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CHARLES BABBAGE'S TABLE OF LOGARITHMS (1827)

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(RR106)

Abstract

In 1827 Charles Babbage published his *Table of logarithms of the natural numbers, from 1 to 108,000*. His logarithms were generally considered to be the most accurate of his day and were reprinted on numerous occasions, well into the twentieth century. This paper describes Babbage's motivation for producing the tables, and the measures taken to ensure their accuracy. An assessment is given of Babbage's contribution to the art of table making.

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Introduction

Compared with major scientific figures of the nineteenth century, such as Michael Faraday or Charles Darwin, Charles Babbage was until recent times a relatively obscure figure. One reason for this obscurity is that it is only since the widespread use of computers in the 1950s that Babbage has become a subject of interest to science historians. But at least as big a reason for our lack of knowledge of Babbage is that he was a Victorian polymath of such breadth that we do not yet have an integrated view of him. In recent years there have been some excellent studies of Babbage's major achievements: his mathematical work (Dubbey 1978), his contributions to political economy (Berg 1980), and of course his calculating engines (eg. Bromley 1980).

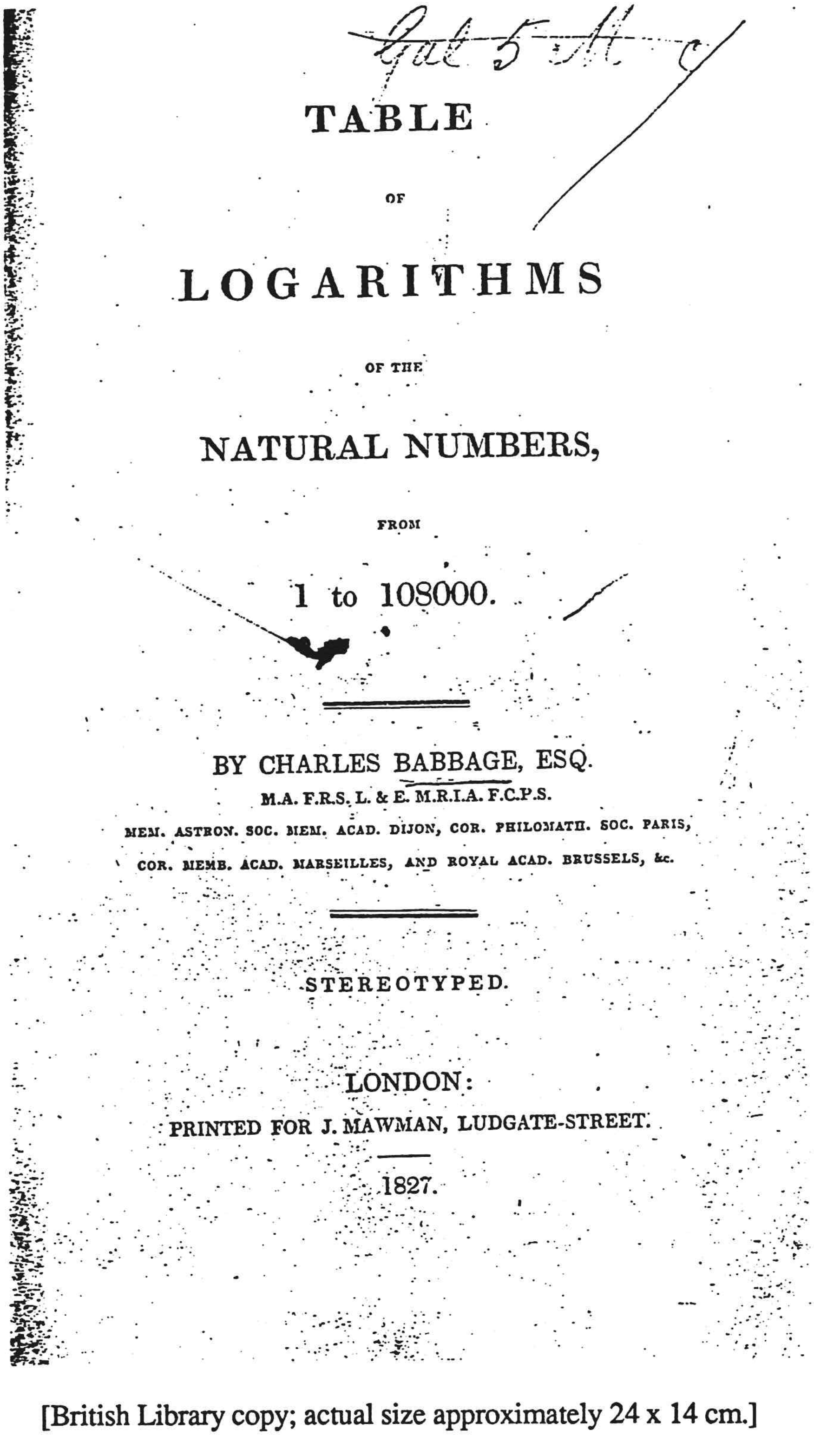
Hyman (1982) has written the first sound biography of Babbage - *Charles Babbage: pioneer of the computer* - but in this task he has clearly been handicapped by the lack of an adequate secondary literature. For example, Hyman's discussion of Babbage's cryptography work occupies the space of about one page and he notes that "no adequate technical discussion of Babbage's work on cryptology has yet been given" (page 227). This deficiency has since been amply remedied by Franksen's 319 page book *Mr Babbage's secret: the tale of a cypher - and APL* published in 1984. This is perhaps indicative of the size of the task ahead for Babbage scholarship; for needed as much, if not more, than Franksen's study are detailed analyses of Babbage's works on life assurance, natural philosophy, religious philosophy, engineering and mechanical sciences and so on. This paper, which describes the publication of Babbage's *Table of logarithms* in 1827, is offered in the spirit of a modest contribution to the secondary literature on Charles Babbage.

In his biography Hyman states:

> After his study of life assurance the next book Babbage published was a Table of Logarithms of the natural numbers from 1 to 108,000. The tables were compared with previously calculated sets of logarithmic tables. Some part of the comparison was carried out by the then Lieut. Col. Thomas Frederick Colby of the Royal Engineers, who pioneered the ordnance survey, and to Colby the book was dedicated. It became the standard set of logarithmic tables for many years, although at the time Babbage no doubt hoped it would soon be superseded by tables prepared directly by the Difference Engine. (p. 60)

This in fact is as much as Hyman has to say on the subject, and indeed there is not a great deal more to be learned from the secondary literature. Hyman's statement contains two assertions, or at least implications: first that Babbage *calculated* the tables, and second that they were *the* standard set of tables. The first assertion, on closer examination, turns out to be untrue: Babbage did not compute his tables, he copied and corrected them from an existing set of tables.[1] The second assertion, that they were *the* standard set of tables overstates the case, although they were certainly *a* standard set of tables; they were also one of the first *practical* tables of logarithms.

[1] B.V Bowden in *Faster than thought* (1953) states: "Babbage also computed a celebrated table of logarithms ..." (p. 11). Morrison and Morrison (1961) state: "In 1826, after a vast amount of labour he published a table of logarithms ..." (p. xiii). Of recent authors, only Williams (1985) has been explicit on this point: "They were not recalculated, but were simply copied from previous publications" (p. 166).



TABLE

OF

LOGARITHMS

OF THE

NATURAL NUMBERS,

FROM

1 to 108000.

BY CHARLES BABBAGE, ESQ.

M.A. F.R.S. L. & E. M.R.I.A. F.C.P.S.

MEM. ASTRON. SOC. MEM. ACAD. DIJON, COR. PHILOMATH. SOC. PARIS,

COR. MEMB. ACAD. MARSEILLES, AND ROYAL ACAD. BRUSSELS, &c.

STEREOTYPED.

LONDON:

PRINTED FOR J. MAWMAN, LUDGATE-STREET.

1827.

[British Library copy; actual size approximately 24 x 14 cm.]

Figure 1 Title page of Babbage's *Table of Logarithms* (1827)

Babbage's early interest in tables

Babbage had a professional interest in tables from an early date. Probably the first documentary evidence appears in his manuscript of November 1822 "The science of number reduced to mechanism":

> Being engaged in conjunction with my friend Mr Herschel about the conclusion of the last year in arranging and superintending some calculations of considerable extent, which were distributed amongst several computers, the delays and errors which are inseparable from the nature of such undertakings soon became sufficiently sensible; and although the larger share of that wearisomeness and disgust, which always attend the monotonous repetition of arithmetical operations, must undoubtedly fall to the lot of those to whom the details of the computations are committed, yet the preliminary calculations, and especially the subsequent comparisons and verification, usually afford a considerable trial of the patience of those who superintend them. (Babbage 1822)

At this time (late 1821) Babbage and his friend John F. W. Herschel were preparing a set of star tables for the Astronomical Society, of which they had been two of the founders in 1820. (Two other founders of the Astronomical Society were Thomas Colby and Francis Baily, of whom more later.) It was to this first experience of table making that Babbage attributed his desire to build the Difference Engine. Although construction of the Difference Engine became Babbage's principle vocation for the next decade and more, he was also involved in a wide range of other scientific and non-scientific pursuits.

Babbage's second experience as a table maker occurred in 1824 when he was offered the position of actuary of The Protector Life Assurance Society. This was a position that Babbage accepted on the advice of his friend Francis Baily, himself an independent actuary and a leading authority and author on actuarial science (DNB1). One of Babbage's first tasks was to produce a new life table, which was published in the company prospectus (Babbage 1824). In the event, the insurance company was not proceeded with, but the table (and Babbage's analysis of the insurance industry) was subsequently published in his *Assurance of lives* (1826). Table making proved to be a not entirely trouble-free experience:

> Most of the tables were computed originally by two independent calculators, when unfortunately both copies were lost together: I have since caused them to be recalculated, some of them again twice over, and I hope they will be found correct. (*Assurance of lives*, p. xiii)

As Babbage's interest in mathematical tables deepened, he began to build up a remarkable collection of tables, eventually totaling some three hundred items. This collection has been described by Williams (1981, p. 239) as being "one of the most complete collections of mathematical tables in existence, perhaps second only to that in the library of the Royal Society". Many of the tables were very rare and valuable so that Babbage's interest could almost be said to have been that of a connoisseur or a collector. Babbage probably acquired tables throughout his lifetime, but he must have acquired a considerable number by an early date: Lardner in his well-known account of the Difference Engine (1834) states that "one private individual" - by whom he almost certainly meant Babbage - possessed not less than 140 volumes of tables.

The need for a new table of logarithms

The motive for producing a new table of logarithms probably arose in the course of conversation in 1825 between Babbage and his friend Thomas Colby. Captain Thomas F. Colby R.N. F.R.S., a noted explorer and practical scientist, was at that time about to embark on "the great work of his life", the Ordnance Survey of Ireland (DNB2). Colby applied a good deal of scientific ingenuity to improving the surveying instruments of the day, and particularly to developing his standard measure known as the "compensation bar". To do the field work for the survey, Colby eventually engaged three military companies, each of 105 sappers and miners. For his survey team, in addition to surveying instruments, Colby needed about 250 sets of 7-figure mathematical tables that both measured up to his criteria for accuracy, and were also serviceable in field conditions.

In terms of accuracy it is well known that all the logarithmic tables of Babbage's day had many errors. For example, Taylor's *Mathematical tables*, one of the most recent (1792) and reliable, had nineteen known errors - most of them quite serious - and presumably as many undetected errors (Lardner 1834). The existing tables also tended to be impractical in that they were very expensive, usually out of print, and far too cumbersome for field conditions - Taylor's tables, for example, occupied two fat folio volumes measuring 13 x 11 inches and weighing several pounds each. These disadvantages applied to the other established 7-figure tables. Even Callet's *Tables portatives* (1795), although described as "portable", were scarcely convenient being about three inches thick and solidly bound. Although there was one set of tables - Charles Hutton's *Mathematical tables* (1822) - that were compact, inexpensive and in print, they were not demonstrably more accurate than the others.

Colby thus encouraged Babbage, and assisted him, in publishing a truly accurate and practical set of logarithmic tables.

Babbage's sources

It is an extraordinary fact that for the best part of 300 years all published sets of tables were derived, directly or indirectly, from the two great logarithmic canons of Briggs and Vlacq.[2] Briggs' *Arithmetica logarithmica* (1624) was produced under Napier's influence and gave the logarithms to fourteen decimal places of the numbers 1 to 20,000 and 90,000 to 100,000. In his *Arithmetica logarithmica* (1628), Vlacq completed Briggs' work by producing the logarithms of 1 to 100,000 to ten decimal places. Even in Babbage's day both of these books were very rare and valuable and today they are only to be found in the world's great libraries; Babbage had a copy of them both.

Both Briggs' and Vlacq's tables contained many known and unknown errors, but so great was the labour of computation and so great the opportunity for error, that all the table makers who followed "simply" edited, corrected and reduced these tables to practical precision - typically seven decimal places. Probably the most accurate 10-figure tables of Babbage's day were Vega's *Thesaurus logarithmorum* (1794), which were based on those of Vlacq, but were printed in a "modern" typographical arrangement. Of the practical 7-figure tables, those of best repute included Gardiner's *Tables of logarithms* ... (1742) which were derived from Briggs and Vlacq, and the tables of Taylor, Callet and Hutton, all of whom adopted Gardiner's typographical arrangement; Babbage had copies of them all.

It is perhaps worth being quite clear on the important distinction between plagiarism - the wholesale copying of someone else's work - and the compilation of a new set of tables from existing ones. Babbage was himself very clear on this point and wrote a paper on errors in tables of logarithms (1827b), in which he described the promulgation of errors in

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[2] Although two other canons were produced in the nineteenth century, de Prony's *Table du Cadastre* and Sang's logarithms, both of these existed only as unpublished manuscripts and so far as is known no published tables were ever derived from them (see Glaisher 1911).

plagiarized tables; he cited a particular case of an anonymous "Chinese" table which he discovered to have been blindly copied from Vlacq.

There was, incidentally, one final and very good reason why Babbage probably never gave a moment's thought to recomputing a table of logarithms: this was that in Paris there existed the manuscript of the monumental *Table du Cadastre* (the tables for the French ordnance survey). These tables, produced under the direction of the Baron Riche de Prony, had been computed by a team not far short of a hundred mathematicians and computers, and promised to make all of the existing canons redundant.

Babbage took as his primary source the 1795 stereotyped edition of Callet's *Tables portatives*. Callet's tables were known to be "one of the most correct and convenient" (de Morgan 1861), but probably Babbage placed at least as much importance on the fact that they were the first tables ever to be stereotyped rather than being printed using moveable type. Babbage had grave misgivings about using moveable type for printing tables, because of the danger of type becoming loose and being reinserted incorrectly by printers. (Lardner (1834) gives an example of this happening in Vlacq's tables, and which led to an error that was propagated through several derivative tables.)

Babbage was convinced that errors in tables arose far more from typesetting and printing than from mistakes in computation, and a good deal of the complexity of the Difference Engine was later to arise from attempting to mechanize the setting of tables. In the course of his investigations of machinery and manufactures Babbage made a study of printing technology, which featured as a major section of his *Encyclopaedia Metropolitana* article on manufacturing machinery (1829) and later in *On the economy of machinery and manufactures* (1832). In the latter he noted:

> As the original composition does not readily admit of change, stereotype plates can only be applied with advantage to cases where an extraordinary number of copies are demanded, or where the work consists of figures, and it is of great importance to ensure accuracy. Trifling alterations may, however, be made in it from time to time; and thus mathematical tables may, by the gradual extirpation of error, at last become perfect. (4th edition, 1834, pp. 74-5)

Printing and proof-reading

Babbage's *modus operandi,* in short, was to have Callet's 7-figure logarithmic tables reset, producing in the process a more accurate and typographically pleasing table (Figure 2). The task broke down into three stages: copy preparation, typesetting, and proof-reading.

So far as copy preparation was concerned, Babbage arranged for the tables to be set *directly* from Callet's logarithmic tables; by working directly from the tables he eliminated any possibility of transcription errors. A minor deficiency of Callet's tables that Babbage wanted to improve was the end figure corrections (ie. rounding up or down) about which Callet had been somewhat casual. Babbage thus had Callet's table read against Vega's 10-figure logarithms, and where Callet had rounded up the figure was marked in red ink. When the tables were set, all the marked figures were "dotted" (see Figure 2, note 3).

Babbage also gave considerable thought as to the best combination of coloured inks and paper. In the event he decided to use black ink on a rather bright yellow paper. (Even today, the first edition of the *Table of logarithms* is slightly dazzling.) This seems to have been an issue on which Babbage had slightly extreme views. It is not quite clear if Francis Baily was poking a little gentle fun at Babbage when he wrote:

Log. 000. N. 100.

0° 16′	2° 46′	Num.	0	1	2	3	4	5	6	7	8	9	Diff.
40″	40″	1000	0000000	0434	0869	1303	1737	2171	2605	3039	3473	3907	434
	50	1	4341	4775	5208	5642	6076	6510	6943	7377	7810	8244	433
	47′	2	8677	9111	9544	9977	0411	0844	1277	1710	2143	2576	1 43; 2 87; 432
	10	3	0013009	3442	3875	4308	4741	5174	5607	6039	6472	6905	3 130
	20	4	7337	7770	8202	8635	9067	9499	9932	0364	0796	1228	4 173; 5 217
45″	30	5	0021661	2093	2525	2957	3389	3821	4253	4685	5116	5548	6 260
	40	6	5980	6411	6843	7275	7706	8138	8569	9001	9432	9863	7 303; 431
	50	7	0030295	0726	1157	1588	2019	2451	2882	3313	3744	4174	8 346; 1 43; 9 390; 2 86
	48′	8	4605	5036	5467	5898	6328	6759	7190	7620	8051	8481	430; 3 129
	10	9	8912	9342	9772	0203	0633	1063	1493	1924	2354	2784	4 172; 5 216
50″	20	1010	0043214	3644	4074	4504	4933	5363	5793	6223	6652	7082	429; 6 259
	30	1	7512	7941	8371	8800	9229	9659	0088	0517	0947	1376	1 43; 7 302
	40	2	0051805	2234	2663	3092	3521	3950	4379	4808	5237	5666	2 86; 8 345; 9 388
	50	3	6094	6523	6952	7380	7809	8238	8666	9094	9523	9951	3 129; 4 172; 428
	49′	4	0060380	0808	1236	1664	2092	2521	2949	3377	3805	4233	5 215; 6 257
55″	10	5	4660	5088	5516	5944	6372	6799	7227	7655	8082	8510	7 300; 427
	20	6	8937	9365	9792	0219	0647	1074	1501	1928	2355	2782	8 343; 1 43; 9 386; 2 85
	30	7	0073210	3637	4064	4490	4917	5344	5771	6198	6624	7051	3 128
	40	8	7478	7904	8331	8757	9184	9610	0037	0463	0889	1316	426; 4 171
	50	9	0081742	2168	2594	3020	3446	3872	4298	4724	5150	5576	5 214; 6 256
17′	50′	1020	6002	6427	6853	7279	7704	8130	8556	8981	9407	9832	425; 7 299
	10	1	0090257	0683	1108	1533	1959	2384	2809	3234	3659	4084	1 43; 8 342; 2 85; 9 384
	20	2	4509	4934	5359	5784	6208	6633	7058	7483	7907	8332	3 128
	30	3	8756	9181	9605	0030	0454	0878	1303	1727	2151	2575	4 170; 424
	40	4	0103000	3424	3848	4272	4696	5120	5544	5967	6391	6815	5 213; 6 255
5″	50	5	7239	7662	8086	8510	8933	9357	9780	0204	0627	1050	7 298; 423; 8 340
	51′	6	0111474	1897	2320	2743	3166	3590	4013	4436	4859	5282	1 42; 9 383; 2 85
	10	7	5704	6127	6550	6973	7396	7818	8241	8664	9086	9509	3 127
	20	8	9931	0354	0776	1198	1621	2043	2465	2887	3310	3732	422; 4 169
	30	9	0124154	4576	4998	5420	5842	6264	6685	7107	7529	7951	5 212; 6 254
10″	40	1030	8372	8794	9215	9637	0059	0480	0901	1323	1744	2165	421; 7 296
	50	1	0132587	3008	3429	3850	4271	4692	5113	5534	5955	6376	1 42; 8 338; 2 84; 9 381
	52′	2	6797	7218	7639	8059	8480	8901	9321	9742	0162	0583	3 126; 420
	10	3	0141003	1424	1844	2264	2685	3105	3525	3945	4365	4785	4 168
	20	4	5205	5625	6045	6465	6885	7305	7725	8144	8564	8984	5 211; 6 253
15″	30	5	9403	9823	0243	0662	1082	1501	1920	2340	2759	3178	7 295; 419
	40	6	0153598	4017	4436	4855	5274	5693	6112	6531	6950	7369	8 337; 1 42; 9 379; 2 84
	50	7	7788	8206	8625	9044	9462	9881	0300	0718	1137	1555	418; 3 126
	53′	8	0161974	2392	2810	3229	3647	4065	4483	4901	5319	5737	4 168
	10	9	6155	6573	6991	7409	7827	8245	8663	9080	9498	9916	5 210; 6 251
20″	20	1040	0170333	0751	1168	1586	2003	2421	2838	3256	3673	4090	417; 7 293
	30	1	4507	4924	5342	5759	6176	6593	7010	7427	7844	8260	1 42; 8 335; 2 83; 9 377
	40	2	8677	9094	9511	9927	0344	0761	1177	1594	2010	2427	3 125; 416
	50	3	0182843	3259	3676	4092	4508	4925	5341	5757	6173	6589	4 167
	54′	4	7005	7421	7837	8253	8669	9084	9500	9916	0332	0747	5 209; 6 250
25″	10	5	0191163	1578	1994	2410	2825	3240	3656	4071	4486	4902	7 292; 415
	20	6	5317	5732	6147	6562	6977	7392	7807	8222	8637	9052	8 334; 1 42; 9 375; 2 83
	30	7	9467	9882	0296	0711	1126	1540	1955	2369	2784	3198	414; 3 125
	40	8	0203613	4027	4442	4856	5270	5684	6099	6513	6927	7341	4 166
	50	9	7755	8169	8583	8997	9411	9824	0238	0652	1066	1479	5 208
			0	1	2	3	4	5	6	7	8	9	6 249; 7 291; 8 332; 9 374

Figure 2 A page from Babbage's *Table of logarithms*

Notes to Figure 2

1 Babbage used the so-called "modern arrangement" for his tables which first appeared around the middle of the 18th century. Typographical niceties apart, Babbage's arrangement was essentially that of prior table makers such as Callet, Taylor and Hutton; they in their turn derived their arrangements from each other and Gardiner; likewise Gardiner leaned heavily on Vega, who borrowed from Vlacq etc. etc. Babbage followed Hutton in adopting "uniform" type rather than the old-style figures with heads and tails. Babbage considered the uniform font much clearer and had type specially cast. Interestingly, the table maker L.J. Comrie (1948) later took exactly the opposite view, and reverted to the old-style figures which he considered less fatiguing and therefore less likely to be mis-read.

2 The range 1-108000 was used so that any angle up to 30 degrees could be converted to seconds for trignometrical calculations (there are 108000 seconds of arc in 30 degrees). This range was probably first used in Callet's *Tables portatives*, and Babbage followed Callet's arrangement.

3 A dot below the least significant figure indicates that it has been augmented (ie. rounded up). De Morgan (1861) states that Babbage was probably the first to use this device: "This example is now frequently followed. It secures an extreme nicety in certain rarely occurring cases; but we never found any practical balance to the inconvenience of a new symbol, except when the augmented figure is a 5." Although some table makers copied the idea, it ultimately fell into disuse.

4 Small figures were used to indicate a change in the third figure of a logarithm (only the last four digits being printed for each entry). Prior table makers had used an asterisk or a clear line to indicate the change, which spoiled the look of the table. Glaisher (1911) noted: "The change of figure in the middle of the block of numbers is marked by a change of type in the fourth figure, which (with the sole exception of an asterisk) is probably the best method". On the other hand Milne in his "The arrangement of mathematical tables" (1915) makes no reference to the Babbage method. The only conclusion to be drawn from this is that it was all a matter of opinion.

> Would it not be desirable to have impressions on papers of various colors:- for instance, I should, myself, like *yellow* paper by daylight, and *pink* or *blue* by candlelight. (BL Add Ms 37183 f357)

Later Babbage went to extraordinary lengths in producing his *Specimens of logarithmic tables printed with different coloured inks on variously coloured papers* (1831a) in 21 volumes, and his *Tables of logarithms ... on different coloured papers* (1831b), in which he experimented with every conceivable combination of hues of paper and ink.

The tables were initially set with moveable type so that corrections could easily be made. As proofs were received, Babbage had them read first against the marked-up copy of Callet, and then twice more against Hutton's and Vega's logarithms. When these corrections had been made, another set of proofs were produced which were read twice more. Finally stereotype plates were made from the moveable type, and another set of proofs produced. It seems likely that the printing job was overlapped so that early pages were in stereotype while the later pages were still being set. At the stereotype stage, the type had been effectively frozen and corrections could only be made at considerable cost - but the vast majority of errors had of course already been eradicated.

In the summer of 1826, during the proof-reading of the stereotype proofs, things began to go slightly awry. Babbage had planned a summer visit to Paris so that, *inter alia*, he could check doubtful logarithms against de Prony's *Tables du Cadastre*. Unfortunately the printer chose that moment to go bankrupt, and the whole project was set back some weeks while the work was transferred to another printer, William Clowes. Colby, left in London to supervise the proof-reading, was himself due imminently to depart for Ireland, and so the proof-reading had to be skimped "particularly in the latter part of the work" (BL Add Ms 37183 f338).

In September 1826 Colby transferred to Ireland to take charge of the Irish survey, and he did his best to finish the proof-reading under very trying circumstances. Altogether, the proofs were read nine times as described by Babbage in his preface to the *Table of logarithms*:

> The proofs of the present tables were read three times: 1st, with the marked copy of Callet's logarithms; 2dly, with a copy of Hutton's logarithms, fourth edition, 1804; 3dly, with a copy of Vega's logarithms, folio, 1794. They were now received from the printer, and were again compared with the logarithms of Vega as far as 100,000; the last 8,000 being read with those of Callet. 5thly, The first 20,000 were read with those in the Trigonometria Artificialis of Briggs. Folio. Goudae, 1633. They were next returned to the printer, and stereotyped, and the proofs from the plates were read; 6thly, with the logarithms of Vega as far as 47,500; 7thly, with the whole of the logarithms of Gardiner, 4to. London, 1742; 8thly, with the logarithms of Taylor, 4to. 1792; and 9thly, by a different set of readers they were again read with the logarithms of Taylor. (pp. v-vi)

This description perhaps gives a rather sanitized account of the difficulties that Colby actually encountered, in his storm-lashed encampment:

> You will laugh at a hill like this which [is] about 2800 or 2900 feet above the level of the sea. But, I can assure you between wind, rain, and other little inconveniences, a tent on its top is by no means a comfortable residence for a person who has about a dozen different things to do which require quiet thought and the presence of books. (BL Add Ms 37183 f328).

In order to have the tables available for the Irish survey, they had to be printed before the final proof-readings of the stereotypes had been completed and a list of eight errata was included in the first edition.

All in all, the quality of proof reading must have fallen considerably short of Babbage's original intention. A century later, James Henderson (1926, p. 109), was probably the first to record that "the logarithms beyond 100,000 ... contain many errors". In their *Index of mathematical tables* (1962) Fletcher, Miller, Rosenhead and Comrie, in order to verify Henderson's remark, had the tables read against Bauschinger & Peters (1910) logarithms and discovered two serious errors and 450 errors of a unit in the last figure. Describing the table as "one of the most accurate ever printed" (vol 2, p. 785) they nonetheless advised the use of Bauschinger & Peters for values beyond 100,000.

Publication

In October and November 1826 Babbage wrote a preface and introduction to the tables which he sent to Colby and Baily for comment. The preface was dated 20 January 1827 and the book, bearing the title *Table of logarithms of the natural numbers, from 1 to 108,000,* emerged from the printers shortly after. Colby paid Babbage £100 for his 250 copies, and the print run was probably not very much bigger than this. A second small printing was produced in 1829, which was bound with a copy of Callet's *Tables of the logarithms of sines and tangents...*, extracted from the *Tables portatives....*[3] A second edition, printed on a more restrained buff paper and incorporating the errata, was published in 1831.

In 1833 Babbage received a written request from a Hungarian man of science, Karl Nagy, to produce an edition for his country of 1500 to 2000 copies "on very light green paper" - a choice no doubt suggested by Babbage (BL Add Ms 37187 f471). Nagy's third edition appeared in three forms: an English version, a Hungarian version, and a German version; the foreign versions included translations of the preface by Nagy. Shortly afterwards Babbage was honoured by being elected to the Hungarian Academy.

Thereafter, the tables were reprinted on at least six further occasions (see Table 1). All the later printings were on white paper. The coloured paper used by Babbage in the early editions was in fact not well made, and Colby reported to him:

> My assistants wear out the first pages of your logarithms very rapidly ... . The color of the paper is of no consequence, provided the quality of it be tough. (BL Add Ms 37189 f411).

To replace the most worn pages, at minimum cost, Colby ordered from Babbage supplies of unbound sheets on more than one occasion. In 1840, Colby requested one final printing of the logarithms - "250 copies ... on tough white paper ... to bind up with Baguay's sines and tangents" (BL Add Ms 37191 f411). The later editions, evidently all produced as ordinary commercial propositions independent of the Irish survey, were printed on good strong white paper and have certainly aged better than the earlier printings. For the 1912 edition the tables were entirely reset, presumably because the stereotypes were lost or unusable. Babbage would no doubt have heartily disapproved of this process as all too likely to introduce errors, especially as facsimile reproductions were then an everyday possibility.[4]

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[3] The 1829 edition, which was probably produced in a limited edition for the Irish Survey, is very rare and is not listed in any of the standard bibliographies or catalogues. The only copy known to the author is in the library of the University of Birmingham.

[4] Babbage even anticipated the possibility of facsimile reproduction in the *Economy*: "It is much to be wished that such a method were applicable to the reprinting of fac-similes of old and scarce books. ... Such a method of reproducing a small impression of an old work, is peculiarly applicable to mathematical tables, the setting up of which in type is always expensive and liable to error[.] (4th edition, 1834, p. 78-9).

Table 1 Editions of Babbage's *Table of Logarithms*

Edition	Date	Bibliographic details
First edition	1827*	*Table of logarithms of the natural numbers, from 1 to 108000;* London: J. Mawman; xx+201 pp.; yellow paper.
	1829*	Reprint of first edition, bound with Callet's *Tables of the logarithms of sines and tangents ...* (Paris 1795); yellow paper.
Second edition	1831	London: B. Fellowes; ?buff paper.
Third edition	1834a*	London: printed for the Hungarian Academy of Sciences; green paper.
	1834b*	*A termesztetes szamok Logarithmai 1 tol 108000;* Hungarian translation of introduction.and preface by Karl Nagy; pp. xiv+xx+201; buff paper.
	1834c*	*Logarithmen der naturlichen Zahlen 1 bis 108000;* German and Hungarian translations of preface and introduction; pp. xvi+xx+xiv+201; green paper.
	1841	London: unknown.
	1844	London: J. Murray; "4th impression".
	1872	London: unknown.
	1889	London: E. and F.N. Spon.
New impression	1912	London: E. and F.N. Spon; New York: Spon and Chamberlain.
	1915*	ditto.

Notes: Items marked * have been personally inspected. Editions were printed on ordinary paper, pp. xx+201, unless otherwise stated.

Sources: British Library Catalogue; Union Catalog; Archibald (1948); Henderson (1926); Tucker (1872); personal knowledge.

Assessment

Babbage unquestionably ranks as one of the great table makers, but this assessment rests largely on his concept of the Difference Engine, and all that that ultimately led to. As a practical table maker, Babbage's contribution was more distinctive than great. Certainly one could not put his tables in the same class as those of Briggs or Vlacq, or even those of Bauschinger & Peters or Comrie in this century.

Accuracy apart, Babbage's tables could have been a good deal more useful than they were: most notably they did not include trigonometrical tables, which Colby always wanted but Babbage never provided, other than by reprinting those of another table maker. Thus his tables, as a practical computing tool, were probably less useful than the much more comprehensive, if less accurate, tables of Charles Hutton. Moreover, the next half century saw the publication of comprehensive 7-figure tables such as *Barlow's tables* and *Chambers's mathematical tables* which were of far more service to practical computers and sold in vastly greater numbers. Babbage's tables no doubt still appealed to the discerning calculater who appreciated their accuracy, but practical computers were better served by the popular tables.

Even Babbage's attention to typography and layout seems to have had little or no influence. For example, in "The arrangement of mathematical tables" (Milne 1915), Babbage is not so much as mentioned; and of course Babbage's ideas on coloured paper and uniform type have proved plain wrong.

The long term significance of Babbage's tables was their unprecedented accuracy; his tables were very well-known and there can be no doubt that they must have helped to raise awareness of the need for, and the possibility of, very accurate tables. The *Table of logarithms* was, however, very much an achievement of craftsmanship rather than genius. Babbage, who admired craftsmanship in all walks of life, would not have depreciated the description.

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