

Project Governance & Control, The Building of the Crystal Palace



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(Augmented with additional materials received since publication)

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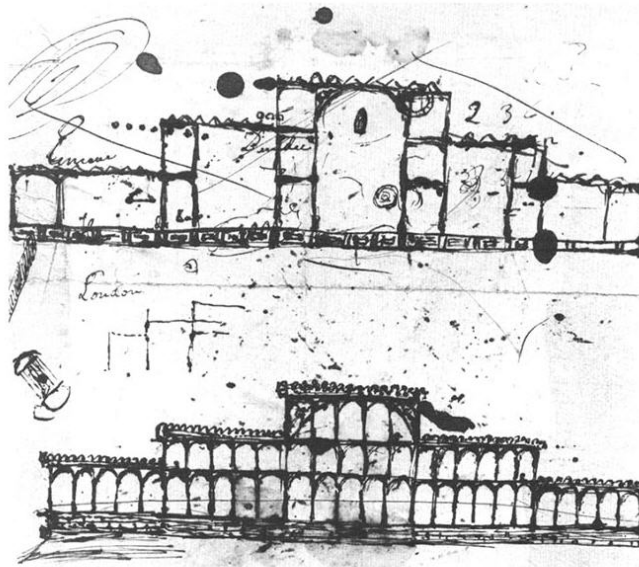


The Building of the Crystal Palace

The Crystal Palace was built in London for the Great Exhibition of 1851. To put this in historical perspective, this is just 35 years after the Battle of Waterloo brought an end to the Napoleonic wars, and 60 years before Henry Gantt began his work¹.

A Brief Synopsis of the Building

The Crystal Palace, was a building the size of a modern shopping mall: 1848 feet [563.3 meters] long, 408 ft [124.4 m] wide and 108 ft [32.9 m] high, with a roofed area of 772,784 square feet [71,794m²] about 19 acres [7 Hectares]. The sketch plans prepared by Joseph Paxton were approved on the 11th June 1850:



Sir Joseph Paxton's original sketch on blotting paper of the Crystal Palace. 11 June 1850.

Fig.1 The famous 'original design'

With the 'design' approved, tenders were sought from industry and the design proposal from Fox, Henderson and Co accepted. Most of the iron work was made by Messrs Cochrane & Co, of Woodside Ironworks and Mr Robert Jobson, of Holly Hall Ironworks. The 293,655 sheets of glass used in the construction were made by Chance Glassworks of Smethwick. Work started on the 15th July 1850, possession of site was granted on the 30th July, the first column was erected on the 26th September and the formal contract signed on the 31st October.

¹ To see the events discussed in this paper in a comprehensive historical timeline download **Project Management - A Historical Timeline:**
https://mosaicprojects.com.au/PDF_Papers/P212_Historical_Timeline.pdf

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The initial construction in Hyde Park required an existing row of elm trees to be preserved within the structure:

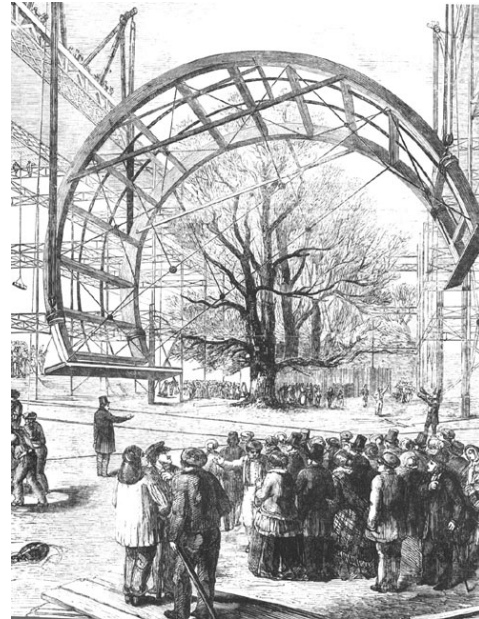


Fig. 2 These main barrel vaults were the only part of the structure made from wood.

The design was highly modular, based on the largest sheet of glass then available measuring 10 inches wide by 49 inches long. And the construction process was highly mechanised with substantial off-site fabrication².



Fig. 3 The exhibition in full swing.

² For more on the construction see: http://en.wikipedia.org/wiki/The_Crystal_Palace

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8 ½ months after the start, the Great Exhibition opened on the 1st May 1851. The construction was substantially complete after 5 months (and consumed close to 1/3 of the glass manufactured in Britain that year). The installation of the 14,000 exhibits overlapped the completion of construction through to the opening. Exhibitors came from all regions of the UK, its dominions and dependencies, and 44 other nations.

The event was a fantastic success with a total attendance of 6,039,195. By way of comparison, the total population of London at the time was estimated at 2,350,000! The total cost of the exhibition was £339,742 and it made a profit of £186,000. The *Royal Commission for the Exhibition of 1851*, which was originally appointed in 1850 to organise the Exhibition, was continued in perpetuity to spend these profits.

Prince Albert decreed the money was to be used to “increase the means of industrial education and extend the influence of science and art upon productive industry”. The Commissioners’ first act was to purchase 96 acres of land in South Kensington, and over the next fifty years they established the Victoria & Albert Museum, Natural History Museum and Science Museum; the Royal College of Art and Music; Imperial College London and the Royal Albert Hall. Although the museum sites were sold to the government in the late 19th century, the Commission remains the landlord of much of the land, and uses its income to fund research fellowships aimed at encouraging bright, early-career scientists to develop their research. The current distributions are some £2 million per year.

The name Crystal Palace was coined by Punch Magazine, adopted by the general public during the exhibition period and remained associated with the building when it was sold to a private company and moved from its location in Hyde Park to a new site in the South of London. The rebuilt structure was located to a hill in the suburb of Sydenham as a venue for other shows and exhibitions.

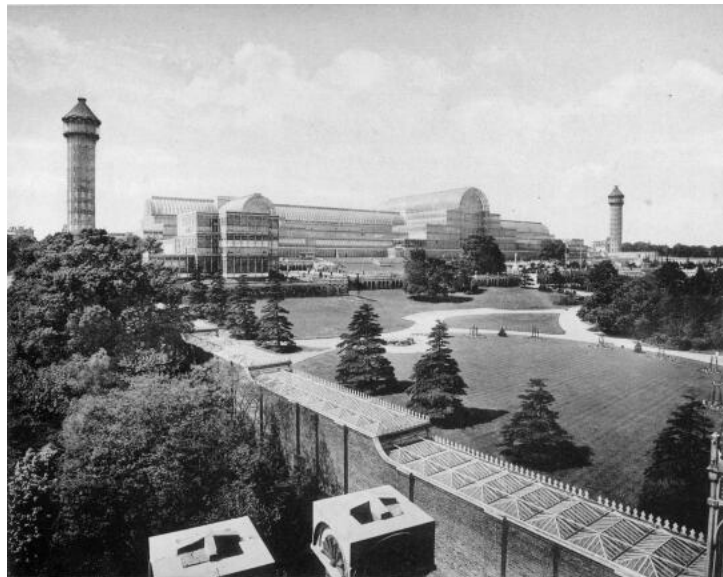


Fig. 4 The rebuilt Crystal Palace in Sydenham (suburb now called Crystal Palace)



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The building was destroyed by fire on the 5th December 1936 (an event witnessed by my mother).



Fig. 5 “This is the end of an age” Sir Winston Churchill

To appreciate the significance of this building, the suburb it was located into, the local football club and the parkland that housed the recycled building all retain the name Crystal Palace³. One of the original exhibits in the parklands remains intact, the Crystal Palace Dinosaurs, a series of sculptures of dinosaurs and other extinct animals, incorrect by modern standards, but representing scientific understanding of 150 years ago. All of the dinosaurs are permanently protected and preserved as Grade 1 Listed Structures⁴.



Governing and Controlling the Construction

My interest in this project is very much focused on the project controls and governance aspects of the management of this remarkable endeavour; and during a trip to the UK in mid-2013, I spent an enjoyable, but frustrating day browsing through the reports of the Royal Commission responsible for the whole of the exhibition and its legacy.

³ YouTube video highlighting the Crystal Palace, the people involved and the exhibition can be seen at: https://youtu.be/lunN7Ob_R9k and <https://youtu.be/CzvHv9CmdKQ>

⁴ For more on the Crystal Palace Dinosaurs see: https://en.wikipedia.org/wiki/Crystal_Palace_Dinosaurs

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The Victoria and Albert Museum holds copies of the five reports of the Royal Commissioners responsible for constructing the exhibition buildings and facilities and staging the Great Exhibition. Reading through them, looking for information on the management of the construction process several aspects stand out. The first is, the first report was not written until after the exhibition finished. And the major disappointment was the fact the construction was contracted to the engineering firm Fox, Henderson and Co, and as a consequence, the actual construction management processes were not documented by the Royal Commissioners.

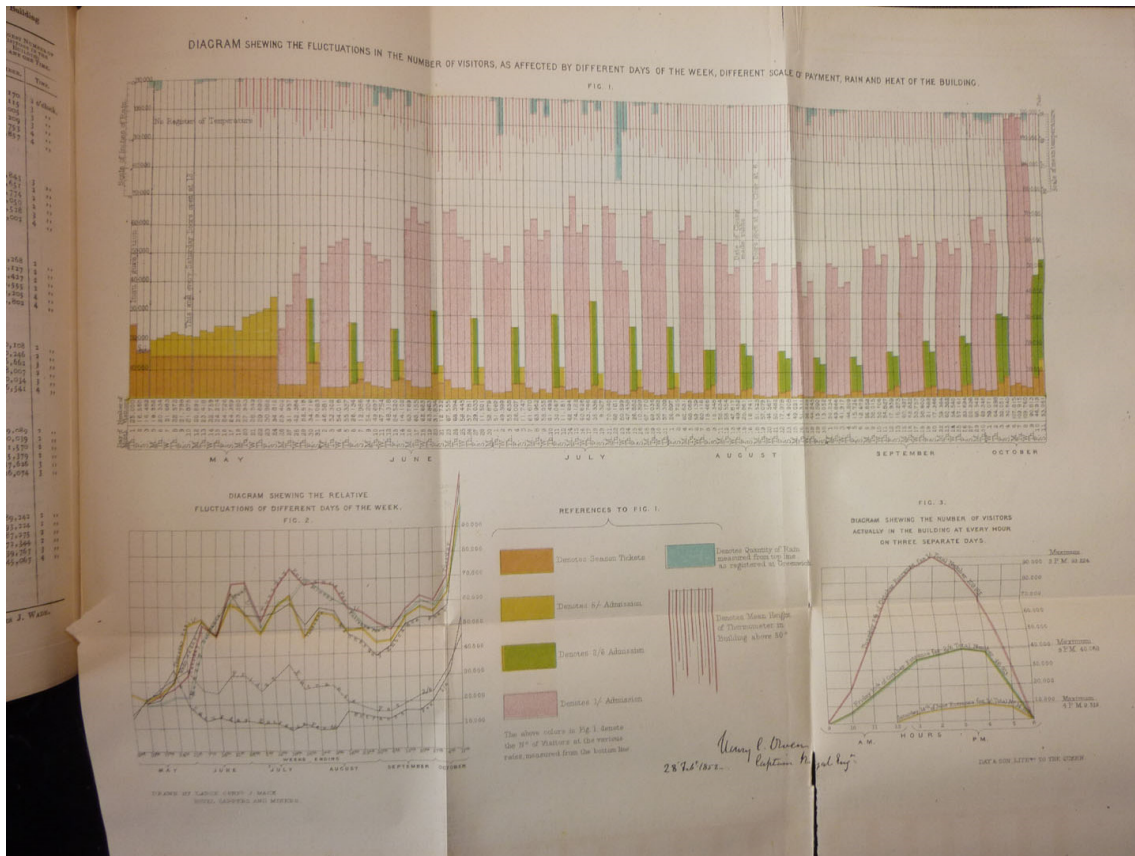


Fig. 6 The very fragile nature of the report prevented a better image being captured. However, the use of graphical images to convey complex data is apparent, as demonstrated by this high-quality chart detailing attendance against a range of daily factors. The chart clearly demonstrates the ideas embedded in William Playfair's *Atlas* of 1801 were understood and in general use (Royal Commissioners are rarely adventurous). The various diagrams include line graphs, histograms and date scales but unfortunately only relate to the period the exhibition was open to the public.

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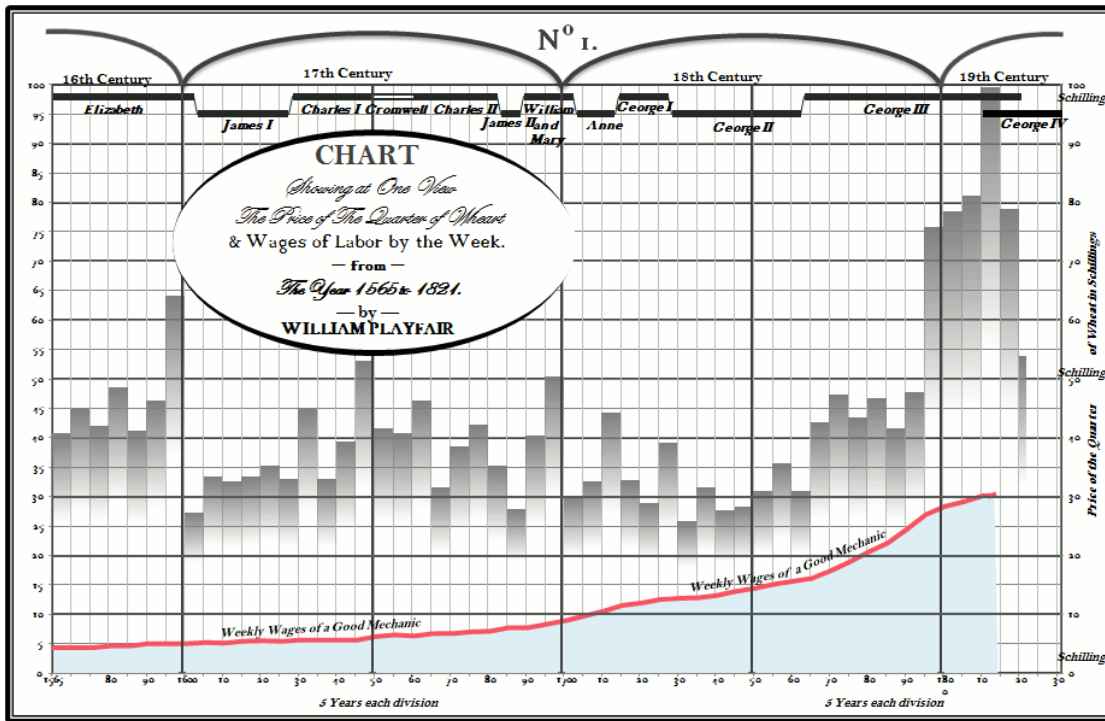


Fig. 7 For comparison, a chart by William Playfair from 1821.

Detailed records of the construction process are also reported by the commissioners. Information on the construction workforce on site indicates sophisticated record keeping, as can be seen from the table below, the workforce on site peaked at 2145, supported by many more off site engaged in the fabrication and transport of the component parts to Hyde Park.

246,210 Panes, 49 inches by 10 inches.
47,445 Ditto other dimensions.
293,655 Panes.

RETURN showing the Number of MEN Paid each Week in Hyde Park, in the Erection of the Exhibition Building.

Week ending—	No. of Men.	Week ending—	No. of Men.	Week ending—	No. of Men.
1850		1850		1851	
3 August	30	6 December	2,128	4 April	2,128
9 "	57	13 "	2,128	11 "	2,153
16 "	60	20 "	2,074	18 "	2,225
23 "	43	27 "	2,035	25 "	2,147
30 "	50	1851		2 May	2,149
6 September	56	3 January	2,145	9 "	1,697
13 "	86	10 "	2,098	16 "	541
20 "	128	17 "	1,758	23 "	499
27 "	293	24 "	1,653	30 "	450
4 October	467	31 "	1,417	6 June	442
11 "	590	7 February	1,333	13 "	381
18 "	808	14 "	1,210	20 "	369
25 "	841	21 "	1,244	27 "	216
1 November	1,538	28 "	1,353	4 July	175
8 "	1,924	7 March	1,613	11 "	152
15 "	1,936	14 "	1,974	18 "	139
22 "	1,935	21 "	2,030	25 "	127
29 "	2,129	28 "	2,071	1 August	103

FOX, HENDERSON, & Co.

Fig. 8 Record of the on-site workforce.



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Recognising the risks associated with using relatively untried technologies in such a monumental structure, quality control was given a very high priority. Inspectors and superintendents were appointed and quality control processes included stress testing components and load testing foundations implemented.

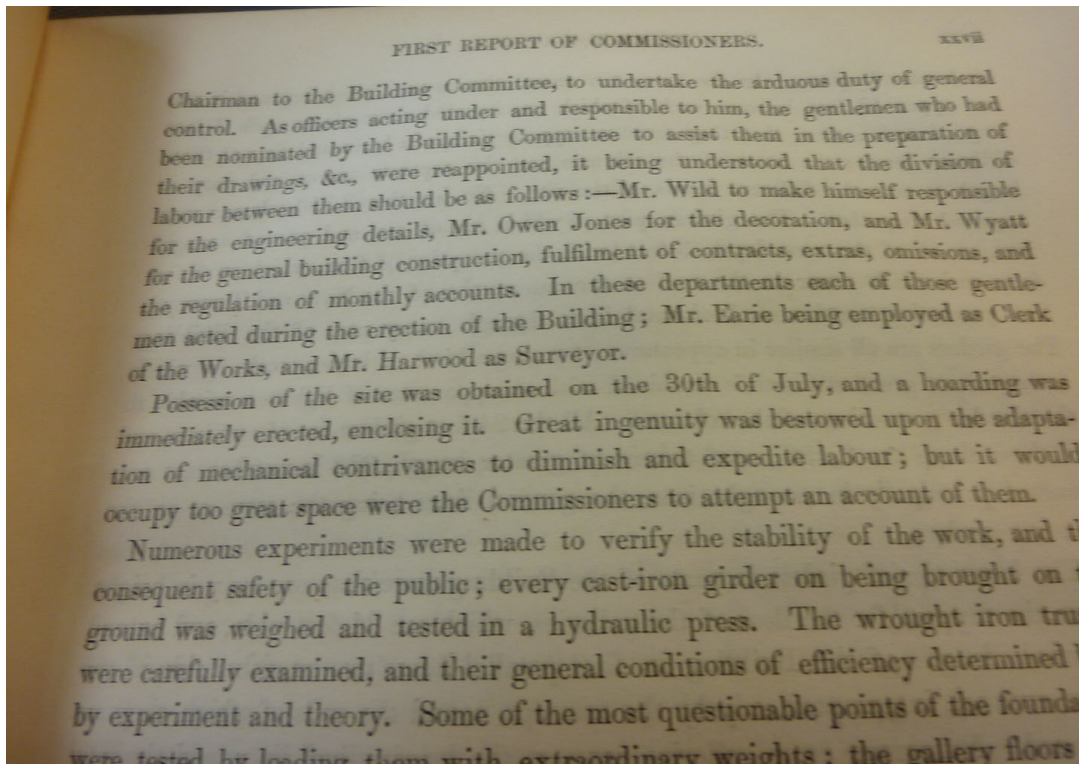


Fig. 9 Commentary on Quality Assurance and supervision.

And as would be expected, the accounting of all costs, including the construction costs was precise to the Farthing (1/4 of a penny). The exhibition was a popular and financial success with a final profit of £186,436 18s and 6d (in pounds, shilling and pence⁵). These profits were used to found the Victoria and Albert Museum and the Science Museum in London.

⁵ For a description of pre-decimal English currency see:
<https://www.royalmintmuseum.org.uk/journal/history/pounds-shillings-and-pence>

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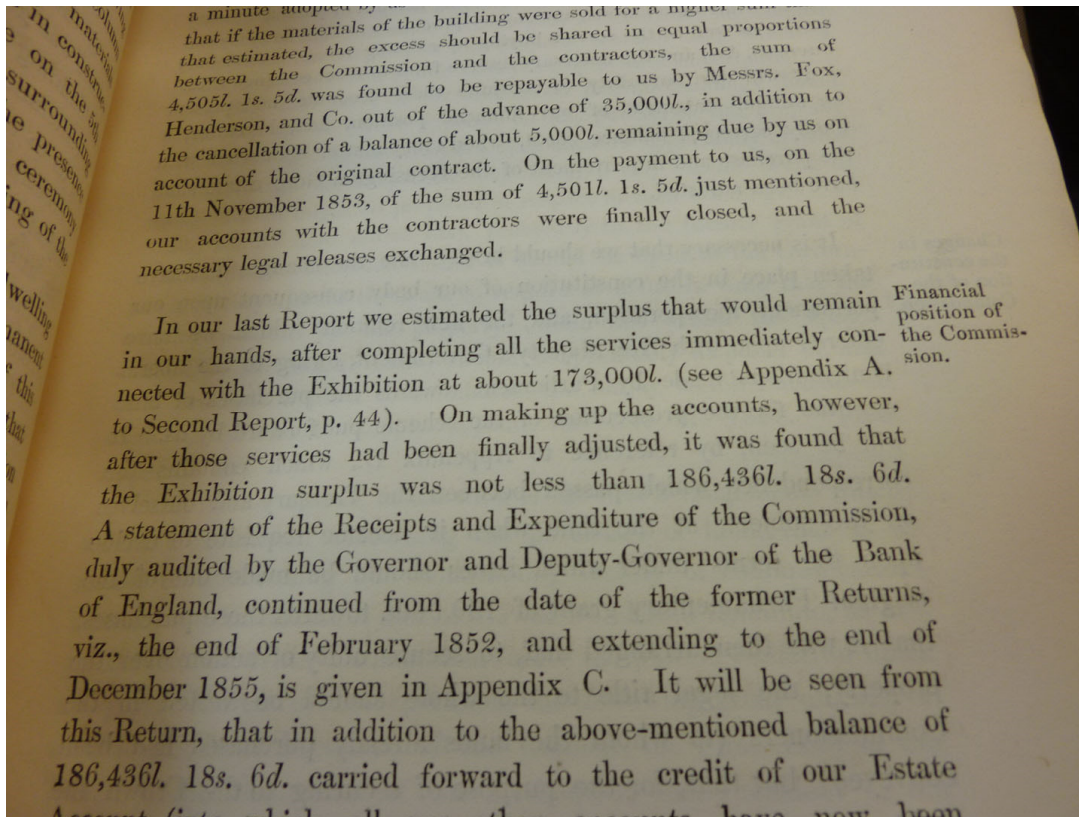


Fig. 10 The final profit.

There is also an interesting recognition of the problems of building such a massive structure in such a short time from a very basic initial design. There were many improvements in the design implemented as the work progressed causing the builder to incur a substantial loss, particularly as finishing late was not an option.

The Commissioners recognised this issue and made provision to compensate Fox, Henderson and Co for the losses that could be justified. Their original tender was £79,800, an additional £35,000 was approved in November 1851 and a final payment of £4,505 1s 5d closed the accounts after taking into account the sale of the structure for £70,000 to Fox, Henderson and Co for re-erection in what's now the suburb of Crystal Palace.

This understanding of the problem and willingness to work collaboratively to resolve it was no doubt helped by the presence of Sir William Cubit on the Commission. He owned a leading construction company and was a founder of what is now, 180 years later, the Chartered Institute of Building. However, for any Royal Commission to be able to properly dispense public money systems needed to be in place to properly quantify and cost the consequences of the changes needed to complete the building. This suggests sophisticated cost accounting processes within the building company as well as the Royal commission.

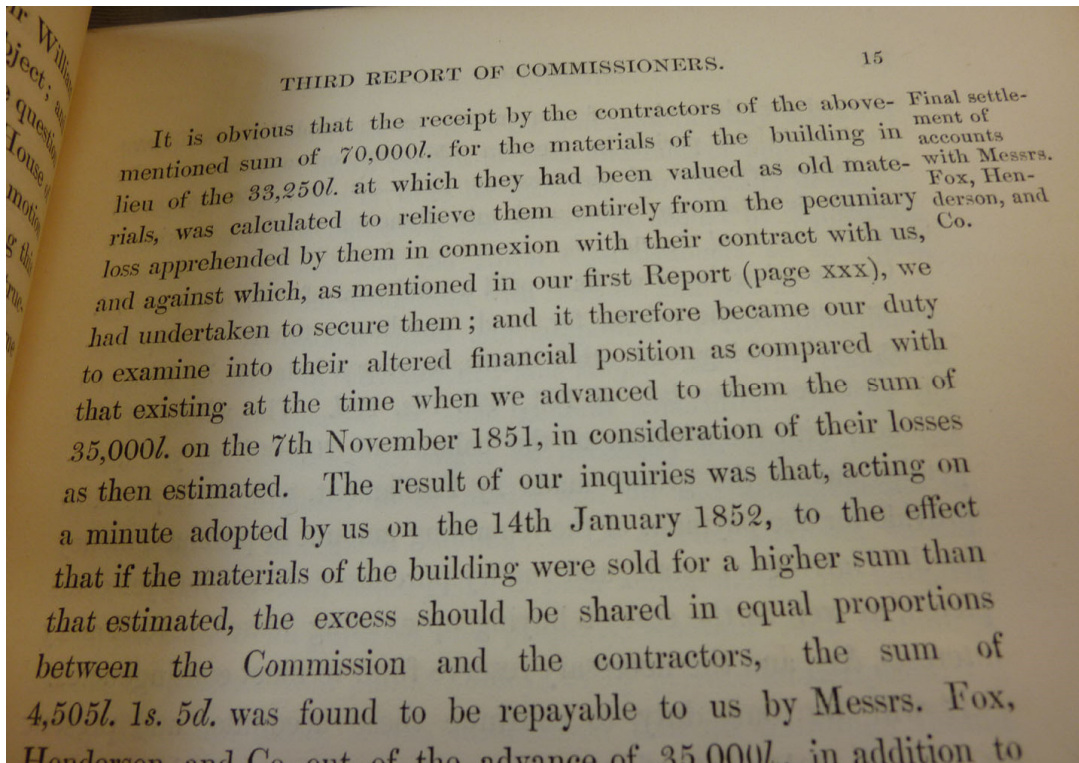


Fig. 11 Summary of the final account.

Conclusion

The reports of the Royal Commissioners show a very fine appreciation of governance. The objective of governance defined by Sir Adrian Cadbury Some 150 years after the Crystal Palace was built and the Great Exhibition staged is to *“holding the balance between economic and social goals and between individual and communal goals. The governance framework is there to encourage the efficient use of resources and equally to require accountability for the stewardship of those resources”*⁶. This defines governance as a pragmatic process focused on outcomes, not the blind imposition of undue process.

The Royal Commissioners demonstrably achieved those objectives by ensuring adequate compensation to the builder and ensuring the preservation of the Crystal Palace despite Parliament voting against retaining it in its original location. Flexibility was shown when needed allowing work to start months ahead of the contract signing which in turn allowed the exhibition to open on time but financial and quality controls were strict and effective.

⁶ For more on governance see:

http://www.mosaicprojects.com.au/WhitePapers/WP1033_Governance.pdf



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Additionally, the results of the building contract strongly suggest the project was effectively controlled and managed. But unfortunately, whilst there are tantalising glimpses of sophisticated systems that could effectively manage extended off-site supply chains, large workforces and mechanised production; whilst dealing with the small tolerances allowed in modular cast iron, none of these have been preserved in the records of the Royal Commissioners. This is probably understandable given the Commissioners were the customer, not the builder and they had the overall responsibility of staging a massive event but it is disappointing.

The primary objective of my research⁷ was to identify the processes used by Fox, Henderson and Co to sequence, schedule, organise and manage the construction of a very large building in a remarkably short timeframe, with particular emphasis on time management. These records were not found and consequently, we still don't really know or understand how the major construction works of the 18th and early 19th century were managed.



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⁷ This paper is one of a series looking at the history of project management and project controls. The research was focused on filling the gap in knowledge of project controls during the industrial revolution.

For more on the development of the concepts supporting the creation and use of bar charts see:
http://www.mosaicprojects.com.au/PDF_Papers/P182_The_origins_of_bar_charting.pdf

For more on the development of scheduling in the 20th century see:
https://mosaicprojects.com.au/PDF_Papers/P042_History_of_Scheduling.pdf

