard).

† Flag of truce boat blown up accidentally by a Confederate mine when returning to Richmond with exchanged prisoners of war. ††*Injured while raising frame torpedoes.*

He remarks:

"Wholesale destruction, like that shown by this table, did not fail to attract the notice of every nation possessed of a sea-coast and a navy. How to make use of the new weapon to defend the former, and to increase the offensive powers of the latter, at once received earnest attention. The investigations thus inaugurated have been actively continued to the present day, but the results, as far as possible, are kept shrouded in mystery. Indeed it is altogether probable that until war compels a general showing of hands, not a few trump cards will never see the light."

He then lays down the fundamental law of naval operations, and supports it by quotations from the highest authorities, that the fleet is not to be used for harbor defense, but for offensive expeditions. Heavy guns in fixed forts must be the reliance for shore defense. But since the experience of the Union fleets at Mobile and New Orleans plainly showed that an energetic admiral may pass the fortifications without fatal losses, it becomes the province of submarine mines to obstruct the channel and hold the enemy's ships under the fire of the heavy guns until they work destruction upon them.

He proceeds as follows:

"The foregoing considerations sufficiently explain the reasons for the establishment of a school of sub-marine mining at Willets Point. A brief outline will now be given of some of the more important investigations which have been conducted there to develop this new branch of national defense.

"The first subjects of study were to determine the best explosive for use in sub-marine warfare; its destructive range against a first-class modern ship-of-war, built of iron upon the double cellular principle; and the effect produced upon this range by variations in the depths of water, the submergence of the charge, the material of the envelope, the air space in the torpedo, and the nature of the fuze—in a word the laws governing the effective transmission of the energy developed by the

explosion through the water to the vessel, and the minimum amount of this energy which may be regarded as certainly destructive.

"Nothing can be accomplished in such an investigation without numerous and accurate measurements.

"Major King had already shown that the Rodman gauge could be used under water; but certain difficulties which he had encountered indicated the necessity of modification in the apparatus before it could be employed with large charges. These modifications, and a new method for determining the scale which avoids the theoretical objections pointed out by Prof. Bartlett to the use of a compression machine, were successfully accomplished.

"It was inferred at the outset—and experience has abundantly confirmed the truth of the inference—that in order to secure determinate results the gauges must be held rigidly in position when acted upon by shock. Different methods were adopted.

"In the first, the charge was lashed in the center of a stout wrought iron ring (3 ft., 4 ft., 5 ft., or 6 ft., in diameter) upon which six gauges were secured in such a manner as to point directly at the charge. This apparatus was suspended in a vertical plane at any desired distance below the surface, by wire rope connected with a wrought iron buoy. By this method any particular experiment could be repeated as often as necessary under identical circumstances; and any single element could be varied without modifying the others.

"Several hundred trials have been made with this apparatus, including comparative tests of mammoth powder, cannon powder, Oliver powder, mortar powder, musket powder, fine sporting powder, safety compound of the Oriental Powder Company, compressed gun cotton, dry and wet, granulated gun cotton, nitro-glycerine, dynamite (2 grades), dualin, rend-rock (3 grades), vulcan powder (2 grades), mica powder (2 grades), hercules powder (2 grades), electric powder (2 grades), Designolle powder and Brugere or picric powder.

"This list includes characteristic types of all explosives known to modern science which are suitable for use in submarine mining. In connection with many other tests covering wetting, freezing, long storage and sympathetic explosions, the experiments have shown that dynamite No. 1, consisting of 75 per cent of nitro-glycerine and 25 per cent of keiselguhr, is the best for our service.

"In so extended an investigation many new points have naturally been developed, but only a few of them can be mentioned here.

"The fundamental distinction between explosive mixtures and explosive compounds is strongly marked in subaqueous explosions. The former burn gradually, and with any strength of envelope likely to be used in sub-marine mining only a small fraction of the theoretical potential energy can be utilized, even when many well distributed points of ignition are employed. The compounds, on the contrary, when detonated waste but little of their full strength. This difference renders hardly possible any direct comparison between these two classes when fired under water.

"The element of time, even with explosive compounds, has proved to be of extraordinary importance. Thus nitro-glycerine exploded under water develops but little more than 8/10 of the intensity of an equal weight of dynamite No. 1, thus suggesting the apparent paradox of a part being greater than the whole. The explanation is believed to lie in the fact that its action is too sudden to be well suited to a resistance like that opposed by water.

"The interposition of a stout wooden case between the charge and the water reduces in a surprising degree the kinetic energy available for effecting destruction upon an exterior object. Thus, with small charges of an explosive compound, a wooden case 2 inches thick absorbs from 40 to 55 per cent of the energy registered upon the gauges when a tin case is used.

"To determine the laws governing the transmission of the shock horizontally through the water to considerable distances, a light wrought iron frame 50 ft. long by 10 ft. by 10 ft. was

employed. The charge was secured at the central point, and 36 gauges, placed symmetrically with respect to a horizontal plane passing through it, were rigidly secured at the angles between the transverse frames. This 'crate,' so called, was suspended below the water surface by two buoys, and charges of dynamite varying from 5 lbs. to 100 lbs. were exploded, and the intensities of their action measured.

"A close study of many experiments with the apparatus above described has fixed the numerical values of certain constants entering a general equation framed upon well established mechanical principles; and has proved that one and the same formula can be applied to all the modern explosive compounds by substituting the proper numerical value for a single constant.

"This discovery has rendered it easy to fix the relative value of the several explosive compounds, and to compute for each the intensity of action which the explosion of a known charge at a known distance will develop in any known direction.

"The complete solution of the problem of destructive range for subaqueous explosions required, in addition, that the intensity of action needful to destroy a first-class modern ship of war should be ascertained.

"To determine this intensity, an iron target was prepared representing a section twenty feet square from the bottom of the Monarch, a vessel constructed upon the double cellular principle. This target was so moored as to secure by the use of heavy anchors and chain cables, strained by a tidal lift, much greater stability than would be given by its own weight; and a systematic series of tests was conducted in the years 1875-7. One numerical value for the intensity of action needful to effect destruction was thus deduced.

"The English official tests upon the Oberon, conducted during the years 1874-6, were reported in professional journals and the daily papers in so great detail that by the aid of the formulæ above mentioned a satisfactory discussion of them was possible, although the official conclusions reached by the royal engineers have never been publicly announced. In this manner

a second and independent value of this important element of the problem was secured.

"Certain preliminary trials conducted at Willets Point upon a very strong wooden raft afforded a third value.

"These three determinations were so accordant that we have reason to be satisfied with the value finally adopted by the board of engineers; and the size of the charges for our mines and their destructive range have been fixed accordingly."

For nearly twenty years, General Abbot, commanding the Engineer School of Application at Willets Point, or detailed to various Boards charged with seacoast fortification and harbor improvement, devoted much of his great research ability to the improvement of those combinations of high explosives and electrical mechanisms which are at the basis alike of modern engineering and of coast defense in warfare. Of the Engineer School his son, Gen. F. V. Abbot, writes:

"After the war was over he was in command of the Engineer Battalion, and under the direction of General Humphreys, then Chief of Engineers, he established in 1866 the 'Engineer School of Application' to which all Engineer graduates reported upon graduation. This 'School' was almost the opening gun in the long campaign for education of Army officers in post-graduate schools. I believe that the only Army School antedating the Engineer School of Application was the Artillery School at Fort Monroe. The Engineer School did not receive official recognition by the Adjutant General in those early days because 'It was not under the Adjutant General, but only under the Chief of Engineers, and so was not properly an Army School.' Those of us who took the courses in those same early days know from the way we had to work to keep up with the requirements that it was a most real school so far as its students were concerned. From the start it was practical as well as theoretical but included much military history and art of war. My father always held that Engineers were *primarily* soldiers, but in addition had to acquire much scientific knowledge. Astronomy as applied in boundary surveys, then often

assigned to the Corps of Engineers, and practical application of the natural sciences formed part of the curriculum.

"At the very start when buildings, books, etc., were hard to get for the school it was my father's custom to assign to lieutenants some French book on a military subject for translation. To one officer, later a most effective Chief of Engineers, was assigned thus, 'Defenses des Etats,' a book of several hundred pages. The young officer thought to himself, as he has often told me in later years, 'The General evidently has forgotten the French he learned at West Point and wants my help to learn what this infernally big book contains,' and went at his job with enthusiasm, and spent many an hour transcribing his translation with unusual care, as his penmanship, like many another's was not all that could be desired. At this date all officers of the Battalion and School were quartered in the one-story cantonment buildings built for the Medical Department for hospitals during the Civil War. They were not sheathed or plastered and were 'warmed' ??? by old fashioned cast iron stoves. Warmed is a relative term, and often the translator's ink froze in the evenings though not more than a few feet from one of these 'Heaters.' One especially cold night one of his classmates and a mutual friend climbed to the roof and dropped a large snowball down the sheet iron stove pipe, which was all the chimneys had on any of the quarters, from the Commanding Officer's, to the smallest barracks. When the snowball reached the hot coals there was an explosion which blew the stove door open, and a rush of steam, smoke, and soot utterly ruined the 100 pages of manuscript of the 'Defenses des Etats.' The next morning the Lieutenant reported at the Adjutant's Office, and apologized to my father for the long delay a recopying of the translation would involve, and expressing the hope that the Commanding Officer was not in urgent need of the same. He was disgusted when my father replied 'Why, of course I have read the book myself, and selected you to translate it only for your own good.'

. . . . . .

"On May 5th, 1869, my father was detailed as a member of

the New York board of Engineers on Fortifications, in those days charged with the preparation of detailed plans of defense of our sea coast against foreign naval attack. He remained a member of this board till he retired for age. For years he was its President. With the approval of the Chief of Engineers, 'Major Henry L. Abbot' was detailed by this board 'To devise and test a sub-marine system for the United States, and to train Engineer troops in its operation.' This was in 1871. In carrying out this program my father personally handled and tested chemically all then known high explosives in order to select that best adapted to use in sub-marine mines. In the course of his experiments he photographically recorded the blowing up of the schooner *Olive Branch,* a triumph in those early days when dry plates were unknown, and wet plates of sufficient sensitiveness to record with very short exposures were just in the testing stage. Thus in two dissimilar branches of chemistry my father was early at the front.

"He developed the spherical welded mine case still universally used. He actually devised and practically tested an electrically controlled system of sub-marine mining, at a time long antedating the use of incandescent lamps, and large dynamo machines. To determine the distances between sub-marine mines needed to permit the explosion of one without destroying its neighbors, he undertook the investigation of the laws of translation of destructive shocks of explosions under water, and derived a formula which indicates with extreme accuracy the pressures to be anticipated at any distance under water from the explosion of a known charge of any explosive, when once the latter's coefficients have been determined by actual explosions of small charges, where the resultant pressures can be accurately measured by proper pressure gauges.

. . . . . .

"He was a pioneer in the study of simultaneous ignitions of large numbers of fuzes, designing and making the electrical connections used at the Flood Rock explosion October 10th, 1885. Now with powerful high-potential dynamos such a problem would be easy, but then wet batteries were the only source

of current. With thousands of fuzes to explode, and hundreds of thousands of pounds of high explosives to be ignited under water, the problem was one of no light responsibility, but the result was a perfect success."

General Abbot's loyalty and pride towards the Corps of Engineers of which he was an ornament found expression in a historical paper, pages 413 to 427 of Volume XV of the Journal of the Military Service Institution. Having traced the formation and history of the Corps from the Revolution until 1861, he says of its service in the Civil War:

"These engineer companies after the return from Fort Pickens served throughout the Civil War with the Army of the Potomac. Space is lacking to detail their important and gallant services. The battalion was attached to the headquarters of the army, under orders of the chief engineer, and besides its special duties was often placed in line of battle. Its officers were habitually detached, as needed to serve temporarily on the staffs of generals commanding army corps and divisions. Its colors were officially authorized to bear the names of the following engagements: Vera Cruz, Mexico, 9 and 28 March, 1847; Cerro Gordo, 17 and 18 April, 1847; Contreras and Churubusco, 19 and 20 August, 1847; Molino del Rey, 8 September, 1847; Chapultepec and City of Mexico, 13 and 14 September, 1847; Yorktown, Va., 4 May, 1862; Fair Oaks, 31 May, 1862; Mechanicsville, 26 June, 1862; Gaines's Mill, 27 June, 1862; White Oak Swamp, 28 June, 1862; Malvern Hill, 1 July, 1862; Antietam, Md., 17 September, 1862; Fredericksburg, Va., 13 December, 1862; Chancellorsville, 4 May, 1863; Franklin Crossing, 5 June, 1863; Kelly's Ford and Rappahannock Station, 7 November, 1863; Wilderness, 5 and 6 May, 1864; Po River, 8 May, 1864; North Anna, 23 May, 1864; Cool Arbor, 3 June, 1864; Siege of Petersburg, June, 1864, to April, 1865.

"Immediately after the close of the war the headquarters of the battalion were established at Willets Point, New York harbor, where has been gradually developed the present Engineer School of Application. . . .

"*War Record of the Corps of Engineers*—Beside the military duties assigned to engineer troops, there are important professional functions which devolve upon engineer officers serving on the staff of generals commanding armies in the field; and in our service the command of volunteer troops, as well, has often devolved on officers of the Corps. In every war with a civilized power since the earliest history of our country these duties have been performed by them in a manner to merit and receive distinguished commendation; and in all these wars their blood has been shed on the field of honor. That this is no exaggeration is shown by the following list of officers who have been killed or mortally wounded in battle since the organization of the present Corps in 1802. All were graduates of the Military Academy:

"Capt. and Bvt. Lieut.-Col. E. D. Wood, Sept. 17, 1814, Sortie from Fort Erie, U. C.

"Capt. W. G. Williams, Sept. 21, 1846, Monterey, Mexico.

"1st Lieut. and Bvt. Captain W. H. Warner, Sept. 26, 1849, by Indians near Pitt River, Cal.

"Captain J. W. Gunnison, Oct. 26, 1853, by Indians near Sevier Lake, Utah.

"Maj.-Gen. I. I. Stevens, U. S. V., Sept. 1, 1862, Chantilly, Va.

"Brig. Gen. J. K. F. Mansfield, U. S. A., Sept. 18, 1862, Antietam, Md.

"1st Lieut. and Bvt. Col. J. L. K. Smith, Oct. 12, 1862, Corinth, Miss.

"1st Lieut. and Bvt. Major O. G. Wagner, April 21, 1863, Siege of Yorktown, Va.

"Major and Bvt. Major-Gen. A. W. Whipple, May 7, 1863; Chancellorsville, Va.

"Captain and Bvt. Col. C. E. Cross, June 5, 1863, Franklin's Crossing of Rappahannock River, Va.

"1st Lieut. and Bvt. Col. P. H. O'Rorke, July 2, 1863, Gettysburg, Pa.

"Captain and Bvt. Col. H. S. Putnam, July 18, 1863, Assault of Fort Wagner, S. C.

"Captain and Bvt. Col. A. H. Dutton, June 5, 1864, Bermuda Hundred, Va.

"Major and Bvt. Brig.-Gen. J. St. C. Morton, June 17, 1864, Petersburg, Va.

"Brig.-Gen. J. B. McPherson, U. S. A., July 22, 1864, Atlanta, Ga.

"1st Lieut. and Bvt. Maj. J. R. Meigs, Oct. 3, 1864, Harrisonburg, Va.

"1st Lieut. Jacob E. Blake, Topographical Engineers, deserves to be mentioned in this list, although his death resulted from the accidental discharge of his own pistol on the field of Palo Alto after an act of the most conspicuous gallantry performed in the sight of both armies.

"Very many of the officers of the Corps have been wounded in battle, some several times, but the list is too long for the space allotted to this paper.

"During the war with Mexico 19 officers of the Corps of Engineers and 24 officers of the Corps of Topographical Engineers served actively in the field. One of them, Captain Williams, was killed, and sixteen wounds were divided among the others. Among those of this little band who subsequently, in the Civil War, reached high rank and distinction may be mentioned in order of seniority in their respective corps: Generals Mansfield, Robert E. Lee, Barnard, Beauregard, Isaac I. Stevens, Halleck, Tower, G. W. Smith, McClellan, Foster, Joseph E. Johnston, Emory, Fremont, Meade, Pope, Franklin, and T. J. Wood.

"During the Civil War the officers of both Corps with few exceptions served with the armies in the field. . . .

"It is a matter of record that 33 officers who either held or had held commissions in the Corps of Engineers, were appointed during this war general officers in command of troops. Of these, 3 became major-generals, and 3 brigadier-generals in the regular army; 15 were major-generals, and 12 were brigadier-generals of volunteers; 8 of the 33 commanded armies; and 10, army corps. At least 8 general officers in the Confederate armies had been officers of our Corps of Engineers,

and among them were General Robert E. Lee and General Joseph E. Johnston."

Of the peace record of the Corps of Engineers he quotes from his friend General Humphreys as follows:

" 'From the earliest period, the several organizations of engineers which we have had in our service, have invariably and exclusively made the surveys for, and the plans of, our sea-coast defenses, whether of a temporary character which were built up to 1818, or of the permanent character which have been since that time projected, and have superintended their construction and the disbursement of the funds appropriated by Congress for the same.

" 'Up to about 1831, its officers were to a great degree the repositors in this country of that knowledge which was requisite for the purpose of making accurate surveys. The location and construction of the roads, canals, and bridges built for the development of the resources of the country, and the accurate methods of surveying, geodetic, topographic, and hydrographic, now in use, are in a great measure due to the talents and labors of its officers.

" 'Almost all the great routes of internal communication in the interests of commerce and speedy transit, now in existence in the country, were first explored, located, and projected by officers of this Corps. The files of the bureau of the Corps in Washington, and the Congressional documents, are rich in reports upon the works of this character, that have been examined into under authority of law, by the Corps of Engineers.

" 'In the matter of the improvement of rivers and harbors, in the interest of commerce, the Corps of Engineers has had almost the exclusive control, and the information on this subject contained in reports of its officers, from the early years of this century to the present time, now filed in the Bureau of the Corps, is a monument to its labors and a most valuable collection of precedents to be used in the future prosecution of such works.

" 'The surveys, examinations, and constructions which have been made by officers of the Corps, have not been confined to

such matters as are solely in charge of the War Department. From time to time the State Department, the Navy Department, the Treasury Department, and the Interior Department have employed its officers in the running of boundary lines, and the surveys for the maps necessary to be used in delicate diplomatic negotiations; in the surveys for, and the constructions of, dock-yards; the surveys for canal routes across the Isthmus of Panama; upon astronomical observations in the interest of science; in the surveys of the coasts, the planning and construction of light-houses and other fixed aids to navigation; the planning and construction of public buildings, of custom houses, post-offices, marine hospitals, etc.; and especially in the construction of the Capitol, the General Post Office, and the Washington Aqueduct in this city.

" 'Scarcely a branch of engineering, whether military or civil, can be mentioned, that has not been improved and expanded by the study and labors of the officers of this Corps.' "

In this Corps, General Abbot served from 1854 to his retirement for age in 1895. He arrived at the top, not only in the excellence of his service but in actual seniority. Yet neither he nor his son, General F. V. Abbot, who also became senior officer of the Corps after distinguished service, and who was for many months Acting Chief, received the actual appointment as Chief of Engineers.

Chapter 5

Family Life and Occasional Occupations

General Abbot married April 2, 1856, Mary Susan Everett of Cambridge, Massachusetts, who died March 13, 1871, aged 39 years. They had four children, two sons and two daughters. The elder son, Frederic Vaughan Abbot, born March 4, 1858, graduated No. 1 in the class of 1879 at West Point, rose to be Colonel and Brevet Brigadier General of Engineers, was retired for physical disability while Acting Chief of Engineers at the age of 62 years, and died September 26, 1928. He left a widow, two unmarried daughters, and a married son engaged in civil engineering. The younger son of General H. L. Abbot, born March, 1871, died as the result of accident while spend-

ing the summer at the ancestral home in Wilton, New Hampshire, aged 10 years. The two daughters at this writing still survive, unmarried.

General Abbot was very gentle and loving in his home life, though so deeply immersed in his unremitting researches and military duties as to be rather difficultly drawn into social intercourse. Not a talkative man, he was a good listener, with face alight with kindly interest, when actually drawn out of his computations, and brought into the social circle. He received the reverence and warm affection due to an unblemished, kindly, generous character.

He was not a voluminous correspondent, nor did he, like some famous characters, make his letters very markedly the expression of his life. His daughter writes: "It was not so much in his letters themselves as in the regularity with which they came that my father showed his constant loving thought of us. Any one not with him knew that each Sunday morning he would be clicking away at his typewriter, and could count on hearing from him."

During his visit of inspection with the National Academy Commission to the Panama Canal in the year 1915, his letters home form a diary of the expedition from which I quote some passages, not so much for their historical value as to give a little closer view of the man himself, outside his official life.

"Havana, Cuba, Dec. 15, 1915. . . . All goes well except today. One of our members knows President Menocal of Cuba, who extended us an introduction to a formal reception at 9:15 a. m., later postponed to 11 a. m. We should have gone together, but no arrangement was made and we went separately. There are several secretaries at the Palace, and I and one other got into the hands of a wrong one. Receiving no notice of the reception I wasted half an hour and then left, leaving my card for President Menocal. . . . The day is lovely and I have had no occasion to change to summer clothing.

"Dec. 16. . . . We actually got off in the middle of the night. Early in a. m. could see mountains skirting the west end of Cuba. Very fine and sea smooth.

"Friday, Dec. 17. . . . More wind today, and enough rolling to make some of us seasick, but not me. We had a Commission meeting today on the slides. . . . We had a wireless telegram today from Washington 'President Wilson is 59 years old and his bride is 43.'

"Sunday, Dec. 19. . . . Nearing our port. . . . Letters mailed on board ship are at arrival transferred to next ship to sail north. . . . So this little sheet will first go north and then the long trip across the Continent before you get it. Let me know when it arrives so I can count the days it is on the road. Shall be too busy to write much, and it would be no use to mail one when I *start*. So do not worry if a long interval occurs. We rather expect to leave on Jan. 2 but may not do so. Love and kisses from

"PAPA."

"Jan. 3, 1916. . . . Here we are homeward bound. . . . The sea today is smooth but several are sick, but I *am all right*. . . . It has been a pleasant trip, and the changes have been so great on the Isthmus that it seems a new world to me.

"Jan. 4. . . . Slight rolling sea. I am all right, and have plenty of room at table for *many* are not. The birthday of my little war daughter is approaching, and as she may find funds useful in her wanderings, I shall endorse the check to her instead of her 'agent.'

"Jan. 7. . . . We lay fog bound at anchor off the entrance of the Mississippi Pass until 7 a. m., when we entered and are slowly creeping up the river, the fog too dense to see the details of the jetty works. We hope to reach New Orleans in time to catch the 9:35 p. m. train for New York. My plan is . . . to proceed to Cambridge to await your arrival. If that occurs in May, I shall have to go to Dartmouth meeting and perhaps to the meeting of the National Academy of Sciences in Washington in April. So the date when we meet again is a long distance in the future. . . . I am feeling finely, having had no illness since I started on this long trip.

"Love and kisses from

"PAPA."

"Jan. 9. . . . Just arrived [in New York] after the long journey from the Isthmus. Find all well here. We had a nice trip and I hope the worst is over with the slides. Ships drawing not over 21 feet were passing when I left. The difficulty is now limited to about a mile in distance, and the fight will end there probably for the future. . . .

"H. L. A."

"Cambridge, February 20, 1916.

"DEAR MAY:

"So May cannot get before May, but she may get behind May. What kind of a dress does May have on to be such an obstruction?

"We are having a remarkable kind of winter. Day before yesterday the mercury read at breakfast, dinner and supper 34°, 42° and 39°. Yesterday these figures were 15°, 15° and 11°. Today it begins at 10°. The lowest I have read was 2°. The snow has been a maximum for 24 years so the Transcript says. I am glad you are out of it. . . . During the warm days one has to swim to get over the streets, and during the cold days look out not to fall on the slippery ice under the snow. . . .

"Go on picking oranges, and having a nice time and come back as good as new; and you will do much to please your loving

"PAPA."

Throughout his life, General Abbot wrote much. The following list of papers was prepared by him, and shows at once the great variety of his interests, and also the concentration of his attention on subjects relating to hydraulics; to indirect artillery fire; to submarine mining, and the use of high explosives; and through a very long period to the subject of the Panama Canal.

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Among many interesting observations done under his direction, there was a series of latitude observations at Willets Point designed primarily as practise in the use of astronomical instruments by the young engineers. But so exacting was the accuracy demanded, and so painstaking the record, that a ten-year series indicated clearly that wandering of the earth's pole which was investigated by Chandler about ten years later, and afterwards continuously observed by international cooperation.

General Abbot also continued for many years to record at Willets Point the aurora borealis. His long (unpublished) series of observations brings out very clearly the association between terrestrial auroræ and the sunspot numbers.

At the time of the improvement of the approaches to New York by the blasting of the Hell Gate ledges, General Abbot arranged an elaborate system of observations for determining the rate of propagation of the earth waves. His report thereon in pages 691 to 704 of the Annual Report of the Chief of Engineers, Part 1, 1886, is full of interest. The following table of results, whose divergences the context leaves no room to attribute to careless observing, is most extraordinary.

DATA AT THE FLOOD ROCK EXPLOSION

Stations	Distance from Flood Rock	Magnifying power of telescopes	Earth wave			Velocity of transmission in miles per second	Remarks
			Arrived in	Mercury in agitation	Earth tremor lasted		
EASTERLY COURSE THROUGH DRIFT	Miles		Sec.	Sec.	Sec.		
Willets Point	8.33	14	8.5	80	..	0.98	By mercury
			8.8	..	62	....	By galvanometer
Pearsalls	16.78	14	6.6	104	86	2.54	
Bay Shore	36.65	18	13.0	35 (?)	..	2.82	
Patchogue	48.52	19	15.4	54	36	3.15	
Goat Island	144.89	15±	58.8	74	56	2.46	
Harvard Observatory	182.68	750	219.8	95+	..	0.83	
NORTHERLY COURSE THROUGH ROCK							
West Point	42.34	31	13.6	76	58	3.11	Lieutenant Mott
		16	10.9	70	52	3.88	Lieutenant Beach
		36	10.9	92	..	3.88	Lieutenant Stuart
Litchfield Observatory	174.37	25	45.0	49+	..	3.88	Professor Peters
		45	45.2	..	..	3.86	Mr. Borst

General Abbot remarks:

"These observations indicate: (1) an extraordinary velocity of wave translation in both directions—which confirms my deduction from the Hallet's Point and certain torpedo explosions, that 'the more violent the initial shock the higher is the velocity of transmission.' At Flood Rock the charge was about six times as large as at Hallet's Point, and the velocity was from two to three times as great, over essentially the same route. (2) The uniformity of velocity to the northward, where the strata consists largely of homogeneous gneiss rock, and where the velocity even for 175 miles exceeded 20,000 feet per second. (3) The varying velocity which appeared to characterize the wave moving to the eastward, through the drift formation of Long Island. Here there seems to have been a gradual increase of velocity, followed by a decrease as the wave advanced—but on the whole a decidedly less rapid rate is indicated than in traversing solid rock, as might be expected in media of varying density and elasticity. The result, although not inconsistent with the Hallet's Point observations, was not discovered from them, except as to the decrease in velocity as the wave disappeared. This is the only point where the four deductions from the earlier observations are modified by this later and more accurately observed explosion.

"The very slow rate of movement to Willets Point is so surprising that it has received the closest scrutiny, but the evidence seems to establish its correctness. The latter rests (1) upon the determination of the absolute instant of explosion; and (2) upon the observed arrival of the tremor, closely verified by the galvanometer observations. The resulting velocity is also roughly confirmed by the observations at Astoria, as will be explained in discussing the photographs.

"The Flood Rock explosion appears to have caused a continuous earth tremor, which, observed under a magnifying power of about 18, lasted about one minute throughout the whole region covered by the observations, the maximum disturbance leading the advance, or nearly so, for at least 50 miles. At extreme ranges the tremor appears to have broken up into

successive waves, with well-marked intervals between them. These facts, the instantaneous nature of the explosion shown by the photographs, and the varying rates of advance through strata not homogeneous, appear to warrant the conclusion that the oscillation followed different routes to any given point—some near the surface, and others at greater depths, where more dense and elastic strata produced changes in the direction of the wave front and yielded higher velocities.

"The whole subject is evidently too complex to warrant definite conclusions as to the velocity of ordinary earthquake waves, where the intensity of the original disturbance must always remain unknown."

He was appointed on two important commissions for the National Academy of Sciences. The first appointment at the request of the Secretary of the Interior, was to the Forestry Commission of the years 1896 and 1897, which was so influential in the organization of the present national forest service. Though then 66 years of age, "he was equal to anyone of the Commission in riding the difficult and in places dangerous trails."

Again in 1915 the President requested the Academy to investigate the Culebra slides at the Panama Canal. Though 84 years old, General Abbot accepted appointment on the Committee of the Academy, refused to let his son or any other near friend accompany him, and visited the Isthmus with the Committee. One of the other members remarked afterwards, "General Abbot was one of the most mentally and physically active of all of us, and went everywhere, in spite of the heat, steepness of the climbing, and in many places uncertain and dangerous trails over the material which had moved, and which was liable to start again at any time."

From May, 1905, to June, 1910, General Abbot was Professor of Hydraulic Engineering on the faculty of graduate studies of George Washington University, and for 23 years he was an active member of the Board of Overseers of the Thayer School of Engineering at Dartmouth College, resigning at the age of 87 years.

Chapter 6

General Abbot and the Panama Canal

One who has read the numerous papers of General Abbot, in which appear the extensive investigation, the keen analysis, the tireless advocacy which he devoted to the lock canal across the Isthmus of Panama, and who is informed of the many occasions when the project came within an ace of abandonment, but was saved by the General's forceful testimony, can appreciate to some degree, at least, the glow of exultation with which he must have looked in 1915, at the age of 84 years, on the triumphant success of this world-famous piece of engineering which owed so much to his exertions.

Retiring for age in 1895 from the Corps of Engineers of which he had been so great an ornament, General Abbot was employed for a time as consulting engineer by the Wisconsin Central Railroad to prepare plans for the development of the harbor of Manitowoc, Wisconsin. In 1895-6, he was also president of a board of consulting engineers on a project to connect Lake Erie with the Ohio River by a ship canal. This project did not come to fruition, doubtless owing to the railroad influence.

On his return from the expeditions of the Forestry Commission of 1896-7, he received a telegram from Mr. Maurice Hutin asking a meeting in New York. This resulted in an offer from the Chief Engineer of "La Compagnie Nouvelle du Canal de Panama" of a place on the *Comité technique*. At first loathe to be connected with an enterprise at that time so besmirched by the circumstances of the fiasco of the de Lesseps enterprise, the frank attitude of the management of the New Company won his serious attention, and at length his cordial cooperation.

Under a concession from the United States of Colombia, dated March 20, 1878, M. de Lesseps, the famed promoter of the Suez Canal, had organized the Interoceanic Canal Company, which from 1881 to 1888 carried on operations designed to construct a sea-level canal across the Isthmus of Panama. The work was practically discontinued in 1888 under distress-

ing financial conditions, and the affairs of the company passed into the hands of a receiver. He constituted a commission of French engineers, which after examination of affairs on the Isthmus, reported that it seemed feasible to complete the project as a canal with locks, but that the data available were "far from possessing the precision essential to a definitive project."

The receiver, following this hint, organized with considerable difficulty the New Panama Canal Company under an agreement safeguarding the interests of the stock and bond holders and creditors of the old company. The New Company was bound to raise 65,000,000 francs, to study with the aid of experts the problem of the Canal, and after the expenditure of half its capital to unite with the representatives of the old company to select a commission to make a definite report on the course to be adopted.

The New Company, therefore, appointed a technical committee of eminent engineers representing the countries of France, Holland, Germany, Russia, England, United States, and Colombia, on which committee General Abbot, as stated above, accepted membership. Under the direction of this committee a great amount of investigation and excavation was done at the Isthmus, so as to determine fully every question raised by the deliberations relating to the best type of canal. These questions had to do with the geology of the Isthmus, the survey of its watersheds, the gauging of its rivers, the cost of excavation in all strata to be encountered, the safety of dam foundations, the questions of meteorology and related flood conditions, the probable tonnage and character of the ships likely to be accommodated, in a word everything which governed the cost, time of construction, usefulness and safety of a canal across the Isthmus of Panama.

In these investigations General Abbot took such a leading part that, as we shall see, he was nominated by the Directors of the New Company to be one of its two representatives on the commission which was to make the final definite recommendation of the plan to be pursued. The significance of this action by French Directors of a French project is apparent.

The *Comité technique* reported unanimously on November 16, 1898, proposing a definite project estimated to cost about $100,000,000, to be completed in about ten years, and suited to meet amply the needs of commerce for a long time to come. Thereupon the Commission of five members arranged for by the agreement was nominated, and of this Commission General Abbot had the distinction of being the only foreign member. After a thorough inspection of the work on the Isthmus, of the results of the investigations made, and of the records of all kinds, the Commission rendered its report on February 28, 1899, containing the following unanimous conclusions:

"In fine, the investigations for the completion of the canal have been conducted in a practical and scientific manner, and upon the most judicious methods.

"The basis on which the project rests has been established by actual experience, and by precise observations upon existing conditions, which the old company began and which the New Company has completed and rectified with the greatest care. The precision of this basis is then certain.

"The three solutions presented meet equally the needs of commerce and are feasible, from a technical point of view, under the conditions of time and expense contemplated, and with the means of execution heretofore in use on the Isthmus. There are, however, good reasons to believe that these means can be sensibly improved when the time comes to begin work, by resorting to improved apparatus and by better dispositions for operating upon a large scale.

"Consequently the Commission is of the opinion that the adopted project is practicable under the conditions of time and expense indicated, and that the New Company has demonstrated that by works which will not exceed an outlay of about one hundred million dollars, and a duration of about ten years it is possible to open the Panama Canal to extensive commerce, to remove the obstacles which the Isthmus opposes to international communication, and thus to complete an immense work that interests all the nations of the world and is the greatest which human genius has ever planned."

The New Company was, of course, fully aware that the Maritime Canal Company, an American concern, was seeking to promote the project of a canal through the country of Nicaragua. Being absolutely sure of the great superiority of the project at the Isthmus of Panama, both as regards engineering feasibility and convenience of operation, no attention was being paid to this rival project, when our War with Spain and the adventure of the battleship *Oregon*, which made the complete circuit of South America to operate in the West Indies, changed the situation completely. An imperative demand arose in America for an interoceanic canal to be owned and controlled by the Government of the United States. Congress was almost definitely committed to the Nicaragua route.

The directors of the New Company realized that the unlimited means of the United States Government made the Nicaragua Canal a certainty, and the difficulty of getting funds to construct a rival canal at Panama almost insuperable. Also the problem of securing labor to work on two great tropical engineering operations would be exceedingly difficult. Accordingly the Directors transmitted the report of the *Comité technique* to President McKinley, in order that the Government might be thoroughly informed of the very different aspect of the Panama project since the completion of the elaborate investigations described.

At the hearing before the Committee on Interstate and Foreign Commerce of the House of Representatives, beginning January 17, 1899, General Abbot was put forward as the principal technical witness of the New Panama Canal Company, and testified in part as follows:

"General Abbot: Perhaps it is proper for me, being an American, to explain my position to the committee. I graduated at West Point and served forty-one years in the Corps of Engineers, United States Army, passing through all the grades up to colonel, inclusive, and being retired for age in 1895.

"During the last seven years of my service I was president of the permanent Board of Engineers in New York, to which are referred the more important questions which come under

the attention of the Chief of Engineers. I was also division engineer for the general supervision of all the engineer constructions in the northeast division, which includes all of New England, New York, New Jersey, Delaware, the Delaware River at and below Philadelphia, and Lake Erie as far west as Toledo. Since then I have been in the active prosecution of the profession of civil engineering. Without any application on my part I have prepared the plans for the new harbor at Manitowoc. I served as the president of the board of consulting engineers, which was established under the Chamber of Commerce of Pittsburgh, in reference to the new ship canal projected from Pittsburgh to Lake Erie.

"I received an invitation from the New Panama Company to join their technical commission, and I will be frank to say that at first I hesitated about accepting it, because I had the general American prejudice that the canal was dead, and I did not care to associate myself with something that was not likely to be successful. But I was assured by Mr. Hutin, the director-general of the New Company, that if any person in the world wanted to know the fact if the completion of the canal was impracticable it was the company itself, because the question with them was one of investing their money, and if I was right in supposing the canal impracticable they wanted to know it.

"With that understanding I went to Paris in May, 1897—nearly two years ago—and last spring I spent three weeks on the Isthmus, going through the route thoroughly, including the Haut Chagres, on horseback and in boats, and looking at everything that is to be done. I have been serving on the technical commission at Paris the rest of the time.

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"A definite and final conclusion has been reached as to the project for the canal. The recent work of excavation done on the Isthmus has been directed to fulfill two objects. One has been to remove many cubic meters out of the most difficult cut, doing that much toward the completion of the canal. The other has been to do it in such a way as to throw light upon

the future operations, including side slopes, unit cost, etc.; that is, instead of working on the whole width of the canal, as the old company was doing, the New Company has sunk a deep cunette, only 30 feet wide at the bottom, to explore in that direction and secure information as to what will be encountered hereafter. . . .

"I may now say a word in general terms about the project before going into details. The great ship canals of the world are limited in number. The Manchester Canal is the only one in which interior locks are required. The Kiel Canal requires locks at its entrances simply to regulate the tide, of which there is a large one on the North Sea and a small one on the Baltic. I have been through both and studied them both. Comparing the existing canals—the Suez, the Manchester, the Kiel canals, and the other great canals of the world—the adopted project for Panama is second to none. In some respects it is the best. The locks are larger than in any other. They could pass the *Oceanic,* the largest ship in the world.

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"There are two great engineering problems connected with this canal. The first one is the regulation of the river Chagres. That river comes down from the mountains shown here on the map [indicating on map], and strikes the line of the canal at Gamboa. It then flows through a hilly country, but here at Bohio it leaves the line of the hills to traverse a low district to the Atlantic. Indeed, the river at its low stage reaches the level of the sea at this point—Bohio. The Chagres is a torrential stream. It was a matter of great importance to note what the floods were, what volume they carried, and what means were necessary to control them. On my arrival at Paris I was surprised at the extent of information which the company had collected in that matter. I had served for four years with General Humphreys on the Mississippi River, and was somewhat familiar with such investigations, and I must say that the work was admirable.

"We have here at Gamboa a continuous record of the height of the water, printed automatically on a tide gauge or, rather,

fluviograph, that record extending from 1880 to the present time. So the New Company has had its finger on the pulse of the river for nineteen years. There were discharge measurements made at the same place for a period of seven years, averaging about nine days during the month, and, if any special floods came down, a larger number. For six years similar measurements were made at Bohio, and for two years at Alhajuela. In order to be sure of a correct relative determination, daily measurements were taken at these three stations for thirteen consecutive months. I have studied the original reports received, giving the velocities and the areas and all the details and I may say now that we know the Chagres River as well as any river in the United States.

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"Mr. Bennett: What is the deepest cut?

"General Abbot: The original cut at the divide, when the company first began, was above sea level 344 feet. The present level of the bottom of the cunette is about 176 feet, giving an excavation of about 168 feet. Nearly down to that level it is actually excavated. With our project, the official project, the intermediate project, the bottom of the canal will be 68 feet high, which will mean 108 feet more to be excavated to reach to 68 feet above the level of the sea. All these levels mean above the level of the sea.

"Mr. Mann: How much of a cut will that make?

"General Abbot: About 276 feet, or something like that, from the original level, but not from the present level. The present level is not estimated from the whole canal cut, but from the bottom of the cunette; from that it is only 108 feet.

"Mr. Bennett: And that will extend about 7 miles?

"General Abbot: No; that is the deepest. The summit level here [indicating on map] is divided here, as you will see on the profile [indicating on map].

"Mr. Bennett: Just generally——

"General Abbot: The deepest cut is restricted to the Culebra, which is less than a mile long. What we call the Emperador,

which is the portion extending between Culebra and the Obispo, is very much less than that.

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"That brings us down to the canal as we propose. The old company had completed altogether, with the works of the New Company, about 50,000,000 cubic yards. So we have 50,000,000 cubic yards taken out and 67,000,000 still to do. That shows that the canal is almost half done, estimated by the number of cubic yards of excavation, which gives a positive measure, more definite than to give it in average depth of cut.

"Now, in reference to these dams. The dam at Bohio, which is at the lower locks, is represented on this map at this point [indicating the map]. The line of the canal is shown by this red line. At Bohio the line of hills which forms the projected lake crosses the river at a place where the dam is projected. Its total length is 1,285 feet. Its maximum height is 75 feet. The depth of water at the dam will vary between 52 feet and 65 feet, according to the level of the lake.

"A great many borings have been made, and they show that both banks are rock. The bed of the stream is at first sand, changing to what the geologists say is a tertiary clay. It is not a deposit of the present period. It forms a good foundation.

"Mr. Hawley: An impervious clay?

"General Abbot: Yes; an impervious clay that Mr. Fteley and all the experts say is a perfectly practicable foundation for an earthen dam. It is not suited to masonry, because we never build a masonry dam unless we can get rock. This shows the cross section [indicating]. This has all been determined by borings, and we know at what depth we shall reach this stratum of clay [indicating on map]. That shows a cross section of the dam. At the foot of the upper slope is a trench cut down to the clay bed and filled in with concrete so as to make a perfectly secure protection against infiltration at the bottom [indicating]. The whole upper slope of the dam is covered with rock flagging laid in cement, so as to make a tight water cover on that side [indicating]. The lower side is covered with rock flagging laid dry, so if any water should get in it could get out

without making trouble. The actual width at the top is 15 meters, or 49 feet.

"It is easy to build this dam, because the locks are projected here in a cut through the rocky hills; and the river can be deflected through this cut by a little provisionary dam or dike here, without adding to the cost [indicating on map], while the dam is constructing. So, as a problem in dam construction, this case is entirely within the limits of ordinary engineering experience, and no serious obstacle or difficulty is presented.

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"I was speaking about the dam at Alhajuela, to create the upper reservoir. That dam, as I explained, is entirely of concrete masonry abutting on rock walls and resting on rock. It is at an ideal position for a dam.

"I have now to explain how water will be transported from the lake thus formed to the canal to supply the summit level during the three dry months of the year. This will be done by a feeder which taps the lake and is carried along the side——

"Mr. Barham: Parallel with the river?

"General Abbot: Essentially parallel; yes, sir. It follows along down on this line [indicating on map], and we have special drawings to show the details. . . .

"In passing from the Lake Alhajuela to the canal we cross the Rio Chilibre, which is a large stream, that would require a drop below the level of the feeder. Therefore, we divide the route into three divisions: First, from the lake to the Rio Chilibre, then across the Rio Chilibre, and then to the canal proper. I will speak now of the first one. This distance is about 2½ miles. It passes over a rocky ridge, which is cut somewhat by cross gullies; and to save the extra length in following around them we propose to make small masonry dikes to stop the flow, and create little ponds, which will form part of the feeder. In that way we save distance and save expense. From the dam to the Rio Chilibre we have only that kind of construction to make, with a few short tunnels under cross ridges.

"Mr. Stewart: Is that trap rock?

"General Abbot: No, sir; it is a hard, solid material which is suitable for construction. The geology of the isthmus is very complicated. We find trap veins injected through argillaceous schist and other ancient volcanic products, and more rarely calcareous rock. There is no trouble in obtaining stone suitable for concrete.

"As to this first division there is nothing especial to say, except that we make a tolerably straight route by using little tunnels under cross ridges, and little dams, or more properly dikes, to check the flow and form the little lagoons in lateral ravines.

"When we come to the Rio Chilibre we pass down to its level by the method of inverted siphons, and rise again to the general level that is necessary to carry the water to the canal itself. This use of pipes is more economical than to build the immense structure of a bridge to maintain this level. The detailed plans are all here [indicating on plan]. Starting from the Alhajuela dam at this point [indicating], we go through this rocky material with these little dikes until we come to the Rio Chilibre and its branch, the Juan Mina. The pipes are laid over the former, as shown here, and then we rise to the level of the canal again. A second inverted siphon crosses this branch of the Rio Chilibre, known as the Juan Mina. The details for these pipe lines have all been worked out. There are three separate pipes resting upon concrete and capable of carrying 25 cubic meters a second.

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"After we have passed this division we strike the third, consisting of the ordinary hills bordering the valley of the Chagres, which are traversed on nearly a straight course, as shown on this map, by means of the same system of small dykes for side ravines, forming little lagoons, and by little tunnels under cross ridges, all of which are of small dimensions. This carries us through to the point where we reach the canal itself. At the very end is a tunnel 430 meters long which carries the water into a natural valley that delivers it into the canal with moderate velocity. . . .

"To regulate the Chagres River there are two points to be considered. The first is, to check the floods enough, when they come down, to prevent any serious velocities here in the upper portion of the lake, which is narrow; and, in the second place, to prevent too much water passing Bohio to the lower level, where it might make trouble.

"To form a trustworthy estimate of these flood volumes a series of observations, extending really over nineteen years, is available, as I have already stated.

"We know since the canal work began that there have been five great floods, and that no flood occurred between 1850, when the railroad was begun, and that time which was comparable to one of those floods.

"Of those five great floods, the last one was measured accurately. That was the flood of 1893. We know definitely how much water passed in that flood. The flood of 1890 was partially measured, as were those of 1888 and 1885. The flood of 1879 was the largest within the memory of the inhabitants, and we have adopted that as our standard.

"We have water marks which enable us to estimate from our gaugings what the discharge must have been at those levels. That volume forms the basis of our estimates for regulating the flood discharge. More water flows at Bohio than at Gamboa or at Alhajuela because the rains in the lower valley contribute to increase the volume as one goes down the stream. The total volume needful to restrain the flood of 1879 at Bohio was 250,000,000 cubic meters, which is 8,800,000,000 cubic feet.

"Of this we propose to reserve 150,000,000 cubic meters in Lake Bohio and 100,000,000 cubic meters in Lake Alhajuela [indicating two different points on the map]. If a flood, even as great as that of 1879, should occur, these lakes would enable us to check its violence by stopping a large part of it in the upper lake and then holding back enough of the remainder in the lower lake to prevent damage below.

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"Mr. Stewart: Are not some of those problems connected

with the building of this canal entirely new and unknown to civil engineering experience?

"General Abbot: No, sir; there is nothing in the project which asks any engineer to go beyond the recognized rules of the profession and the regular service practice. There is nothing here which would be considered otherwise than ordinary engineering work.

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"Mr. Barham: I would like to ask if there is a project of this kind in the world, or if there ever was such a project, a project like this, carried out, creating an artificial lake, carrying water in pipes, creating another artificial lake and an artificial waterway, as planned here. Is there any parallel to this in the world?

"General Abbot: The only difference is in the size of the vessels that are to go through. On the Monongahela River, with all that immense coal commerce, the passage is regulated on this principle of locks and dams. It is a well-known method of regulating rivers.

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"The Chairman: I understand you to say that you have personally observed all portions of this projected work?

"General Abbot: I have been over it and spent three weeks on it, and looked over every foot of the ground, and have seen all that can be seen.

"The Chairman: Are you familiar with the surveys?

"General Abbot: Yes, sir; I have been through the reports very carefully. Everything was open to the members of the *Comité technique,* and I am satisfied the work has been well and carefully done.

"The Chairman: As an engineer are you satisfied as to its practicability?

"General Abbot: Entirely so. I will go further than that. I will say that there is nothing in it that has not been exceeded in difficulty elsewhere. For example, we have higher dams elsewhere. A dam is building in New York to-day 120 feet

higher than that at Alhajuela. Many earth dams are existing to-day of a larger size than this contemplated one at Bohio. The question of the Culebra is—there has been no excavation elsewhere as large as that projected—but that is a question of machinery and material. We have investigated the material and we know what that is. The machinery, of course, can be obtained; that is, any new machinery that may be needed.

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"Mr. Mann: I understood you to state that it will cost about $100,000,000 to finish the canal?

"General Abbot: Yes, sir.

"Mr. Mann: Is that based on the proposition that the cost of finishing it will be the same in proportion as the cost of the work already done?

"General Abbot: By no means; it is based on the operations of the New Company.

"Mr. Mann: I mean the work on the ground; the experience of the old company on the ground. Do you take that as a basis——

"General Abbot: Not at all.

"Mr. Mann (continuing): For future work, or do you estimate without regard to that?

"General Abbot: We base our limit prices on the work of the New Company in taking out 4,000,000 cubic yards.

"Mr. Mann: You take the estimates, then, of what the New Company has done and reject entirely the experience of the old company?

"General Abbot: We are well aware that the system of administration in the old company was not that which would be carried out in the New Company.

"Mr. Mann: I am simply asking for the facts.

"General Abbot: The cost is estimated on operations which have been conducted with care and with good engineers, and with every provision for good work.

"Mr. Mann: Then if the New Company should in fact, when it goes to work, have about the same financial administration

that the old company had, the canal would cost a good deal more than your estimate.

"General Abbot: Of course; that applies to anything——

"Mr. Mann: But I am talking about this. I am talking about facts now.

"General Abbot: Well, the New Company is organized on an entirely new basis.

"Mr. Mann: I was simply trying to get at the facts.

"General Abbot: The fact is, we assume honest administration.

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"Mr. Stewart: What do you ask of the United States? What do you expect?

"General Abbot: I simply appear as a technical engineer——

"Mr. Stewart: What do you conceive personally that the company asks from the United States?

"General Abbot: My personal wish is this—as an American, not as a representative of this company at all—I think the United States Government appreciates and the people of the country appreciate the necessity of an isthmian canal. I think before we actually begin to spend money that the whole subject ought to be investigated. Congress has appointed two commissions to investigate the Nicaraguan Canal, but since the collapse of the old company is quite ignorant of the progress and present conditions at Panama.

"Mr. Stewart: You ask no money?

"General Abbot: None.

"Mr. Stewart: You ask no franchise or corporate rights?

"General Abbot: Those questions will be answered by another person, who can answer them better than I can. You asked me my personal opinion. What I would desire would be to have an impartial hearing before a board of impartial engineers whose duty it would be to investigate the two canals and decide which would be the better. It is not worth while to construct two canals. The canal that is the better should be constructed.

"Mr. Barham: You think that that investigation ought to be made now, considering the money that has already been expended?

"General Abbot: Undoubtedly I do, because the results of that expenditure are all favorable. All it requires is a moderate sum—less than any other canal—to complete it."

It was later intimated that the New Company was authorized by the terms of the Colombian concession to reincorporate as an American company. The upshot was that an act passed authorizing the President to determine the most practicable and feasible route for an Isthmian canal, with the cost of constructing the same and placing it under the control and ownership of the United States.

President McKinley appointed the so-called Walker Commission, which after examination of both proposed routes preferred the Panama route from an engineering standpoint, but considered that the cost of acquiring the French rights was prohibitive, and recommended Nicaragua. Thereupon the President and several of the directors of the Company resigned, and after a meeting of the stockholders the Company met the figure of the Commission, $40,000,000 for all the French rights. On learning of this new condition the Walker Commission reversed its recommendation, and found the Panama route most practicable. The Hay-Herran Treaty was negotiated with Colombia to enable the United States to have full control, but the treaty was rejected in Colombia. Panama then revolted from Colombia, was recognized by the Government of the United States, and granted the desired rights over the Canal in the Hay-Bunau-Varilla Treaty which was duly ratified, and the project of a Panama Canal under the exclusive ownership and management of the United States became practicable.

The question now presented itself: What sort of a canal should it be? In this matter General Abbot's influence was the deciding factor. He had already published several articles, which were widely read, which demonstrated the enormous superiority of the Panama route. He had shown therein that

the Chagres river, long considered a very dangerous stumbling-block to the Panama canal, really lent itself admirably, with a fairly high-level lock canal, both to the convenience of construction and the subsequent operation, and that with proper construction its highest floods would be no danger or hindrance. On the other hand, he showed that the San Juan river, which formed so long a segment of the Nicaragua route, was so difficult of engineering control, and so tortuous to navigation, as to be in itself almost a reason for abandonment of the other route. Adding to this the enormous rainfall, thick fogs, frequent severe earthquakes, and treacherous harbors, prevailing in Nicaragua, there remained no question that the Panama route was highly preferable.

But now the Chief Engineer, Mr. John F. Wallace, appointed to have charge of work at Panama, preferred the so-called sea-level project (though requiring a tidal lock to control the rise and fall at the Pacific terminus). General Abbot's engineering sensibilities were outraged by this proposal, against which all the investigations of the New Company and the advice of their numerous French and foreign experts unanimously militated. Article after article issued from General Abbot's pen in popular as well as technical journals in which he marshalled that array of evidence so perfectly familiar to him, owing to his long association with the project, and proved beyond peradventure the great advantage in cost, in time of construction, in safety, and in satisfactoriness and even speed of operation of the fairly high-level lock canal over the so-called sea-level type.

His main arguments were four in number.

First: The estimated time and cost of "sea-level" canal is about double that for lock canal.

Second: In the "sea-level" canal, for 19 miles a large ship must continuously be changing her course in a channel of width only about one-quarter of her length, and at times of flood with currents as high as four feet per second.

Third: In the "sea-level" canal the highly variable Chagres river is to be arrested by an immense dam at Gamboa, rising

180 feet above the surface of the canal and only a quarter mile away. The water is to be admitted to the canal in fairly uniform manner from the lake so formed by sluices. Tributaries of the Chagres below Gamboa are to be diverted by levees and embankments. Between Gamboa and Bohio several tributaries liable to great freshets are to be controlled like the Chagres itself by large dams. Fifteen other tributaries on both banks are not provided specially for, but may pour their floods into the canal itself. In all of these complications there is so much of danger and, at best, of cross currents and streaming set up in the canal as to be highly hazardous to shipping.

Fourth: The Culebra cut, which, as later experience proved, was subject to considerable slides, would be far more formidable to the "sea-level" project because so much deeper.

Under date of April 1, 1905, President Roosevelt, dissatisfied with progress made, reorganized the Commission and provided for a new board of consulting engineers. Mr. Wallace resigned on June 25, and was succeeded by Mr. John F. Stevens as Chief Engineer. On June 24, the President appointed a board of thirteen consulting engineers of whom five were foreign experts. Among the eight American members was General Abbot, then 74 years of age.

The Board visited the Isthmus, asked for and obtained additional investigation, and developed an irreconcilable difference of opinion. Eight members, including all the foreign experts, favored a "sea-level" project with important modifications from previous ones. The other five members, of whom General Abbot was one, favored a lock canal with a summit level 85 feet above mean tide, formed by a dam at Gatun, thus substituting lake navigation over a large part of the way. Majority and minority reports, together with his own views, those of Secretary Taft, of Engineer Stevens, and of the Commission, were forwarded to Congress by President Roosevelt on February 19, 1906. These latter authorities all agreed substantially with the minority of the Board, and indeed with every commission of engineers which had previously studied the problem.

General Abbot in his book "Problems of the Panama Canal" [7] thus summarizes what happened:

"The Senate Committee on Interoceanic Canals of which Senator Millard is Chairman, acting under a resolution of the Senate adopted January 9, 1906, at once proceeded to make an exhaustive investigation of all matters relating to the Canal, the government of the Zone, and the management of the Panama Railroad Company. The printed Hearings comprise three large volumes, covering 2,967 pages, with a separate reprint (988 pages) reproducing the testimony of the engineers appearing before the Committee. Finally, on May 12, a vote on the type of canal to be recommended was taken: it resulted in a tie, five Senators favoring a sea-level and five a lock canal, each being of the general type recommended by the majority or the minority of the Board of Consulting Engineers. Subsequently, by the vote of a member absent on the first ballot, the former type was given the preference; and accordingly Senator Kittredge on May 17 reported a bill providing for the construction of a sea-level canal. On May 25 this bill was made unfinished business, and was vigorously debated for several days. In the meantime the Sundry Civil Bill containing the Canal Appropriation for the coming year was under consideration by the House, and after an able discussion of the plan to be adopted it was amended, on motion of Mr. Littauer on June 15, by inserting the words: 'Provided, That no part of the sum herein appropriated shall be used for the construction of a canal of the so-called sea-level type.' This amendment was adopted by a vote of 110 to 36. In the Senate, the bill providing for a sea-level canal was finally brought to a vote on June 21, but in a radically modified form. An amendment offered the same day by Senator Hopkins struck out all after the enacting clause and substituted: 'That a lock canal be constructed across the Isthmus of Panama connecting the waters of the Atlantic and Pacific oceans, of the general type proposed by the minority of the Board of Consulting Engineers, created by order of the President dated January 24, 1905, in pursuance of an Act entitled: "An act to provide

[7] The Macmillan Company, New York, 1907.

for the construction of a canal connecting the waters of the Atlantic and Pacific oceans" approved June 28, 1902.' This radical amendment had been carried by a vote of 36 to 31 and the bill itself was then passed without a division. In the House this bill was passed also without division on June 27, and was signed by the President on June 29, thus becoming definitively the law determining the type of canal to be constructed by the United States."

General F. V. Abbot writes regarding the matter as follows:

". . . During the heated debate in the Senate over the location of the canal, the celebrated controversy between advocates of the Nicaragua Route, and the Panama Route, my father took an exceedingly active part. Senator Morgan was the energetic proponent of the former route, and Senator Spooner of the latter. Mr. Taft was strong for Panama, and my father kept him supplied with much ammunition for presentation to the Senate. About this time my father met Senator Mark Hanna, he convinced that powerful man of the superiority of the Panama Route, and this occurring at the most critical time of the debate had great bearing on the adoption of the Spooner Amendment, over the most strenuous opposition of Senator Morgan. My father had a number of hearings before the Senate Committee on Isthmian Canals, which make interesting reading. The amendment was adopted by a vote rather late in the day. That afternoon I was walking up Connecticut Avenue, in company with General Mackenzie, leading my bicycle, when Secretary Taft and Mrs. Taft came up from behind us, and the Secretary called to me to come alongside of his carriage. Not knowing what in the world to do with a bicycle when talking to a Secretary of War, I handed it to General Mackenzie to hold, and ran out into the Avenue. The Secretary leaned over to me and said, 'Colonel Abbot, I have just received a telephone message from the Capitol that the Spooner Amendment has just passed the Senate. Get on your wheel and take a message to that effect from me to your father, whose complete knowledge of the

big subject has enabled me to present the matter to the Senate Committee convincingly, and so to him is largely due the adoption of the Panama Route'."

Ten years later, in 1915, General H. L. Abbot was appointed member of a committee of the National Academy of Sciences to investigate, at the request of the President of the United States, the safety of the Culebra Cut. This, writes his daughter, was "one of the real satisfactions of his life. At the age of 84 down he went alone, lugging a heavy bag of Canal documents. First by train to New York; then one night at Fred's; then by train to New Orleans, and steamer to the Isthmus. There followed busy days, not wasted either. He spent one day inspecting from 7:15 a. m. to 5 p. m., and then closed with an evening session of the Commission for good measure. He came home none the worse to a temperature of 8° Fahrenheit, and did not even take cold! I always like to remember that episode."

Thus in the enjoyment of one of the great satisfactions of his life we take leave of this strong, patriotic, able, diligent, influential man, who, having served his country 41 years in military life, served her surpassingly well for 20 years more as a great engineer.