

JOSEPH CLEMENT

Born 1779, Great Ashby, Westmoreland, UK; died 1884; Babbage's chief mechanic for the Difference Engine.

Introduction¹

When Charles Babbage began work on his famous Difference Engine, he was in need of a professional mechanic and draftsman. He managed to arrange for the majority of his work to be done in the work-shop of Joseph Clement. This arrangement continued for a number of years, essentially during the entire time that the Difference Engine was under active construction. The arrangements between Babbage and Clement are reasonably well known (Hyman 1984) and the story of how the two of them came to part company has been part of almost every paper written about the project. However, very little information is available about Joseph Clement himself. Clement was not simply a run-of-the-mill machinist who happened to be fortunate enough to work for Babbage, and who was partly responsible for the failure of the construction of the Difference Engine (an impression easily obtained from reading the majority of accounts of the project). Rather he was a highly respected member of the mechanical engineering community when Babbage first contacted him and when Babbage actually delegated a large part of the responsibility of the actual design of the Difference Engine to Clement.

In 1990, while examining some letters in the Fitzwilliam Museum in Cambridge, I came across two letters from Charles Babbage (August 19, 1863 and August 26, 1863) to a certain George Clowes². Clowes evidently was associated with a publishing venture because the content of the letters was Babbage's response to having been shown some proofs of an article written by a Samuel Smiles.³ The article concerned the life of Babbage's chief mechanic and draftsman Joseph Clement. In the first letter (August 19, 1863) Babbage offers some corrections to the proofs and says "he is too busy to do more but will pass the proofs on to Mr. Wilmot Buxton, who fully comprehends the subject."⁴ In the second (August 26, 1863) Babbage begins:

I enclose a letter from Mr. Buxton which it may be interesting to Mr. Smiles to see. The substance of it or any extracts are at his service but I have not permission to publish the writer's name. I wish it to be returned to Dorset St.

and then continues to give a summary of his dealings with Mr. Clement. We conclude that these letters relate to a book called *Industrial Biography* written by Samuel Smiles in 1863 (Smiles 1882).⁵ It contains not only a chapter on the life of Joseph Clement, quite evidently the one for which Babbage had been given the proofs, but

¹ From Williams 1992.

² These letters once belonged to Douglas Hartree, the early British computer pioneer, and were evidently given by him to the Fitzwilliam Museum in 1947. The author does not know how they came into the possession of Hartree.

³ George Clowes was likely associated with the London publishing firm of John Murray. It was this firm that published the first edition of Smiles' book.

⁴ Mr. Wilmot Buxton was Babbage's friend and, after Babbage's death, produced a biography which has only recently been published. It was not unusual for Buxton to deal with matters relating to Babbage's engines; for example, he was the person who explained the working of the first Difference Engine when it was displayed in the Exhibition of 1862.

⁵ Smiles first wrote *Industrial Biography* in 1863. It subsequently had at least sixteen other editions published in both Britain and America. There also exist at least two editions in Spanish. Further information on Smiles can be obtained from examining his autobiography and the work of Timothy Travers.

also an appendix consisting of a lightly edited version of the letter (August 26, 1863) I had seen in the Fitzwilliam Museum. The book is typical of the Victorian writings designed to inspire the populace with successful tales of hard-working individuals who have made their own way in life, and, in what follows, I have attempted to eliminate the most obvious inspirational tales and concentrate on what I believe to be the more factual information.¹10 Unfortunately, Smiles, who occasionally mentions the papers Clement left behind, does not give any information as to the location of any papers or relics.

Joseph Clement (1779-1844)

Joseph Clement was born in Great Ashby in Westmoreland (northern England) in 1779. He came from simple stock; his father was a weaver by profession, with a strong interest in nature. It is reported that his hobby was a beetle and insect collection and that he set up a number of bee hives near his loom so that he could watch their activities without leaving his work. Joseph appears to have inherited at least some of his mechanical ability from his father, as Old Clement was known to have a lathe that he used both for recreation and for turning items, such as bobbins, that he needed in his profession. While no portrait appears to exist of Joseph Clement, he is described as a heavy-browed man without any polish of manner or speech. He had a very heavy North Country accent, developed in his youth, which never left despite his living most of his adult life in other areas of Britain. Although he did attend the village school, it was only to master the rudiments of reading and writing, and he was almost illiterate as an adult. Indeed John Herschel (the son of the great astronomer and himself an astronomer of note), a friend of Babbage, actually comments on the impression that Clement gave in matters of business: while Babbage was away in Europe, Herschel was looking after the business side of the construction of the Difference Engine and wrote to Babbage saying (December 22, 1827):

... C. told me he must have £150, which he (after much hesitation and what at first I took for reluctance, but which I fancy to be the mere consequence of his singular slowness of thought) put into writing in the following form which is a curiosity at least as great as the Engine will be when done.

This is to certify that eight men have been employed on Mr. Babbage's calculating machine this five weeks past. I have likewise got a man to assist me in the drawing. Joseph Clement December 5th 1827. I want £150 to enable me to go on.

After his short schooling, Clement worked with his father at the weaver's trade, but the increasing mechanization of that industry soon led to his seeking alternate employment. From age 18 to 23 he apparently worked as a thatcher and then a slater in the area around his village. As this trade did not occupy him full time, he became friends with the village blacksmith; together, they produced a lathe which Clement used to manufacture various instruments such as flutes, clarinets, and Northumberland bagpipes. Clement's cousin, a watch and clock maker who had spent some time in London, lent him some books on mechanics and he used these as a resource guide to construct a microscope for his father's use in his hobby of collecting insects, and a reflecting telescope. Anyone with this level of talent was not likely to stay as a part-time village thatcher and, sometime in 1805, he left to take a job in the nearby town of Kirby Stephen, where he was employed in the construction of looms at a wage of 3 shillings 6 pence per day. He apparently lived with his employer, a Mr. George Dickinson, to whom he sold the telescope for the sum of £12. In late 1805 he moved to Carlisle and, in

¹ Unless otherwise noted, all personal information concerning Clement in this paper is based on the contents of the 1882 edition of *Industrial Biography* (Smiles 1882).

1807, to Glasgow. While in Glasgow he happened to meet a Mr. Peter Nicholson, a writer of popular woodworking books at the time. Mr. Nicholson lent Clement one of his drawings of a power loom and Clement, although he had no training, copied it so expertly that Nicholson had difficulty in telling the original from the copy. The writer was so impressed that he gave Clement a series of free lessons in technical drawing. After a year in Glasgow, Clement again moved, this time to Aberdeen, where he was employed by Leys, Masson & Co. in the construction of power looms. Clement evidently found the tools inappropriate, for he constructed a turning lathe with a sliding mandrill¹ and guide screw,² and a device for correcting errors in the guide screw. He also produced a special tool holding device, the slide rest, which, although not unknown earlier, was one of the earliest in Britain. During this time his wages rose from one and a half guineas per week to three guineas (1 guinea = 21 shillings), showing that his employers were quite pleased with the quality of work he was able to produce. Not content with simply advancing his employers' stock of tools, he evidently enrolled in the Marischal College in Aberdeen where he attended at least one course in Natural Philosophy during the 1812-1813 term. Later in 1813 he took his savings, which had amounted to almost £100, and moved to London. After spending a few weeks in an ordinary machine shop, he moved to one of the most famous engineering firms of the day, that of Joseph Bramah, famous for engineering feats ranging from hydraulic presses that could lift 1,144, tons, to the construction of continuous-process papermaking machines. Clement was placed in charge of the tools in the shop and quickly distinguished himself in not only improving the tools, but in organizing and improving the flow of work. On April 1, 1814 Bramah and Clement signed an agreement in which Clement was to be the chief draftsman and superintendent of Bramah's main works at Pimlico. Unfortunately Bramah died on December 9, 1814, and his sons, who returned from college to take over the business, did not see Clement as indispensable as had, apparently, their father. The contract was broken and Clement joined the firm of Maudslay and Fields as their chief draftsman. Finally, in 1817, he struck out on his own and set up a small shop in Prospect Place, Newington Butts, where he advertised himself as a mechanical draftsman and manufacturer of small machinery requiring first class workmanship.

Some indication of Clement's talent can be taken from the fact that he often produced the illustrations of mechanical machinery in the *Transactions of the Society for the Encouragement of Arts*. Between 1817 and 1832 his tiny signature can be found in the corner of many of the best drawings of such complex items as theodolites, complicated drawing machines, and lathes. In the process of his technical drawing work, he often had to produce both paper drawings and copper engravings of perspective views of circles, ellipses, and other complex items.

In 1827 the Society of Arts again gave him their Gold Medal, and in 1828 their Silver Medal, for the invention of several improvements to lathes, the most important of which was a device to change the speed of rotation of the work as the tool came closer to the axis of rotation, as it might when turning the surface of a large flat disk. Another of his successes was the development of a very large and accurate planing machine by means of which the surfaces of metal plates of large dimension could be finished to a fine tolerance. Although he never attempted to patent this device, a full description was published (Varley 1832) but, perhaps because of his

¹ A mandril, now spelled 'mandrel' is the spindle running through the center of the headstock. It is turned by the driving pulley to which it is keyed and at one end holds the work with a faceplate or chuck. The meaning of 'sliding mandril' is not clear. It may imply a two-part spindle in which the inner cylinder, keyed to rotate with the outer cylinder, can be slid in and out, toward and away from the work. This might well be an example, as suggested by the editor of this Department, of Babbage simply making up terms to express his thoughts whereas Clement would have been in the habit of using the accepted terminology of the mechanical engineering practice of his day.

² The guide screw, also 'feed screw' or 'lead screw,' is a long screw with rectangular threads mounted parallel to the main axis of the lathe by which the tool holder on the slide rest is moved longitudinally. If used to cut screw threads, its pitch must be precise and uniform.

limited skill at writing, it was not done by Clement himself. Another of his inventions which, at the time, was highly regarded, resulted from his need to produce large accurate drawings for Babbage's projects. He therefore designed and constructed a special drawing table which, because of its size, required an intricate and adjustable set of supports.

His list of inventions and improvements is impressive, but none has had more impact than his attempt, started in 1828, to produce screws and bolts with standard diameters and with threads of a standard shape and pitch-essential elements for interchangeability. Although his campaign in this area did not immediately result in success, his best journeyman at the time, Mr. (later Sir) Joseph Whitworth, was the man who ultimately established the standard Whitworth thread, which dominated British machine practice for almost 175 years until replaced by the metric standard. Whitworth left Clement's shop when the demand for work on Babbage's Difference Engine came to an end. He moved to Manchester and within a few years became the foremost precision machinist in Britain. In later years, Charles Babbage even had some correspondence with Whitworth, who had offered to undertake the actual construction of his Analytical Engine, but this was never taken beyond the initial stages of discussion. As Hyman (1984) speculates, Whitworth, having seen the effects of the Difference Engine project upon the advancement of the tool-making industry, may well have thought it worth undertaking the construction of the Analytical Engine just because of the potential 'spin-offs' it might produce. When Clement died in 1844, the business was continued by his nephew. The new owner was evidently not as good a workman as his uncle had been and the business gradually faded away.

Clement-Babbage Relationship

In 1823, when the Government grant of £1500 made it feasible for Babbage to think seriously about constructing his Difference Engine, he needed a proper draftsman and mechanic. In one of the letters mentioned earlier (August 26, 1863) he states:

At the commencement of the Diff. Engine I wanted a person to assist me in the drawings and afterwards if necessary to construct the Engine. The late Sir Isambard¹ Brunel recommended Mr. Clement as likely to suit me. Mr. Clement then possessed one lathe small but very good having also an excellent screw. His workshop at that time was his front kitchen. The lathe had also a very valuable slide rest rather too large for it. His small stock of tools were all excellent of their kind. As soon as any part of the Diff. Engine was contrived and drawn, I proceeded to ask Clement what was the perceived mode of making it. The plans then in use were tedious and demanded the skill of the very best workmen. Now as I required an identity amongst hundreds and even thousands of similar parts the then existing methods were insufficient. I suggested special tools and by the aid of Clement's admirable skill and availing myself of his practical knowledge arranged the plan of several new machine tools. So far was the 1st Diff. Engine from not [sic] having a printing apparatus that I well remember the discussion I had with Clement on its first suggestion. I remarked that I required what I should call a coordinate machine which I explained to Clement. I then sketched two slides at right angles to each other and proposed to place these vertical slides at the back of a lathe having a cylindrical mandrel. This plan was adopted and at once gave us the command of the use of circular cutters, drills, and saws over every part of the plane. Copper plates were inscribed by steel figure punches on this machine. Again I required for making the bolts the vertical motion of an horizontal plane upon a slide rest. I proposed inclined planes as the

¹ Note that this reference is to Sir Mark Isambard Brunel, not his son, Isambard Kingdom Brunel, although by the time this letter was written they were both dead.

simplest method but Clement preferred four screws driven by a central wheel which probably was the best of the two plans. Under the demands of the Diff. Engine the number of machine tools increased and Mr. Clement converted a large building at the back of his house into a workshop. The improvements in tools are mainly due to the stronger system of iron framing now employed; circular cutters, slides, slotting, and even planing machines, adapted to ornamental turning may be found drawn and described in several of the older authors in that subject.

It would appear that Babbage, either through the haze of years or because of a lasting feud, could not accurately remember his first dealing with Clement nor the state of Clement's establishment. This letter makes it look very much like Clement was a poor man who happened to have the luck of being recommended to Babbage. The fact that Clement possessed only one small lathe was not an indication that his business was not a success, but rather than he was in a specialized shop dedicated to high quality workmanship. We have seen how, in earlier years, he had actually made several lathes of very high quality and was fully used to constructing any tool that he needed. Again, Babbage's remark that his workshop was in his front kitchen would also imply a certain lack of success and sophistication. Clement was, as amply demonstrated by Herschel's remark above, not a sophisticated man, but he was, certainly successful and well respected in his craft when Babbage first met him. The fact that he was good enough to have already won his Society's Gold Medal (an honor of which Babbage, who received the Gold Medal of the Astronomical Society in 1824, was always very proud) seems to have been overlooked in any consideration of Clement's contributions to the construction of the Difference Engine. The latter part of this letter seems to be, other than the first few sentences, in accordance with what must have been the actual working relationship. Babbage appears to give Clement credit for some of the advances in the machine tools and methods of construction and the description of their working relationship (essentially Babbage suggesting a special tool and Clement agreeing that one was needed but making it to his own design) rings true.

In fact Babbage completely abdicated the office of design engineer for the Difference Engine and, at least for a time, left entirely in Clement's hands the technical details of how it was to be implemented. During the time that Babbage went off on his trip to Europe, leaving Herschel in charge of the Difference Engine project, the two friends wrote several letters back and forth. The majority of the contents of these letters concern the changes that Clement had made to the detailed design of the Difference Engine. Herschel spends a lot of effort, including drawing diagrams, trying to explain to Babbage these modifications. Herschel, whatever his qualifications in other areas, was not good at explaining complex mechanical questions and, at the end of one letter (December 22, 1827) is forced to admit:

On reading this description I see that it is unintelligible and what is worse that I can't mend it. I had it all there before my mind when I left Clement, and last night when he called here I rehearsed it to him, and now I am puzzled, but you will see the principles from this....

Again, when describing some of the work that had taken place, Herschel tells Babbage about some new drawings containing (February 12, 1828):

... in part a new scheme of Clement's who says you left it to him to plan as well as he could.

Babbage's reply shows that he had complete confidence in Clement (May 9, 1828):

I left Clement so well acquainted with all the mechanical actions of the machine that I have not the least fear of his making such changes as he may think necessary.

Later, in the same letter, he again demonstrates the fact Clement had been given a free hand when he indicates that Clement had made very major changes to the mechanical motions:

The plan for locking the axes in their places until the wheels are ready to be bolted seems to me better than rollers which latter I never intended and know not how they got into the drawings.

Although not absolute proof, these quotations imply that Clement had a much larger hand in the actual detailed design of the Difference Engine than has previously been appreciated. The one other major factor in the Babbage-Clement relationship was the fact that, when the working relationship deteriorated to the point where they parted company, Clement took all the tools and drawings that he had made for the Difference Engine project and left Babbage without the means of continuing. There is no doubt that Clement had a legal right to take the tools, but the fact that he did so has caused him to have a lot of bad press. It would appear that both Babbage and Herschel were not unaware of this potential problem. In the letters between Herschel and Babbage, mentioned above, are a number of remarks which seem to indicate a growing unease with Clement's activities. Just prior to Christmas 1827, Herschel wrote to Babbage about the progress of the project (December 22, 1827):

I went over to him [Clement] to see how he gets on, at the early part of the week. He has been making a new drawing to show the effect of certain alterations he recommends (which I shall explain presently) I am so new to the scale of daily weekly and monthly progress that such work ought to make, that I will confess to you it seemed to me not to have got on too much since you left.

A few weeks later he again writes to Babbage (February 12, 1828)

Clement ... tells me he keeps 10 men constantly at work on the Engine. I saw 7 there in the workshop and one man working on the drawings when I last called. He seems to have been chiefly at work on the drawings ... he has drawn upon me for £200 more making in all £350 since you left England. Verily it makes not much show, but I am a sad novice in matters of workmanship and I suppose the secret is that good work is not cheap.

Having received no answer from Babbage,¹ Herschel, apparently getting more concerned about several aspects of the project, writes again (April 10-17, 1828):

Clement has drawn on me for £200:0:0 more making in all £550 since you left. It may be that £550 worth of work is done, but I confess it makes marvelous little show for the money.

Babbage eventually wrote back (May 9, 1828):

¹ It is not surprising that Babbage had not yet answered as Herschel had simply sent the letters to Rome and Florence knowing that these cities were on Babbage's route. Babbage did receive the letters, but only after a delay.

I have just received yours of the 10-17 April. The accounts you gave me of the progress of the machine are by no means discouraging as to the work done and the drawings. It is a species of work which makes but little show. As to the actual steel and brass cut up for my use I fear it is little and that Clement is spending much time in making tools. This is to a certain extent necessary and requires considerable supplies of money but I should wish you incidently [sic] if possible to find out whether it is not Clement's intention to make me pay for the construction of these tools and then to keep them as his own property. From the multitude he is making it looks so.

Babbage had obviously become more than just a little suspicious. Considering this early suspicion, and the fact that Babbage had access to the best of advice from very knowledgeable friends and associates, it is interesting that he let the problem develop to such an extent that it eventually put him out of business.

BIBLIOGRAPHY

Biographical

Babbage, C., Letter dated May 9, 1828 (4 quarto pages), Library of the Royal Society, London, UK, Herschel Papers, Babbage letter 226.

Babbage, C., Letter dated August 19, 1863 (2 quarto pages), Fitzwilliam Museum Library, Cambridge, UK, Mss 69/1947.

Babbage, C., Letter dated August 26, 1863 (3 quarto pages), Fitzwilliam Museum Library, Cambridge, UK, Mss 70/1947.

Buxton, W.H., *Memoir of the Life and Labours of the Late Charles Babbage Esq. FR.S.*, Vol. 13, Charles Babbage Institute Reprint Series of the History of Computing, MIT Press, Cambridge, Mass., 1988.

Herschel, J.F.W., Letter dated December 22, 1827 (4 folio pages), Library of the Royal Society, London, UK, Herschel Papers, Babbage letter 218.

Herschel, J.F.W., Letter dated February 12, 1828 (4 folio pages), Library of the Royal Society, London, UK, Herschel Papers, Babbage letter 219.

Herschel, J.F.W., Letter dated April 10-17, 1828 (4 folio pages), Library of the Royal Society, London, UK, Herschel Papers, Babbage letter 225.

Mackay, Thomas, ed., *The Autobiography of Samuel Smiles*, E.P. Dutton, New York, 1905.

Smiles, Samuel, *Industrial Biography: Iron Workers and Tool Makers*, John Murray, London, 1882.

Travers, Timothy, *Samuel Smiles and the Victorian Work Ethic*, Garland, New York, 1987.

Varley, Timothy, *The Transactions of the Society for the Encouragement of Arts, London*, 1832, p. 157.

Williams, Michael R., 'Joseph Clement: The First Computer Engineer,' *Ann. Hist. Comp.*, Vol. 14, No. 3, 1992.

UPDATES