

A MEMOIR OF COLONEL SIR PROBY CAUTLEY, F.R.S., 1802–1871,
ENGINEER AND PALAEOLOGIST

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[Plates 8 and 9]

PROBY CAUTLEY was the sole projector and executive director of one of the largest irrigation canals ever built in the world, the Ganges Canal, the first new cut made by the British in India. In this respect, he was among the pioneers of perennial canal building, begun in Uttar Pradesh and present day Pakistan in about 1820 and continued well into this century. In addition, he was responsible with Dr Hugh Falconer (F.R.S. 1845) for making, describing and classifying an enormous collection of sub-Himalayan fossils. He presented the collection to the British Museum, where it forms, along with the book describing it, an important source of reference for Indian palaeontology.

For his merit as an engineer and palaeontologist, Cautley was elected to the Fellowship of the Royal Society in 1846. He was knighted for his services to India and was further honoured by his selection in 1858 to serve on the newly formed Council of India, which ruled India in place of the East India Company after the Indian Mutiny.

A small number of surviving letters, and the corpus of his printed papers and books, combined with the resources of genealogy and military records, enable us to reconstruct the story of his life, a life interesting in its own right and because it typifies the life of many of those army officers engaged in the nineteenth century in public works in India.

THE VICAR'S SON

Proby Thomas Cautley was born on 3 January 1802 in Roydon (now Raydon), a small Suffolk village ten miles south-west of Ipswich (1). His father, Thomas Cautley, was rector of the parish, and his mother, Catherine, *née* Proby. He was the second child born to them, an older brother having died as an infant (2) (Figure 1).

The Cautleys were a northern family, originating in Cumberland, Westmorland, and Yorkshire. Proby's father went to school in Bolton (3), probably the Bolton a few miles east of Askrigg in Wensleydale, and one of

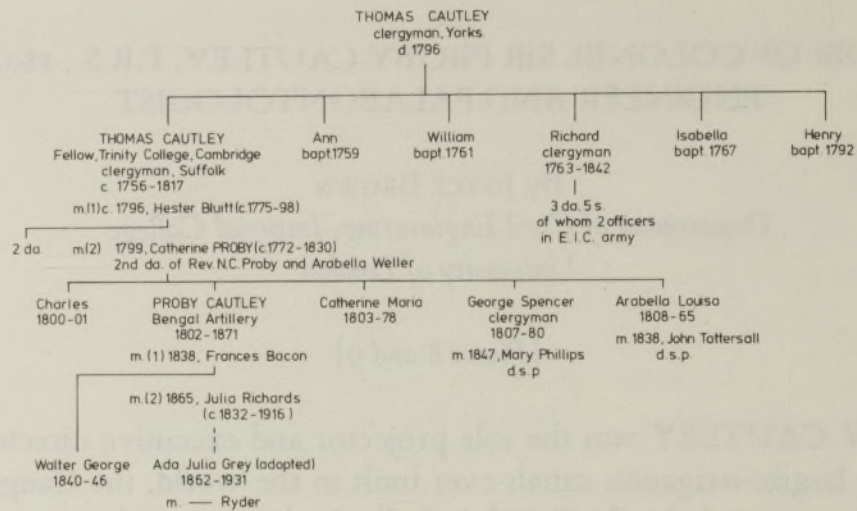


FIGURE 1. Cautley family tree

Proby's sisters was born in nearby Woodhall (4), perhaps because of family connexions with the village.

Both Proby's grandfathers were clergymen (5). His father, Thomas Cautley (c. 1756-1817), was a scholarly man who had spent most of his life in the university. He had entered Trinity College, Cambridge, in 1772, and remained there taking the degrees of B.A., M.A. and B.D. (6). He was chosen Second Wrangler in his B.A. examination, and elected a Fellow in 1778. He remained in the university until about 1796, holding various administrative offices (7). One incident of his life at Cambridge has survived, and shows him signing a memorial along with nine other Fellows, objecting to what they considered an irregularity in the 1786 election for the Fellowship. The Master demanded an apology, and on this being refused had an admonition against each of the protesting Fellows entered in the Conclusion Book, a severe punishment for men who might later wish to be considered for high offices in the university. The Lord Chancellor as Visitor to the College was consulted and advised an apology, but Thomas Cautley and two others refused to sign it, and in any event the apology was not accepted (8).

About 1796, Thomas Cautley married and left the university to take up residence in Roydon, a living he had held since 1791 (9). His wife, however, died in 1798 after the birth of their second child (10). Eighteen months later, he married Catherine Proby, one of the daughters of a neighbouring clergyman; they were married in the church of Stratford St Mary on 23 December 1799 (11).

Catherine Proby (c. 1772-1830) was the second of the eight daughters of the Reverend Narcissus Charles Proby (1738/9-1804) and his wife Arabella,

née Weller, (1752–1841), both of Irish origin. There were at least also three sons (12). By the standards of the day, the Reverend Proby was wealthy, owning land in Cheshire, Stratford St Mary and Ireland; each daughter had a marriage settlement of £1000 (13).

The Reverend Proby died on 20 December 1804 (14), but a year earlier, the Reverend Cautley had combined his own with his father-in-law's living (15). After the Reverend Proby's death, the Cautleys moved into the Stratford parsonage. Proby had a sister, Catherine Maria, a year younger than himself, and later his brother George and another sister, Arabella, were born (16).

The Cautleys were very comfortably off with the income from two livings. The atmosphere of the home was intellectual, and there is evidence of interest shown in painting, 'botanizing', collecting fossils and reading (17). Life in the village was simple and pleasant. Stratford St Mary straggles along what was the old coaching road to London, and there is still a lock on the River Stour, which runs through the village—perhaps of interest to the children. George, in later life, produced some little books of verses (18), and in a poem dedicated to Proby on the opening of the Ganges Canal reminds him of

The garden brook, home of thy first essay,
The mimic sluice, and fairy waterwheel,
And those mild eyes which blest thy thoughtful play . . . (19)

The Reverend Cautley did not live long to enjoy the pleasures of family life. His health declined after 1807 (20), and he died on 13 July 1817 (21), and was buried in Roydon Church, where the tablet also commemorates his first wife.

Proby had by then already gone to Charterhouse. His brother George entered Pembroke College, Cambridge, in 1825 (22), and also became a clergyman, while his sisters remained at home with their mother until her early death on 5 June 1830 (23). There are memorials to her and to Proby's father in Stratford St Mary church.

Proby's childhood was passed in the midst of a large family: his own family, and, living nearby, his grandmother Proby and his mother's seven sisters and their offspring. This was in marked contrast to his life in India, in which vast continent he was to arrive alone, aged 17 years and 9 months.

CHARTERHOUSE AND ADDISCOMBE

In January 1813, at the age of 11, Proby was sent away to school and entered Charterhouse, where he remained a pupil until July 1818 (24). The school, founded in 1614 and situated near St Paul's, had approximately 200

pupils at this period (25). The 'Foundation' or Gown Boys were considered more important than the other students, boarders and day scholars, but Proby is not listed among them (26). The fees were £80 p.a., a sum which put the school outside the range of all but the fairly wealthy. Pupils were admitted between the ages of 10 and 14, and not kept beyond the age of 19. During Proby's time, the headmaster was the Reverend John Russell, in office from 1811 until 1832 (27). The second master was the Reverend Robert Watkinson, and Cautley was in his house (28). Most of his time at Charterhouse must have been passed under the system already traditional in public schools, with the rule of monitors, fagging, corporal punishment, and an education made up mainly of Latin and Greek, with a little Mathematics. There was a strong connexion between Charterhouse and the Indian service, and an education at Charterhouse and Addiscombe was not an unusual background to Indian military life (29).

The choice of a military career resulted in Proby's being taken, on 29 July 1818, by his uncle, Archibald Elijah Impey (30), to East India House to apply for admission as a cadet in the Company's Artillery and Engineers Seminary at Addiscombe. Each director of the East India Company was entitled to nominate annually a certain number of boys to the Seminary, and Proby was one of the nominations for 1817 of James Pattison, recommended to him by Impey. Proby supplied evidence of his birth date and good health, and both he and his uncle swore that he had received the appointment gratuitously (31).

There were at this time two armies in India, which had grown up side by side: the army of the East India Company and the army of the Crown. Chartered as a trading company in 1600, the East India Company had been transformed against its intentions into a military power, largely because of the necessity of maintaining its trading position by military force, sometimes against native chieftains, sometimes against other European powers, notably the French. The forces of the East India Company were raised and administered under the three 'presidencies' of Bengal, Madras, and Bombay into which British India was divided. They consisted of Indian troops under British command, and a minority of European troops enlisted at home or from white mercenaries in India. The army closely resembled the European model, with numbered regiments of the line. It was reinforced by its first complete regular battalion from the British army, sent out in 1754. By the end of the eighteenth century there were twenty-seven regiments in India, in each of which there were two or three battalions of Crown troops. Although the two armies had to work together, there was no cross-posting between them (32).

The East India Company recruited and trained its own gentlemen cadets,

until 1809 paying for them to be trained at Woolwich Military Academy. The expense of this, however, and the fact that only forty-six candidates a year could be accepted at Woolwich led to the Company's setting up its own military seminary. The Reverend Dr Andrew, 'who had for some years kept an Academy on Woolwich Common, and educated several of the Company's Cadets preparatory to their admission into Woolwich . . .' (33) seemed a suitable man to take on the task of running the seminary. A house and fifty-seven acres were purchased at Addiscombe, near Croydon. Dr Andrew received £80 per head per annum from the company for sixty pupils, admitting them usually at the age of 16, although later regulations, in 1813, allowed entry at 14, provided cadets did not leave for India before they were 16 (34). The year was divided into two terms with two examinations annually; cadets stayed for four terms, unless they were found on Public Examination to be 'qualified for the Scientific branches of the Profession in less than 4 terms' (35).

Cautley entered Addiscombe in July 1818, and was there until 6 April 1819 (36). For admission, cadets had to be 'well grounded in arithmetic, including vulgar fractions, write a good hand, and must have acquired a competent knowledge of the English and Latin grammars' (37). The fees were £30 per annum, and the East India Company supplied everything, as well as 2s 6d per week pocket money. If the cadet did not proceed to India, expenses incurred on his account had to be reimbursed.

A history of Addiscombe, written in 1894 (38), allows us a glimpse of the life there in Cautley's time. Dr James Andrew was still Head and Professor of Mathematics and Classics, and there were seven other teachers. Conditions seem to have been fairly pleasant. There was no corporal punishment, but cadets could be fined or given extra drill, or shut in the 'Black Hole' on bread and water, a punishment that ended every evening at nine o'clock, though it could be resumed the next day. The cadets wore a uniform of blue, faced with red with gold trimmings, a bell-top shako of black beaver, with a white plume, and chinchain attached by brass lionheads (39).

On a typical day, the boys were roused by bugle, assembled on parade for inspection, and then went to chapel and study. After breakfast and half an hour's recreation, there was a parade before the Lieutenant-Governor, then study until the main meal at one o'clock. There was further study from two until four o'clock, followed by drill. The boys were then free until six o'clock. The evenings were spent in study, or leisure activities such as reading, singing, reciting and boxing (40).

The main emphasis of the course was on Mathematics and Fortification, but Military Drawing and Surveying, Civil Drawing, Hindustani, French and

Latin were also studied (41). The Public Examination, held twice a year, was a formal occasion in which the candidates knew what they would be asked. In Cautley's time, Colonel William Mudge (42) was Public Examiner. Later, as a member of the Council of India, Cautley was present at one of these Public Examinations (43).

Cautley was at Addiscombe for less than a year, his passage through the Seminary perhaps hastened in response to an urgent request from India in 1818 for artillerymen, for some under the age of 16 in his class were allowed to embark (44). Colonel Mudge, in his report of the Public Examination of 6 April 1819, made a plea for candidates in future to be allowed to stay longer (45). The Seminary prepared cadets for the infantry, artillery or engineers, reserving, without prejudice to their rank, their best students every year for the engineers. From 1811 onwards, these cadets were sent for six months on the Trigonometrical Survey under Colonel Mudge, and from 1815, they spent an additional twelve months at Chatham under Colonel Pasley (46), studying the practical aspects of mines and explosives (47). At Cautley's Public Examination, nine cadets were reserved for the engineers, and the other twenty-nine, including him, were assigned to the artillery (48). One of the boys reserved for the engineers that year was Arthur Cotton, with whom he was to come into conflict later in his career. Cautley received a prize for Drawing, a copy of 'Edwards' Perspective'. He was commissioned Second Lieutenant on 19 April following, and was admitted to the service on 11 September 1819, on his arrival in Calcutta (49).

FIRST YEARS IN INDIA, 1819-1824

On leaving Addiscombe, Cautley set sail immediately for India, presumably on the *Marquis of Wellington*, to which he had been assigned; she sailed on 23 May from the Downs (50). A cadet's commission dated from the period of his leaving England, but his pay and allowances did not begin until his arrival in India (51). The passage cost between £55 and £95, either in a Company vessel or other licensed ship, according to whether one ate with the third mates in their mess, or dined at the officers' table; there was an additional payment of £15 passage money to the owners of the ship (52). Even for £95 the cadet was carried in the steerage. His best remedy was to join another cadet and hire a cabin. The cadet required a letter of credit for £100 to buy regimental outfit in India, a procedure recommended as the sea air often tarnished the gold or silver lace (53). The artilleryman's uniform was blue with red facings and gold trimmings.

The journey, round the Cape, took between four and six months, for it was

not until the 1840s that the efficient overland route was established via Cairo and Suez, and it was 1869 before the Suez Canal was opened.

The ship finally docked at Diamond Harbour, ninety miles from Calcutta, and cadets had to hire boats to take themselves and their luggage to Fort William in Calcutta, a journey up the Hooghly river of between twelve and eighteen hours (54). As the cadet received pay from the date of his delivering his credentials to the fort-major, it was advisable to call on him as soon as possible. He was then allotted a quarter in Fort William, and the head-servant of the barracks provided furniture and advice on procuring servants. Three or four weeks might be granted for acquiring uniform and making arrangements to proceed up country to join the corps. The journey was often made in a *budgerow*, a decked boat accommodating two passengers and their luggage, with one or two masts for sailing and ten or twelve oars (55). The passage up the Ganges could take anything between two and six months, and is recorded in 1833 as taking six months when Charles Morrison, Registrar of the Surveyor General's Office, conducted a small fleet of boats from Calcutta to Mussoorie to establish a field office (56). The mortality rate among young men between their departure from England and arrival at their corps was as high as 8% (57), some dying at sea, others from tropical disease or as a result of sudden squalls in which boats were lost on the river journey (58).

On arrival, the cadet settled in and engaged servants, of whom it was necessary to employ several to perform different functions—a washerwoman, a bearer, a sweeper, a cook, a table attendant and a man to pull the *punkah*, or large cloth fan swinging on a frame suspended from the ceiling. Each of these cost only a few rupees a month, but they were all considered essential if the officer lived in the garrison. The total cost, with his mess bill, might be 60 rupees a month (the rupee was worth 2s 6d at par in 1820), but young officers living in pairs in bungalows might share some of the servants and live for about 40 rupees (59). A horse and groom, fairly indispensable, cost an additional 16 rupees a month. An ensign's pay and allowances were roughly 200 rupees per month (60), and he could live very well for 100 rupees, but it was necessary to have some savings because in the event of sick-leave, the Company would pay the passage home, but not the return (61). Furlough of three years was not granted until the end of ten years' service, and officers were only paid for two and a half of the three years (62).

Savings were necessary also because of the custom of purchasing 'steps', in which sums of money were raised from subordinate officers and offered to senior officers to induce them to retire (63). Since promotion was strictly by seniority of service, a senior officer's retirement meant that the whole company

moved up the regimental list and those in the right position on the list reached a new rank. A promotion to a 'brevet' rank might be made for merit if there was no vacancy in the requisite rank; this conferred the title, but not the corresponding pay. Cautley's military career must be seen in the light of this: he was promoted Second Lieutenant on 19 April 1819, Lieutenant on 21 November 1821, Brevet Captain on 19 April 1834, Captain on 13 October 1835, Major on 3 October 1845, and Lieutenant-Colonel on 5 May 1849; he retired on 17 May 1854, and was made an honorary Colonel on 28 November 1854 (64). Every officer who retired after twenty-five years' service, including one furlough of three years, was allowed to retire with the full pay of the rank to which he had attained (65). Cautley qualified for this.

Unfortunately, it appears that none of Cautley's letters to his family has survived, and, indeed, on parting from them in 1819, he presumably never saw his mother again, and it was to be twenty-six years before he met his brother and sisters again. Army records show, however, that in the first two years in India he was stationed at the Presidency of Fort William near Calcutta. In 1821, he was stationed in Rajpootanah (Rajputana)*, in 1822 at Cawnpore (Kānpur), and in 1823 and 1824 at Agra (66). His time was spent in artillery duties, such as the reduction of numerous forts in the kingdom of Oudh (67). Then, early in 1825, he was sent to assist in the reconstruction of the Doab Canal, which took off from the eastern bank of the River Jumna in the foothills of the Himalayas. He received only one call to military duty, at the end of 1825, the rest of his career in India being taken up with hydraulic works.

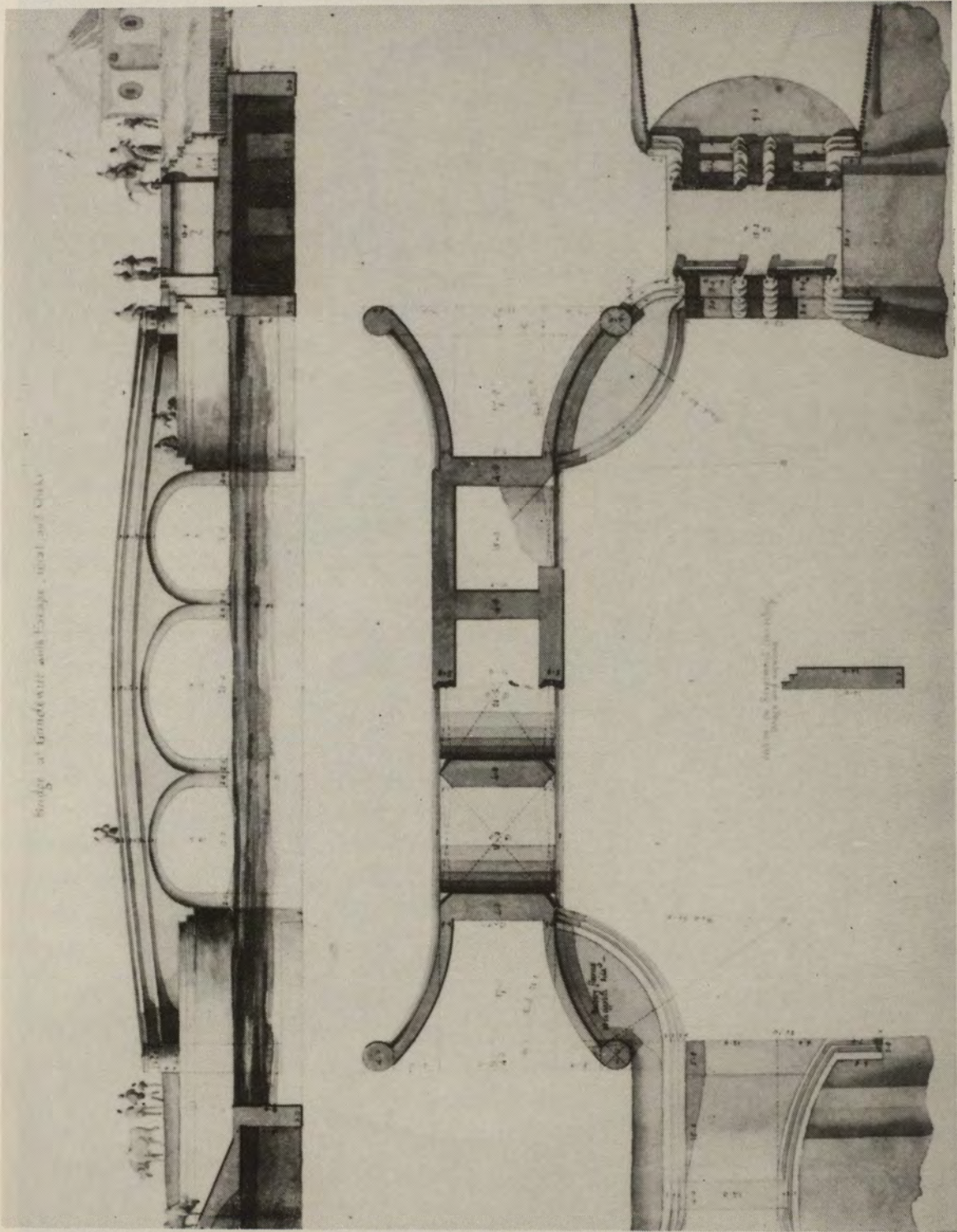
The incident in 1825 concerned the decision of the Army to lay siege for a second time to the fort of Bhurtpore (Bharatpur). Taken by the British in 1808, the fort had been settled in the hands of a native chieftain not hostile to the government. His infant successor, however, was overthrown in March 1825, an apparent act of defiance to British authority. Accordingly, Lord Combermere, Commander-in-Chief of the Army in India, marched at the head of 30 500 men and laid siege to the fort between 9 December 1825 and 18 January 1826, when it fell. Only slight casualties were experienced and large booty was taken (68). Cautley and other canal officers took part, and we have one glimpse of Cautley in an anecdote he told himself years later of how, exhausted by hours of incessant duty, he fell asleep in his battery, and was awakened by the sudden *cessation* of the cannonade to find the place taken! (69).

*Place-names are given in their nineteenth century spelling. The modern spelling, where different, is given in brackets after the first mention of the name.



SIR PROBY CAUTLEY, F.R.S. (1802-1871)
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Gundewur Bridge with escape, *ghat* and *choki* on the Doab Canal (from Cautley's sketch-book c. 1830. Reproduced by permission of the Department of Civil Engineering, Imperial College, London.)

THE DOAB CANAL, 1825-1843

Cautley's appointment to assist in the restoration of the Eastern Jumna, or Doab, Canal was perhaps random, but it altered the course of his life, for he became, as a result of these early experiences, one of the pioneer engineers of irrigation works in India. His achievement as a hydraulic engineer is discussed in more detail elsewhere (70), and although it formed a major part of his life, Cautley's work in irrigation is given only in summary in this paper.

The Doab Canal was one of two old Mogul canals which took off from either side of the River Jumna at almost the same point high in its course. The western canal had been begun in the fourteenth century and then extended in the seventeenth century, at which date the eastern canal was also constructed. They were not new cuttings so much as systems formed by linking together existing rivers and streams. The western canal had fallen into disrepair by 1760, while the eastern had probably never functioned properly because of the steep slope on which it ran (71).

The western canal was restored first, and reopened in 1825. Work began on the eastern canal under Captain Robert Smith (72) and he had been working on the canal for two years when Cautley was sent to join him. The canal took its head at Fyzabad (Faizābād) in the foothills of the Siwaliks, the line of low hills running parallel with the Himalayas. It ran south for 140 miles more or less following the line of the River Jumna, curving inwards in a south-westerly direction to flow into the river at Selimpur near Delhi (Figure 2). The fall of the terrain was severe in places, a total fall of 421 feet in 134 miles, of which 186 feet occurred in the first 28 miles. The ground varied from shingle or stone boulders to sand or beds of clay. There were two difficult stretches over sand, one in the northern stretch and one at the tail. Drainage from the mountains cut across the canal bed in the north in four seasonal torrents, the beds of which were dry at some times of the year or full of flood water at others. The canal is very fully described in Cautley's own report of it written in 1845, when he was handing over charge of it to his successor (73).

Smith had already begun excavation in different places by the time Cautley arrived, but no masonry structures had been built. By a fortunate chance, a sketch book, almost certainly Cautley's, has survived, and this contains beautifully executed drawings, delicately coloured, of some of the bridges on the canal, and one or two elaborate structures where a bridge, escape, and *ghat*, or bathing steps, formed one unit (74) (Plate 9). The larger structures or those built on sand required very strong foundations, and Cautley made use of the native practice of constructing masonry walls close together linked to one another by small brick arches, the space between being filled with piles (75).

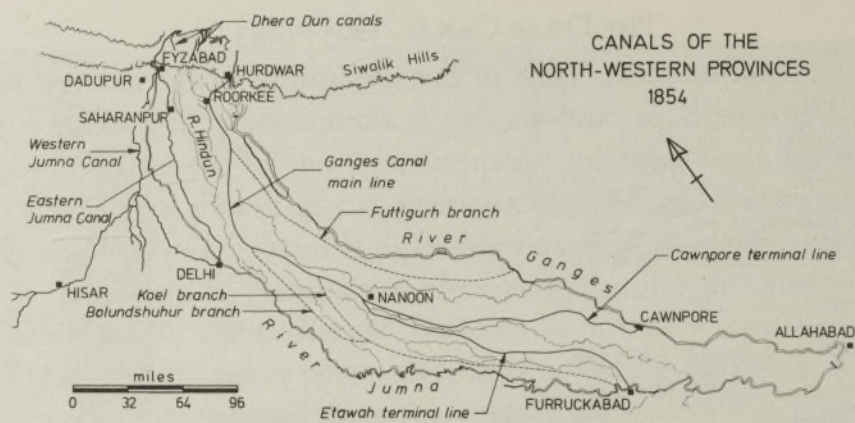


FIGURE 2. Sketch-map of canals of North-Western Provinces, 1854

Smith and Cautley worked on the canal for five years, building the structures and employing nomadic tribes to clear out the bed. Regulating works, in the form of bridges and dams which incorporated sluice gates, or stop logs, were built in the north to control the seasonal torrents which crossed the line of the canal. The canal was formally opened on 3 January 1830, and Smith having departed for Europe on sick leave, it fell to Cautley's lot to manage the canal works during the first difficult months. Failure to deal with the problem of the slope meant that the newly admitted water moved with such speed down the canal that the water raised the bed and carried forward vast quantities of silt. Cautley was formally appointed Superintendent a year later in April 1831, with Robert Napier (76) as his assistant, the Napier who later became Commander-in-Chief of the Army in India.

Cautley's immediate remedy was to begin building small waterfalls on the steep slopes in the northern and southern divisions. Eight were built between 1830 and 1834, and then after a review of the levels in 1837 (77), another six were added. These had the effect of reducing the velocity and thus controlling silt deposition. The work was very demanding, for heavy flooding frequently damaged the regulating works in the north, and Cautley had to devise stronger and stronger tail-works to protect them. He also installed self-regulating sluice gates in the dams, gates which fell quickly to a horizontal position under pressure of flood water (78).

Cautley organized the work in three divisions of the canal and was assisted by a staff of four and a native establishment. He was responsible to local government for all expenditure. Water-courses were taken off the canal at four-mile intervals and revenue was collected by native agents. From 1837–1838 the canal made a profit and therefore helped to promote other irrigation schemes. By 1847, its irrigable area was 421 875 acres to benefit a population of

291 000 (79). Permanent headworks were built in 1878, and the canal still plays an important role in irrigation today.

Cautley was in charge of the canal until 1843, when he was relieved of executive control, but remained in independent control as Superintendent of Canals in the North-Western Provinces (80).

While working on the Doab Canal, Cautley also designed three water-courses for the Dehra Dun, a triangular tract of land 48 miles wide from west to east, and between 10 and 15 miles from north to south, lying in the foothills of the Himalayas (81). These were canals in miniature, less than 20 miles long, and less than 5 feet wide, but they carried an important water supply. The Beejapur water-course was designed by Cautley in the winter of 1837-1838, and built by Captain Henry Kirke (82) between 1839 and 1841. It ran from the village of Beejapur and irrigated a triangular tract of land 7500 acres in extent to the west of the town of Dehra. Although only eleven miles long, it passed over country on such a steep slope that no less than ninety-six falls were needed to overcome it. Another water-course, the Rajpur, ran for twelve miles through the town of Dehra, carrying drinking-water and irrigating an area to the east of the town. This was also built by Captain Kirke between 1841 and 1844. A third water-course, the Kuttha Puthur (Katapatthar), designed by Cautley in 1841 (83), was not built until several years later.

In all these works, it is important to realize the empirical nature of Cautley's work, and its influence on his later career. In tackling the problem of the slope of the canal bed, it was only gradually that he formulated a theory of the desired velocity of flow and the possible slope on which it could be carried. The only theoretical work which existed at this time was by the French, and there is no sign that Cautley made use of the work of Dubuat (84), for example, prior to 1840 when he was designing the Ganges Canal.

In this period of his life, Cautley formed friendships which proved to be lifelong. One was with his senior on the canal, Captain Robert Smith, whom he remembered in his will (85). Smith's exceptional artistic talent is revealed in a number of surviving oil paintings, aquatints, water colours, and pencil sketches (86). Much of his energy went to the repair of ancient Mogul monuments in and around Delhi, though his architectural taste was apparently somewhat eccentric, in a style 'suggestive of confectionery' (87).

Apart from his assistant, Robert Napier, who was with him for five years, Cautley was also friendly with John Colvin (88) and his young assistants on the Western Jumna Canal. Colvin had been appointed in 1820 to restore one of the branches of the Western Jumna Canal, and in 1827 became Superintendent of

Canals in the Delhi Territory. Colvin's colleagues spoke of him as 'the sagacious and benignant patriarch of irrigation in Upper India', and admired his ability to deal with the local cultivators (89). Cautley must certainly have had many discussions with him about hydraulic problems. Colvin's headquarters were at Dadupur (Dādūpur), thirty miles from Cautley's station at Saharanpur, an easy ride away. When the rains came, Colvin shut himself up in his heptagonal house with his two assistants to pass the time as profitably as possible; one year, young Lieutenant Baker studied Italian, so that he could read Italian works on irrigation (90).

William Baker (91) had arrived in India in 1828 and been posted to work under Colvin in 1829. He was later to have a distinguished career in irrigation, and to give valuable administrative service as the first Secretary of the new Public Works Department, formed in 1854. Cautley described him as a colleague 'whose friendship has been one of the bright lights in my Indian career (92)'. Another assistant on the Western Jumna Canal arrived in 1832, Lieutenant Henry Durand (93), whose outstanding talents subsequently brought him high office in the government, culminating in his appointment as Lieutenant-Governor of the Punjab. But in the 1830s they were all young men, and with Baker and Durand, Cautley developed a special mutual interest, as will appear later.

The life of a canal officer was not unpleasant, if we may judge by the account of it in a memoir of Baker written after his death:

During a great part of the year, the canal officers were in movement over the wide extent of the irrigation system, stretching from the heads southwards to Delhi, a distance of 130 miles as the crow flies, and from the Jumna westward to Darba on the borders of the Bikaner Desert, nearly the same distance. All officers, we believe, who have served . . . on the canals of Upper India look back on their peripatetic life there as a happy time. The morning's journey was accomplished, sometimes by boat, sometimes on horseback along the springy turf of the banks, or on foot with a gun. Pea-fowl abounded in the plantations, and the sight of a peacock carrying the ponderous splendour of his train across the canal never ceased to be a marvel; . . . occasionally on a winding part of the bank one intruded on the solitude of a huge nilgai; whilst every now and then one came on a clan of monkeys who, aided by the branches of some spreading *ficus* that overhung the stream, were crossing it by a great trapeze performance. And the alternation of engineering and administrative work gave an unusual variety and zest to the occupation of the busy hours. (94)

The officers were allowed to wear a simple Norfolk jacket of homespun, open for undress, with the band buttoned for full dress, the rest of their garments being of white drill or homespun, according to the season of the year (95).

Cautley shows the other side of the coin, however, when he speaks of the hard and dedicated life of the canal officer in the wet season:

. . . the necessity frequently of being exposed during the day in heavy rains, or having to visit the bunds and dams at all periods of the year—to oppose by his own energy, skill and quickness in resources, an element at any time the most difficult to contend with, but in the case of the mountain torrents opposed to his numerous and difficultly situated works requiring the utmost steadiness and decision of character. (96)

FOSSIL-HUNTING, 1831–1840

A new dimension was added to Cautley's life in 1831 with the arrival at Saharanpur of Hugh Falconer (97), a young and genial Scot, who was to become a close friend. Born in Forres in 1808, he had been educated at the universities of Aberdeen and Edinburgh, from which he had taken the degrees of M.A. and M.D. respectively, in 1826 and 1829. In the latter year, he received a nomination as assistant-surgeon on the Bengal establishment of the East India Company, and made his way to London. There he met Dr Nathaniel Wallich (98), a distinguished Danish naturalist, who had just returned from India in 1828 bringing with him some eight thousand specimens of Indian plants, which he was engaged in sorting. Falconer, who had time in hand before sailing, became an eager assistant in this task, while also learning what he could of geology and Indian fossils from William Lonsdale (99), a geologist and palaeontologist, at this time Assistant-Secretary and Curator of the Geological Society of London. Falconer therefore arrived in India with more than a passable knowledge of Indian natural history.

Arriving in Calcutta in September 1830, Falconer examined and wrote an account of some fossil bones from Ava belonging to the Asiatic Society of Bengal (100). Early the next year, while stationed at Meerut, he was detailed off to conduct a party of invalids to the healthy air of Mussoorie in the foothills of the Himalayas, where a military convalescent home had been established in 1827. As he passed through Saharanpur, his natural interests took him to the Honourable Company's Botanic Garden, and there his meeting with the Superintendent, Dr John Forbes Royle (101), led to a lifelong friendship. When Dr Royle went on leave to Europe the next year, Falconer was

appointed Acting Superintendent; and eventually in 1832, Superintendent. The garden consisted of forty acres of ground, and by Royle's efforts, a greatly expanded collection of Indian plant specimens. It was run by a staff of forty under the control of the Superintendent, who also performed medical duties in the army station (102).

This post was very much to Falconer's taste, and his enjoyment of life in Saharanpur must have been greatly enhanced when he met Cautley, who had a house there while working on the Doab Canal. They shared a common interest in geology and palaeontology. Cautley had already published a note on the presence of coal and lignite in the Sewalik (Siwalik) Hills (103). This, with other evidence, suggested to Falconer that an animal fauna would be found (104). In 1831, he investigated the geological formation of the Sewalik Hills, which he reasoned were of tertiary age (105). The Sewalik Hills was the description used by him and Cautley to describe the range of lower elevations stretching along the south-west foot of the Himalayas from the River Indus to the Brahmapootra (Brahmaputra).

Some years prior to Falconer's arrival, Cautley had found a 'black cylindrical fossil', but he was not sure that it was a portion of animal remains (106). Falconer, however, on going to the same locality at the end of 1831 found several more pieces (107). Their searches produced further portions, but nothing remarkable until April 1834, when Falconer found the shell of a fossil tortoise in the Timli Pass (108). This inspired Cautley to search in the Kalowala (Kāluwāla) Pass east of the Jumna, and there, by means of blasting, more perfect remains were uncovered (109). Then, at the end of the year, the great discovery was made: William Baker and Henry Durand, the young officers working under Colvin on the Delhi Canal, found a large deposit of fossils near the valley of Murkunda (Mārkaṇḍa) and below Nahan (110). Their attention had been drawn to the possibility of finding fossil remains after the Nahan Rajah had presented them with a fossil tooth found at Sumroti, near the valley of Pinjore (Pinjaur). In November, Falconer went to the same area, and got three hundred specimens of fossil bones (111). Cautley plunged eagerly into collecting, and during 1835 their joint exertions laid bare a treasure-house of remains. A letter from Cautley to the Secretary of the Asiatic Society of Bengal, read to the Society on 4 November 1835, described what was probably a typical fossil expedition with Baker and Durand.

I had to visit Dadupur [headquarters of the Delhi Canal] . . . , and found both BAKER and DURAND as eager as myself for a short excursion into the Sewaliks; and as all our parties were out, we determined on visiting

those most westerly, who were working at a village called Moginund [Moginand] . . . about 50 miles W. of Dadupur . . . ; here [at Moginund] we remained three days, returning to Dadupur by regular marches. . . . The hills were covered with fossils like all the others (how they could have escaped observation before, must remain a source of wonder). Mastodons and hippopotamus's remains looking one in the face at every step! Amongst the remains collected were those of the *rat* and *porcupine*, too perfect to admit of any doubt. The specimens of each consisting of the *palate*, with the two lines of *molars*!!! . . . A great number of perfect bones, the whole series of a leg for instance, jaw bones, and other remains were fairly found and dug out from the rock . . . (112)

The fossil fauna was rich not only in the number of individuals, but also in the number of species. These included a very large number of mammals: *Proboscidea* (*Mastodon*, *Stegedon*, *Loxodon*, and *Euelephas*); several species of *Sus* and *Hippohyus*, and of *Equus* and *Hippotherium*; species of *Camel*, *Giraffe* *Cervus*, *Antelope*; new types of *Bovidae* and *Carnivora*, as well as birds (ostrich, crane, and so on), and reptiles (crocodiles) and fossil fish. They took particular satisfaction in finding remains of a colossal ruminant, which they called *Sivatherium*, a huge animal almost as large as an elephant with a broad head like an ox's, horns like an antelope's, and a trunk, and an enormous tortoise, *Colossochelys Atlas*, estimated to have had a shell twelve feet long and six feet high (113). Falconer's imagination was fired in the contemplation of their vanished world. Writing in 1840, he reflected:

What a glorious privilege it would be, could we live back – were it but for an instant – into those ancient times when these extinct animals peopled the earth! To see them all congregated together in one grand natural menagerie – these Mastodons and Elephants, so numerous in species, toiling their ponderous forms and trumpeting their march in countless herds through the swamps and reedy forests: to view the giant *Sivatherium*, armed in front with four horns. . . . We have only to light the torch of philosophy, to seize the clue of induction, and . . . to proceed into the valley of death, when the graves open before us . . . ; the dry and fragmented bones run together, each bone to his bone; the sinews are laid over, the flesh is brought on, the skin covers all, and the past existence – *to the mind's eye* – starts again into being, decked out in all the lineaments of life (114).

As the fossils came to light, the four main discoverers (for Baker and Durand took the business as seriously as Cautley and Falconer) set to work to measure, record, describe, and compare. Their comparative method relied on

Cuvier's book, *Ossemens Fossiles* (115), but its failure to arrive from Europe for some time forced them on to their own resources, and they slew and prepared skeletons of tigers, buffaloes, antelopes, and other Indian quadrupeds in order to make comparisons between recent and fossil bones (116). This method is clearly seen at work, for example, in a paper by Cautley on the fossil crocodile, where he compares the dimensions of his fossil remains with two recent skeletons, one of an animal eleven feet long and another of one eight feet long (117). The fossil bones were, in general, larger.

The most interesting remains were described in papers submitted to *Asiatic Researches*, the *Journal of the Asiatic Society of Bengal*, and the *Proceedings of the Geological Society of London* (118). Falconer and Cautley wrote separately, and jointly, and Baker and Durand also published their findings.

This activity did not go unnoted by the scientific world, and in 1837, Falconer and Cautley were awarded the Wollaston Medal of the Geological Society in duplicate 'for their geological researches and their discoveries in fossil geology in the sub-Himalayan Mountains (119)'. John Forbes Royle accepted the medals on their behalf, and they were conveyed to India by a returning officer (120). Cautley had been elected a Fellow of the Geological Society on 25 March 1835 (121).

The main fossil-hunting activity lasted eight years, between 1832 and 1840. Cautley and Falconer decided to present their enormous collection to a national museum, but the Geological Society, their first choice, could not provide enough space to accommodate it. They therefore offered it to the British Museum, if the Trustees would pay the expense of having the collection shipped from Saharanpur to London. Over two hundred letters passed between Cautley and the Military Office and the British Museum between 1838 and 1846, and they show the difficulties he had in getting the fossils from Saharanpur, by military carts to Selimpur, and from there to Delhi, where they travelled by river to Calcutta for transshipment to England (122) (Figure 3).

Cautley was anxious to keep the collection intact. In a letter of 1838 he wrote:

It appears to me that the value of a collection of this sort depends entirely on its being kept undivided! every fragment is likely to elucidate some point in the structure of the animal to which it belonged. . . . The Student in turning his attention to any one particular genus, will in all probability have to work out his results thro' 500 different portions of the skeleton & fragments which might by any attempt at Selection be thrown aside . . .
(123)

7. A few selected specimens of portions of cranium of B. or with horns entire - of this cranium you have a number of specimens, so in the event of the box being lost, the enclosed sketch of the fossil may be useful - the horns which are in pairs can easily be joined together. I think that the above are the most valuable of the collection, but the contents of caskets are filled as closely as possible with fragments of fossil fish, shells, teeth &c. &c.

Believe me very dear Sir
yours very faithfully
P. Cautley

To the Rev^d.
J. Forshall
British Museum

12. The 187 Chest appears to have been sent to England on the "Mantoliva" last year 1841 therefore if you have not got them, they may be found in the India House. This news has reached me since my last letter, and they were shipped on this vessel, July 1841, agreeably to letter of Mr. B. B. B. addressed to Geo. Gen. in Council dated 10 July/41 including Invoice of "Fossils of Tertiary".



Sketch of Fossil B. or Horns, found in the Lamber Hill between the T. orna and S. orna, sent to the British Museum

FIGURE 3. Part of a letter of 28 July 1842 of Cautley to J. Forshall, Secretary of the British Museum, describing the contents of a box of fossils he is dispatching to him (British Library, Add. MS. 28599, f. 95v) reproduced by permission of the British Library

Cautley packed the fossils himself in small chests, and a total of 214 chests, each weighing about four hundredweights, finally made their way to London at a cost to the British Museum of £602. An additional twenty-two chests were sent to India House in April 1843. Falconer arrived in London on leave in 1834, and began the work of sorting the collection and preparing drawings of them for publication.

To this period of his life belongs Cautley's first marriage. His bride was Frances Bacon of Saharanpur, third daughter of the late Anthony Bacon, Esquire, of Elcott, Berkshire (124). They were married on 20 September 1838 at Landour, the healthy hill resort in the foothills of the Himalayas. Saharanpur, where they lived, was a pleasant town, not too hot, with fresh vegetation and beautiful trees because of the small river and new canal running through it. The traveller Victor Jacquemont was impressed by it when he visited Cautley there in 1830 and saw Cautley's collection of rocks (125).

A son and only child of the marriage, Walter George, was born on 30 July 1840, and baptised at Landour on 26 September 1840 (126). By 1842, however, Frances Cautley was concerned about his health, and set off for England with him, arriving in the summer of 1843. Over two years were to pass before her husband joined her.

THE GANGES CANAL, 1838-1854

In 1836, Cautley embarked on the project which was to dominate his thinking for the next eighteen years. A detailed assessment of his ability as the engineer of the Ganges Canal is made elsewhere (127), and only a brief account will be given here.

The idea of a canal derived from the Ganges came from Colvin, for such works were proving profitable financially, both in revenue and in protection from famine. At his suggestion, Cautley explored the possibility of deriving water at Hurdwar, high in the course of the Ganges, but his preliminary survey in November 1836 was not encouraging, and Colvin having left India, the matter fell into abeyance. Severe famine in 1837-38, however, revived the matter and Cautley undertook a further survey in December 1838. The resulting report of 1840 (128) became the basis for the design.

The canal took its head at a point in the river $2\frac{3}{4}$ miles above Hurdwar. Here a branch of the river was deepened to bring the water past Hurdwar to a point where the new cut could begin. The canal was brought twenty miles across country of a rugged and broken profile to Roorkee; from there it descended into the plain for 180 miles to Nānoon (Nānu) with two long branches taken off at the 50th and the 110th mile; at Nānoon it split into two

long channels of 165 miles each, one returning the water to the Ganges at Cawnpore and the other discharging into the Jumna at Furruckabad (Farrukhābād) (Figure 2).

The design underwent several changes. The report of 1840 described a scheme for the first twenty miles and for a channel of 255 miles with seventy-three miles of branches (129). The government at first gave only begrudging support to the scheme and Cautley had to carry out the survey of the lower districts without assistance, a task that involved nearly 600 miles of levelling (130). The result of the survey was presented in a report of 1845, which gave the government a choice of three schemes for the lower part of the canal (131). Later, in 1850, as work proceeded, Cautley slightly modified the design (132).

Excavation began in April 1842, but progress in the first years was slow, mainly through lack of government enthusiasm. Two reports were requested by government, one a more detailed scientific assessment, produced in February 1842 (133), and the other a medical report on sanitary aspects of canals, completed in March 1847 (134). Lord Ellenborough (135), as Governor-General, made only a small annual grant and stipulated that navigation must be the primary object and irrigation secondary. Thus it was October 1847 before this condition was removed and sufficient money to pay an adequate staff granted through the enthusiasm for the project of Ellenborough's successor, Sir Henry Hardinge (136). During this period, also, Cautley took his three-year furlough, and the canal works progressed only slowly in his absence because of the call to military duty of the canal officers who were left in charge. However, from October 1847 building was rapid and the canal was sufficiently complete for water to be admitted in April 1854.

The major task for Cautley as engineer was to design the system so that water admitted at the head could travel with sufficient velocity to reach all parts. From his experience on the Doab Canal he knew what acreage could be watered from a certain discharge of water, and this enabled him to plan a system to distribute the quantity estimated to be available at Hurdwar. In order to work out the size of the channel, Cautley used the formula of the French hydraulician Dubuat (137) on various hypothetical sections, once he had decided on the other variables, that is, the slope and the desired velocity. His choice of these relied heavily on his experience of what had worked on the Doab Canal.

The construction problems related mainly to the first twenty miles between Hurdwar and Roorkee in the rough *khadir*, or low land, of the Ganges. Deep excavation up to thirty feet was required in places, while the east-west slope of the land had to be overcome by introducing four falls. The drainage from the

hills collects in three separate basins discharging seasonally into four streams which crossed the path of the canal, and these had to be dealt with in specially devised structures. The canal was carried across a three-mile valley in a massive aqueduct. Below Roorkee the problems centred round deflecting away from the canal the drainage of local streams and rivers.

The northern division, therefore, contained all the novel structures of the canal: bridges with sluice gates at the headworks at Myapoor to regulate the quantity of water entering the canal; two large brick structures known as 'super-passages' at the fifth and ninth miles to carry the seasonal torrents across the canal in passageways 200 feet and 300 feet wide respectively; four falls of nine feet, two of them incorporated into the super-passages; a level-crossing at the thirteenth mile consisting of regulating works set at right angles to one another to admit up to 800 feet of flood water to cross the canal; and between the fifteenth and eighteenth miles the triumph of the Solani aqueduct. Here the canal travelled for two miles in an earthen brick-lined channel thirty-five feet in height from the bed of the Solani river, entered a brick and mortar aqueduct bridge 1110 feet long and then continued for another half mile in a further earthen embankment. Massive quantities of earth had to be moved manually to raise the embankment, which, built without compaction machinery and in a period before the science of soil mechanics was understood, was an astonishing achievement. The bridge was also an engineering feat, remaining until the end of the century the longest aqueduct bridge in the world; it was composed of fifteen spans of fifty feet each and carried water ten or twelve feet deep in a channel 172 feet wide. Great precautions were taken to make this a safe structure and it was built on huge cubes of brickwork twenty feet square sunk twenty feet below the river bed (Figure 4).

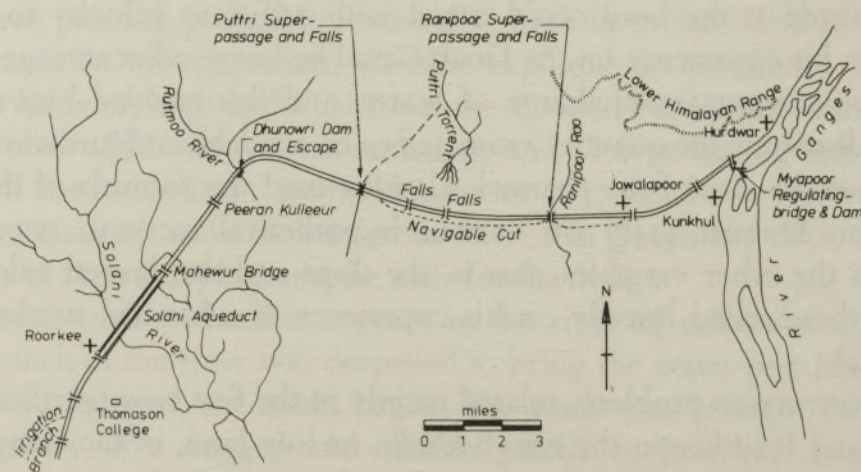


FIGURE 4. Sketch-map showing Northern Division of Ganges Canal, 1854 (redrawn from J. G. Medley, *Irrigation Works* (1873), Plate II)

Other structures on the canal were bridges at three-mile intervals with water-course heads incorporated into them, inlets and outlets for drainage water, and a total of fourteen falls to regulate the slope of the bed—eight of these have now been adapted to generate hydro-electric power (138).

Cautley's role in building the canal was to have absolute responsibility for the design of the structures and their execution. By modern standards he had a tiny staff, headed by only seven senior officers, one to organize materials and the others in charge of the six administrative divisions of the canal. They were supported by a small European establishment and a slightly larger native one, while the work of excavation was carried out by nomadic tribes working under contract. Very little mechanical aid was to hand, while all the construction materials had to be supplied by the canal officers' own resources. Cautley's indication to James Thomason (139), Lieutenant-Governor of the North Western Provinces, of his need for a supply of 'well-educated artificers' (140) led eventually through Thomason's efforts to the setting up in 1848 of a College of Engineering for officers and others; this has since become the University of Roorkee. Cautley later established there the Cautley Gold Medal to be awarded annually to the best mathematician of his year (141). Cautley was also personally answerable for expenditure and for building the canal within his estimate; in this respect, he was reasonably successful.

This great work was not without faults, but they were faults which it was understandable for its designer to make. This was the largest irrigation canal in the world at the time and the theory of flow in such a large open channel did not exist; indeed, systems such as the Ganges Canal had to be built before the theory could advance. In practice, the slope Cautley chose proved to be too steep, with resulting high velocities, and in the ten years after the opening of the canal remedial work had to be carried out to flatten the slopes. Cautley's error was his failure to realize that what had worked well on a small canal would not work on a large one with much greater volumes of water, and that Dubuat's formula, derived as it was from experiments on small channels, might prove inadequate.

For all this, the canal is still important today and with the Lower Ganges Canal, added between 1872 and 1878, totals over 1000 miles of main channel and irrigates over one and a half million acres in one of the most densely populated areas of India.

As already mentioned, Cautley had during this period taken his first and only furlough. He left India in February 1845, his place on the canal being taken by his old friend, Major William Baker. His leave, however, was not a time of happiness. He arrived back in London on 30 October 1845, and was

reunited with his wife at No. 35 Hertford Street, Mayfair, the house in which she had supposedly been living in his absence. The true state of affairs was revealed the following summer, however, when he discovered her adultery with a Major Leonard Cooper, an officer in Her Majesty's Army (142). Husband and wife separated, and she gave birth to twin children later that month (143). When Cautley brought an action against Cooper in the following August in Her Majesty's Court of Exchequer Pleas for 'adulterous intercourse and criminal conversation', Cooper allowed judgement to go by default, and Cautley was awarded £1000 damages by a jury of the County of Surrey. While in England, he put in hand proceedings to obtain a divorce *a mensa et thoro*, granted in the Consistorial Court of London on 19 May 1848, and a divorce by Act of Parliament on 15 July 1850 (144), which he had to obtain to free himself from financial obligations.

In addition to this domestic upheaval, Cautley's son died on 14 October 1846, aged six years, from 'inflammation (six months) and marasmus' (145).

Doubtless, Cautley met Falconer, who was on leave in England between 1843 and 1847, and was preoccupied with bringing out the first parts of *Fauna Antiqua Sivalensis* (146). This was published under the patronage of the Government and the East India Company, each of whom subscribed for forty copies (147). Designed originally to appear in twelve separate parts, only nine were completed, and produced between 1845 and 1849. Falconer returned to India in December 1847 before completing the letter-press describing the plates; but three years after his premature death in 1865, his friend Charles Murchison reconstructed as well as he could from Falconer's notes a description of the plates (148). The latter, ninety-two in all, were magnificently drawn by G. H. Ford and figured 1123 specimens, with sometimes three, four or five views of some of them. Another eighteen plates remained unfinished and unpublished (149).

For this, and for his work in projecting the Ganges Canal, Cautley was elected to the Fellowship of the Royal Society on 2 April 1846 (150). His candidature was supported by nineteen Fellows from personal knowledge, including John Forbes Royle and Falconer, the latter having been elected a year earlier, on 13 February 1845 (151).

Cautley returned to India via Italy and Egypt in order to visit hydraulic works there. Irrigation engineering was more advanced in Italy in this period than anywhere else, and Cautley hoped particularly to observe the Italian method of dealing with problems associated with drainage lines crossing the canal route. He spent six weeks in Lombardy and Piedmont (152), but although he no doubt derived some ideas from the visit, he saw nothing on the

scale of the works he was contemplating in India. Taking the steamer from Trieste to Egypt, Cautley visited briefly the works at the head of the delta of the Nile before setting sail for Bombay, where he arrived on 14 December 1847. On 11 January 1848 he had resumed charge of the Ganges Canal works (153).

By April 1854 the works were sufficiently advanced for Cautley to contemplate an official opening to take the form of the admission of water onto the Solani aqueduct. The temporary bund which separated the canal cutting from the Ganges was accordingly breached on 1 April and the water travelled slowly to reach the aqueduct on 7 April. Here it was held back by gates until the opening on 8 April (154).

The ceremony was given all the splendour of a royal occasion. A large and colourful crowd, perhaps 50 000 strong, assembled with their tents and camels, while from five in the morning troops arrived to take up their positions on each bank and on either side of the waterway of the aqueduct bridge. The canal labourers were also present, drawn up in squads under their leaders on the steps of the earthen embankment. After gun salutes to greet first the Maharajah of Gwalior on a richly caparisoned elephant, and then John Russell Colvin (155), Lieutenant-Governor of the province, the ceremony began at six o'clock with a Christian religious service for the European guests. Then the official party ascended the staircase to the top of the aqueduct, where Colvin undid one of the levers which kept the canal gates closed. A senior canal officer released the other, on which signal all eight gates were thrown open. The waters rushed through, the band played the national anthem, the soldiers on the aqueduct fired salvos, and the natives shouted *Gunga Mhye ke Jey!* [Long live Mother Ganges!] (156).

The occasion was marked by two dinners that evening, one given by the Lieutenant-Governor to Cautley, and one given by Cautley to his overseers and subordinate officers. Cautley replied to Colvin's speech with what seems to have been characteristic modesty, saying that the success of the undertaking had depended on the encouragement he had received from Supreme and Local Government, and 'the zeal, energy and willing aid given to me by every officer on the Canal'. The Governor-General, Lord Dalhousie (157) had taken the keenest interest in the canal, while James Thomason (158), Colvin's predecessor, (who had died prematurely in 1853), had been his personal as well as his official friend. 'When cordially supported by two such men my success is not remarkable, and the aid they gave me was never limited to official acts, but was perhaps more effectual in the form of kindly encouragement and the warmest support in their private correspondence' (159). Cautley went on to

thank individual officers and to give to each the credit that was due to him for particular works. The reporter observed,

It was impossible to behold without strong feelings of interest this distinguished veteran of science [Cautley was fifty-two] standing thus modestly on the scene of his glories, and hurrying with the simplicity of a child from any egotistical references that the occasion might seem to force on him, to the generous and therefore to him welcome office of praise and thanks to others.

The evening was rounded off with a display of fireworks, and illumination of the aqueduct and nearby canal buildings. A ball completed the celebrations on the following Monday evening (160), given by Cautley to the Lieutenant-Governor in the College of Engineering at Roorkee, shortly to be renamed Thomason College of Engineering in memory of James Thomason.

News of the opening of the canal sped by the newly installed electric telegraph, only ten days old, from Meerut to the government in Calcutta. Dalhousie wired back, 'I have rejoiced over your message. All honour to Colonel Cautley' (161).

Cautley now decided to retire from the service and received permission to do so with effect from the date of his departure in May 1854 (162). To honour him for his services to India, the Governor-General ordered a special salute of thirteen guns to be fired from the ramparts of Fort William as Cautley passed down the river on board the Governor-General's yacht to join the packet that would take him to England (163). Such an honour set aside normal precedent, which forbade any special regard to be paid to officers retiring from the scene of their public service (164). The Governor-General also, in a special Minute of 5 May 1854, gave unstinted praise to the Ganges Canal works, emphasizing the canal's magnitude in comparison with every other canal work in the world at the time, and repeating the words quoted by the Lieutenant-Governor of the North-Western Provinces in his Dispatch that 'there is no more striking fact in connexion with it, than that such a truly gigantic undertaking should have been in its designs the product of a single intellect, and in its execution the work of a third part of one man's professional life' (165). The Minute ended by urging that the Directors of the East India Company should draw Cautley's achievements to the attention of Her Majesty's government 'in the hope that they will meet with their due reward from the Sovereign's gracious favor'.

Before Cautley's departure, a meeting was held in Calcutta Town Hall on 29 April under the chairmanship of Sir Lawrence Peel (166), in order to decide on some kind of memorial. The resulting public subscription produced over

4000 rupees (£400) to pay for a bust of Cautley, to be placed in the Town Hall of Calcutta (167). He also received a clock from the City of Calcutta, referred to in his will (168) and the will of his adopted daughter (169). His canal colleagues presented him with a piece of plate of his own choice, and the letter of Baird Smith (170), a senior officer, offering it, and Cautley's reply were published in the *Delhi Gazette*. Baird Smith spoke of Cautley's canal colleagues as men 'who will long cherish as among the pleasantest recollections of their lives, their association with you . . .', 'a dear and valued friend, of whose innumerable kindnesses their memories are full to overflowing . . .' (171).

True to the Governor-General's orders, Cautley embarked on his barge at Baboo's Ghat at seven o'clock in the morning of 16 May, and, as the salute was fired, passed down the river to go on board the P. and O. steamer *Bentinck* (172), which sailed that day bound for Southampton via Suez. A public announcement of Lieutenant-Colonel Cautley's departure from India was sent by telegraph to Agra (173). His service in India was over.

ENGLAND, 1854-1871

The knighthood that the Governor-General had earnestly requested was bestowed on Cautley on 29 July 1854 (174). Lord Dalhousie had written to Sir Charles Wood (175), then President of the Board of Control, to recommend it strongly (176), and wrote in confidence to an old friend, '. . . I do not think they can refuse it. If they do refuse, I will raise a storm about their ears. For I will write straight to the Queen, . . . and will lay before her what he has done for the glory of her crown and for the annals of her reign (177)'. The honorary title of Colonel was conferred on 28 November 1854 (178).

Cautley does not seem to have been in residence in London until about 1858 when he took rooms at 31 Sackville Street near Piccadilly (179). Falconer rented rooms there too for a period in 1861 and 1862. Here Cautley resided until September 1868, when he retired from public life.

After the Mutiny in 1857, an Act of 1858 (180) transferred the power of the East India Company to the Crown. There was to be a Governor-General in Council in Calcutta, and in London in place of the Court of Directors and Board of Control a new Secretary of State with a Council of fifteen members. Cautley was among the first fifteen appointed, and took his place on 8 September 1858 (181) under Lord Stanley as Secretary of State, and from June 1859 under Sir Charles Wood. The work was dealt with by committees, whose decisions were ratified by the Council (182). Cautley served first on the Finance, Home and Public Works Committee, and later became Chairman of the Public Works Committee and a member of the Military Committee (183).

The Council dealt with finance, currency, legislation, revenue, foreign policy, the army, and public works, and communicated its decisions to the Governor-General in India.

Apart from the weekly meeting of the Council, the committee work must have taken up a good deal of Cautley's time. Two old friends were also appointed: Henry Durand for a short period, and William Baker from 1862. Cautley served a complete ten years, resigning on 30 September 1868 (184).

In the first years after his return, Cautley was busy completing his *Report on the Ganges Canal Works*, published in 1860 (185). Messrs. Smith and Elder had offered to publish five hundred copies at a total cost of £6350 (186), which no doubt accounts for its scarcity today.

In 1863 Cautley became engaged in a public argument over the design of the Ganges Canal (187). His adversary was Sir Arthur Cotton (188), who had had a distinguished career in India as the designer of the great deltaic irrigation works in Madras. In 1863, Cotton was requested by the East India Irrigation Company to report on the expenditure required to put the Ganges Canal into more efficient running order with a view to the Company's buying it from the government. As indicated earlier, the high velocities of the canal in its early years created problems, and it was easy for Cotton to produce a critical report. Cautley later claimed that this was done to allow the East India Irrigation Company to make the government a low offer for the canal (189). Cotton's *Private Memorandum upon the Ganges Canal* (190) soon became public knowledge, for he reported his findings to both the Calcutta Chamber of Commerce and the Indian government (191). Cautley eventually obtained a copy from the East India Irrigation Company, and believing he should defend himself against any implied charge of misuse of public funds, he published a pamphlet, the first of several brought out by him and Cotton for private circulation between 1863 and 1865.

Cotton asserted in the *Private Memorandum* that there were nineteen mistakes in the design of the canal, five of them fundamental (192). The argument centred chiefly round the position of the head of the canal, Cotton maintaining that a suitable head could have been established at Sookertal (Shokartar Bāngar) at the confluence of the Solani and Ganges rivers, ninety-five miles below Hurdwar, by building a weir across the Ganges. Thus the Solani aqueduct and expensive works in the northern division need not have been built, and some mileage of channel could have been saved. Cautley's defence was that it would have been both difficult and expensive to dam the Ganges lower in its course, and furthermore the northern part of the plain would have remained unirrigated. Each engineer's experience was in a different kind of

terrain, but Cotton maintained that what he had done on rivers in Madras could be done on the Ganges. Other points of difference concerned the use of brick when stone could be obtained in the sub-Himalayas, that the whole of the water was admitted at the head instead of at various points on the river and thus had to be conveyed 350 miles to certain areas, that there was no permanent head, that the slope was too steep, and that there were a number of defects in the efficiency of the canal for navigation.

In his *Reply to Statements . . .*, Cautley admitted that he had been wrong about the slope (193), but he denied other criticisms, observing wryly, 'It will be found more easy to propose weirs and dams on the sandy tracts of the Ganges and Jumna than to execute them' (194). Cotton promptly produced *Observations . . . on the foregoing Reply . . .* (195), to which Cautley responded with *A Disquisition on the heads of the Ganges and Jumna Canals* (196). The exchange began to become ludicrous with Cotton's *Reply . . . to Colonel Sir Proby Cautley's 'Disquisition on the Ganges Canal'*, Cautley's *A Valedictory Note . . . respecting the Ganges Canal . . .* and Cotton's *Reply to Sir Proby Cautley's Valedictory Note . . .* (197). The engineering world no doubt followed it all with interest, and various articles appeared in the *Times*, brought out by Cotton's party and supporting his views (198). Cautley's annoyance is shown in a handful of letters written between 1864 and 1866 to Captain James Crofton (199), who had been appointed in February 1864 by the Public Works Department to report on the remedial works that were needed. On 10 November 1864 he wrote:

I have directed Smith & Elder to send you a copy of the *Times* of the 2nd of this month . . . Two & a half columns of admiration of Sir A. Cotton is rather a strong dose. The writer . . . has evidently been assisted by an Engineer, & it required no great wit to suppose that that Engineer is Sir Arthur Cotton. . . . I confess that I never expected to receive a blow of this sort from the '*Times*' – it is no use enquiring whether it is fair to review Pamphlets in Private Circulation . . . (200)

Crofton's report in November 1864 suggested various remedial measures for the canal (201), and was reinforced by the findings of a committee set up in February 1866 to decide between Cotton's proposals for a new head and Crofton's scheme. The committee supported Crofton's remedies (202) and despite attempts by Cotton's friends to keep the argument going, the whole affair finally subsided into silence. In a Dispatch of 1 March 1865, the Governor-General had already exonerated Cautley from all blame. He wrote, 'Whatever be the present ascertained defects of the Ganges Canal, the claims of

Sir Proby Cautley to the consideration of the Government of India for his eminent services are, in our estimation, in no way diminished, and his title to honour as an Engineer still remains of the highest order' (203).

Ironically enough, weirs were later built across the Ganges lower in its course, at Okhla for the headworks of the Agra Canal and at Narora for those of the Lower Ganges Canal, but Cautley was right in his insistence that the rivers of Madras and Upper India could not be treated in the same way, and in the economic considerations which led him to take the head of the canal from Hurdwar.

Despite the anxiety the canal continued to cause him in these last years of his life, Cautley took some part in the social life of London. He was elected a member of the Athenaeum in 1855 (204), he kept a stall at the opera (205), and he received visits from old army friends (206). He kept up his interest in Geology and was a member of Council of the Geological Society between 1855 and 1857 (207).

In this period also, he married again. His bride was Julia Susannah Richards of Wellington Terrace, Marylebone, a woman some thirty years his junior, and they were married on 11 February 1865 at All Saints Church, St John's Wood (208). She brought to the marriage a son and daughter. Cautley adopted the younger child, Ada Julia, born on 3 December 1862 (209), and gave her the name Cautley. In his will he made provision for the education of her brother (210).

In 1868, he retired from public life to a large house called The Avenue at Sydenham Park. His life there was destined to be short. He had suffered from asthma for years, and in the last years of his life had repeated attacks of bronchitis. In a letter to Crofton on 25 November 1865, he wrote:

I am suffering from an attack of Bronchitis and throat affection which always keeps me low; but I shall be well in a week I hope. November however is not a month to be cheerful in, in London. We could give you some of our fogs, and smoke, in return for some *sun*, if you could spare it . . . (211)

and he referred to it again the following winter as something as he was dreading (212). He succumbed finally after two weeks' illness on 25 January 1871, aged sixty-nine (213).

By his will he left his property in Nice to his 'valued friend Col. Robert Smith', and an income from his estate to his wife and sister Catherine; on his wife's death, his adopted daughter was to receive an income for life. On the death of wife, sister and daughter, his estate was to pass to his cousin George

Cautley (214). His widow survived until 4 October 1916, when she died, aged eighty-four (215), and his adopted daughter until 24 June 1931 (216).

Benign and modest in personality, Cautley was at the same time a man of great intellectual capacity and astonishing administrative ability. His strong sense of duty and patriotism contained no tinge of piety. His readiness to acknowledge generously the work of all his officers, his 'genial love of his work for the sake of its benefit to humanity (217)', together with a certain simple pleasure in his achievements, are no doubt the qualities which endeared him to his friends. Writing to Falconer in 1839 he describes how he is showing the local landowners how to make watercourse heads:

. . . much to their satisfaction – & a good deal to my own too – for after all the pleasure of giving a running stream of water on lands, where water has not been seen before – & the results in the sheets of splendid crops that we of the spade & shovel scatter on the face of this Country – is almost as great as that of collecting Mastodons & Hippopotamus remains . . . (218)

Cautley's contribution to palaeontology, along with Falconer's, rests on his scientific approach to the subject and the importance of his collection for students of Indian fossils. His success as engineer of the world's largest irrigation canal at the time resides firstly in the benefits it brought and has continued to bring to the lands it watered, and, secondly, on its demonstration of the feasibility of building such large works. Several generations of engineers relied on Cautley's experience and the meticulous account he left of his work, and the Ganges Canal ushered in an age of canal-engineering in Northern India and modern Pakistan which has continued steadily since.

ACKNOWLEDGEMENTS

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PUBLISHED WORKS OF P. T. CAUTLEY

Engineering

- 1839 'A description of the use of wells for foundations', *J. Asiat. Soc. Beng.*, **8** (1839), 327–340. Reprinted in F. Abbott, *Practical Treatise on Permanent Bridges for Indian Rivers* (2nd ed. Agra, 1850; reprinted, Roorkee, 1860).
 ?1841 *Report on the Central Doab Canal* (Allahabad).

- 1842 'On the proposed formation of a canal of irrigation from the Jumna, in the Dhera Dun', *J. Asiat. Soc. Beng.*, **II** pt 2 (1842), 761-775.
- 1845 *Notes and memoranda on the water courses in the Dehra Doon, North West Provinces, 12 February 1845* (Calcutta).
- 1845 *Report on the Ganges Canal from Hurdwar to Cawnpore and Allahabad* (Calcutta).
- 1846 *Plans and maps to illustrate Report on the Ganges Canal from Hurdwar to Cawnpore and Allahabad* (London).
- 1850 *Estimate of the probable expense to be incurred in constructing the Ganges Canal Works, including the main trunk line, the Cawnpore and Etawah Forks, and the Futehgurh, Bolundshuhur and Coel Branches* (Umballa).
- 1851 *Slope Tables for the Use of the Canal Department, North Western Provinces . . .* (Umballa).
- 1851 *Useful Tables for the Canal Department, North Western Provinces*, edited by Cautley [Agra].
- 1853 *Notes and memoranda on the Eastern Jumna, or Doab Canal, and on water courses in the Dehra Doon* (Roorkee). Also published in *Professional Papers, Civil Engineering College, Roorkee, No. 1*.
- 1860 *Report on the Ganges Canal Works; from their commencement until the opening of the Canal in 1854*, 3 vols and folio atlas (London).
- 1863 *A Reply to Statements made by Major-General Sir Arthur Cotton, on the projection of the Ganges Canal Works* (London: printed for private circulation).
- 1864 (with A. Cotton) *A Discussion, regarding the projection and present state of the Ganges Canal, and the measures required to make it reliably useful and profitable* (London: printed for private circulation).
- 1864 *A Disquisition on the heads of the Ganges and Jumna Canals, North-Western Provinces, in reply to Strictures by Major-General Sir Arthur Cotton* (London: printed for private circulation).
- 1864 *A Valedictory Note to Major-General Sir Arthur Cotton, respecting the Ganges Canal, with a postscript touching certain misrepresentations of a writer in the 'Times' on the same subject* (London: printed for private circulation).

In addition, the following papers are said to have been published in *Selections from the Records of the Government of the North Western Provinces*, 4 vols, 2nd ed. Agra 1855-1856.

Report on the influence of the Jumna canals on the Jumna river. Report on the Khirkee and Chuttuzpoor bunds, December 1848. Memoranda on Hall and Ainslie's brick-making machines, as used in the Roorkee brickfields.

Geology and palaeontology

- 1828 'Notice of the occurrence of coal and lignite in the Himalaya', *Asiat. Res.*, **16**, 387-396.
- 1832 'On the gypsum of the Himalaya', *J. Asiat. Soc. Beng.*, **I**, 289-296.
- 1834 'Discovery of an ancient town near Behut, in the Doab', *J. Asiat. Soc. Beng.*, **3**, 43-44.
'Further account of the remains of an ancient town, discovered at Behat, near Seharanpur', *J. Asiat. Soc. Beng.*, **3**, 221-227.

- Letters to Asiatic Society about the discovery of fossil deposits, *J. Asiat. Soc. Beng.*, **3**, 527–529, 592–593.
- 1835 [P. T. Cautley], 'On a new species of snake discovered in the Doab', *J. Asiat. Soc. Beng.*, **4**, 217.
 'Note on the gold washings of the Gumti River', *J. Asiat. Soc. Beng.*, **4**, 279–282.
 Letter to Asiatic Society about further fossil discoveries, *J. Asiat. Soc. Beng.*, **4**, 585–587.
 (With H. Falconer) 'Synopsis of fossil genera and species from the upper deposits of the tertiary strata of the Sivalik Hills, in the collection of the authors', *J. Asiat. Soc. Beng.*, **4**, 706–707; in French in *Ann. Sci. Nat.*, 2nd ser., **7** (Zool.) (1837), 60–62.
- 1836 (With H. Falconer) '*Sivatherium giganteum*, a new fossil ruminant genus, from the Valley of Markanda, in the Sivalik branch of the Sub-Himalayan Mountains', *J. Asiat. Soc. Beng.*, **5**, 38–50. Also published in *Asiat. Res.*, **19** (1836), 1–24; in *Phil. Mag.*, 3rd ser., **9** (1836), 193–201, 277–283; and in French in *Ann. Sci. Nat.*, 2nd ser., **5** (Zool.) (1837), 348–370.
 'Note on the teeth of the Mastodon à dents étroites of the Siwalik hills', *J. Asiat. Soc. Beng.*, **5**, 294–296.
 'Note on Mastodons of the Sewaliks', *J. Asiat. Soc. Beng.*, **5**, 768–770.
 'Note on the fossil crocodiles of the Sivalik hills', *Asiat. Res.*, **19**, 25–32.
 'The fossil gharial of the Sivalik hills', *Asiat. Res.*, **19**, 32–38.
 (With H. Falconer) 'Note on the fossil hippopotamus of the Sivalik hills', *Asiat. Res.*, **19**, 39–53.
 (With H. Falconer) 'Note on the fossil camel of the Sivalik hills', *Asiat. Res.*, **19**, 115–134.
 (With H. Falconer) 'Note on the *Felis cristata*, a new fossil tiger, from the Sivalik hills', *Asiat. Res.*, **19**, 135–142.
 (With H. Falconer) 'Note on the *Ursus sivalensis*, a new fossil species, from the Sivalik hills', *Asiat. Res.*, **19**, 193–200.
 'On the remains of mammalia found in the Sewalik mountains, at the southern foot of the Himalayas between the Sutlej and the Ganges', *Proc. Geol. Soc.*, **2**, 395–397. Paper reported in *Phil. Mag.*, 3rd ser., **8**, (1836), 575–577.
- 1837 (With H. Falconer) 'On additional fossil species of the order *Quadrumana* from the Sewalik Hills', *J. Asiat. Soc. Beng.*, **6**, 354–360; *Phil. Mag.*, 3rd ser., **12** (1838), 34–40; abstract in French in *Ann. Sci. Nat.*, 2nd ser., **8** (Zool.) (1837), 255–256.
 Extract from a letter to Dr Royle on remains of a quadrumanous animal, *Proc. Geol. Soc.*, **2**, 544–545.
- 1838 'Note on a fossil ruminant genus allied to *Giraffidae*, in the Sewalik hills', *J. Asiat. Soc. Beng.*, **7**, 658–660; *Ann. Nat. Hist.*, **3** (1839), 167–169.
- 1840 'On the structure of the Sewalik Hills, and the organic remains found in them', *Trans. Geol. Soc.*, 2nd ser., **5**, 267–278 (read 9 March 1836); *Madras J. Lit. and Sci.*, **12** (1840), 292–303.
 (With Hugh Falconer) 'Notice on the remains of a fossil monkey from the tertiary strata of the Sewalik Hills in the north of Hindostan', *Trans. Geol. Soc.*,

- 2nd ser., 5, 499–504 (read 14 June 1837); *Madras J. Lit. and Sci.*, 12 (1840), 304–309; abstract in *Proc. Geol. Soc.*, 2 (1837), 568–569, and *Phil. Mag.*, 3rd ser., 11 (1837), 393–394.
 ‘On the fossil remains of *Camelidae* of the Siwaliks’, *J. Asiat. Soc. Beng.*, 9, 620–624.
- 1844 (With H. Falconer) ‘Communications on the *Colossochelys Atlas*’, *Proc. Zool. Soc.*, 12, 54–55, 84–88.
- 1845 (With H. Falconer) ‘On some fossil remains of *Anoplotherium* and giraffe, from the Sewalik Hills in the north of India’, *Proc. Geol. Soc.*, 4 pt 2 (1843–1845), 235–249; *Calcutta J. Nat. Hist.*, 5 (1845), 577–589.
- 1845–1849 H. Falconer and P. T. Cautley, *Fauna Antiqua Sivalensis being the Fossil Zoology of the Sivalik Hills in the North of India*, 9 pts (London).
- 1846 H. Falconer and P. T. Cautley, *Fauna Antiqua Sivalensis, being the Fossil Zoology of the Sewalik Hills in the North of India, Part I, Proboscidea* (London). The only part of the letter-press published. Reprinted as pp. 1–64 in Charles Murchison, ed., *Description of the Plates of the Fauna Antiqua Sivalensis from Notes and Memoranda by Hugh Falconer . . .* (London, 1867).

NOTES

- (1) Baptismal register of Roydon, Suffolk. The parish registers of Roydon and Stratford St Mary are held by East Suffolk Record Office, Ipswich.
- (2) *Ibid.*, and Burial register of Stratford St Mary, Suffolk. Charles William Cautley, born 3 October 1800, buried 26 March 1801.
- (3) J. A. Venn, ed., *Alumni Cantabrigienses, Part II, 1752–1900* (Cambridge, 1940), vol. 1, p. 542; W. W. Rouse Ball and J. A. Venn, eds, *Admissions to Trinity College, Cambridge, vol. 3, 1701–1800* (London, 1911), p. 233
- (4) Census 1851, East Bergholt. Also, Bishop’s Transcripts, Askrigg (Archives Department, Leeds City Council). See note 16.
- (5) Cautley’s paternal grandfather, Thomas Cautley, 1752, ordained deacon in the diocese of Chester; 1755, ordained priest; 1758–1762, vicar of St Crux, York; 1761–1775, vicar of St Helen’s, York (records in the Borthwick Institute of Historical Research, York); 1762, appointed to living of Great Ouseburn, Yorks. (*Gentlemen’s Magazine*, 32 (1762), 343); buried in Great Ouseburn, 25 May 1796 (Burial register of Great Ouseburn, Borthwick Institute of Historical Research, York). Cautley’s maternal grandfather, Narcissus Charles Proby (1738/1739–1804). Trinity College, Dublin, B.A. 1760, M.A. 1764 (Venn, *Alumni Cantabrigienses*, note 3, vol. 5, p. 206); c. 1784–1803, rector of Stratford St Mary, and at about the same time of Tuddenham St Mary according to his memorial tablet in Stratford St Mary church. Details of the Proby family have been supplied to me by Commander A. Crawford, R.N. (retd.), descendant of Arabella Crawford (née Proby), elder sister of Cautley’s mother, and by Mr Francis Carbutt, a descendant of Letitia de Montmorency (née Proby), a younger sister of Cautley’s mother.
- (6) See above, note 3.

- (7) 1780 and 1783, Moderator; 1781, Taxer; 1784–1785, Junior Dean; 1790–1792, Junior Bursar; 1794, Junior Proctor; 1792–1795, Tutor (Rouse Ball and Venn, note 3, p. 233; *Gentlemen's Magazine*, 50 (1780), 496; *ibid.*, 51 (1781), 544; *ibid.*, 53 (2) (1783), 983.)
- (8) D. A. Winstanley, *Unreformed Cambridge* (Cambridge, 1935), pp. 238–255.
- (9) *Gentlemen's Magazine*, 61 (2) (1791), 1239.
- (10) The children were: Hester, baptized 27 November 1796, and Rachel Elizabeth, born 27 May 1798 (Baptismal register of Roydon). His wife, Hester Cautley, née Bluit, was buried on 15 June 1798, aged 23 (Burial register of Roydon).
- (11) Marriage register of Stratford St Mary.
- (12) Will of Narcissus Charles Proby, Prerogative Court of Canterbury, January 1805. PROB 11/1419, f. 45, Public Record Office, London.
- (13) *Ibid.*
- (14) Memorial tablet in Stratford St Mary church.
- (15) Thomas Cautley instituted to living of Stratford St Mary, 28 September 1803 (Joseph Foster, ed., *Index Ecclesiasticus* (Oxford and Cambridge, 1890), p. 32).
- (16) Catherine Maria Cautley, born at Roydon, 12 March 1803 (see note 1); George Spencer Cautley, born at Stratford St Mary, 18 April 1807 (see note 1); Arabella Louisa Cautley, born at Woodhall, Yorks., 3 November 1808 (see note 4).
- (17) Will of Catherine Cautley, Prerogative Court of Canterbury, July 1830; PROB 11/1773, f. 434, Public Record Office. Will of Mary Proby, Prerogative Court of Canterbury, 1868; Principal Probate Registry, Somerset House, London.
- (18) George Spencer Cautley, *The Afterglow: Songs and Sonnets for my Friends* (London, 1867 and 1869); *The Three Fountains: a faery epic of Euboea* (1869); *A Century of Emblems . . .* (London, 1878).
- (19) In *The Afterglow*. . . , note 18.
- (20) His will, dated 1807, speaks of his ill-health (Will of Thomas Cautley, Prerogative Court of Canterbury, August 1817. PROB 11/1595, f. 415, Public Record Office, London) and there are few entries in the parish registers by him after 1811.
- (21) *Gentlemen's Magazine*, 88 (2) (1817), 90.
- (22) Venn, *Alumni Cantabrigienses*, note 3, p. 542.
- (23) Memorial tablet in Stratford St. Mary church.
- (24) W. D. Parish, ed., *List of Carthusians, 1800–1879* (Lewes, 1879).
- (25) Anon., *Charterhouse, its foundation and history: with a brief memoir of the founder, Thomas Sutton Esq.* (London, 1849); E. M. Jameson, *Charterhouse* (London, 1937).
- (26) B. Marsh and F. A. Crisp, eds, *Alumni Carthusiani, a Record of the Foundation Scholars of Charterhouse, 1614–1872* (printed privately, 1913).
- (27) A. H. Tod, *Charterhouse* (London, 1900), p. 15.
- (28) *The Royal Kalendar* . . . (London, annually, 1813 *et seq.*); Charterhouse Register 1769–1872, typescript owned by the Society of Genealogists, 37 Harrington Gardens, London, SW7.
- (29) Marsh and Crisp, note 26, p. xii.

- (30) Archibald Elijah Impey (1766–1831), a natural son of Sir Elijah Impey (1732–1809), the first chief justice appointed on the supreme court of justice at Calcutta, who was accused of conniving with Warren Hastings in some of the charges brought against the latter. A. E. Impey was married to Catherine Cautley's sister, Sarah.
- (31) Cadet Papers, 1817. L/MIL/9/131, ff. 285–288, India Office Library, London.
- (32) Corelli Barnett, *Britain and Her Army, 1509–1970* (London, 1970), pp. 275–276; Lord Birdwood, 'The story of the Indian army', *J. Roy. Soc. Arts*, 101 (1952–1953), 44–55.
- (33) A history of Addiscombe 1809–1860, compiled in the India Office Military Department mainly from the Minutes of the Committee of Correspondence, the Seminary Committee, and the Political and Military Committee. L/MIL/9/357, f. 1. India Office Library.
- (34) *Ibid.*, f. 10.
- (35) *Ibid.*, f. 18.
- (36) Register of Seminary Cadets 1809–1820. L/MIL/9/333, p. 24. India Office Library.
- (37) V. C. P. Hodson, ed., *List of the Officers of the Bengal Army, 1758–1834* (London, 1927–1947), pt 1, p. xxiv.
- (38) H. M. Vibart, *Addiscombe; its Heroes and Men of Note* (London, 1894).
- (39) Robert and Christopher Wilkinson-Latham, *Infantry Uniforms 1742–1855* (London, 1869). pp. 171–172, and Plate 74.
- (40) Vibart, *Addiscombe*, note 38, pp. 101–102.
- (41) *Ibid.*, p. 154.
- (42) William Mudge (1762–1820). Major-General, Royal Artillery. F.R.S. (1798). 1798, appointed Director of the Trigonometrical Survey; 1809, appointed Lt. Governor of the Royal Military Academy, Woolwich; 1809–1820, Public Examiner at Addiscombe Military Seminary.
- (43) Vibart, *Addiscombe*, note 38, p. 296.
- (44) A history of Addiscombe . . . , note 33, f. 24.
- (45) *Ibid.*, f. 27.
- (46) Charles William Pasley (1780–1861). General, Royal Engineers. F.R.S. (1816) K.C.B. 1812–1841, Director of Royal Engineer establishment at Chatham for field instruction; 1841–1846, Inspector-general of railways; 1840–1856, Public Examiner at Addiscombe Military Seminary.
- (47) A history of Addiscombe . . . , note 33, ff. 8, 15.
- (48) Seminary Committee Reports, 1815–1820. L/MIL/1/11, Report No. 85. India Office Library.
- (49) Hodson, *Officers of the Bengal Army*, note 37, pt 1, p. 322.
- (50) Annual list of cadets . . . 1815–1818 L/MIL/9/260, p. 28. India Office Library; *The East-India Register and Directory, for 1820 . . .* (London, 1820), list of East India ships for the season 1818–1819, bound in after p. lxxii.
- (51) [?Henry V. Cary], *The Cadet's Guide to India: containing information and advice to young men about to enter the army of the Hon. East India Company, by a Lieut. of the Bengal Establishment* (London, 1820), p. 2. [Hereafter cited *Cadet's Guide*.]
- (52) Hodson, *Officers of the Bengal Army*, note 37, pt 1, pp. xxiii–xxiv.

- (53) *Cadet's Guide*, note 51, pp. 4-5.
- (54) *Ibid.*, p. 23.
- (55) [Albert Fenton], *Memoirs of a Cadet, by a Bengalee* (London, 1839), p. 37.
- (56) R. H. Phillimore, ed., *Historical Records of the Survey of India*, vol. 4 (Dehra Dun, 1958), pp. 171-172.
- (57) W. A. Burke, 'Report on the mortality among officers and men in H.M. service in Bengal, and on the comparative salubrity of different stations', *J. Asiat. Soc. Beng.*, 8 (1839), 63.
- (58) [Fenton], note 55, pp. 95-6.
- (59) *Cadet's Guide*, note 51, pp. 35-38.
- (60) *The East-India Register and Directory, for 1820 . . .* (London, 1820), table of pay and allowances . . ., bound after p. lxxii. Pay and allowances for a 2nd lieutenant totalled 169 rupees in the garrison and 219 rupees in the field.
- (61) *Cadet's Guide*, note 51, pp. 33-34.
- (62) Hodson, *Officers of the Bengal Army*, note 37, pt 1, p. xxvi.
- (63) 'First months of Indian military life'. *Calcutta Review*, 12 (1849), 78.
- (64) See above, note 49.
- (65) *Ibid.*, p. xxxviii. Company regulation in 1793.
- (66) *Bengal Directory*, 1820, 1822, 1823, 1824; *Calcutta Kalendar*, 1821.
- (67) Obituary notice, *Illustrated London News*, 4 February 1871.
- (68) F. W. Stubbs, *History of the Bengal Artillery* (London, 1877), vol. 2, pp. 192-217.
- (69) [H. Yule and R. Maclagan], *Memoir of General Sir William Erskine Baker, K.C.B., compiled by two old friends, brother officers, and pupils* (London, 1882), p. 10.
- (70) Joyce Brown, 'Sir Proby Cautley (1802-1871), a pioneer of Indian irrigation', *History of Technology*, 3 (1978), 35-89.
- (71) Major [John] Colvin, 'On the restoration of the ancient canals in the Delhi territory', *J. Asiat. Soc. Beng.*, 2 (1833), 105-127.
- (72) Robert Smith (1787-1873). Bengal Engineers, 1805-1830. Colonel, C. B. 1822-1830, Garrison Engineer and Executive Officer, Delhi; 1827-1830, Superintendent of the Doab Canal.
- (73) P. T. Cautley, *Notes and Memoranda, on the Eastern Jumna, or Doab Canal, and on the Water Courses in the Deyra Doon* (Roorkee, 1853). [Hereafter cited *Notes and Mem.*]
- (74) [P. T. Cautley], *Doab Canal Sketches, c. 1833*, Library of the Department of Civil Engineering, Imperial College, London, SW7.
- (75) P. T. Cautley, 'A description of the use of wells for foundations', *J. Asiat. Soc. Beng.*, 8 (1839), 327-340. Reprinted in F. Abbott, *Practical Treatise on Permanent Bridges* (2nd ed. Agra, 1850); 3rd ed. Roorkee, 1853; reprinted, Roorkee, 1860.
- (76) Robert Cornelis Napier (1810-1890). Bengal Engineers, 1826-1890. Field-Marshal, 1st Baron Napier of Magdala, G.C.B.; G.C.S. 1831-1836, assistant on the Doab Canal; 1849-1856, Chief Engineer, Punjab; 1870-1876, Commander-in-Chief in India; 1876-1883, Governor of Gibraltar; 1887-1890, Constable of the Tower of London.

- (77) P. T. Cautley, *Report on the Levels of the Doab Canal* (1837), Appendix A in *Notes and Mem.*, note 73, pp. 167–184.
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- (84) Pierre Louis Georges Dubuat (1738–1809), *Principes d'hydraulique vérifié par un grand nombre d'expériences, faites par ordre de Gouvernement* (Paris, 1779, 1786, 1816).
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- (87) [Yule and Maclagan], note 69, p. 9.
- (88) John Colvin (1794–1871). Bengal Engineers, 1810–1839. Colonel. C.B. 1827–1836, Superintendent of Canals, Delhi Territory.
- (89) [Yule and Maclagan], note 69, pp. 7, 10.
- (90) *Ibid.*, p. 14.
- (91) William Erskine Baker (1808–1881). Bengal Engineers, 1826–1877. General; K.C.B. 1829–1836, assistant on the Delhi Canal; 1836–1845, Superintendent of Delhi Canals, and of Sind Canals; 1845–1848, Director of Ganges Canal Works; 1854–1855, Secretary to Government of India in Public Works Department; 1859–1861, Military Secretary at the India Office; 1861–1875, Member of the Council of India.
- (92) P. T. Cautley, *Report on the Ganges Canal Works: from their commencement until the opening of the Canal in 1854*, 3 vols and folio atlas (London 1860), vol. 2, p. 628. [Hereafter cited *Ganges Canal Works*.]
- (93) Henry Marion Durand (1812–1871). Bengal Engineers, 1829–1871. Major-General, K.C.S.I., C.B. 1832–1836, assistant on the Delhi Canal; 1842–1844, private secretary to Governor-General; 1861–1865, secretary to Government of India in Foreign Department; 1865–1870, Governor-General's Council; 1870–1871, Lieutenant-Governor of the Punjab.
- (94) [Yule and Maclagan], note 69, p. 11.
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- Memoirs and notes of the late Hugh Falconer, A.M., M.D.*, 2 vols (London, 1868), vol. 1, pp. xxiii–liii.
- (98) Nathaniel Wallich (1786–1854). Danish botanist. 1815–1828, Superintendent of the East India Company's Botanic Gardens in Calcutta.
- (99) William Lonsdale (1794–1871). Geologist and palaeontologist. 1829–1842, Assistant Secretary and Curator of the Geological Society of London.
- (100) H. Falconer, 'Notes on certain specimens of animal remains from Ava', *Gleanings in Science*, 3 (1831), 167–170.
- (101) John Forbes Royle (1799–1858). F.R.S. (1837). Assistant-surgeon in East India Company's service. 1823–1832, Superintendent of the East India Company's Botanic Garden at Saharanpur; 1837–1856, Professor of *materia medica* at King's College, London.
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- (105) *Ibid.*, vol. 1, p. xxvi; *J. Asiat. Soc. Beng.*, 1 (1832), 97, and 3 (1834), 182.
- (106) C. Murchison, *Palaeontological Memoirs*, note 97, vol. 1, p. xxvii; *J. Asiat. Soc. Beng.*, 1 (1832), 249.
- (107) *J. Asiat. Soc. Beng.*, 1 (1832), 97.
- (108) C. Murchison, *Palaeontological Memoirs*, note 97, vol. 1, pp. xxvii, 5.
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- (111) *J. Asiat. Soc. Beng.*, 4 (1835), 57.
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- (113) C. Murchison, *Palaeontological Memoirs*, note 97, vol. 1, pp. 22, 23.
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- (118) See list of Cautley's published works at end of paper.
- (119) *Proc. Geol. Soc.*, 2 (1837), 476, 508–510; 27 (1871), xxxi–xxxiii.
- (120) *J. Asiat. Soc. Beng.*, 6 (1837), 619, 890–892.
- (121) *Proc. Geol. Soc.*, 2 (1835), 340.
- (122) Proby Cautley correspondence, 1838–1846. British Library, Add. MSS. 28,599.
- (123) *Ibid.*, f. 5.
- (124) India Office Records, Bengal Marriages, vol. 57, p. 92. India Office Library.
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- (130) See atlas of *Ganges Canal Works*, note 92, for maps of survey.
- (131) P. T. Cautley, *Report on the Ganges Canal, from Hurdwar to Cawnpore and Allahabad* (Calcutta, 1845), and P. T. Cautley, *Plans and maps to illustrate Report on the Ganges Canal from Hurdwar to Cawnpore and Allahabad* (London, 1846).
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- (133) [F. Abbott], *Report of the Special Committee, appointed to examine the project of the Ganges Canal* (Agra, 1842).
- (134) *Ganges Canal Works*, note 92, vol. 3, 24-58.
- (135) Edward Law, Earl of Ellenborough (1790-1871). Governor-General of India, 1841-1844.
- (136) Sir Henry Hardinge (1785-1856), first Viscount Hardinge of Lahore, Governor-General of India, 1844-47.
- (137) See above, note 84.
- (138) George Kuriyan, *Hydro-electric power in India—A Geographical Analysis*, Monograph No. 1, The Indian Geographical Society (Madras, 1945). This describes the first seven power-houses; the eighth was added in 1956.
- (139) James Thomason (1804-1853). 1843-1853, Lieutenant-Governor of the North Western Provinces.
- (140) Anon., 'The Hon. James Thomason, late Lieut.-Governor, N.W. Provinces', *Calcutta Review*, 21 (1853), 502-504.
- (141) Thomason Civil Engineering College, Roorkee, *Prospectus 1867*, p. 19.
- (142) Cautley's Divorce Act, 13 and 14 Vic., 1850.
- (143) Birth in the Sub-district of Kemp Town, BRIGHTHELMSTON, SUSSEX. General Register Office, St Catherine's House, London. The children were born on 26 June 1846 and registered simply 'male' and 'female' with the surname Cautley.
- (144) See above, note 142. Until the Matrimonial Causes Act of 1857, only divorce 'from bed and board' could be obtained, granted by an ecclesiastical court, a total divorce being obtainable only by Act of Parliament.
- (145) Death in the Sub-district of Hampstead in the County of Middlesex. General Register Office, St Catherine's House, London.
- (146) See list of Cautley's published works at end of paper.
- (147) Murchison, note 97, vol. 1, p. xxxvii.
- (148) Charles Murchison, ed., *Description of the Plates of the Fauna Antiqua Sivalensis from Notes and Memoranda by Hugh Falconer, M.D.* (London, 1868). This is the same account as appears in Charles Murchison, ed., *Palaeontological Memoirs*, note 97.
- (149) Plates A-R in the British Library (Natural History), London, SW7.

- (150) Royal Society Certificates of Candidature, vol. IX, 176. Royal Society Library, London, SW1.
- (151) *Ibid.*, vol. IX, 142.
- (152) *Ganges Canal Works*, note 92, vol. 1, pp. 99–104.
- (153) *Ibid.*, vol. 1, p. 104.
- (154) *Delhi Gazette, Supplement*, 12 April 1854; *The Mofussilite*, 13 April 1854.
- (155) John Russell Colvin (1807–1857). 1853–1857, Lieutenant-Governor of the North Western Provinces.
- (156) *Delhi Gazette, Supplement*, 12 April 1854.
- (157) James Andrew Broun Ramsay, tenth Earl and first Marquis of Dalhousie (1812–1860). Governor-General of India, 1848–1856.
- (158) See above, note 139.
- (159) *Delhi Gazette, Supplement*, 12 April 1854.
- (160) *Delhi Gazette, Supplement*, 20 April 1854.
- (161) J. G. A. Baird, ed., *Private Letters of the Marquess of Dalhousie* (Edinburgh and London, 1910), p. 296, and *Illustrated London News, Supplement*, 5 August 1854.
- (162) General Orders Governor-General No. 511 of 1854, published in *Calcutta Gazette*, 13 May 1854.
- (163) General Orders Governor-General, No. 487 of 1854, published in *Calcutta Gazette*, 13 May 1854.
- (164) *Ibid.*
- (165) Copy of Minute of the Governor-General of India in Council, 5 May 1854. Order of the Bath, 1850–1856. W.O. 104/vol. 5. Public Record Office, London.
- (166) Sir Lawrence Peel (1799–1884). Chief Justice of the Supreme Court of Calcutta, 1842–1855.
- (167) *The Delhi Gazette*, 6 May, 20 May 1854; *The Bengal Hurkaru*, 1 May, 15 May 1854; *The Englishman*, 1 May 1854. Subscription lists published daily, for example in *The Bengal Hurkaru*, 18–25 May 1854.
- (168) See above, note 85.
- (169) Will of Ada Ryder, Prerogative Court of Canterbury, 3 September 1931. Principal Probate Registry, Somerset House, London. She bequeathed the clock to the Victoria and Albert Museum, London.
- (170) Richard Baird Smith (1818–1861). Madras Engineers, 1836–1839, Bengal Engineers, 1839–1861. C.B. 1840, assistant on the Doab Canal; 1843–1850, Superintendent of the Doab Canal; 1854–1859, Director of Ganges Canal; 1859–1861, Secretary to Government in the Public Works Department.
- (171) *The Delhi Gazette*, 31 May 1854.
- (172) *Ibid.*, 24 May 1854; *The Englishman*, 17 May 1854.
- (173) *The Mofussilite*, 18 May 1854.
- (174) Order of the Bath, 1850–1856. W.O. 104, vol. 5. Public Record Office, London.
- (175) Sir Charles Wood, first Viscount Halifax (1800–1885). 1846–1852, Chancellor of the Exchequer; 1852–1855, President of the Board of Control for India; 1859–1866, Secretary of State for India; 1870–1874, Lord Privy Seal.

- (176) Baird, *Private Letters of Dalhousie*, note 161. p. 315. Letter of Dalhousie to Sir George Couper, Bart., 26 August 1854.
- (177) *Ibid.*
- (178) See above, note 49.
- (179) Cautley's name appears in Post Office Directories at this address from 1858–1868, with Dr Charles Murchison in 1859, with Dr Hugh Falconer and Christopher Heath (junior surgeon) 1861 and 1862, with Christopher Heath 1863–1865, with Peter Dalton (surgeon) 1866–1867, and with Harry Lobb (surgeon) 1868. Rate-books of St James's Piccadilly (Westminster Public Library, London, SW1) show the rates were paid by George Theobald, presumably the landlord.
- (180) 21 and 22 Vic., c. 106.
- (181) Minutes of the Council of India, 8 September 1858. India Office Library Records, C/1, f. 9.
- (182) Algernon West, *Sir Charles Wood's Administration of Indian Affairs from 1859 to 1866* (London, 1867), p. 11.
- (183) Minutes of the Council of India, 3 November 1859. India Office Library Records, C/3, f. 594.
- (184) *Ibid.*, 29 October 1868. India Office Library Records, C/21, f. 368.
- (185) See above, note 92.
- (186) Minutes of the Council of India, 13 January 1859. India Office Library Records, C/2, f. 49.
- (187) Described more fully in Brown, *op. cit.*, note 70.
- (188) Arthur Thomas Cotton (1803–1899). General. K.C.S.I. 1836, 1843–1845, Cauvery Delta Works; 1846, Godaveri Delta Works.
- (189) P. T. Cautley, *A Disquisition on the heads of the Ganges and Jumna Canals, North-Western Provinces, in reply to Strictures by Major-General Sir Arthur Cotton* (London, 1864), pp. 98–99.
- (190) A. Cotton, *Private Memorandum upon the Ganges Canal*, printed as an appendix in P. T. Cautley, *A Reply to Statements made by Major-General Sir Arthur Cotton, on the projection of the Ganges Canal Works* (London, 1863).
- (191) A. Cotton, *On Irrigation and Navigation in Connection with the Finances of India* (London, 1863); address delivered to the Calcutta Chamber of Commerce, 7 May 1863; and Cautley, *Reply to Statements*, note 190, p. 3.
- (192) Cotton, *Private Memorandum . . .*, *op. cit.* in Cautley, *Reply to Statements*, note 190, pp. 43–45.
- (193) Cautley, *Reply to Statements*, note 190, p. 23.
- (194) *Ibid.*, p. 17.
- (195) A. Cotton, *Observations . . . on the foregoing Reply in Cotton and Cautley, A Discussion, regarding the projection and present state of the Ganges Canal, and the measures required to make it reliably useful and profitable* (London, 1864).
- (196) See above, note 189.
- (197) A. Cotton, *Reply . . . to Colonel Sir Proby Cautley's 'Disquisition on the Ganges Canal'* (London, 1864); P. T. Cautley, *A Valedictory Note to Major-General Sir Arthur Cotton, respecting the Ganges Canal, with a postscript touching certain misrepresentations of a writer in the 'Times' on the same subject* (London, 1864); A.

Cotton, *Reply to Sir Proby Cautley's Valedictory Note on the Ganges Canal* (London, 1865).

- (198) *Times*, 2 November 1864, 19 April 1865.
- (199) James Crofton (1826–1908). Bengal Engineers, 1843–1882. Lt.-General. 1850–1859, assistant on the Bari Doab Canal; 1863–1864, Superintending Engineer, Eastern Jumna Canal; 1865–1874, Irrigation works, Punjab; 1874–1882, Inspector-General of Irrigation and Deputy Secretary to the Government of India.
- (200) Letters of Sir Proby Cautley to James Crofton, 1864–1866. MSS Eur. A. 38. Letter of 10 November 1864. India Office Library.
- (201) James Crofton, *Report on the Ganges Canal*, dated 23rd November 1864, [1864].
- (202) *Report of the Ganges Canal Committee . . .* (Roorkee, 1867).
- (203) Collections to Public Works Despatches to India. L/PWD/3/350, Despatch No. 34. India Office Library.
- (204) Humphrey Ward, *History of the Athenaeum, 1824–1925* (London, 1926).
- (205) MSS Eur. A. 38, note 200, letter of 10 November 1864.
- (206) *Ibid.*, letters of 26 June 1865, 3 October 1866.
- (207) *Q.J. Geol. Soc.*, **II** (1855), **12** (1856).
- (208) Marriage in the Parish of St Marylebone, 11 February 1865. General Register Office, St Catherine's House, London.
- (209) Birth in the Registration District of St Marylebone, 3 December 1862. General Register Office, St Catherine's House, London. The birth was registered in the name Grey and appears to be illegitimate.
- (210) See above, note 85.
- (211) MSS Eur. A. 38, note 200, letter of 25 November 1865.
- (212) *Ibid.*, letter of 3 October 1866.
- (213) Death in the Registration District of Lewisham, 25 January 1871. General Register Office, St Catherine's House, London.
- (214) See above, note 85.
- (215) Death in the Registration District of Camberwell, 4 October 1916. General Register Office, St Catherine's House, London.
- (216) Death in the Registration District of Truro, 24 June 1931. General Register Office, St Catherine's House, London.
- (217) W. H. Greathed, 'On the practice and results of irrigation in Northern India', *Min. Proc. Inst. Civ. Eng.*, **35** (1873), 157.
- (218) British Library, Add. MSS 28, 599, note 122, f. 17v. Letter of 13 March 1839.