

# Faulty Figures and Paper Technologies: Cost Estimating in Late Nineteenth-Century America

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## Introduction

In the late nineteenth century, a new genre of book began to be published for a new readership of building professionals in the United States. This was the building-cost estimating handbook, or estimator, and it was a response to uncertainties that arose from changing practices of valuation and new modes of knowledge production and circulation that were crucial to the development of the nascent American building industry. This paper focuses on two early examples of this genre, seeking to understand for whom these books were published, from what sources their contents were derived, and how their appearance and circulation in the United States in the last decades of the nineteenth century reflected changing social and cultural conditions in the American building trades during the coalescence of general contracting. I suggest that closer attention to estimating as both a practice and a body of knowledge that depends on the circulation, storage, and analysis of quantitative and qualitative information can help us better understand the circumstances that both enabled and were reshaped by the advent of the American general contractor [1].

## Old Price and New Markets

The correct way to estimate the cost of prospective building projects became a subject of consternation and debate among American builders and some architects in the 1870s. In the pages of monthly trade journals like *American Builder* and *Carpentry and Building*, correspondents from across the industrialising regions of the United States complained of an increasingly chaotic building market, as experienced builders found themselves competing for work against men of no particular qualifications beyond ‘a good opinion’ of themselves [2]. As historians of nineteenth-century building culture in the United States have shown, the pressures of market competition had already begun to reorganise the political economy of artisanal work in the antebellum era, forcing even master craftsmen to use percentage discounts to bend the stability of ‘old price’ to market forces [3]. After the end of the Civil War, however, a far more extensive and integrated building market was created, as communication and transport networks drew builders and contractors out of their local markets and into closer competition with one another. At the same time, periodic financial booms and busts rippled across the country, encouraging speculative building, destabilising prices, and in lean times stiffening competition. Advertisements for estimates on major building projects brought in ever greater numbers of submissions, not just from local builders but also from building concerns stationed a considerable distance from the proposed building site. And as these calls for competitive price proposals received responses from contractors large and small, near and far, experienced and inexperienced, responsible and reckless, the wide range of prices for the same project brought the question of estimating expertise into view. For builders, vast discrepancies between estimates—but especially the recklessly low underestimates, or ‘plungers’, as some called them—represented an existential threat to the entire industry. A single untenably low bid took work away from more competent or responsible builders, often bankrupted the winner of the contract, and sometimes ended in the collapse of the project. Moreover, as many pointed out, disparate estimates left a bad impression on America’s capitalists (builders’ ideal clients), for the lack of agreement over price suggested not merely a failure of precision but also a lack of competence in matters of business among builders generally. One *Carpentry and Building* correspondent yearned for a day when contractors ‘shall be so thoroughly educated by their mechanical journals as to show capitalists very slight differences in their estimates [4]’. In competition, then, building entrepreneurs found a

strange kind of community—ungoverned and perhaps ungovernable—in which the activities of some affected the interests of all. Reflecting on the estimating debate that had spanned several years in *Carpentry and Building*, one correspondent in 1879 expressed satisfaction that, if nothing else, the universality of the bidding problem had stirred a sense of ‘unity of interests financially’ among carpenters and builders across the country [5].

But what were the causes of the discrepancies in estimates, and how were they to be resolved? While some bemoaned the recklessness and even the dishonesty of some contractors, many instead argued that the root of the problem was not in fact moral but rather technical—not competition’s corruption of traditional ethical codes but ‘a lamentable degree of ignorance among the whole class of builders’ regarding sound estimating technique [6]. The inclination among a new generation of contractors to forgo formal craft apprenticeships meant that many were left to educate themselves. ‘For lack of a competent master to examine and criticise the first efforts of the novice at estimating’, wrote one commentator, these ‘builders are compelled to gain their experience in the most expensive school, and the errors of judgment incident to all first efforts are paid out of capital [7]’. Some continued to insist that the only sure way to arrive at accurate estimates was by trained judgment and the kind of tacit knowledge that could be gained only from years’ spent actually working in the building trades. The predicament was, however, that if a young contractor had ‘no definite judgment until he obtains it by experience’, then in the meantime he would ‘carry on his business in a haphazard way, guessing out his estimates, the very evil we are crying against [8]’. But incompetence in estimating was not unique to newcomers to the building trades; it could also be found among those who may have long ago mastered the technics of their trade but were less expert in the clerical niceties and financial complexities of industrial business. Indeed, by the turn of the twentieth century ‘the ability to estimate’ was seen as nothing less than ‘the dividing line between the journeyman and the master builder [9]’. Given this, it was acknowledged that American ‘building interests’ generally would be served by systematising methods of estimating and making advice readily available to anyone who was inclined to enter their ranks by way of the competitive tender.

### **Rule Books and Estimators**

At the beginning of the 1870s, however, it was not only that there were no formal modes of training. There were not even any widely circulated books to which American builders could turn for guidance on estimating. The idea of such a book remained novel enough to Americans by 1880 that, when the editor of *Carpentry and Building*, Anson O. Kittredge (whom we will meet again), received a copy that January of a new edition of the *Builder’s Price Book and Guide for Estimates*, compiled by one Henry C. Bevis and published in London, he remarked that the book, giving prices of current building materials and machinery, ‘differs from anything published upon this side of the Atlantic [10]’. Lamenting that the book itself was ‘of small practical value to American builders, because the prices are made for the English market’, Kittredge observed that it nevertheless could serve ‘to indicate to what system the matter of estimates may be reduced [11]’.

Indeed, the state of estimating at this time was strikingly different in Britain, where building price books and estimators had been readily available to all since at least the early seventeenth century and by the nineteenth century had become a fiercely competitive market in themselves. Annually updated editions were issued by at least three competing publishers—each book known by the names of its original compiler, Robert Laxton, Benjamin Crosby, and Z. Skyring, respectively—in a race to keep up with volatile London prices, prompting some authors to also offer ‘perpetual’ price books that explained the general principles of estimating and provided formulas for reconciling these with fluctuating prices and local customs [12]. At the same time, the work of building quantification in Britain was being professionalized as a dedicated service by independent surveyors who prepared bills of quantities, ‘taken off’ from plans and specifications, to serve as the basis for contractors’ price estimates [13].

There is no unambiguous explanation for the belated appearance of published building price books in the United States [14]. Several attempts had been made—the first perhaps in 1833 by the young Irish builder and architect James Gallier,

then newly arrived in New York from London—to compile a comprehensive set of estimating rules representing all trades into a single book, but none appears to have been successful [15]. It is possible that most antebellum building craftsmen, whose operations remained highly localised even in coastal cities until after the Civil War, would have found a general-purpose price book irrelevant. As scholars have argued, standards of value and measurement are anything but neutral conventions; they either grow from local practices and social relations—varying geographically, situationally, and historically—or they are imposed as instruments of statecraft and infrastructures of commercial expansion [16]. In the tight-knit artisanal communities of agrarian America, conversely, the illegibility of local measurement and valuation practices to would-be interlopers no doubt had its advantages. Well-placed locals, meanwhile, would have had ready access to reliable—if often heavily controlled—price information through their own networks, customs, and institutions. Indeed, another possibility is that the public dissemination of building price information not only would have made no sense in preindustrial America but also could have been actively suppressed.

As it happens, one type of price book could be found within the libraries of American guild halls from the mid-eighteenth through the nineteenth century. These were not, in the strict sense, publications, however. They were instead a proprietary kind of document, jealously guarded by elite companies of master craftsmen in order to maintain a system of ‘old price’ [17]. Privately printed in small runs or written in manuscript, these books contained schedules of prices for every category of work in the company’s trade, as well as elliptical explanations of the rules for measuring and converting dimensional quantities—typically in lineal and cubic feet—into pecuniary quantities, in dollars and cents [18]. The most prominent example of these was the rule book of the Carpenters’ Company of the City and County of Philadelphia. When none other than Thomas Jefferson sought a copy in 1817—wishing to consult an authoritative source as he negotiated with builders for the construction of what would become the University of Virginia—he was rebuffed on account of ‘an express rule of the Carpenter’s Company that the book is not to be seen out of the pale of their Church [19]’. Allowing a non-company member, even a former US president, to peruse the prices was grounds for expulsion according to the company’s strictly enforced by-laws, and careful records were kept of members who removed the book from the carpenters’ hall. Early editions were printed without prices, the figures added by hand only to the copy that was never to leave the hall; later editions were kept only in manuscript [20]. Not all craft companies were so secretive about their methods of valuation—Jefferson settled for the Pittsburgh carpenters’ rule book—but it is notable that the Philadelphia carpenters’ price controls seem to have held a special authority in and beyond their own local jurisdiction [21].

The published books on estimating that began to appear in the late nineteenth century, still called ‘price books’ but more often ‘estimators’, were very different from the craft companies’ rule books, though vestiges of the old order can be seen in them. They reflected not only changing relationships within and among the building trades but also technical, epistemological, and institutional shifts in the reckoning and dissemination of price itself. Unlike the secret books of prices and rules used as regulating instruments of guild power, estimators offered their public readership a compilation of techniques and tools for quantifying the work of not just any one trade but all of them, from brick laying to paper hanging. The once-observed particulars of each trade, and more, were thus made available to a national market of book-buying mechanics.

The first book that appears to have met with any success was Frank W. Vogdes’s *The Architect’s and Builder’s Pocket Companion and Price Book*, first published in 1871 [22]. An architect practicing in Louisville, Kentucky, who claimed twenty-five years of experience, Vogdes meant for his book ‘to afford to the Building Fraternity those facilities and advantages derived by Civil and Mechanical Engineers [23]’. Noting his own need for such a book in his many years of practice as an architect, Vogdes presents the book to ‘the profession’, hoping that ‘it will save the labor of many calculations, of almost hourly occurrence [24]’. From engineering treatises he selected tables to aid in a variety of calculations that he believed would be useful to architects and builders, supplementing them with his own original contributions. As the title of the book promises, Vogdes also included what he called a ‘Bill of Prices for Carpenters’ Work’, compiled from ‘the standard of value for such work for over forty years in one of the most flourishing cities in the Union [25]’. While the majority of the items listed in this bill do clearly fall under the carpenter’s jurisdiction, they

also encompass brick work, excavating, well digging, masonry, slating, painting, glazing, plastering, and tinwork [26]. This peculiar conflation reflects the managerial purview of the American carpenter's position: in a land of plentiful forests carpenters had long been the most powerful among the building craftsmen and were often to be found performing the role of lead contractor, directly overseeing carpentry work while subcontracting with other trades for the rest [27]. Vogdes does not list the categories and items of work in the order of the building process, the convention adopted by most later estimators, but instead alphabetically, which was more common in craft companies' rule books. The language of his price explanations also recalls these books, insofar as a basic rule is given for measuring and valuing a particular building element—usually in terms of lineal or cubic feet—followed by a series of exceptions (most lines beginning with 'for' or 'if') for which percentage adjustments or multipliers are provided. In a clear departure, however, Vogdes explicitly notes that prices are 'presented to those interested in estimating the value of such work, in the full belief that it will prove a valuable assistance both for the purpose of basing a formal "Proposal" upon, and in ascertaining the value of, work after it is completed [28]'.

Filled predominantly with tables of precalculated values—from US weights and measures to standard sizes of drawing paper to properties and units of materials like wood and different metal alloys—Vogdes's handbook more resembles the ready reckoners used by merchants and engineers than it does the earlier craft rule books or the later estimators [29]. The book provides no instructions as to how the task of estimating itself is to be done, conceding that the book is intended as a labour-saving reference for experienced builders rather than as a guidebook for young contractors seeking to learn the technique of estimating. It would have been useful only insofar as readers brought to it their own knowledge of the building and estimating processes. Nonetheless, Vogdes's *Pocket Companion and Price Book* appears to have remained popular among contractors in many parts of the country for as long as two decades, reissued in at least four updated and expanded editions. The last, published in 1895, is almost a hundred pages longer than the first edition—with additional tables quantitatively describing newer materials like concrete—but intriguingly the bill of prices remains constant across all extent editions from 1871 to 1895, with text, numbers, and even typesetting unchanged.

## **Paper Technologies**

A more instrumental response to the estimating question was presented to builders in 1885 by Jasper D. Sibley, an architect, and Anson Kittredge, the editor of *Carpentry and Building*, among other trade journals. This was not a single handbook but rather what I would like to call, borrowing a term from historians of capitalism, a complement of 'paper technologies' that comprised a booklet of 28 *Handy Estimate Blanks*—sold in single copies or by the dozen—and a pocket-sized user's manual of sorts titled *The Practical Estimator* [30]. The latter provided 'full descriptions for [the blank forms'] use, as well as a list of all the items ordinarily entering into a building, so arranged as to be a convenient and systematic reminder' [31]. If Vogdes's project was more about compilation and calculation—collecting various dimensional, mechanical, and pecuniary values together for the experienced builder's labour-saving reference—then Kittredge and Sibley's was one of methodology and discipline, designed above all but not exclusively with the neophyte contractor in mind. Most significantly, neither *The Practical Estimator* nor the *Handy Estimate Blanks*, as the latter name suggests, included any price information whatsoever. Where Vogdes had provided values in dollars and cents, Kittredge and Sibley inserted the opposite: blank spaces.

In addition to introducing a degree of 'system' into the practices of inexperienced contractors, Kittredge and Sibley also saw their book as a kind of machine whose use would benefit even the most seasoned estimators. Estimating itself is a kind of 'machine work', they note, and 'in the absence of adequate machinery for performing it, it is done in an expensive manner, and frequently in a very bungling way [32]'. The problem for any contractor was not just the tedious, rote, and mentally taxing nature of estimating—'the drudgery of the work and the constant tension of mind necessary to recollect little things and place these items in proper place [33]—but also the conditions under which it was typically performed. Unlike the large contracting firms that had dedicated estimating departments, the small-time contractor found himself estimating at odd hours, between other demands, and sometimes in a hurry when hurry was demanded. Interruptions were

unavoidable, with the result that the most common error in estimating was not miscalculation or misjudgement but simple omission due to lapses of memory or attention [34].

The most effective trade technology to alleviate difficulties of this type was nothing more than a list of all the kinds of building work, elements, and materials that might factor into the estimate. *The Practical Estimator* offered just such a list, ‘arranged for use as a reminder or “tickler” in preparing estimates [35]’. It divided items by trade—masonry (including excavation); carpentry; painting; tinning, slating, and galvanised metal work; and plumbing and gas fitting—placed them in ‘the same order that would be pursued in the erection of the building’, and subdivided them further into constituent tasks and items, with additional blank lines on which the user could add his own items. As the media historian Lisa Gitelman has shown, preprinted ‘blanks’, or blank forms, proliferated in the nineteenth century, particularly in administrative lines of work. Filling in forms helped nineteenth-century Americans ‘locate goods, map transactions, and transfer value’, she writes, ‘while it also helped them to locate themselves or others within or against the sites, practices, and institutions that helped to structure daily life [36]’. Catering to ‘the repetition of certain kinds of writing’, blanks worked ‘to direct and delimit expression’, often in order to reform practices that had ossified into inefficient habits [37]. As Kittredge and Sibley themselves point out, blanks were already a common feature in the businesses of ‘many of the most prominent and most successful contracting firms in the country’. Representing ‘the outgrowth of their experience’, a building firm’s blanks were (not unlike the craft guild’s rule books) guarded as trade secrets, ‘for fear some competitor may have the opportunity of copying features which in practice have been found to afford advantages [38]’.

Kittredge and Sibley thus sought to make systematic methods available to the small contractor who built only four or five modest buildings in a year and thus lacked both the experience and the ‘bulk of trade’ to profit from the institution of any such carefully designed system of information management. What they offered, then, was not so much new information as a machine for methodically organising information the builder presumably already had. While *The Practical Estimator* provided explicit instructions about proper estimating technique, the blanks did a more implicit kind of work—prompting the user for specific details and thereby teaching him what information needed to be gathered, as well as how to structure the knowledge he already possessed [39]. Before the pages pertaining to the estimate proper, for example, the cover of the *Handy Estimate Blanks* booklet offered structured space for contextual details that the average builder might not be in the habit of gathering in a systematic way: blanks for enumerating the drawings and other documents on which the estimate was based, blanks for detailing the project schedule and terms of payment (for these ought to influence the builder’s price, the authors argued), blanks for making site-visit notes, and blanks for recording any specific terms on which the proposal was made. Having made a record of all this, the contractor who won the contract could keep track of any changed or additional expectations introduced when it came time to execute the work.

The most important feature of the *Handy Estimate Blanks*, however, were the six ruled columns that appeared to the right of the list of building tasks [40]. The first three were for the estimated quantities, prices, and costs; the second three were for actual quantities, price, and cost, to be recorded as the work progressed if the contract was awarded. This schema, it was hoped, would instil in the mind of the contractor a clear distinction between the concepts of quantity take-offs, market price, and actual cost. But the columns were also meant to encourage habits of systematic record keeping and comparative analysis of costs both estimated and actual. The idea was ‘to link together as closely as possible the estimated cost of a piece of work with the actual cost of performing the same [41]’. In *The Practical Estimator*, Kittredge and Sibley discuss the importance of ‘systematic comparison’ in estimating: ‘While the work of taking off quantities from drawings can be reduced to a system and a high degree of accuracy attained, there is scarcely anything but judgement to govern the estimator in the matter of the prices put upon the different items [42]’. The only way to know whether one’s estimate had been accurate was to compare it with the actual cost of building. Admitting that filling in every actual figure next to every estimated figure for every item in every project was not likely to be practicable for the ordinary builder, Kittredge and Sibley nevertheless argued that regular ‘experiments of this kind’ would help ‘to keep a wholesome check on estimating’ [43].

## Conclusion: Of Prices and Costs

In their insistence on the importance of record keeping and analysis, Kittredge and Sibley's *Handy Estimate Blanks* and *Practical Estimator* signal a conceptual shift that would reach full expression in the building industry only in the twentieth century: the shift from the idea of price as given (by custom or by the market) to one based on exacting methods of cost keeping, analysis, and manipulation. This was mirrored in other industries, as well, especially steel production. Upon leaving the railway business to enter steelmaking in the 1870s, Andrew Carnegie was surprised to find that cost keeping was not practiced in the industry. 'Show me your costs sheets,' he would lecture his foremen. 'It is more interesting to know how well and how cheaply you have done this thing than how much money you have made, because the one is a temporary result, due possibly to special conditions of trade, but the other means a permanency [44]'. Kittredge himself, a graduate of the Miami Commercial College in Dayton, Ohio, would play no small part in cultivating a comparable sense of accountability among American builders. Better known today to historians of finance than to historians of construction or architecture, he spent the last decades of the nineteenth century simultaneously editing multiple trade journals for both the building industry and the accounting profession. In *Carpentry and Building* he sustained a continuous discourse on business techniques, taking every opportunity to encourage builders to systematise their estimating, cost-accounting, and timekeeping methods. For these were the techniques that would distinguish the expertise of the successful general contractor from the know-how of the master builder. Building-cost estimating handbooks to come would look less like craft rule books and more like business manuals as their authors turned their attention from compiling prices—listed alongside weights and measures and the mechanical properties of materials, as so many facts arbitrarily given by custom or nature—to instructing contractors on how to keep and analyse their own costs.

## References

- [1] On American general contractors, see James F. O'Gorman, 'O. W. Norcross, Richardson's "Master Builder": A Preliminary Report', *Journal of the Society of Architectural Historians*, vol. 32, no. 2, May 1973, pp. 104–113; Sara E. Wermiel, 'The Rise of the General Contractor in 19th Century America', *FMI Quarterly*, no. 3, 2008, pp. 116–129; Brian Bowen, 'General Contractors and Architects in Nineteenth-Century America', pp. 383–389 in Ine Wouters et al., (Eds), *Proceedings of the Sixth International Congress on Construction History*, Brussels 2018, vol. 1, Brussels: CRC Press/Balkema, 2018.
- [2] 'Necessity of Uniform Prices in the Building Trades', *Carpentry and Building*, vol. 1, no. 6, June 1879, p. 116.
- [3] Bryan E. Norwood, 'The Measurer: Quantifying Labor in the Early American Republic', unpublished conference paper presented at the Society of Architectural Historians 73rd Annual International Conference, Seattle/Virtual 2020; Donna J. Rilling, *Making Houses, Crafting Capitalism: Builders in Philadelphia, 1790–1850*, Philadelphia: University of Pennsylvania Press, 2001; Lisa Beth Lubow, 'Artisans in Transition: Early Capitalist Development and the Carpenters of Boston, 1787–1837' (Ph.D. thesis, University of California, Los Angeles, 1987); and Catherine W. Bishir et al., *Architects and Builders in North Carolina: A History of the Practice of Building*, Chapel Hill: University of North Carolina Press, 1990.
- [4] 'Methods and rules for Estimating', *Carpentry and Building*, vol. 1, no. 4, April 1879, pp. 77.
- [5] 'Discrepancies in Bids: A Standard of Valuation Needed', *Carpentry and Building*, vol. 3, no. 7, July 1879, pp. 137.
- [6] Mart, 'Necessity of Uniform Prices in the Building Trades', *Carpentry and Building*, vol. 1, no. 6, June 1879, p. 116.
- [7] Anson O. Kittredge and Jasper D. Sibley, *The Practical Estimator*, New York: David Williams, 1885, pp. 1.
- [8] Mart (note 6), p. 116.
- [9] Edward Nichols and S. R. Noe, *Estimating*, Chicago: American Technical Society, 1924, p. 1.
- [10] 'New Publications', *Carpentry and Building*, vol. 2, no. 1, January 1880, p. 9.
- [11] Ibid.
- [12] See, for example, William Thorne, *The Perpetual Guide*, London: Simpkin & Marshall, 1824; and Richard Elsam, *The Practical Builder's Perpetual Price-Book*, London: Printed for Thomas Kelly, 1837.

- [13] Still today the practice of quantity surveying is almost unheard of in the United States, while remaining established custom in the British construction industry. See Brian Bowen, 'The Quantity Surveyor: MIA in the USA', pp. 227–234 in Karl-Eugen Kurrer, Werner Lorenz, and Volker Wetzka (Eds), *Proceedings of the Third International Congress on Construction History*, Cottbus 2009, Cottbus: Brandenburg University of Technology, 2009; and F. M. L. Thompson, *Chartered Surveyors: The Growth of a Profession*, London: Routledge & Kegan Paul, 1968.
- [14] American business publishing more generally began only after independence was won from Great Britain. The first American commodity price current was published in Philadelphia in 1783, the year the Treaty of Paris was signed. John J. McCusker, 'The Demise of Distance: The Business Press and the Origins of the Information Revolution in the Early Modern Atlantic World', *American Historical Review*, vol. 110, no. 2, April 2005, pp. 295–321.
- [15] James Gallier, *The American Builder's General Price Book and Estimator*, New York: Stanley & Co., 1833.
- [16] Witold Kula, *Measures and Men*, trans. R. Sreter. Princeton: Princeton University Press, 1986; and James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*, New Haven: Yale University Press, 1998, pp. 9–84.
- [17] Originally borrowed from British craft traditions, old price was practiced by company-approved measurers who literally measured a building after the work was finished and used the company's formulas and prices to determine the total building cost. The fee for this service in America was customarily 3 per cent, split between the client and the builder who completed the work. It was also common for the client and builder to each hire their own measurer.
- [18] For a near-comprehensive list of American carpenters' price books, see Elizabeth H. Temkin, 'Annotated Bibliography of Builders' Rule Books Published in America', Washington, DC: National Park Service, 1976.
- [19] Letter from William Thackara to Benjamin Henry Latrobe, 22 December 1817, enclosed with letter from Latrobe to Thomas Jefferson, ca. 26 December 1817, p. 278 in *The Papers of Thomas Jefferson*, Retirement Series, ed. J. Jefferson Looney, vol. 12, 1 September 1817 to 21 April 1818. Princeton, NJ: Princeton University Press, 2014.
- [20] See also Norwood, 'The Measurer' (note 3); and Rilling, *Making Houses* (note 3), pp. 69–90.
- [21] Even after the company's power had waned in the late nineteenth century, old editions of the price book were sometimes used by third parties to settle disputes in court. It is also interesting to note that two pirated editions of the book appeared, in 1801 and 1819, under the same title, *House Carpenters' Book of Prices and Rules*.
- [22] Vogdes's handbook was also frequently recommended by *Carpentry and Building* correspondents. In the 1883 edition Vogdes thanks the '7,000 purchasers' of earlier editions. This edition of the book was also reviewed favourably among new publications in *Carpentry and Building*, vol. 5, no. 12, December 1883, pp. 245. The notice predicts that the new, expanded edition 'is likely to be even more popular in the future than it has been in the past'.
- [23] Vogdes cites four authors as his sources in the preface: Haswell, Nystrom, Byrne, and Scribner. To date I have only been able to locate one of these: John W. Nystrom, *A New Calculating Machine*, Philadelphia: R. W. Barnard & Sons, 1852. Frank W. Vogdes, preface to *The Architect's and Builder's Pocket Companion and Price Book*, Philadelphia: Henry Carey Baird, 1871, p. 9.
- [24] Ibid.
- [25] Ibid., p. 154. The city is presumably either Louisville, Kentucky, where Vogdes worked and lived, or perhaps St. Louis, Missouri, which had fairer claim to being among the reunited nation's 'most flourishing cities'. Chicago, also relatively nearby, was still a very young city, having a population of only a few hundred white settlers forty years before Vogdes's writing.
- [26] Ibid., pp. 14–15.
- [27] Mary N. Woods, *From Craft to Profession: The Practice of Architecture in Nineteenth-Century America*, Berkeley: University of California Press, 1999, pp. 10–14.
- [28] Vogdes, *Pocket Companion and Price Book* (note 23), p. 154.
- [29] Historians of computing have shown that ready reckoners—cheaper and more reliable than mechanical devices—were among the dominant tools used as aids to calculation, particularly multiplication, from the seventeenth through the mid-twentieth century, when digital calculators were introduced. See Bruce O. B. Williams and Roger G. Johnson, 'Ready Reckoners', *IEEE Annals of the History of Computing*, vol. 27, no. 4, October 2005, pp. 64–80. See also William

Deringer, 'Pricing the Future in the Seventeenth Century: Calculating Technologies in Competition', *Technology and Culture*, vol. 58, no. 2, 2017, pp. 506–528.

[30] Seth Rockman has proposed the term paper technologies to describe the 'written means of storing and conveying information [that] functioned as the material infrastructure of the rapidly expanding Atlantic economy' starting in the eighteenth century. Seth Rockman, 'Paper Technologies of Capitalism', *Technology and Culture*, vol. 58, no. 2, 2017, pp. 487–505.

[31] Advertisement for *Handy Estimate Blanks* and *The Practical Estimator*, both published by David Williams, in *Carpentry and Building*, vol. 9, no. 10, October 1887, p. xvii.

[32] Kittredge and Sibley, *Practical Estimator* (note 7), pp. 4–5.

[33] *Ibid.*, p. 4.

[34] *Ibid.*, p. 5.

[35] *Ibid.*, p. 27.

[36] Lisa Gitelman, *Paper Knowledge: Toward a Media History of Documents*, Durham: Duke University Press, 2014, pp. 21–22. See also JoAnne Yates, *Control through Communication: The Rise of System in American Management*, Baltimore: Johns Hopkins University Press, 1989.

[37] Gitelman, *Paper Knowledge* (note 36), p. 22.

[38] Kittredge and Sibley, *Practical Estimator* (note 7), p. 6.

[39] On the disciplinary function of handbooks, see Angela N. H. Creager, Mathias Grote, and Elaine Leong, 'Learning by the Book: Manuals and Handbooks in the History of Science', *BJHS Themes*, vol. 5, 2020, pp. 10.

[40] Unfortunately I am not aware of an extant copies of the *Handy Estimate Blanks*. This account is based on Kittredge and Sibley's description of them in *The Practical Estimator*.

[41] Kittredge and Sibley, *Practical Estimator* (note 7), p. 21.

[42] *Ibid.*, p. 13.

[43] *Ibid.*, pp. 13–14.

[44] Harold C. Livesay, *Andrew Carnegie and the Rise of Big Business*, New York: Pearson Longman, 2007, p. 112. See also Jonathan Levy, *Ages of American Capitalism: A History of the United States*, New York: Random House, 2021, pp. 229–259.