



# THE UNIVERSITY *of* EDINBURGH

This thesis has been submitted in fulfilment of the requirements for a postgraduate degree (e.g. PhD, MPhil, DClinPsychol) at the University of Edinburgh. Please note the following terms and conditions of use:

This work is protected by copyright and other intellectual property rights, which are retained by the thesis author, unless otherwise stated.

A copy can be downloaded for personal non-commercial research or study, without prior permission or charge.

This thesis cannot be reproduced or quoted extensively from without first obtaining permission in writing from the author.

The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the author.

When referring to this work, full bibliographic details including the author, title, awarding institution and date of the thesis must be given.

**The Role of Instruments in Exploration:  
A Study of the Royal Geographical Society 1830-1930**

**Jane Amanda Wess**

PhD in Geography  
The University of Edinburgh  
2017

## **Abstract**

The thesis presents the first in-depth study of the role of measuring instruments in a leading scientific society concerned with field science. It draws upon a substantial literature in the history of science, geography, and exploration and makes use of actor network theory. The thesis considers the instruments to have been assimilated into an iterative cyclical process. By studying each aspect of the cycle, a comprehensive understanding of the integration of instruments into the working practices of the Society, the process of exploration, and ultimately the British imperialist endeavour, has been achieved. The start date is that of the founding of the Society. The end date approximates to the retirement of the map curator Edward Reeves, when recording practices at the Society changed. The century has coherence as the instruments remained essentially similar. The thesis therefore draws on a range of archival material: the journal articles, the medal awards, and the maps in addition to the paper archives, minute books and instruments themselves. The empirical findings have been enriched by reference to a substantial literature from historians of science, historical geographers and instrument historians.

The thesis documents instrumental activity on behalf of the Society from acquisition to disposal or loss, regarding activity on behalf of the Society as 'added resource'. The thesis argues that the ambitions of the Society were slow to be enacted, and that a collection of instruments for lending was not formed until 1850. The preparation of travellers has been discussed as a complementary activity; systematic provision is likewise found to have been slow. Having studied fifty expeditions with respect to instrument mobilisation, from which excerpts are presented, a number of factors are identified which affected success, and the fallibility of instruments is confirmed. The itineraries of over a thousand individual items have been charted and made available in a database which will assist future research.

The agencies of the instruments have been considered to be knowledge creation, individual reputation, empire, and social relations. The RGS developed strategies for militating against the fallibility of instruments in the field to provide credible outcomes. The instrumental data was manipulated by a growing body of professionals which served to moderate results. The instruments conferred social and epistemological authority to some groups more than others, but not necessarily in the manner predicted by existing theories. The geographical endeavour could be subsumed into imperialist demands. The instruments reflected and strengthened existing social hierarchies. The conclusions drawn indicate that historians of science and geography need to look at the role of instruments in more detail than extant models of knowledge creation, including ANT, suggest.

## Lay Abstract

The thesis looks at the way the Royal Geographical Society used measuring instruments in order to further exploration in the century between 1830 and 1930. As the instruments were frequently sent out multiple times, and the same locations on the globe were repeatedly visited, the process can be considered cyclical, with data from the observations being sent back to the RGS in London. The resulting maps were compared and contrasted to contribute to an agreed knowledge of far-flung places. The start date is that of the founding of the Society. The end date approximates to the retirement of the map curator Edward Reeves, when recording practices at the Society changed. The century has coherence as the instruments remained essentially similar. The thesis draws on a range of material: The journal articles, the medal awards, and the maps in addition to the paper archives, minute books and instruments themselves.

The thesis investigates the procurement of instruments by the Society, comparing what was considered ideal with what happened in practice. It views the instruments as items of value, with the RGS adding to that value by repairing, calibrating, testing, weeding out, inscribing and eventually insuring them. The thesis argues that the ambitions of the Society were slow to be enacted, and that a collection of instruments for lending was not formed until 1850. The Society also prepared travellers who were to use the instruments in the field, spending money and effort on producing texts and providing hands-on training. When the instruments and the travellers came together in the field the results should have been reliable. However, having studied fifty expeditions, it was found a number of factors could hamper observations, and the instruments were often fallible.

The RGS developed strategies for dealing with fallible observations so that knowledge was created anyway. One method was the manipulation of results by human calculators and draughtsmen who could alter results if they were unbelievable. Another was the publication of papers containing no instrumental data. The mere fact of borrowing instruments was sufficient to increase the chance of a paper being published; it was not always necessary to use them effectively. The instruments were shown to enhance reputations but had less of a positive effect on women and non-Europeans. The RGS worked closely with the state; when under pressure, as in WW1, the government appropriated the Society's amenities including the instruments so they worked directly for the British Empire. The instruments were also shown to reflect and strengthen existing social hierarchies. These findings do not align completely with any model of science.



## LIST OF CONTENTS

Title Page	1
Abstract	2
Lay Abstract	3
List of Contents	4
List of Figures	7
Acknowledgements	12
Abbreviations	14
CHAPTER 1: Introduction	15
Purpose of study	15
Primary Source Material	17
Archival Approach	21
Questions of Methodology	22
Thesis Framework and Principal Research Questions	27
CHAPTER 2: The Research Context	33
Histories of Science as Practice	33
Histories of Geography and Exploration	37
Instrument Studies	47
Conclusion	50
CHAPTER 3: Patterns of Activity	52
Instrument Acquisition	52
Instruments Deployed	59
Management of Instruments	63
Borrowers and Their Training	64
Expeditions	66
Types of Measurement or Activity	71
Outcomes	72
Conclusion	74
CHAPTER 4: Instruments and their Embedded Value	76
Defining 'Proper' Instruments	76
Acquisition Practice	85
Instrument Management	91
Instrument Design	100

Supporting Mathematics	107
Conclusion	113
CHAPTER 5: The Preparation of the Travellers	115
Recognition of Need	115
Advisory Texts	116
The Role of Hints (1883) Onwards	126
In-house Instruction	129
Conclusion	143
CHAPTER 6: Mobilisation in the Field	145
Factors Affecting Instrumental Practice:	148
The Ability of the Traveller	148
Physical Conditions	159
Human and Political Constraints	162
Logistical Issues	168
Systemic Issues	174
Conclusion	183
CHAPTER 7: Manipulation of Results	186
Calculation	189
Drawing and Map-Making	205
Conclusion	218
CHAPTER 8: The Agency of the Instruments	220
Knowledge Creation	220
The Creation of Reputations	235
The Creation of Imperial Power	240
The Construction of Social Relations	251
Conclusion	264
CHAPTER 9: Conclusion	265
Overview	265
Empirical Data Presented	267
Embedding Resource in Instruments	267
Resource Invested in Users	269
Mobilisation in the Field	271
Management of Data	273
The Agency of Instruments	275

BIBLIOGRAPHY	278
LIST OF EXTANT INSTRUMENTS	310

## List of Figures

- 1.1: First page of 'Instruments Lent To Travellers' (1860-1933)
- 1.2 a and b: Pages from 'Catalogue of Instruments' (1879-1933)
- 1.3: *The Arctic Council planning a search for Sir John Franklin* by Stephen Pearce, (1851)
- 1.4 a and b: The Map Rooms at Savile Row and Lowther Lodge, 1912 and 1913
- 3.1: Number of Instruments Acquired by Year 1830 -1930
- 3.2: Expenditure on Purchase of Instruments by Year 1830-1930
- 3.3: Comparison of Acquisition and Expenditure 1830-1930
- 3.4: Report Listing Instruments Lent To Expeditions between 1879 and 1883
- 3.5 a and b: Number of Instruments Purchased From Individual Makers 1830-1879 and 1879 -1930
- 3.6: Instruments Commonly Used c.1830-1860
- 3.7: Instruments Commonly Used c.1860-1900
- 3.8: Instruments Commonly Used c. 1900-1930
- 3.9 a and b: Choice of Instrument: A Comparison Between the Number of Barometers and Aneroids Acquired, and Between the Number of Sextants and Theodolites Acquired 1879-1930
- 3.10: Expenditure on Instrument Repair 1864 to 1930
- 3.11: Comparison of Spend on Acquisition and Repair 1864-1930
- 3.12: Composition of Borrowers 1830-1930
- 3.13: Annual Expenditure on Expeditions, Publications and Education 1877- 1914, from Jones M. (2005)
- 3.14: Number of Expeditions by Year Supported with Instruments 1830-1930
- 3.15 a to j: Destinations of Expeditions by Decade 1830-1930
- 3.16: Itinerary of Watch 9

- 3.17: Number of Instruments by Type of Measurement or Activity 1879-1930.
- 3.18 a and b: Proportion of Borrowers Publishing, and Number Publishing in non-RGS Publications 1830-1930
- 3.19: Borrowers who became Medallists 1830-1930
- 4.1 a, b, and c: Title Pages for Jackson (1841), *Hints to Travellers* (1854), and Galton (1856)
- 4.2: Some Instruments Listed by Jackson (1841)
- 4.3: Changes in Sextants
- 4.4: Changes in Compasses
- 4.5: National Instruments
- 4.6: Instruments from the Arctic Expedition of 1875
- 4.7: The Wild Photo-Theodolite, 1926
- 4.8: The First Listing of Instruments in the *JRGS* 1851
- 4.9: The Kew Certificate for 2.5 inch Aneroid RGS No 12
- 4.10: Watch RGS No 21 by Friedlander 1892
- 4.11: Frontispieces of Advisory Works on Instruments: Jones (1830), Gilbert (1829), and Simms (1834)
- 4.12: Francis Galton and his Instruments
- 4.13: George's Pattern Double Sextant and Artificial Horizon
- 4.14: Edward Reeves and His Instruments
- 4.15; *Hints To Travellers* (1883) p.152
- 4.16 a and b: William Whewell's Tidal Isomap, and Magnetic Isomap of 'India and High Asia' by Hermann and Robert Schlagintweit
- 4.17 a and b: Francis Baily, Frontispiece from Baily (1827)
- 5.1: Pages Demonstrating Mathematical Calculation from *Hints* (1883)

- 5.2 a and b: Hypsometers from *Hints* (1865) and *Hints* (1906)
- 5.3: Illustrations from the Ninth Edition of *Hints* (1906)
- 5.4: John Coles
- 5.5: An Example of the Sheets for Working Provided by Coles
- 5.6 a and b: The Lone Traveller Versus the Professional Surveyor in the Mid-Nineteenth century.
- 6.1 a, b, and c: Common Problems in the Mobilisation of Instruments
- 6.2: Galton's Note Concerning Reading Thermometers
- 6.3: Edward Whymper Descending the Pointe Des Ecrins in the 1860s
- 6.4: Douglas Freshfield Contemplating Snow
- 6.5: Photograph Entitled 'Camel Carrying a Chronometer' by Francis Rennell Rodd, 1927
- 6.6: 'Montoil Pagans Running Away From The Survey Party' from Joan Alexander
- 6.7 a and b: Isabella Bishop's Baggage Coolies at Chekiang, and a Sedan Chair, 1895
- 6.8: Robert Cheesman, Camel Boy, and Camel, Dohat Salwa Coast, 1921
- 6.9: A Sketch by Albert Markham Entitled 'Commander Markham's Farthest North' in 1875
- 6.10 a and b: Barograph by Casella and Recording of Tremors Krakatoa. 1883
- 6.11 a and b: Ralph Bagnold and Colleagues in the Libyan Desert in 1929-30:
- 7.1 a and b: Boiling Point Observations by William Chippindall on the White Nile in 1875, and by John Gregory in Yunnan in 1922
- 7.2: Calculating Instruments
- 7.3 a and b: David Livingstone's Data with Thomas McClear's Comments, Livingstone's Map of his Route from Sesheke to Loanda, 1854
- 7.4 a and b: George Everest's Suggestions for Tabling Results, and William Spottiswode on Probabilities.

- 7.5 a, b, and c: Speke's Notebooks, Manuscript Map of Speke and Grant's Route from Zanzibar to the Nile, and Sketch of Route by Speke To Lake Victoria, 1857-1859
- 7.6 a and b: Calculating and drawing in the field: Maudslay Drawing in Yucatan 1889, and computations at Nizamghat on the Mishmi Expedition in East India 1912-13
- 7.7: Drawing Instruments
- 7.8: Isochronic Passage Chart for Travellers by Galton, 1881
- 7.9: Political and Physical Chart of the World on Gall's Projection, by Bartholomew, 1869
- 7.10: Sketch Maps by Harry. H. Johnston and William Marsh Strong Demonstrating Differing Results by Different Instruments
- 8.1: Robert Schomburgk's Map of British Guayana, 1836
- 8.2: Galton's map of Africa Between 10 and 30 Degrees South latitude, 1852
- 8.3: Map of Burton and Speke's Expedition from Pangani to Fuga, 1857
- 8.4 a and b: John Duncan's Map From Whyda to Adafodia in 1845 and 1846, and Rae's Map of the Arctic Exploration of 1854
- 8.5: Sketch Map of N. Morocco by Walter Harris, 1889
- 8.6: 'Map showing the Plane-table and Compass Traverse by Frank Kingdon Ward and Earl Cawdor in South-Eastern Tibet in 1924'
- 8.7: Portrait photographs of John Rae and Frederick Selous, Medallists
- 8.8: Map to Show the Work of the Peru-Bolivia Boundary Commission 1911 to 1913
- 8.9: Schomburgk's Luggage Carried by Indigenous People
- 8.10: "Moobarik Bombay" who Accompanied Captain Speke in Central Africa, 1860
- 8.11 a and b: Map Attributed to Lal and Ram Singh, 1913, and the Published Map Attributed to Stein Dated 1933.
- 8.12: Tibetan Porter Carrying Kingdon-Ward's Supplies

8.13 a, b, c and d: Images from the London Illustrated News showing Norman Lockyer's 1871 Eclipse Expedition to India, and Observing the Transit of Venus in Honolulu in 1874

8.14 a and b: 'Team Member with Surveying Equipment' in Tibet in 1905, and Edward Wheeler Photographed in 1921



## Acknowledgements

I would like to thank the Arts and Humanities Research Council for making this research possible through the Collaborative Doctoral Award.

My academic supervisor Prof Charles Withers immersed me rapidly into the rich literature of historical geography, opening up a new world of ideas and debate. His wide reading and extensive knowledge has been an inspiration, as has his ability to write concisely and beautifully. I am extremely grateful to him for investing faith in my ability to succeed in this project, which for me was a second start. His energy and momentum has been tireless in advising new reading, and the incorporation of different points of view. In spite of being four hundred miles away, the department of Geography at Edinburgh has made me feel welcome and given me a sense of belonging.

My second supervisor Dr. Catherine Souch at RGS-IGB could not have been more supportive. Catherine has been generous with her time in giving me advice, especially on the vital structuring of the literary review and the conclusion. As well as practical and academic help she has provided encouragement. At all times I have known she is there should the need arise.

My third supervisor, Eugene Rae, has shared my enthusiasm for instruments and been a willing participant in many conversations about the incredible journey of such and such, the exploits of so and so with the amazing anemometer by Cary (for example). These enthusiasms make me eager to get to the RGS every day. Eugene has a very considerable knowledge of the instrument collection which he has been generous in sharing.

Stephanie Wyse has provided technical support without which I could not have produced chapter 3 in this form. Sarah Evans has been a constant support, and her PhD has been valuable as a model for this work. Francis Herbert, the retired Map Curator, shared the results of his research with me and Ted Hatch, the retired draughtsman, has also provided information regarding the practices of the drawing office before the digital age. Marie Gallagher was kind enough to spare her time to help me with formatting.

I would like to thank all the staff in the Foyle Reading Room for their hard work and patience. In particular Jan Turner enabled me to produce a small exhibit for the Annual conference in 2016, and Joy Wheeler has provided many images very promptly. Our community of PhD students, now a substantial body, has been an important element of the project. We share the enthusiasms, the frustrations and the pleasure of being associated with the RGS -IBG, working together to promote the RGS-IBG, supporting each other's presentations, and discussing progress every month.

I would like to acknowledge the support from a raft of colleagues outside the RGS-IBG. I am constantly grateful for the encouragement of Simon Schaffer whose opinions count more than I can say. Dr. Jennifer Leonard of Sydney University was kind enough to read and comment on chapter 1. Others include my one-time collaborator Alan Morton, my one-time

colleague Kevin Johnson, my friend Jane Insley who has also embarked on the challenge of a Phd, and the wider community of curators: Gloria Clifton, Alison Morrison Low, Megan Barford, Richard Dunn, Peggy Kidwell, Kim Sloan, Stephen Johnston.... I could go on at great length. Alison provided luxurious and welcoming hospitality whenever I visited Edinburgh. The community of historical geographers has been a new discovery for me, opening up fresh avenues of research and providing a friendly and lively forum for discussion. It is usual to thank your family for suffering, but the PhD years have been a good time for us.

What has been special about the last three to four years is the RGS-IBG itself. I look forward to seeing Taslima and Annette on the desk. I smile at numerous people who smile back. I have no idea of their names or what they do but we enjoy interesting conversations over lunch. The sun streams in through the windows, and every day becomes enjoyable. Whatever the foibles of the RGS between 1830 and 1930, the Society has got a lot right now. It has been a privilege to be part of it.

## **Abbreviations**

RGS Royal Geographical Society

RGS-IBG Royal Geographical Society with the Institute of British Geographers

RS Royal Society

JRGS Journal of the Royal Geographical Society

PRGS Proceedings of the Royal Geographical Society

GJ Geographical Journal of the Royal Geographical Society

CM Council Minutes of the RGS

IC RGS Instruments Committee minutes

FC RGS Finance Committee minutes

EC RGS Expedition Committee minutes

SPC RGS Scientific Purposes Committee minutes

ScM Science Museum, London

RAS Royal Astronomical Society

AP 52 ILT Instruments Lent to Travellers 1860-1933

AP 52 CI Catalogue of Instruments 1879-1933

AP 52 IIR Instruction and Instruments Report 1883

JMS Journal manuscript

LMS Library Manuscript

CB Correspondence Block

SSC Small Special Collection

## Chapter One:

### Introduction

*If you want to study a scientist, find out first what kind of instrument he or she is using, and then observe what the scientist does to the instrument and with the instrument.<sup>1</sup>*

#### **Purpose of Study**

This thesis addresses the role of instruments within the context of the exploratory endeavour supported by the Royal Geographical Society in its first century of its existence. It places the instruments at the centre of the undertaking, asking what input was required in order to provide and maintain them, and what output was expected and obtained from them. The outputs include the data, maps, and publications, but also the authority the instruments symbolised, the credibility they established, and the hierarchies they reflected and created.

Measuring instruments are intrinsic to modern science. Historians of science increasingly incorporate artefacts into their discourses in recognition of their distinctive place in knowledge creation.<sup>2</sup> 'With the 'material turn' in the humanities, historians of science have paid greater attention to collections of all kinds, and to their structures and histories.'<sup>3</sup> One of the many rich and varied approaches to the construction of science to have emerged in the past forty years is Actor Network Theory (ANT), which is particularly applicable to field science.<sup>4</sup> Exploration in the period under study has characteristics both general to field science and unique to its spatial and temporal locations. This study investigates the role the instruments played in the construction and maintenance of exploration as a practice during the period, and questions to what extent the practice of exploration can be explained with reference to ANT. There is a substantial contextual literature in the history of science, but there has not been a detailed study of an institutional archive in order to support various claims relating to instruments in order to understand the ways in which their influence was brought to bear and with what result.

From its inception in 1830 the Royal Geographical Society (RGS) has been a central institution for the promotion of geography, being situated physically and culturally at the heart of the British Empire.<sup>5</sup> The Royal Geographical Society- Institute of British Geographers (RGS-IBG) continues to have resonances both with other national geographical institutions and the various scientific societies which were founded in London at around the same time; it is both significant and typical. The RGS-IBG possesses an archive which can provide a

---

<sup>1</sup> Jones D. (2005) p.6

<sup>2</sup> Wise and Smith (1986), Latour (1987), Schaffer (1992b), Porter (1995), Wise (1995), Alder (2002), Galison (2003), Gooday (2004), Aubin, Bigg and Sibum (2010), Crease (2011)

<sup>3</sup> Finnegan (2008)

<sup>4</sup> Latour (1987), (2005)

<sup>5</sup> Driver (2001) p. 25, Stafford (1989) pp. 211-212

unique insight into the practice of geography. This thesis forms part of a larger programme of academic research into various aspects of the collection.<sup>6</sup> It represents an opportunity to study mathematical instruments together with their related documentation, which provides detailed evidence of their use.

The words in the title require explication. 'Role' is considered broadly and includes the provision of empirical data and other material outputs, the conferring of authority, credibility, and scientific status for geography and exploration. For the actors the meaning of 'instrument' was assumed: 'Instruments' were artefacts separate from the bodies of the humans involved in using them, or the phenomena they were investigating. They included those lent out for use in the field, those used in the Map Room, those used in instruction, and those accepted as relics. While all these are acknowledged, and the actors' category is preserved, the focus is on the first three activities as being directly engaged with exploration. The instruments either measured and produced numerical results or, in the case of drawing and sketching instruments, transformed those numbers into representations in two dimensions.

The term 'mathematical instrument' was still used in this period and all those included under this term are the subject of study.<sup>7</sup> Generally speaking they are measuring or drawing instruments used by practitioners, as distinct from philosophical instruments which are designed to encourage contemplation by their demonstration. Items referred to as 'apparatus', such as photographic apparatus and telegraphic apparatus, are not included. The definition of an instrument in ANT is too broad to be usefully applied here.<sup>8</sup>

'Exploration' was a term under construction in the period of the founding of the RGS; a great deal of work was done by the institution to define it, the contributory tensions being manifest in various ways.<sup>9</sup> Exploration was normally understood to be the investigation of parts of the globe not previously well-known to Europeans, with a view to establishing useful scientific, cultural and economic knowledge. The RGS increasingly undertook other activities during the century, but the study is restricted to that of exploration. 'Explorer' was a word not universally applied in the period; 'traveller' the more generally assigned term, is therefore used here, following Adriana Craciun.<sup>10</sup>

The various societies founded in London around 1830 played a significant role in the defining of new scientific disciplines. While the growing professionalization some historians have discussed as a complementary development was too tenuous to be confidently included at the RGS, it is argued it had some impact.<sup>11</sup> As geography was becoming established as a discipline taught in schools and universities during the period under consideration, the RGS

---

<sup>6</sup> <http://www.rgs.org/OurWork/Research+and+Higher+Education/AHRC+Collaborative+Doctoral+Awards/AHRC+Collaborative+Doctoral+Awards.htm> April 2017

<sup>7</sup> Exposition Internationale (1910), Warner (1994) p. 66-68

<sup>8</sup> Latour (1987) p. 68

<sup>9</sup> Kennedy (2014) p. 1

<sup>10</sup> Craciun (2011) abstract

<sup>11</sup> Driver (2001) p. 32, Cock (2005) p. 96

took on a wider remit.<sup>12</sup> Geography had a particularly salient role in empire building and colonialism, but its status as a science was fraught.<sup>13</sup>

It was expected that the instruments, which embody a great deal of knowledge and skill, would be used in the establishment of the credibility of geography, and that the legacy of these instruments in the form of numerical data, maps and charts, should be pressed into service to uphold the interests of their owners. The production of quantitative results has been seen as essential in positioning the members of the RGS as distinct from various other groups such as indigenous people, traders, and those travelling for pleasure or sport.<sup>14</sup> This view, it is argued, is simplistic as it corresponds to an ideal situation. It can be shown that many and varied departures took place from the theoretical models of the scientific method, or the predicted patterns of a system such as ANT. It is argued the instruments played a vital role in conferring credibility, but not always in the straightforward manner of producing reliable numerical results.

### **The Primary Source Material**

Starting in the 'club land' of the West End of London, around which it resided for nearly a century, the RGS moved to South Kensington in 1913. The centrality of its sites has been influential in maintaining the Society as an important constituent of the scientific establishment from the early nineteenth century.<sup>15</sup> While only the paper repository is referred to as the 'archive', the building, maps, paintings, lantern slides, library, photographs and artefacts form a cohesive, inseparable whole, each a constituent part of the Society's history.

In 2004, the Society's collection was opened up to the public in a new facility.<sup>16</sup> Simultaneously the RGS-IBG set up a programme of doctoral studies of various aspects of the collection, of which this is one.<sup>17</sup> The building currently consists of three sections: an authoritative Victorian core, a 1930s lecture theatre expanding the audience but maintaining control, and a twenty-first century facility where the public can engage with the materials.

Jacques Derrida notes that; 'The technical structure of the archiving determines the structure of the content.'<sup>18</sup> The paper archive consists of: the council minute books and the committee minute books of the society, the former from its founding in 1830, the latter from 1841, correspondence in the form of Director's enquiries, reports of events, lists of medal winners and awards, papers submitted to the Journals, referees' comments on those papers, and special collections relating to explorers which have usually been donated by their relatives. The changes predicted by archival theory in respect of digitisation have not taken

---

<sup>12</sup> Bridges (2002) p. 61

<sup>13</sup> Driver (2001) p.50, Withers (2010) p. 188

<sup>14</sup> Kennedy (2014) p. 2

<sup>15</sup> <http://www.rgs.org/HomePage.htm> December 2013

<sup>16</sup> <http://www.unlockingthearchives.rgs.org/> February 2014

<sup>17</sup> Davis-Brown (1998) p.18

<sup>18</sup> Derrida (1995) p.17

place, as the funding has not been available, which serves to privilege the physical space in South Kensington.<sup>19</sup> The society purchases maps and books but the collection of instruments was closed in 1990. The instruments are stored according to where they went, with those going to multiple places in a separate category; this arrangement, if idiosyncratic, is revealing of their strong association with the expeditions.

Two documents are particularly important in understanding the acquisition and use of the instruments. The first, begun in 1860, is entitled 'Instruments Lent to Travellers,' and gives a list of expeditions consisting of dates, travellers, and destinations with the Society's instruments as seen in fig 1.1.<sup>20</sup> The second, entitled 'Catalogue of Instruments,' appears to have been started around 1879.<sup>21</sup> It consists of a listing by type of the individual instruments, the date of acquisition, and the cost if purchased. The instruments are cross-referenced to pages of 'histories' where the itinerary of each instrument is recorded, as seen in fig 1.2.

---

<sup>19</sup> [http://www.nationalarchives.gov.uk/about/our-role/plans-policies-performance-and-projects/our-projects/discovery/August 2016](http://www.nationalarchives.gov.uk/about/our-role/plans-policies-performance-and-projects/our-projects/discovery/August%202016)

<sup>20</sup> AP 52 ILT

<sup>21</sup> AP 52 CI

**I**

LIST OF INSTRUMENTS LENT TO TRAVELLERS.

No.	Date.	Name of Explorer.	Place of Exploration.
1	March 27 <sup>th</sup> 1861	Dr. J. Rae, M.D.	Canada & British Columbia.
2	April 2 <sup>nd</sup> 1861	Consul J. Retherick.	Sources of Nile from Khartoum.
3	April 3 <sup>rd</sup> 1863	Mon <sup>r</sup> . Jules Gerard.	Gambia - West Africa.
4	Aug. 5 <sup>th</sup> 1863	Mon <sup>r</sup> . B. Du Chaille.	River Gaboon.
5	Oct. 10 <sup>th</sup> 1864	Capt. B. Pim.	Nicaragua - South America.
6	April 21 <sup>st</sup> 1865	R. B. W. Walku, Esq <sup>re</sup> .	River Gaboon.
7	Feb. 25 <sup>th</sup> 1867	E. Wymper, Esq <sup>re</sup> .	Greenland.
8	Sep. 23 <sup>rd</sup> 1867	Rev <sup>d</sup> . J. W. Holland.	Mt. Sinai - Palestine.
9	Mar. 28 <sup>th</sup> 1867	H. Whiteby, Esq <sup>re</sup> .	Brazil - River Amazon.
10	May 22 <sup>nd</sup> 1868	W. W. Reade, Esq <sup>re</sup> .	River
11	July 2 <sup>nd</sup> 1868	G. J. H. Hayward, Esq <sup>re</sup> .	N. W. of the Punjab.
12	Oct. 12 <sup>th</sup> 1868	Rev <sup>d</sup> . J. W. Holland.	Mt. Sinai, etc.
12 <sup>3</sup>	May 24 <sup>th</sup> 1869	S. W. Baker, Esq <sup>re</sup> .	Nile Lakes.
13	Nov. 25 <sup>th</sup> 1869	C. F. J. Drake, Esq <sup>re</sup> .	Mt. Sinai, etc.
14	Dec. 14 <sup>th</sup> 1869	Rev <sup>d</sup> . J. Wakefield.	Mombas, towards Lake Victoria.
15	May 19 <sup>th</sup> 1870	R. B. Shaw, Esq <sup>re</sup> .	Pamir Steppe - India.
15 <sup>3</sup>	Mar. 31 <sup>st</sup> 1871	St. V. Erskine, Esq <sup>re</sup> .	Natal. South Africa.
16	Feb. 9 <sup>th</sup> 1872	Lieut. L. S. Dawson, R.N.	Zanzibar to Ujiji.
17	Nov. 22 <sup>nd</sup> 1872	Lieut. W. L. Cameron, R.N.	Search after Livingstone.
18	Nov. 30 <sup>th</sup> 1872	Lieut. W. J. Grandy, R.N.	Congo Expedition.
19	Nov. 1 <sup>st</sup> 1873	C. J. Hegan, Esq <sup>re</sup> .	Bolivia - South America.
20	Nov. 11 <sup>th</sup> 1873	Capt. A. H. Markham, R.N.	North Polar Expedition.
21	Dec. 4 <sup>th</sup> 1873	Dr. C. Becke.	Sinai - new position.
22	May 20 <sup>th</sup> 1874	W. L. Watts, Esq <sup>re</sup> .	Iceland.
22 <sup>3</sup>	Feb. 11 <sup>th</sup> 1874	Col. C. Gordon.	Nile Lakes.
23	July 28 <sup>th</sup> 1874	Lieut. C. M. Watson, R.F.	Nile Lakes.
24	May 19 <sup>th</sup> 1875	C. D. Young, Esq <sup>re</sup> , R.N.	Lake Nyassa.
25	May 28 <sup>th</sup> 1875	W. L. Watts, Esq <sup>re</sup> .	Iceland.
26	June 21 <sup>st</sup> 1875	Capt. A. Young, R.N.R.	Arctic Regions.
27	May 20 <sup>th</sup> 1876	H. K. Cothrell, Esq <sup>re</sup> .	Lake Nyassa.
28	May 24 <sup>th</sup> 1876	Capt. A. Young, R.N.R.	Smith's Sound - Arctic.
29	Oct. 13 <sup>th</sup> 1876	Rev <sup>d</sup> . L. W. Thomson.	East coast of Africa.
30	Dec. 4 <sup>th</sup> 1876	C. Congreve, Esq <sup>re</sup> .	Paraguay, South America.
31	Feb. 16 <sup>th</sup> 1877	J. A. Stretchley, Esq <sup>re</sup> .	West coast of Africa. Ivory Coast.
32	June 18 <sup>th</sup> 1877	A. C. Craven, Esq <sup>re</sup> .	East coast of Africa.
33	Nov. 11 <sup>th</sup> 1878	Keith Johnston, Esq <sup>re</sup> .	East coast of Africa.
34	Dec. 3 <sup>rd</sup> 1878	H. Forbes, Esq <sup>re</sup> .	Celebes.
35	Jan. 1879	F. A. A. Simons, Esq <sup>re</sup> .	New Granada.



Fig 1.1 First page of 'Instruments Lent To Travellers' (1860-1933).<sup>22</sup>

<sup>22</sup> AP 52 ILT p.1



*Theodolites*  
6 inch - Transit

No	Date	Makers Name	Price	Cost	Out on Hire	Age of History	Remarks
1	Sept 1877	Troughton & Simms	84-0-0	50-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
2	Sept 1877	Lang	22-0-0	6-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
3	Sept 1877	Lang	52-0-0	12-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
4	May 1878	Lang	52-0-0	12-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
5	April 1878	Lang	52-0-0	12-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
6	Jan 1878	Troughton & Simms	33-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
7	May 1878	Lang	52-0-0	12-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.

5 inch - Ordinary & Transit

No	Date	Makers Name	Price	Cost	Out on Hire	Age of History	Remarks
8	June 1878	Troughton & Simms	35-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
9	Nov 1878	Carlisle	44-5-0	37-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
10	Nov 1878	Lang	35-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
11	Nov 1878	Lang	34-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
12	Nov 1878	Lang	34-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
13	July 1878	Lang	34-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
14	Nov 1878	Carlisle	44-5-0	37-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.

4 inch - Ordinary and Transit

No	Date	Makers Name	Price	Cost	Out on Hire	Age of History	Remarks
15	Oct 1878	Troughton & Simms	25-0-0	8-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
16	Nov 1878	Carlisle	36-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
17	Nov 1878	Carlisle	36-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
18	Nov 1878	Carlisle	36-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
19	Nov 1878	Carlisle	36-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.

3 1/2, 3 1/2 inch - Transit

No	Date	Makers Name	Price	Cost	Out on Hire	Age of History	Remarks
20	Sept 1878	Carlisle	25-0-0	8-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
21	July 1878	Carlisle	25-0-0	8-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
22	Jan 1878	Lang	30-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
23	Jan 1878	Lang	30-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
24	Jan 1878	Lang	30-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
25	Jan 1878	Lang	30-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
26	Jan 1878	Lang	30-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
27	Jan 1878	Lang	30-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
28	Jan 1878	Lang	30-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
29	Jan 1878	Lang	30-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.
30	Jan 1878	Lang	30-0-0	10-0-0	50	50	Used for the first time in 1878. It was used for the first time in 1878. It was used for the first time in 1878.

*History of Instruments*  
Theodolites - (3 inch - Transit)

1. Sent to Mr. Douglas Baskerville in March 1878. Returned 20th Feb 1878. Lost again to some person by order of Council 25th March 78. Sent off as lost by order of Council, 14th June 1879.
2. Purchased July 1879, and lost some time to Mr. E. White for work in ...
3. Purchased Jan 1872, and lost some time to Mr. N. M. Conway for work in ...
4. Purchased June 1877, and lost some time to Mr. N. M. Conway for work in ...
5. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
6. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
7. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
8. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
9. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
10. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
11. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
12. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
13. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
14. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
15. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
16. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
17. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
18. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
19. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...
20. Purchased June 1878, and lost some time to Mr. N. M. Conway for work in ...

Fig 1.2a and b: Pages from 'Catalogue of Instruments' (1879-1933) showing the theodolites acquired and their assignment to expeditions respectively.<sup>23</sup>

The Council minutes and Committee minutes for the century in question were trawled for references to instruments, relevant journal manuscripts were consulted, and personal archives searched. Ten of the eleven editions of an instruction manual *Hints to Travellers* (hereafter *Hints*) produced by the RGS fall into this period. It is unusual and fortunate to have both the documents and artefacts surviving together. The instruments were involved in producing data for maps and charts, and in the publication of papers and books. They also appeared in portraits, photographs, and lantern slides.

Unlike a museum collection, the instruments were not assembled to demonstrate technical developments or tell particular stories: their role was not that of public engagement. There is no exact moment when they were transformed from a working tool into an archival source. Their potential as historical records has only been recognised relatively recently: in the 1970s many valuable items were sold in order to fund the acquisition of cine cameras and other contemporary equipment.<sup>24</sup> There is a certain sadness that only about 10% remain, and

<sup>23</sup> AP 52 CI p.3 and p.53  
<sup>24</sup> Survey and Instrument Committee 20<sup>th</sup> Nov 1972

a longing for completeness which Derrida might have described as 'mal d'archive.'<sup>25</sup> While the collection is listed on the database at the RGS, its existence is not widely known even among historians of scientific instruments. A list of extant instruments has been included as an appendix.

### **Archival Approach**

The fundamental underpinning of current understanding of how history is created is provided by archival theorists. The postmodern approach asserts that history is a human construct and therefore not the same as the past. For Keith Jenkins 'History is a form of literature that carries with it our philosophies of life.'<sup>26</sup> History is always for someone, and is all about power, so that dominant voices can silence others; 'Truth is dependent on someone having the power to make it true.'<sup>27</sup> According to Derrida, history therefore becomes historiography.<sup>28</sup> Richard Brown and Beth Davis-Brown argue that: 'If we accept that any process of perception and representation is a process of constructing reality from an observer's given social position, then there are more truths than can be confirmed but some have legitimacy due to power.'<sup>29</sup> For Joan Schwartz and Terry Cook 'Archives are not passive storehouses of old stuff but active sites where social power is negotiated, contested, confirmed'. Cook advocates that historians should move from studying product to process, as has become the consensus more recently.<sup>30</sup>

Steven Shapin, like Jenkins, is particularly concerned with credibility: 'The role of credibility has expanded to fill the space vacated by the defeat of the grand narratives - from a pertinent point of view it is the only topic'. Shapin claims that scientists are critical of their results but not sufficiently critical of their practices.<sup>31</sup> Shapin's criteria for credibility omit the results themselves, which were frequently questioned according to findings from this thesis, albeit not sufficiently rigorously. While Shapin castigates many deficiencies in traditional histories, a focus on credibility to the exclusion of content could limit the engagement with history to a small academic readership by ruling out much of interest to general audiences.<sup>32</sup> Jan Golinski believes historians have an obligation to produce narrative.<sup>33</sup> This thesis supports this contention, using both narrative and arguments concerning credibility to illustrate particular instances within a broader picture.

Thomas Osborne remarks on the mundanity of archives, letting us focus on what carries on as normal; 'power is ordinary'. Overwhelmingly ordinary but full in its detail, the

---

<sup>25</sup> Derrida (1995) p.57

<sup>26</sup> Jenkins (1991) p.xiii

<sup>27</sup> Jenkins (1991) p.28

<sup>28</sup> Derrida (1995) p.17

<sup>29</sup> Brown and Davis-Brown (1998) p.22

<sup>30</sup> Cook (2001) p.4

<sup>31</sup> Shapin (2010) p.34

<sup>32</sup> Secord (2004) p. 655

<sup>33</sup> Golinski (1998) pp.187-191

RGS archive, in spite of the inevitable randomness of the archival process, reflects the views of what was considered important in the age of imperialism at the heart of the British Empire. The period under consideration is characterised by the hegemony of the nation state, and the RGS archive is therefore typical of those set up by state and state-related institutions with which it was closely associated. Jennifer Milligan describes the setting-up of an archive as controlling the memory of a state, and controlling who had power to intervene in that memory. As vital building blocks in the construction of histories, archives need to be treated critically both in terms of individual documents and as entities in themselves.<sup>34</sup>

Being immersed in the culture of their time and place, the creators of the RGS archives in the century under review saw them as embodying liberal values of objectivity, distance, transparency, and virtue. Yet current approaches to history and to archives are incompatible with this unquestioning acceptance of neutral, unambiguous, passive sources of truth. As ANT predicts, there is a collision of cultures between the archivers of the period and indigenous people, with the former frequently citing 'irrationality' on behalf of the latter. Similarly, postmodernist historians now see the archivers as irrational in many of their beliefs.<sup>35</sup> ANT has been criticised for discriminating against disadvantaged people.<sup>36</sup> Archival theory recognises the imbalance of representation in any construction of history. While radical postmodern views of archives are multiple and illuminating, Osborne provides a pragmatic assessment by describing the use of archives in terms of what he calls a 'principle of credibility'. 'These are real spaces with 'real and effective histories'. They have epistemic value in that they hold a certain type of knowledge, and an ethical value as they bestow status on the user.<sup>37</sup> Archival theory instils a note of caution but also adds an aspect of richness in the inseparability of content, systems, and power.

### **Questions of Methodology**

In being a work of systematic survey whose aim is to examine the work of one institution and its instrumental provision over a century, the thesis is admittedly ambitious in its scope and aims. Because it is, it is appropriate to offer some remarks on its principal intentions, on what distinguishes this thesis from the work of those others, cited throughout this work, who have studied instruments, exploration and the RGS, and, in some cases, the biographies of individual scientific devices or of individual explorers at work in particular parts of the world. It is also appropriate to offer some words of justification for the approach adopted. This is not to dismiss those other possibilities presented by the nature of the archival record and the source materials, including that of the extant instruments themselves,

---

<sup>34</sup> Cook and Schwartz (2002) p. 185

<sup>35</sup> Kennedy (2014) p.2

<sup>36</sup> Leigh Star (1991) p.43

<sup>37</sup> Osborne (1999) p. 53-54

and it is certainly not to diminish the work of others. It is, rather, to make clear what the precise features of this systematic approach are and to offer reasons for its adoption.

The systematic approach adopted here is, a consequence of the rich nature of the available sources. Rather than focus upon individual instrument types or upon a particular period of time, or a region of the world which was the subject of RGS-supported expeditions in particular periods the thesis considers instrument type, provision, and the chronology and geography of use at an institutional level. The systematic approach adopted here is distinctive in the scale of its analysis: in looking at the work of one institution and at the relationships between institutional policy, instrumental provision and the consequences of that provision, over a century. The Society's engagement with instruments included procurement of the devices, their management, the training of potential users, the mobilisation of instruments in the field, and the preparation of recorded data for publication. As shown, each element permits more detailed analysis: procurement and management requires attention to evidence on instrument expenditure, calibration, and repair; training of users requires attention to evidence of texts and instruction; mobilisation in the field requires attention to observational methods; preparation for publication requires attention to calculation and drawing.

Systematic analysis of every activity involving instruments, over a century and over the entire range of the Society's geographical interests, has the potential to illuminate general trends and differences over time and over space. To look at the work of the RGS in this way is to show 'the instrumental activity' of the RGS as both the result of processes at work in the institution itself, and as a series of stages 'in the field' which allowed users to understand the world, overcome nature's obstacles, and, at least by intent, provide consequential outcomes. Of course, other research directions and themes were possible. During the research, the itineraries of over 1220 individually identifiable objects were recorded, and, for a small number, the instruments were followed through acquisition, deployment on various expeditions, repair when applicable, and disposal or loss. This approach is consistent with work on the biography of scientific objects, their working life history, even 'life geography'. Similarly, it is possible in the majority of cases to connect RGS instrument purchase to particular instrument makers, thus to establish connections between instrument history, the historical geography of exploration, and the history of instrument makers.

However, it was decided that while this revealed individual practices, such methods of 'following the thing' and of individual narratives connecting maker, device, and user did not afford the same depth of insight into how the institution worked as a whole. Similarly, acknowledging that, over time, different instruments were in use in different places by different travellers offered the possibility of, potentially, rich case studies but at the danger of losing sight of the bigger questions that connected them. The Society's equipping of expeditions with instruments and the training of users capable of extracting information from

them, and any changes over time in this process of provision, would not have been so apparent if case studies of individual itineraries had formed the basis of the argument. Nevertheless, in taking fifty travellers to illustrate the range of instrumental practices and individual experiences in the field, some insight has been offered into the possibilities for more individuated personal histories and geographies of instrumental engagement. Similarly, to have focused on one region of the world diminished the possibility for understanding more generally the chronology and the geography of exploratory activity using instruments and of seeing how instrumental activity was undertaken in a range of climates, terrains, and with different human interlocutors. To focus on a narrower time period runs the risk of down-playing longer-term shifts in institutional policy.

As it is hoped to show, understanding developments in the RGS, and more generally in the 'long' nineteenth century, over the longer term is necessary in order to put the rhetoric of progress and contemporary notions of professionalization and scientific expertise into perspective. In short, the systematic approach used here, demonstrably connected though it is with other possible approaches and the work of other scholars, has been adopted in order to explore, as has not before been done, the instrumental activities of a major nineteenth-century geographical institution over a century.

A model is necessary which can observe the entire process of incorporating instruments into exploration. It was expedient to consider the multiple expeditions on which instruments were taken as cycles of knowledge creation. The input to these cycles was constituted both by the instruments themselves, and the people who extracted meaning from them. Observations in the field then took place, where aspects of nature were captured, and the data was usually transmitted to the Map Room at the RGS. After the reduction process, the output was the map or a form of publication which amended agreed knowledge. The cycle was then repeated. This model allows comprehensive questioning of the whole process, as there are no activities undertaken by the RGS with respect to their instruments which lie outside this fundamental blueprint.

The model is very similar to the theoretical description provided by ANT, which has been advocated as a template because it was found to satisfy Golinski's criterion. By comparing the activities of the RGS as seen through their archives with the theoretical model of ANT, new knowledge can be gained, and our understanding of the applicability of ANT to field science can be nuanced. The thesis is not a defence of ANT, recognising criticisms, but uses ANT as a 'foil' because it is the best theoretical model for furthering understanding.<sup>38</sup>

ANT advocates a constructivist approach; facts are not intrinsic to nature awaiting discovery, but constructed as a social process.<sup>39</sup> The expositions by Bruno Latour in *Science in Action* (1987) and *Reassembling The Social* (2005) may be taken as the principal

---

<sup>38</sup> Macgregor Wise (1997) p.39, Lee (1994)

<sup>39</sup> Latour (2005) p. 91-92

exponents of the method, the latter being a defence and clarification of the former.<sup>40</sup> ANT describes rather than explains what is happening in terms of constantly-changing networks, or relations between groups; 'ANT is not about traced networks but about tracing.'<sup>41</sup> Actors, or 'actants', leave inscriptions, or traces. They perform and have agencies, which are not necessarily intentional.<sup>42</sup> The removal of intention introduces non-human actants, a controversial but crucial part of the model. Scientists are constantly incorporating countless different types of materials, machines, texts, people, and animals in their networks. They are 'clever enough to include a broad range of non-human resources in their alliances.'<sup>43</sup>

An essential component is the inscription device, or instrument, which is anything used to provide a visual reconstruction. Scientific knowledge is built up through cycles of accumulation of inscriptions, matching the physical cycles of the RGS instruments. The instruments are the interface between the nature and the scientist, where inscriptions are produced. The instruments as the meeting point of the physical world and the paper world have not commanded historians' attention as much as they deserve. Andrew Pickering has made important additions in this respect.<sup>44</sup> He sees 'science as an evolving field of human and material agencies reciprocally engaged in a play of resistance in which the former seeks to capture the latter.'<sup>45</sup> For Pickering, science involves grappling with the material world, not just engaging with social entities, but does not demand a pre-existent reality. The agency of material things is captured temporarily by instrumental and human ensembles, manifests itself as resistant to human intentions, and is therefore inseparable from human material practice.<sup>46</sup> Mike Crang and Nigel Thrift have described instruments as 'ill-mannered mediators between the natural phenomena and their users.'<sup>47</sup> These are underpinning theoretical concepts for the thesis. The study of instruments benefits from ANT's concept of non-human agency which means scientific instruments, the environment, or the natural objects of investigation can affect outcomes and processes.<sup>48</sup>

The study of field science is enlightened by the concept of 'immutable mobiles', usually inscriptions such as data, maps, plans or charts, which are essential for the dissemination of natural knowledge, and which form an integral part of science. Golinski quotes Sven Widmalm; 'Mapping is a 'paradigm' example of the representational practices of fieldwork science'.<sup>49</sup> These 'immutable mobiles' circulate repeatedly in order to build up inscriptions and networks. Complementary to the immutable mobiles are 'centres of

---

<sup>40</sup> Blok and Jensen (2011) p.18

<sup>41</sup> Latour (1987) p.243, Law and Hassard (1996) p.374, p.378

<sup>42</sup> Latour (1996) p.373

<sup>43</sup> Blok and Jensen (2011) p. 27 and p. 39

<sup>44</sup> Pickering (1995)

<sup>45</sup> Pickering (1995) p.23, Daston (2000) p.1

<sup>46</sup> Golinski (1998) p.203-4, Daston (2000) p.1-3

<sup>47</sup> Crang and Thrift (2000) p. 289

<sup>48</sup> Latour (2005) p.79

<sup>49</sup> Golinski (1998) p. 100,

calculation' where the inscriptions from the immutable mobiles are collated, analysed, and from where they are disseminated in new forms. Within the centre of calculation the data gathered is analysed and abstracted to several levels.<sup>50</sup>

These are concepts of an idealised science. In practice human actants meet constant resistance to immutability and mobility, and have to spend considerable resource to aspire to both features. Similarly, resources are spent in constructing centres of calculation which are capable of strengthening networks in the form of publishing and generally disseminating convincing results. Knowledge is familiarity, so data brought back is re-used in subsequent visits.<sup>51</sup> Instruments allow the scientists or explorers to replace nature with inscriptions in the form of numbers.<sup>52</sup> These numerical inscriptions then form immutable mobiles which on return to the centre of calculation, can be turned into maps and printed reports.

ANT makes a clear distinction between science-in-the making and that which has achieved consensus and is therefore considered as a conceptual 'black box', not usually re-opened. The latter constitutes the body of knowledge which is not normally the subject of inscriptions, and is assumed known. However, Golinski observes that the instruments were often under scrutiny themselves, which led to logical problems; this aspect will be studied in chapter 6 and constitutes a demonstration of the fluidity of the process of 'black boxing'.<sup>53</sup> Latour asserts that 'buying a machine without question... strengthens the case of whatever is bought.. it makes it more of a black box'. However, in many cases, especially in the first half of the period, bought instruments were questioned so as to weaken the box. ANT does not castigate irrationality, but observes that actants build support in order to surmount these logical difficulties.

The instruments have agency in several ways: they dictate how things should be done, as in the gestures performed and by whom. They dictate who can afford them and who can afford to be trained in their use, and they require a return to the centre to be calibrated and repaired. They act on behalf of their owners, but also have agency in resisting the smooth running of obtaining information from the natural phenomena under investigation, as 'ill-mannered mediators'.<sup>54</sup> Instruments enshrine authority by being difficult to argue against because they embody a great deal of 'black boxed' knowledge, and it is expensive for others to replicate the results. The cost of procuring and using the instruments is rewarded by numbers which are stronger and work harder for the purchaser.<sup>55</sup> While we appear to have an attachment to numbers, we often forget the resources needed to produce them.<sup>56</sup> Davis

---

<sup>50</sup> Latour (1987) p.217-233

<sup>51</sup> Latour (1987) p.22

<sup>52</sup> Blok and Jensen (2011) p. 44

<sup>53</sup> Latour (1987) p.29, Golinski (1998) p. 134

<sup>54</sup> Thrift and Bingham (2001) p.289

<sup>55</sup> Smith and Wise (1989) p.684

<sup>56</sup> Cline Cohen (1982) p.226, Latour (1987) p.184

Baird emphasises the invisibility of instruments in the conceptual black box. The knowledge has gone inside the instrument which can now serve in different surroundings.<sup>57</sup>



Fig 1.3 *The Arctic Council planning a search for Sir John Franklin* by Stephen Pearce, 1851.  
58

ANT proceeds by identifying groups. The central group was the council of the RGS, members of which are seen in fig 1.3, who were proactive in negotiating networks, disciplining themselves and others, endeavouring to build the circle of inscriptions to acquire knowledge 'scientifically', and being acted on and displaced by other agencies with alternative networks.<sup>59</sup> It is also recognised that being a centre of calculation was an important aspect of the work of the RGS, and that role was embodied in the precise locations of the various premises of the Society in London. Further, it is argued that the map room within each location, featured in fig 1.4, was the repository of the knowledge and was the most important physical and intellectual space of the institution, and one of the most important spaces of the British Empire.

---

<sup>57</sup> Baird (2004) p.163-165

<sup>58</sup> NPG 1208 © National Portrait Gallery, London

<sup>59</sup> Latour (1996) p.29





Fig 1.4 a and b The Map Rooms at Savile Row and Lowther Lodge in 1912 and c.1913 respectively.<sup>60</sup>

### Thesis Framework and Principal Research Questions

Following this introduction a review of the relevant literature in chapter 2 sets the scene for the presentation of the quantifiable empirical data in chapter 3. The framework of the thesis then follows the model of cycles of knowledge creation before concluding in chapter 9. The first phase of the cycle is the provision of instruments and the enhancement of their embodied value; this is the subject of chapter 4. The instruments are considered to be receptacles of resource, following the ideas of Felix Driver, Shapin, David Livingstone, Charles Withers and Iwan Morus on the ‘situatedness’ of knowledge.<sup>61</sup> These resources move into and through the field as described by Driver.<sup>62</sup> The term ‘value’ has complex and multiple meanings. The value of the instruments on acquisition by the Society can be considered their monetary cost. It is argued that their value increased due to their association with the Society, for reasons grounded in actual management practices and sublimated concepts of authority. Even when they became liabilities in the field, resources were expended on retaining and protecting them.

Much of the instruments’ value was gained from resources outside and previous to their engagement by the RGS. It is pertinent to ask, therefore, what value was added by the Society. Firstly, the Society expended resource on debates concerning what was ‘proper’, thus conferring authority on a particular set of instruments. Having modified these requirements according to financial and other circumstances, the Society then acquired the instruments by various means. The Society is shown to have augmented the value of its collection by management practices including listing, repairing, calibrating, inscribing and insuring. It also kept abreast of instrument design by interaction with makers, and with the

<sup>60</sup> RGS 025941, RGS 052578

<sup>61</sup> See for example Jöns, Livingstone and Meusbürger (2010) introduction

<sup>62</sup> Driver (2001) p. 9

mathematical supporting structure through interactions with practitioners and other government departments, such as the Royal Observatory and the Admiralty.

It is argued that the RGS added considerable value to its instruments by these means. The bought instruments were not eternally in the 'black box', but were simultaneously used as tools, as subjects of investigation, and as advocates for investigation of specific physical phenomena.<sup>63</sup>

The other component of the input to the circle of knowledge creation was the user of the instrument. These instruments required competent, disciplined users in order to unlock their potential. Chapter 5 investigates the two principal methods the RGS used to prepare their travellers; publication and tuition, discussing to what extent they were effective. Drawing on the work of Max Jones, Withers, Felix Driver, Peter Collier and Robert Inkpen, it monitors changes in the content and style of the many editions of *Hints*. It investigates in-house instruction from the Society's personnel; Captain Charles George, John Coles and Edward Reeves, and demonstrates the content and level of the tuition.

Chapter 5 argues that considerable investment was made in the potential users before the instrumental mobilisation took place in the field. This had consequences which become apparent further on in the cycle. ANT would see this phase as the RGS disciplining its travellers. However, it is argued that the system could be over-turned by various privileges in which the intended ambition was thwarted.

Chapter 6 concerns a crucial episode in the cycle- the mobilisation of instruments in the field in both senses of the word 'field'. From a study of the available documents it is possible to say where each instrument went, when, and with whom from 1879. Similar data can be extracted, albeit with more difficulty, from 1830. Overall patterns have been identified. Specific to the instruments were issues concerned with arrival at the destination, transport on the route, calibration, environmental and weather conditions, skill and attitude of the travellers, and the availability of various crucial types of assistance from indigenous people. Personal archives in the form of special collections and correspondence have been exploited to obtain first-hand reports of instruments and their use. Just over ten per cent of the expeditions involving instruments supplied by the RGS in the period are investigated to provide a sense of the issues faced and the responses to them.

Chapter 6 argues that there was variable success in mobilising the potential of the instruments to capture the aspect of nature required. Much of the resource input noted in chapters 4 and 5 was wasted. The instruments cannot, in many cases, be considered immutable mobiles.

Either in the field or at the 'centre of calculation,' the next phase involved reducing data to the 'hard facts' necessary for public consumption; this process is considered in chapter 7. This chapter asks 'what were the networks involved, who owned the data, and

---

<sup>63</sup> Golinski (1998) p.134

what changes took place over time?’ The questions relate to those in chapter 5 as the ability of the travellers to reduce their own data was salient. Discipline in standardisation was important especially when considering the compiling of data from various expeditions. This chapter asks to what extent the RGS was successful in extracting information from the travellers, and who held the authority to manipulate and present their results. With regard to ANT, chapter 7 argues that data and sketch maps are not always immutable mobiles given the evident manipulation of the data, both by the travellers and those in the Map Room, subsequent to mobilisation in the field.

Lastly, the results of the labours were presented, usually in the medium of printed texts and maps, back in London, where they manifest as agreed knowledge. The instruments’ agency is discussed in chapter 8. Four agencies are investigated; the creation of knowledge, the creation of the ‘explorer’, the creation of Empire, and the creation of social hierarchies. Here the thesis connects the instruments, journal papers, maps, medals, and images, and so exploits a broad section of the RGS collection.

A central concern of the thesis is to discover the extent to which the data produced by the instruments was effective in producing agreed new knowledge. Ideas on the significance of number from Theodore Porter, Mary Poovey and others are drawn on. It is also important to know and to show what the agency of the instruments was in respect to the credibility of the travellers and their reception. It is salient to ask to what extent the RGS instruments were used in imperial enterprises and how this changed over time, drawing from and contributing to studies such as those of Graham Burnett, Brett Bennett, Philip Curtin, Dane Kennedy, Michael Mahoney and Matthew Edney.<sup>64</sup> The agency of the instruments in reflecting and reinforcing social hierarchies is also investigated but is frequently hidden.

The conclusions are presented in chapter 9. The thesis attempts to reconcile two apparently incongruent premises. There is ample evidence for Eugene Rae, Catherine Souch and Withers’ statement; ‘the RGS took instruments and their correct use to be key features associated with the advance of geographical science.’<sup>65</sup> Procurement of instruments was the third of six stated objectives upon foundation in 1830.<sup>66</sup> The first edition of the *JRGS* stated; ‘the objects... as is now suggested would be; 3. To procure specimens of such instruments as experience has shown to be most useful, and best adapted, to the compendious stock of a traveller, by consultation which, he may make himself familiar with their use’.<sup>67</sup> The instruments were seen to form part of the paraphernalia necessary to enter scientific society: ‘By Royal patronage the Society will be enabled to afford such an effectual encouragement to

---

<sup>64</sup> Burnett (2000), Bennett (2011), Curtin (2002), Kennedy (2014), Mahoney (2016), Edney (1997)

<sup>65</sup> Rae, Souch and Withers (2015) p.158

<sup>66</sup> CM 4<sup>th</sup> Nov 1830,

<sup>67</sup> *JRGS* 1 (1831) p. vi

geographical Science and Discovery, as may contribute to the particular interest of his Majesty's Dominions, and to the general advantage of the Civilised World.'<sup>68</sup>

Withers also asked a crucial countering question: 'Why the emphasis on instruments if they were fallible?' incorporating a judgement formed from familiarity with much material in the archives.<sup>69</sup> The central question is therefore 'How can these two apparently true statements co-exist?' The thesis concludes by addressing this dilemma and allowing both premises to stand.

It is argued that the RGS spent considerable resource both on its instruments and its travellers. The mobilisation in the field in particular fell short of best practice with respect to the ideal scientific method for the large majority of expeditions, supporting Withers' contention. It has been found the RGS had strategies to deal with dubious data which became endemic to its practices in the Map Room and in the production of published papers. Paradoxically, the resource embedded at the earlier stages could work to corrupt the knowledge produced, as it was this resource itself rather than its successful mobilisation that increased the chances of publication. Hence the 'fallibility' in the narrow sense of flawed readings at the site of observation stands, but in the wider view of the process of knowledge creation, the RGS worked around these difficulties to the extent that they disappeared.

The RGS travellers were largely gentlemen of means, but the manipulation of their results to form a consensus enabled a professional class to exert influence. Ultimately power rested with the consensual processes of the Society. The instruments worked for their users, but bestowed greater authority on those who already had social status. The RGS held an altruistic attitude towards science compared with the various British governments, and was not generously funded, even when it contributed directly to the British Empire. However, in times of crisis its entire resources were commandeered by the nation state revealing the actual ownership of the instruments.

It is argued that ANT is an excellent model, with 'black boxed' instruments and immutable mobiles representing an ideal situation. In concurrence with Golinski, it was found bought instruments continually escaped the black box, and in fact they were not usually confined before the 1870s; rather they played simultaneous roles as tools and subjects of investigation.<sup>70</sup> Again, the concept of an immutable mobile is an idealised one, as in the real world no two instruments can be the same, and no instrument can perform in the same way over space and time. The same is true for data which can be manipulated before publication. Throughout the period there were instances where the template of good practice was adhered to; in many more instances there were multiple obstacles resulting in the data and the final product failing to achieve the encapsulation of nature required. However, the RGS worked successfully and seamlessly to provide agreed geographical knowledge and

---

<sup>68</sup> CM 4<sup>th</sup> Nov 1830

<sup>69</sup> Rae, Souch, and Withers (2015), Withers (2013) p.167–79

<sup>70</sup> Golinski (1998) p.134

maintained the premise that 'instruments and their correct use were key features associated with the advance of geographical science.'<sup>71</sup>

---

<sup>71</sup> Rae, Souch and Withers (2015) p.158

## Chapter 2:

### The Research Context

*A critic can only review the book he has read, not the one which the writer wrote.*<sup>1</sup>

#### Introduction

This chapter reviews the relevant scholarly literature that has shaped both the conceptual approach and contextual background of the thesis. While it is difficult to disentangle the strands clearly, the contributions have been divided into three main areas: Those which concern the history of science as practice, those which concern the history of geography and exploration, and those which concern the history of instruments. In all these areas there is a focus on the 'long' nineteenth century.

#### Histories of Science as Practice

Postmodern beliefs in how science is constructed were discussed in chapter 1 and form the context of the thesis. The thesis draws on the concept of the 'situatedness' of knowledge.<sup>2</sup> Shapin and others provide a firm foundation for this approach: 'We are now interested in habitus, we were not in the nineteenth century when knowledge was disembodied.'<sup>3</sup> Livingstone is quite clear; 'Knowledge is always embedded, whether it in people, instruments, books, maps, or buildings'.<sup>4</sup> For Donna Haraway, quoted by Livingstone, 'truth is never the view from nowhere.'<sup>5</sup> Schaffer also credits Haraway, describing situated knowledge as questioning 'the foundational myths of traditional objectivity: the subject as a simple, singular point of empirical knowledge-gathering, the scientific gaze as an omniscient observer.'<sup>6</sup> The work of a large number of writers on situatedness is particularly pertinent to the model of embodied resource fundamental to chapters 4 and 5.<sup>7</sup>

Livingstone remarks that 'space is rapidly becoming a central organising principle.'<sup>8</sup> His work '*The spaces of Knowledge*' provided a framework for a historical geography of science.<sup>9</sup> Simon Schaffer's work on laboratory science and the field is also fundamental to the thesis. In his essay on accurate measurement and Englishness Schaffer remarks that for

---

<sup>1</sup> McLaughlin (1981) <http://izquotes.com/quote/302462>

<sup>2</sup> Latour (1997) p. 249-250

<sup>3</sup> Shapin (2010) p. 8

<sup>4</sup> Livingstone (2010) p. 4

<sup>5</sup> Livingstone and Withers (1999) p.16

<sup>6</sup> [https://conceptsinsts.wikispaces.com/Situated+Knowledges+\(Schaffer\)](https://conceptsinsts.wikispaces.com/Situated+Knowledges+(Schaffer)) August 2017

<sup>7</sup> Morus (2006), Shapin (2010), Livingstone and Withers (1999) Naylor (2005a), (2000b) p. 631, (2010), Driver (2001), Powell (2007), Smith and Agar (2016)

<sup>8</sup> Livingstone (2010) p. 3

<sup>9</sup> Livingstone (1995)

the actants 'what worked in one place could be made to work elsewhere, the key to imperial power.'<sup>10</sup> Current ideas on 'situatedness,' which have been challenged by some historians, are in direct conflict with the view expounded by practitioners at the RGS during the period under review.<sup>11</sup> The actants believed in the objectivity, universality, and abstract disembodied nature of science.

One aspect of nineteenth-century science important to the thesis is that of the primacy of number.<sup>12</sup> Matthew Norton Wise dates the beginnings of this reliance on number to the late eighteenth century: 'only then ....did the rhetoric of precision acquire the power to carry conviction in virtually every imaginable domain'.<sup>13</sup> Porter notes that a vast array of mathematics is available which is flexible and well-suited to communication. He also remarks that a shift away from informal expert judgement towards reliance on quantifiable objects is a way of privileging public standards over private skills, an observation with particular relevance for this work, as the thesis argues the professional middle classes were beginning to have an impact on the establishment.<sup>14</sup> Patricia Cline Cohen argues that the prestige of quantification was ascendant in the mid nineteenth century.<sup>15</sup> Ian Hacking describes the early nineteenth century as generating a world becoming numerical and measured in every corner of its being'.<sup>16</sup>

Poovey's work is especially relevant to the accommodation of numerical data within texts, noting that numbers have often been graphically separated from narrative.<sup>17</sup> Numbers embody theoretical assumptions about what should be counted, and how quantification contributes to systematic knowledge, what she calls the 'modern fact'. There is a supposition that systematic knowledge should be gained from numbers.<sup>18</sup> Andrea Rusnock asserts that the table itself was the most important technology for collecting and displaying quantitative information, and that it was culturally specific and political.<sup>19</sup> Along with the moral efficacy of precision went the necessity of reliable standards, whose role had become more widespread and crucial in an enlarging sphere of influence.<sup>20</sup>

Susan Cannon's promotion of 'Humboldtian' science, being focussed on empiricism, numerical data collection, and being instrument-led, has been especially helpful for this thesis.<sup>21</sup> Cannon defined 'Humboldtian' Science as 'the accurate, measured study of widespread but interconnected real phenomena in order to find a definite law and a

---

<sup>10</sup> Schaffer (1994) p.9, Schaffer (1995) p. 136

<sup>11</sup> Ophir and Shapin (1991) p. 16

<sup>12</sup> Regard (2009) p. 11, Cannon (1978) p. 95, Cline Cohen (1999), Porter (1996)

<sup>13</sup> Wise (1995) P. 92

<sup>14</sup> Porter (1995) p.5, Porter (1999) p.226

<sup>15</sup> Cline Cohen (1999) p.205-6

<sup>16</sup> Hacking (1990) p.61

<sup>17</sup> Poovey (1998) preface xii

<sup>18</sup> Poovey (1998) p. xv

<sup>19</sup> Rusnock (2002) p. 6

<sup>20</sup> Schaffer (1997) p. 448

<sup>21</sup> Cannon (1985) ch 4, Cock (2005) p. 96, Raj (2002) p. 175

dynamical cause.<sup>22</sup> She argues that to refer to nineteenth-century empirical science as 'Baconian' is meaningless, but that Alexander von Humboldt's work was implicated in the shift from natural philosophy towards the new disciplines of physics and biology in the early Victorian period. She describes Humboldtians as characterised by a belief in eventual patterns from masses of data, and the use of instruments to a 'ridiculous' degree.<sup>23</sup> The thesis argues that Humboldtian science was an ideal at the RGS, that it was brought to bear in the first expeditions equipped by the Society, but not realised subsequently mainly due to financial constraints. Anne Godlewska has also written on Humboldt and his times, linking his instrumental practices with his application of number across multiple fields.<sup>24</sup> Crosbie Smith and Wise distinguish Whewell's 1833 *Astronomy and General Physics*, which accorded well with Humboldt and John Herschel's views, 'as a major turning point in the scientific culture of Britain.'<sup>25</sup> This work was influential during the mid-nineteenth-century. Burnett also acknowledges the role of the new Humboldtian approach and its emphasis on instruments.<sup>26</sup>

A further general application of the unifying concept of mathematics was in geometry. Greenwich was seen as the geometrical centre of the world.<sup>27</sup> Nick Baron identifies geometry as a uniting force, and he argues the globe as representing a space of potential became an emblem.<sup>28</sup> Bourguet, Licoppe and Sibum describe 'geometrical grid' as a powerful means of defining territory.<sup>29</sup> The length, angle and positional instruments relied totally on this application of geometry to the surface of the Earth.

Professionalisation has been a strong theme in the historiography of nineteenth century science since Jack Morrell wrote on this in 1990.<sup>30</sup> Randolph Cock takes issue with the fact that Morrell restricted his view to the development of universities arguing convincingly that the Navy provided an 'incubator' for science in this period, which had been overlooked.<sup>31</sup> Training is a major component of the thesis which, in agreement with Cock, found hidden resource from the Navy utilised by the Society. Before investing in its own training programme the Society relied on the Navy, The Meteorological Office, and on Greenwich Observatory. It continued to rely on professional calculators and map makers during the century.

For Aileen Fyfe and Bernard Lightman, to distinguish a science which was 'popular' from that which was not in this period is ahistorical. They show how the growth of consumerism extended to science, which became itself another commodity. The producers

---

<sup>22</sup> Cannon (1985) p. 105 [http://en.wikipedia.org/wiki/Humboldtian\\_science](http://en.wikipedia.org/wiki/Humboldtian_science), Dettlebach (1996)

<sup>23</sup> Yeo (1985) p. 266

<sup>24</sup> Godlewska (1996)

<sup>25</sup> Smith and Wise (1989) p.93

<sup>26</sup> Burnett (2000) p.93

<sup>27</sup> Smith and Wise (1989) p. 724

<sup>28</sup> Baron (2013)

<sup>29</sup> Bourguet, Licoppe and Sibum (2002) p. 9

<sup>30</sup> Morrell (1990)

<sup>31</sup> Cock (2005) p.110-111



were forced to compete for attention, whether the products were books, periodicals, lectures or exhibitions.<sup>32</sup> These ideas are crucial to the context of this thesis which concerns in part the publication strategies of the RGS. Many related issues are incorporated in collected works.<sup>33</sup>

Science and the state is another important theme. Richard Yeo's collection of essays has a bearing on the context of the period leading up to that under question, as does John Gascoigne's biography of Joseph Banks, since the inadequate resource provided by the British government is a constant theme.<sup>34</sup> Roy MacLeod argues that it was only in mid and late nineteenth-century that learned academies and other institutions devoted to the practical application of knowledge acquired their modern language and dress, as science 'became associated with a rationale that endorses and dignifies, by its appeal to nature, the instruments of the nation state.'<sup>35</sup> The RGS was a central institution in this appeal to nature. Work by MacLeod and others is valuable in providing context and support for inferences drawn from the RGS archives. Bennett describes the mid-nineteenth century as 'a watershed' in governance of the British Empire, but is scathing as to its effectiveness. 'The scientific empire was a delusion.'<sup>36</sup>

Several historians have written on the complex role of the state vis-a-vis the RGS. Livingstone concurs with Robert Stafford that national expansion provided RGS with its leading unifying motif in the early years.<sup>37</sup> Shapin describes a science which is blended with economic, military and civic projects.<sup>38</sup> Bennett makes the point that scientific networks were becoming formalised in the early to mid-nineteenth century.<sup>39</sup> Gascoigne identifies a 'scientific imperialism' promoted by Sir John Barrow first at the Admiralty and then at the RGS, but also notes that, in Britain, science and the state were slow to unite.<sup>40</sup> Robin Butlin points out that the RGS did not explicitly function as a tool of Empire, and could hide behind the objective of being founded to promote geography as a science. Yet the Map Room was much in demand from the military and other arms of government.<sup>41</sup> Driver notes that openly imperialist motives were contested, although the RGS was 'virtually an arm of the scientific state'.<sup>42</sup> The RGS might be said to be one of the 'invisible colleges of authoritative opinion' described by MacLeod.<sup>43</sup> He argues that older forms of patronage were replaced by bureaucratic authority, the ideology of enquiry, discipline of reason, rhetoric of objectivity, and

---

<sup>32</sup> Lightman (2007), Yeo (2001)

<sup>33</sup> Mordavsky (2007), Clifford, Wadge, Warwick, and Willis (2006)

<sup>34</sup> Yeo (2001), Gascoigne (2003)

<sup>35</sup> MacLeod (2003) introduction

<sup>36</sup> Bennett (2011) p.30 and p.38

<sup>37</sup> Livingstone (1992) p. 171

<sup>38</sup> Shapin (2010) p. 13

<sup>39</sup> Bennett (2011) p.30

<sup>40</sup> Gascoigne (2003) p. 47-53

<sup>41</sup> Butlin (2009) p. 285

<sup>42</sup> Driver (2001) p. 44-45

<sup>43</sup> MacLeod (2003) p. 10

political neutrality. He asserts a meritocracy was developing with less concern for status of birth.<sup>44</sup> The RGS was laden with tensions between the older forms of patronage which co-existed alongside the newly-emerging professional classes.

### **Histories of Geography and Exploration**

The various sub-topics considered in this section are geography as a science, field science and trust, maps and their study, empire, and studies based specifically on the RGS.

#### *Geography as a Science*

Livingstone discusses the management of scientific space and the embodiment of knowledge in instruments, integrating science into geography: 'scientific knowledge is a geographical phenomenon acquired in specific sites, it circulates, it transforms the world.'<sup>45</sup> He describes concepts such as the agency of landscape and spaces of speech. In his *The Geographical Tradition* he investigates pre-Darwinian Geography and advocates looking at its institutions, expeditions, imperialism, and disciplinary aspirations; advice which this thesis has followed.<sup>46</sup>

The fragility of geography as a respectable science has been well documented. The instruments played a role in providing 'hard' numerical science in the endeavour to create and maintain the position of geography within the scientific community. Withers relates the concerns over the audiences for section E at the annual BAAS meetings held around the country from 1831. The BAAS was adamant that it was there 'not to amuse the public but to advance science.'<sup>47</sup> Parallel to this concern, the term 'explorer' had to be negotiated in the early nineteenth century.<sup>48</sup> Explorers were more than travellers, and according to Kennedy came to be 'proto-professionals'. Kennedy asserts that the tension between exploration as experience and exploration as epistemology is central. The first resulted in the descriptive outputs enjoyed by the public, the second was apparent in the 'hard' science characterised by numerical data.<sup>49</sup> Bridges asserts that the RGS was successful precisely because it managed to link the tradition of travel writing and the search for the exotic and picturesque with 'hard-nosed' science and economic concerns-ideas central to the thesis.<sup>50</sup> The balancing act between science and entertainment, one a constant thread of the thesis, is remarked on by Golinski.<sup>51</sup>

---

<sup>44</sup> MacLeod (2003) p. 1, p.5 and p. 11

<sup>45</sup> Livingstone (2010) p.4 and p.18

<sup>46</sup> Livingstone (2010) p.156

<sup>47</sup> Withers (2010) p. 191

<sup>48</sup> Craciun (2011)

<sup>49</sup> Kennedy (2013) p. 2

<sup>50</sup> Bridges (2002) p.61

<sup>51</sup> Golinski (1998) p. 92

Driver identifies the ill-defined nature of geography as both a positive and negative attribute.<sup>52</sup> He argues convincingly that rather than seeing the British Empire, and particularly the RGS, as a confident institution, historians would more profitably regard the enterprise as tentative and unsure. Early fellows had to work hard to establish the credibility of geography.<sup>53</sup> Driver describes *Hints to Travellers* as an 'attempt to exert authority on a field already too large and diverse to be mastered'.<sup>54</sup> Dorinda Outram also emphasises the weak position of exploration and explorers in particular; 'They were not so much dominant as vulnerable'.<sup>55</sup> As well as being physically vulnerable their reputations were susceptible to damage.<sup>56</sup> Geography, as it produced narratives from far-flung places, was especially open to attacks on its credibility.<sup>57</sup>

Some writers have considered the distinction between observation and experiment. Lorraine Daston argues that experiment and observation had become separate by 1750s, but they both should be repeatable and communicated.<sup>58</sup> David Aubin, Charlotte Bigg and Otto Sibum note that observation was considered non-intrusive, and experiment artificial. They argue, however, that observation was seen as a weaker, less idealised science and a social and culturally determined experience.<sup>59</sup> The RGS did not primarily concern itself with experiment, which may constitute a further factor in the 'fragility' of geography as a science.

### *The Field and Trust*

An aspect of the history of geography in this period that relates to geography's position as a science is the debate between 'armchair' or 'critical' geographers, and those in the field, a feature which does not have a parallel in other disciplines.<sup>60</sup> 'Critical' geographers were those who perused and assimilated multiple sources in order to produce the optimum map.<sup>61</sup> Lawrence Dritsas devotes considerable attention to a history of the 'critical geographers' and their reliance on ancient, Arab or Portuguese sources.<sup>62</sup> However, the ancient map of the interior had been replaced by blanks by the eighteenth century, which would accord with the replacement of 'Geography Fabulous' by 'Geography Militant'.<sup>63</sup> Dritsas recounts that the critical geographers argued that the explorers were limited to what they could see themselves, whereas the critical geographers could consult many different

---

<sup>52</sup> Driver (2010) p. 2

<sup>53</sup> Driver (2010) p. 50, Withers (1990) pp.980-989

<sup>54</sup> Driver (1999) p. 21

<sup>55</sup> Outram (1995) p.292.

<sup>56</sup> Pakenham (1992) p.26

<sup>57</sup> Outram (1995) p. 283

<sup>58</sup> Daston (2000), Daston (2011)

<sup>59</sup> Aubin, Bigg and Sibum (2010) p.6

<sup>60</sup> Harbsmeier, Ries, and Nielsen (2012)

<sup>61</sup> Cox (2016)

<http://www.rgs.org/OurWork/Research+and+Higher+Education/AHRC+Collaborative+Doctoral+Awards/Current+projects/Armchair+geography.htm>

<sup>62</sup> Dritsas (2011) p. 258

<sup>63</sup> Conrad (1924), Driver (2001)

accounts. They saw the travellers as 'mere' collectors of facts, which were subsequently analysed in the metropolis, or 'centre of calculation'. Dritsas urges caution in viewing them as constantly warring factions remarking that they each contributed to knowledge creation.<sup>64</sup>

Driver links this debate with the move from cabinet to field, both physically and intellectually.<sup>65</sup> Instruments were part of the armoury of the traveller, and not of the armchair geographer, so can be seen as an influence in bringing geography into the fold of the nineteenth century scientific disciplines. The promotion of geography as a science entailed both gathering new information and combining and comparing it with information previously obtained, but the increased emphasis on instruments following Humboldt, and the increasing quantity of new data returning from the field, augured for the decline of knowledge not based on new empirical data. This relatively late move towards observation and away from ancient works could be viewed as an aspect of the tentative nature of geography as a science.

Various aspects of field science are likewise pertinent to the thesis. Keith Richards discusses field versus laboratory practice, identifying the conflict between survival and rigorous measurement in the former, which is apparent from material in the RGS archives.<sup>66</sup> The move from static collecting to experimentation, which applied to both laboratory and field science, is apparent in the activities of earlier generations, but by the 1830s, it is argued, the field was more established.<sup>67</sup> The instruments at the RGS were not directly involved in collecting, and while the expeditions became more focussed on specific phenomena as the century wore on, these instruments were not primarily involved in experiments. The porosity of field and practice has been identified by Alix Cooper.<sup>68</sup> The thesis supports her argument in noting how new types of instrument widened the field of enquiry.

Withers discusses trust: 'In order that others elsewhere should believe what they were told about things they had not seen by people they did not know, conduct in the field had to be appropriate. Fieldwork with its attendant practices of exploring, trusting, observing and regulating is so central a part of geography's history.' Withers cites David Gooding, arguing convincingly that the 'scale of calibration is moral.'<sup>69</sup> Regulation is necessary of oneself, others, of other things and of error. 'Accepting each other's testimony is a generative and judgemental form of knowledge undertaken as a wider community.'<sup>70</sup> Adi Ophir and Shapin also consider the issue of trust which increases for those who cannot access the places of knowledge physically.<sup>71</sup> Outram argues that to turn a traveller's tale into an exploration account which made higher truth claims, was made more difficult by the Enlightenment which

---

<sup>64</sup> Dritsas (2011) p.262-264 and 268-172, Withers in Outram (1995) p. 44

<sup>65</sup> Driver (2001) p.9, 17-19 and p.48

<sup>66</sup> Richards (2011) p. 55

<sup>67</sup> Ackermann and Wess (2003)

<sup>68</sup> Cooper (1998)

<sup>69</sup> Withers (2011) pp.44-46

<sup>70</sup> Withers (2010a) p. 187

<sup>71</sup> Ophir and Shapin (1991)

'separated the moral self and the perceiving self.'<sup>72</sup> The thesis draws upon this work to demonstrate how the RGS produced creditable accounts in these circumstances.

### *Maps and Their Study*

Maps have received considerable attention from authors from different perspectives. Earlier histories tend to be more descriptive and narrative-led, later ones more theoretical in line with the current discipline. Gerald Crone, W.A. Seymour and Robert Skelton have produced useful work on practices in the former genre.<sup>73</sup> In the latter, Mark Monmonier describes maps as 'powerful tools of persuasion' demanding 'unquestioning acceptance' of cartographic messages, and as 'contests, prizes or strategems.'<sup>74</sup> For Kenneth Akerman they embody scale, selection, generalisation, sign language, authority and power.<sup>75</sup> He notes that 'world' is a cultural term, 'globe' a geometric one.<sup>76</sup> He is uncompromising when providing reasons for mapping: governance by a single ruler, habitation by a dominant people, colonisation.<sup>77</sup> On the production of maps he writes; 'Each geographical map is made by plagiarising an existing map, a travel narrative, chart, indigenous information etc.'<sup>78</sup> These observations are useful in shedding light on the numerous iterations of maps in the RGS, in line with Edney's suggestion that historians should 'pay attention to internal questions of the physical and graphic form of maps and the practices of mapping.'<sup>79</sup>

Burnett provides a brief historiography of cartography describing the 'European obsession with the possession of nature', and that 'through cycles of reproduction landmarks became icons of the colony.'<sup>80</sup> The thesis supports this in the study of African expeditions in particular. Edney confronts the special position of maps: 'modern culture grants maps a privileged status as object bearers of truth.'<sup>81</sup> In his work on India he is uncompromising as to the power of mapping: 'The geographers created and defined the spatial image of the Company's Empire. The maps came to define the Empire itself.'<sup>82</sup> 'We must establish a debate in which old understandings of maps, of their creation, and of their use are replaced by better (that is, more consistent and coherent) theories.'<sup>83</sup> This thesis concurs with these writers in viewing mapping as defining an area in the likeness of the culture of the mapmaker.

Latour addresses crucial themes for the thesis: He writes of La Perouse's expedition to make general points. 'The whole idea is to bring something back. Without dozens of

---

<sup>72</sup> Outram (1999) p.283

<sup>73</sup> Crone (1953), Seymour (1980), Skelton (1958)

<sup>74</sup> Monmonier (1995) p.1

<sup>75</sup> Akerman (2007) p. 4

<sup>76</sup> Akerman (2007) p. 67

<sup>77</sup> Akerman (2007) p. 139

<sup>78</sup> Akerman (2007) p. 142

<sup>79</sup> Edney (2014) abstract

<sup>80</sup> Burnett (2000) p. 6-7

<sup>81</sup> Edney (1987) p.165

<sup>82</sup> Edney (1997) p.2-3

<sup>83</sup> Edney (2014) abstract

innovations in inscription, projection, computing, writing and archiving his expedition would be wasted, alternatively without his expedition the construction of the instruments, log books, latitudes and longitudes etc would not be any good if they didn't win over help to muster and align new allies in Versailles.<sup>84</sup> Latour emphasises the advantages of maps; 'They are immutable, they are made flat, the scale can be modified, they can be reproduced at will, they can be recombined. They can be superimposed and they can be made part of a written text. The last is the greatest.' Especially pertinent to the study of the twentieth century developments is the following: 'They (maps) can merge with geometry, diagrams and numbers.... the mobilisation of many resources through space and time is essential for domination on a grand scale. A written, printed, mathematical form has greater credence than common sense.' While benefiting from these ideas, the thesis disputes the immutability of maps.

### *Empire and 'Self and Other'*

Work on field instruments in this period needs to be informed by literature regarding the making of Empire, which provides an informed and rich backdrop to any understanding of the functioning of the RGS.<sup>85</sup> As 'Colonialism is now safe for scholarship,' there is a wealth of recent material to draw upon.<sup>86</sup> Only through the study of colonial 'others' could Europe's history and culture be celebrated as unique and triumphant.<sup>87</sup> Butlin asserts that 'geography was linked overtly and covertly with imperial power through agencies of surveying and mapping-means of capturing and controlling places overseas- and of cultural superimposition and modification through exploration and exploitation.'<sup>88</sup> Kapil Raj takes issue with the simplistic equating of map-making with Empire, pointing out the pre-existence of non-European maps.<sup>89</sup>

Helen Tilley notes the Times referred to the British Empire as a 'Geographical Society on a Large Scale' in 1869.<sup>90</sup> However, not all historical geographers link geography and imperialism directly.<sup>91</sup> Some writers take a tentative view, for example John MacKenzie, Mary Louise Pratt, and Anne McClintock are cited by Miles Ogborn.<sup>92</sup> Others are uncompromising in their projection of geography in this period as being incontrovertibly linked to empire-building.<sup>93</sup> Many writers on Empire in the long nineteenth century note a confidence around

---

<sup>84</sup> Latour (2011) p. 66

<sup>85</sup> MacLeod (2000b)

<sup>86</sup> Dirks (1992) Introduction p. 5

<sup>87</sup> Dirks (1992) p. 7

<sup>88</sup> Butlin (2009) p.277

<sup>89</sup> Raj (2007) p. 64

<sup>90</sup> Tilley (2011) p.64, *The Times* May 25<sup>th</sup> 1869

<sup>91</sup> Kennedy (2015) p.1

<sup>92</sup> Ogborn (2003) p.155- 156

<sup>93</sup> Raj (2002) p. 159 and p. 174, Driver (2010) p. 22 and p. 40, Gascoigne (2015) p. 132

1830 which had become 'anxiety, division and self-doubt by 1885.<sup>94</sup> However, Richard Drayton disagrees with the hardening attitudes, citing a slave rebellion in 1823 put down very harshly, he reckons it was European's ability to abuse non-Europeans with impunity which led to a hardening.<sup>95</sup> These changes can be supported by the thesis which noted an increasing difficulty obtaining resources from indigenous people from then. As in the case of Driver describing the RGS, Richards has pointed to the tentative nature of the imperial project in general.<sup>96</sup> Cock notes, however, that scientists tended to 'talk up' their imperialist claims, and that some participants were disinterested scientists, citing Francis Beaufort as an example.<sup>97</sup>

Historians have discussed the 'centre and periphery' model which is related to empire. Heike Jöns is an advocate of the model: 'An emerging centre of calculation is both place of departure and destination of cycles of accumulations. Inside such a centre the accumulated resources are systematised, classified, tied together and re-represented in order to build a strong web of associations that make up a new knowledge claim'.<sup>98</sup> MacLeod disputes this view.<sup>99</sup> Some writers such as Raj and Sujit Sivasundaram argue that the centre-periphery model does not recognise sufficiently the influence of indigenous people on science.<sup>100</sup> The thesis argues that the RGS operated in a manner which conformed closely to the centre-periphery model. The thesis uses the model recognising that the nature of archives precludes the unbiased representation of indigenous people.

The hardening of attitude towards the end of the nineteenth century, noted above, is commented on by Michael Adas in connection with measures of human worth.<sup>101</sup> European judgements were grounded in the assumptions that there were transcendental truths and an underlying physical reality existed independently of humans and valid for all people. For them, the control over nature made possible by science 'proved' the superiority of Europeans. Adas argues that racism frequently prevented Europeans from acknowledging the work of indigenous people who were thought to be at an earlier stage of development.<sup>102</sup> The thesis certainly concurs with arguments about the lack of acknowledgement of indigenous contributions to knowledge-making. Adas argues that Europeans believed indigenous people had not got a grasp of space, and lack of precision in measurement was a sign of 'murky' thought processes.<sup>103</sup> Jöns argues that by imposing ethnic labels on their informants and by replacing native sketches with surveys based on precise astronomical instruments, the

---

<sup>94</sup> Agnew and Livingstone (2011), Bridges (2002), Regard (2009) p. 3, p.11, Curtin (2002) p. 40, Kennedy (2002), Headrick (1988) p. 6

<sup>95</sup> Drayton (2002) p.224

<sup>96</sup> Richards (1993) p.1- 3,114

<sup>97</sup> Cock (2005) p.100

<sup>98</sup> Jöns (2011)

<sup>99</sup> Hodge (2011) p.18

<sup>100</sup> Sivasundaram (2011) p. 124, Raj (2007) p.64

<sup>101</sup> Adas (1989) p.3-4

<sup>102</sup> Adas (1989) p. 157-8

<sup>103</sup> Adas (1989) p.265

Europeans contributed to the marginalisation of these people and their knowledge as 'other', subordinate, and less enlightened.<sup>104</sup> The thesis has found instances where European practices of instrument use and measurement has distinguished 'self and other' on these grounds. Edward Said's influential work on orientalism has enabled historians to view differences as constructed.<sup>105</sup> As Frederick Regard puts it; geography is unique as it 'inhabits the uncertain terrain where 'Self 'faces 'Other.' The imperial outlook is inseparable from the need to make these distinctions.<sup>106</sup>

Some historians have endeavoured to add the voices of various 'Others.' Driver points out that there are several categories of indigenous intermediaries.<sup>107</sup> Michael Bravo's work on the Sakhalin 'episode' is an exemplar of the endeavour to recognise the part played by 'other' voices. He amends Latour's view of immutable mobiles. For him the performance of giving is very important: 'The geographical gift re-orders local relations into categories of space and time.'<sup>108</sup> Clive Barnett sees the challenge of post-colonial cultural criticism as being 'not simply to celebrate an ahistorical multiculturalism, but to demonstrate the unequal relations of appropriation.'<sup>109</sup> Kennedy compares the European concept of the interior of Africa to the concept of an ocean, in that it was empty until an explorer put traces on it.<sup>110</sup> Barnett notes the twin failures to write Europe's desire upon Africa or to hear anything that might be said by Africans.<sup>111</sup> Douglas Lorimer confronts the overt racism in tales of exploration from the 1870s to the end of the nineteenth century, although he argues that counter-voices have been overlooked.<sup>112</sup> He also identifies the period after 1870 as one of increasing tension and upheaval following the Great Depression of that decade.<sup>113</sup>

The emerging genre of travel writing was bound up with 'self and other.' Work on travel writing and constructed narrative is helpful in considering the published reports of travellers and their instruments in the field.<sup>114</sup> Alison Russell remarks on writers' renewed interest in the literary form.<sup>115</sup> Carl Thompson asserts that travel writing offers the reader a movement between the familiar and the unknown.<sup>116</sup> Travel writing and its academic study has largely concerned Western writing on other places and cultures.<sup>117</sup> It became a particular genre for women. A problem was that of trust, so protocols of decorum were constructed.<sup>118</sup>

---

<sup>104</sup> Jöns (2011) p. 160, p.164

<sup>105</sup> Said (1993) p. 132-149

<sup>106</sup> Regard (2009) p. 6

<sup>107</sup> Driver (2015) p. 17

<sup>108</sup> Bravo (1999) p.199 and p.219

<sup>109</sup> Barnett (1996) p. 240

<sup>110</sup> Kennedy (2014) p. 2

<sup>111</sup> Barnett (1996) p. 241

<sup>112</sup> Lorimer (1997) p. 17, p. 25

<sup>113</sup> Lorimer (2013) p. 151

<sup>114</sup> Colletta (2015), Hulme and Youngs (2002), Youngs (2004), (2006), (2013).

<sup>115</sup> Russell (2000) p. 1

<sup>116</sup> Thompson (2011) preface

<sup>117</sup> Thompson (2011) p.8

<sup>118</sup> Thompson (2011) p. 64, Keighren, Withers and Bell (2015) p.72



Innes Keighren, Withers and Bill Bell note that instruments were cited to gain credibility.<sup>119</sup> All travel writing is a record or product of an encounter between self and other; it reveals the traveller's values preoccupations and assumptions.<sup>120</sup> Travel writing is not the same as guidebooks because the writer presents a personal view and not simple 'facts', but not fiction either.

Ulrike Brisson places travel writing firmly in a political context arguing that politics has been under-represented in travel literary criticism.<sup>121</sup> However, Bridges disagrees: 'There was some political control but more significant were various kinds of relationships stopping short of direct administration. Trade, diplomacy, missionary endeavour, and scientific exploration might all contribute to British expansion and all brought their own travel writing.'<sup>122</sup> Bridges also argues the strident tone emerging after 1885 made heroic adventures less appropriate.<sup>123</sup> Helen Carr traces the three phases of travel writing, also emphasising uncertainties in the late Victorian period.<sup>124</sup> Firstly, didactic 'realist' then more literary and then the travel writing of today by accomplished authors. Pratt asserts that travel writing is one of the ideological apparatuses of Empire.<sup>125</sup>

### *The Role of the RGS*

The final part of this section deals with literature specifically concerning the RGS in the period. The histories of the Society by Clements Markham and Hugh Robert Mill in 1881 and 1930 respectively have been useful for the major debates but also for details such as the spatial setting of the instruments within the Society's sites.<sup>126</sup> The RGS features briefly in many works on nineteenth and early twentieth century historical geography, but of more note are works particularly focused on the Society.<sup>127</sup>

Driver gives a balanced view of the RGS's attitude towards imperialism. He quotes from the RGS initial prospectus which describes 'geography's importance in conferring just and distinct notions of physical and political relations of our globe.' He gives a clear exposition of the role of the RGS in terms of the nation state. He also notes that openly imperialist motives, such as the project in Abyssinia, were contested.<sup>128</sup> The thesis concurs with this view of a Society straddling functions to delineate its space. Barnett notes the eliding of imperial and scientific aspiration: he describes David Livingstone's Zambezi mission as being a combination of botany, zoology, geography, geology, geomagnetism,

---

<sup>119</sup> Keighren, Withers and Bell (2015) p. 93

<sup>120</sup> Thompson (2011) p. 10

<sup>121</sup> Brisson and Schweizer (2009) p. 10

<sup>122</sup> Bridges (2002) p.153

<sup>123</sup> Bridges (2002) p.66

<sup>124</sup> Carr (2002)

<sup>125</sup> Pratt (2007) p. 202

<sup>126</sup> Markham (1881), Mill (1930)

<sup>127</sup> Cock (2005) p. 103 and p.109, Heffernan (2011), Bridges (2002) p.53

<sup>128</sup> Driver (2010) p. 40-44

ethnography, economics and political intelligence.<sup>129</sup> Livingstone asserts that the RGS was the 'cultural power base of the English geographical confraternity.'<sup>130</sup>

Livingstone and Stafford argue that overseas exploration provided the Society with its identity, although spiritual enlightenment played a part.<sup>131</sup> Livingstone also notes a new direction towards geographical instruction at the end of the century, with a consequent decline in the status of exploration. This development has been observed, although the thesis found that exploration formed part of the revival of activity after WW1, and that expeditions were gaining in momentum at the end of the period under scrutiny.<sup>132</sup>

A number of writers have established the strong connections between the RGS and government which is a context for the thesis. Bennett claims that Roderick Murchison established what a scientist should be: practical efficient and revenue-producing.<sup>133</sup> Gascoigne describes Barrow at the Admiralty and the RGS as following Banks in promoting scientific imperialism.<sup>134</sup> Driver adheres to this view: 'RGS's founding programme was a continuation of the Banksian project by other means.'<sup>135</sup> Cock links the work done by those such as Barrow and Beaufort to incorporate science into government projects and notes the large number of naval officers in the early years of the RGS. However, Jones notes that 'The preoccupation with Antarctica was unintelligible on a merely imperialist framework' as was the fascination with the Northwest Passage.<sup>136</sup> The thesis has been enriched by the multiple approaches to the RGS, finding that the position of the Society was complex, dynamic and constantly in flux.

Recently several studies have been devoted to more detailed aspects of the Society. Like Cock, Driver remarks that the Admiralty presence was substantial in the early years which were dominated by naval exploration and hydrographic survey, with the majority of papers submitted being from the Admiralty, Colonial Office, Foreign Office or India Office.<sup>137</sup> Burnett takes the early strong ties of the Society with the Admiralty further by arguing that the practitioners of traverse surveys, typical of the Society's early expeditions, drew their methods from navigation and hydrography.<sup>138</sup> While this was the case to the extent that the instruments and their detailed use were similar, traverse surveys relied on landmarks and constituted a departure from maritime surveying. This will be considered in chapter 6 more closely. Driver does not believe the RGS was a centre of calculation because it was too heterogeneous. However, this thesis argues that the RGS was an excellent example of a

---

<sup>129</sup> Barnett (1998) p. 243

<sup>130</sup> Livingstone (1992) p. 159

<sup>131</sup> Livingstone (2010) p. 160 and p. 171, and Stafford (2002)

<sup>132</sup> Livingstone (2010) p. 193

<sup>133</sup> Bennett (2011) p.34

<sup>134</sup> Gascoigne (2003) p.53

<sup>135</sup> Driver (2010) p.46

<sup>136</sup> Jones M. (2005) p. 336

<sup>137</sup> Driver (2010) p. 34 and p. 41

<sup>138</sup> Burnett (2000) p.87

centre of calculation for exploration, while simultaneously having other roles. Driver's work on *Hints* has been cited above. He documents training at the RGS from 1841, in particular focussing on the production of the many editions of *Hints*, and identifying the tentative nature of the early editions.<sup>139</sup> He remarks on the awkward compromise between Galton's 'get up and go' style and Herschel's scientific aspirations, but does not discuss the departure represented by the fifth edition, which the thesis argues was significant for reasons explored below.

Jones has provided useful data on resources spent on training and major expeditions.<sup>140</sup> He attributes the activity of the 1850s as being the result of moving sites, and subsequent reforms to the death of Livingstone, although these claims are difficult to substantiate.<sup>141</sup> He then looks at *Hints*, identifying changes in the 1880s.<sup>142</sup> Jones is not aware of earlier developments, for example he overlooks the supplying of charts or the appointment of a draughtsman long before his period of interest.<sup>143</sup> However, the move from 'field to study, from exploration to education' accurately reflects the changing priorities of the Society at the end of the nineteenth century, contributing to Stoddart's work<sup>144</sup>.

Collier and Inkpen focus on the debate over what sort of surveying should be taught, which took place at the end of the nineteenth century.<sup>145</sup> They claim convincingly that geography became a discipline between 1870 and 1914. They point to Halford Mackinder's 'New Geography' of 1887 as marking the start of the new discipline. They argue that more diverse views could be held after Murchison's influence waned. They identify a professionalised class challenging the establishment, arguing that the heat of the debate demonstrated the importance of surveying. They contrast the triangulations of the Survey of India with topographical surveys, and with the methods of survey undertaken by explorers. While Collier and Inkpen give an excellent account of developments in training at the RGS, this thesis disputes that the nature of the training changed in line with the rhetoric as they suggest, demonstrating that it remained essentially the same in the early twentieth century.

A compilation on Instruments of Exploration appeared in 2015.<sup>146</sup> The essay included by Rae, Souch and Withers which concerns the RGS specifically has been cited. Rae, Souch and Withers make use of the archive material particularly relating to the instruments; the 'Instruments Lent to Travellers' and the 'Catalogue of Instruments', identifying the instrument culture at the RGS. However, like Jones, by focussing too narrowly on one period, they argue a change took place at a particular time, in this case the 1860s. The thesis argues that many similar statements of intent were made throughout the nineteenth century, with

---

<sup>139</sup> Driver (2010) p.51

<sup>140</sup> Jones M. (2005) p.329

<sup>141</sup> Jones M. (2005) p.314 and p.331

<sup>142</sup> Jones M. (2005) p.321

<sup>143</sup> Jones, M. (2005) pp. 325-32

<sup>144</sup> Stoddart (1980)

<sup>145</sup> Inkpen (2002) p.274

<sup>146</sup> McDonald and Withers (2015)

little or no resulting effect. The only specific moment when it could be argued practice improved significantly was 1879. In general there was a gradual move towards self-conscious management of instruments.

### **Instrument Studies**

There are broadly two bodies of work on instruments, both have enriched this thesis. Firstly there have been many excellent technical and empirical studies. William Knowles-Middleton has written on the barometer and thermometer, Henry King on the telescope, and James Bennett on position-finding instruments.<sup>147</sup> The construction of the latter by means of scale division has been studied by Allan Chapman.<sup>148</sup> In addition there have been catalogues of major surviving collections.<sup>149</sup> There have been useful compilations of instrument makers and the production of instruments by E.G.R (Eva) Taylor in the 1950s, and more recently by Gloria Clifton and Alison Morrison-Low.<sup>150</sup> The most relevant work in this field is that of Anita McConnell who published extensively on instruments used in aspects of earth science and on their makers.<sup>151</sup> McConnell produced catalogues and studies of instrument makers, providing considerable new information as a result. Another in this genre was John Milburn in his examination of the relationship between the instrument maker George Adams and the state.<sup>152</sup>

The National Maritime Museum has commissioned works on its globes, sextants, sundials, and most recently Richard Dunn has produced a work on navigational instruments.<sup>153</sup> Smith and Norton Wise, starting from a different perspective, mention Thomas Sumner's method of finding longitude and devote attention to compass production.<sup>154</sup> Instruments are integral to Rebekah Higgitt and Richard Dunn's compilation of essays.<sup>155</sup>

The second body of work consists of scholarly studies being produced in the light of contemporary outlooks. The issues have been documented by Rachel Laudan.<sup>156</sup> The topics most pertinent for this thesis are: instruments in ANT or other models, credibility and morality of instrument use, instrumental and non-instrumental observation, and the hierarchies instruments impose. The first of these, discussed in chapter 1, will be re-visited with regard to the specific use of instruments.

Richards quotes Latour: 'Instruments are conceived, designed, improved and replicated to capture some theorised property of nature, and once standardised they fix the

---

<sup>148</sup> Knowles-Middleton (1964), (1966) King (1955) , Bennett (1987)

<sup>148</sup> Chapman (1996)

<sup>149</sup> Turner (1973), De Clercq (1997), Morton and Wess (1993)

<sup>150</sup> Taylor (1966), Morrison-Low (2007), Clifton (1995), Baker ( 2009) pp.169–191

<sup>151</sup> McConnell (1980a), (1980b), (1981), (1982), (1986a), (1986b), (1988), 1992a),(1998), (2005) (2007)

<sup>152</sup> Millburn (2000)

<sup>153</sup> Dekker (1999), Mörzer Bruyns and Dunn (2009), Higton and Ackermann (2002), Dunn (2016)

<sup>154</sup> Smith and Wise (1989) p. 726 and p. 754

<sup>155</sup> Higgitt, Dunn and Jones (2015)

<sup>156</sup> Laudan (2003)

nature of that property.’<sup>157</sup> ‘Qualitative experience is converted into the outcome of the practice of measurement which uses instruments designed to reduce it to quantitative data representing a set of pre-determined properties’. While in theory these statements apply, in practice changing instrument design and changes in the method by which phenomena were measured made comparisons over time difficult.

Golinski remarks that practitioners worked hard to distinguish object from instrument. He remarks that instruments are initially often objects of investigation. Only when they become trusted tools are they used in conjunction with others in complex systems which can reproduce results far from the original. Bourguet, Licoppe, and Sibum note that Humboldt’s unity of science rested on interaction with instruments and trained users rather than upon abstract principles.<sup>158</sup> Research for this thesis indicates that mathematical principles were important to only a small minority of RGS travellers, even though, the thesis also argues, the mathematical principles were an essential part of the resource the travellers received.

Withers argues that understanding how geographical knowledge is gained through the use of instruments is vital for a full appreciation of the methods and practices of the actants.<sup>159</sup> He points to the prominence of instruments in a number of instructive texts of the mid nineteenth century, concluding that the stress placed upon the regulation of observation, the necessary instruments, and the credibility through conduct in observation, both human and instrumental, was in order to ‘develop methodological principles for geography at a time when science was making its own rules and geography was seeking to establish itself.’ Regulation is necessary of oneself, others, of other things and of error.<sup>160</sup> The work by Withers and Fraser MacDonald is specifically devoted to instruments. It is a collaboration which contains chapters discussing the themes of standards, manufacturers, credibility, competence and proper usage. The contribution by Rae, Souch and Withers has been discussed above.<sup>161</sup>

There is some agreement, in accordance with ‘Humboldtian science,’ that approaches to instruments changed in the early nineteenth century. Bourguet, Licoppe and Sibum put this clearly: ‘A new regime of knowledge, grounded in empirical trials and the use of instruments was thus perceived as a challenge to previous observational practices.’<sup>162</sup> Bourguet asks ‘How did it happen that travellers now carried instruments and made measurements?’ Golinski argues that new classes of instruments in the nineteenth century were made available through industrial production. This is certainly true of both the sextant and compass<sup>163</sup> Burnett states that ‘instrumentation was important but instrumental rhetoric more

---

<sup>157</sup> Richards (2011b) p. 150

<sup>158</sup> Bourguet, Licoppe and Sibum (2002) p.8, p.13

<sup>159</sup> Withers (2013)

<sup>160</sup> Withers (2011) p.45-46

<sup>161</sup> Withers and MacDonald (2015) p. 12, Rae, Souch and Withers (2015)

<sup>162</sup> Bourguet, Licoppe and Sibum (2002) p. 3

<sup>163</sup> Bourguet (2002) p.137, Chapman (1990), Smith and Wise (1989) p. 754

so.<sup>164</sup> Invoking Humboldt suggested an explorer was working within what many thought was the most reliable and measurement-centred geographical science of the day.’ This has been corroborated by the thesis. Schaffer and Withers both advocate the supposed morality of precise measurement.<sup>165</sup> Driver remarks that instruments were used to minimise subjectivity but pertinently notes that this was only one strategy and was liable to fail given the resources required to use the instruments in the field’.<sup>166</sup> The thesis concurs with this view. Schaffer investigates specifically the difficulties with instruments asking what constituted passable. This central question was rarely addressed directly. Rather, travellers threw resources at the problem relying on a network of instruments and associations for credibility.

The distinction between artefacts and human or animal bodies acting as instruments in producing numerical results has been mentioned and remains fraught. Bourguet, Licoppe, and Sibum note a ‘Tense distinction between bodies and instruments which is a fluctuating problem.’<sup>167</sup> There is a consensus that instruments were seen as an improvement on bodies: Schaffer quotes Herschel as using the phrase ‘vague and inadequate senses.’<sup>168</sup> Several writers consider instruments as extensions of the body, John Tresch for example; ‘they were totems and extensions of the researcher’s self- heightening perceptions providing scaling etc.’<sup>169</sup> Bourguet describes Louis Ramond as using instruments as a ‘continuum of himself’.<sup>170</sup> Outram concurs with this view as described above in the debate between armchair geographers and travellers. She argues that instruments were seen as an extension to human senses rather than a replacement, and therefore the tendency to denigrate knowledge based on sense perceptions applied to exploration in general. She points out the dilemma caused by a necessary reliance on the person and their senses, which opposed the disembodiment of science as an Enlightenment ideal.<sup>171</sup> This thesis argues that by the time the RGS was lending instruments to expeditions in the mid-1830s, instruments were seen as replacing rather than extending human or animal bodies.

The use of the human body as an instrument has been addressed by Raj.<sup>172</sup> Raj underestimates the prevalence of the use of pacing as a measure of distance, and the use of scientific artefacts by the pundit surveyors, making their practices less exceptional than he infers. Bourguet, Licoppe and Sibum comment on the ‘artificial dualism’ between instruments and bodies, but also on the split which occurs in controversies when instruments are considered more objective.<sup>173</sup> The thesis argues that instruments were consistently

---

<sup>164</sup> Burnett(2000) p.15

<sup>165</sup> Withers (2011) p.45-46, Schaffer (1995)

<sup>166</sup> Driver (1998) p.25

<sup>167</sup> Bourguet, Licoppe and Sibum (2002) p.7

<sup>168</sup> Schaffer (1997) p.441

<sup>169</sup> Tresch (2010) p. 270

<sup>170</sup> Bourguet (2010) p.101

<sup>171</sup> Outram (1999), Driver (2010) p.13

<sup>172</sup> Raj (2002) p.159

<sup>173</sup> Bourguet, Licoppe and Sibum (2002) p. 7 Introduction

considered more objective and therefore superior to human or animal bodies. The particular case of recording instruments, where the human intervention is less apparent, has also been the subject of deliberation.<sup>174</sup> Schaffer raises the issue of a personal factor which was used to take account an observer's characteristics; these personal traits were taken account of by a few travellers. This is the human equivalent of instrument error, which was also applied by a minority of RGS travellers.

The situation is not clear cut. Bourguet cites Humboldt, whose predilection for measurement has been noted, on the loss of charm of nature through the repetitive measuring; 'measuring altitudes, counting stamens.' A hundred years later this trope became common currency at the RGS.<sup>175</sup>

The circumstances dictated by instruments are also the subject of attention. The thesis considers questions posed by Golinski: 'What can be transported and what is local? What does the hardware carry with it? What capability does the hardware have to change practice or discipline users?'<sup>176</sup> The last is particularly challenging. Both Burnett and Raj discern a hierarchy within surveying, with trigonometric surveys at the top.<sup>177</sup> This can be corroborated by previous work on David Gill.<sup>178</sup> As well as a hierarchy of surveying types there is a hierarchy among the instruments. For example, Tresch cites the field instrument and the master instrument.<sup>179</sup> It is apparent that instruments can no longer be considered straightforward pieces of technology: their role has become a complex area of enquiry.

## **Conclusion**

The thesis is situated in relation to a rich secondary literature as outlined above. To date, however, there has been no in-depth research of a scientific institution's incorporation of instruments into its practices both in the field and at the centre of calculation. A cyclical model was suggested by ANT, which is here used as a foil. There is a wealth of material on what is called 'embedded resource', but not a consideration of instruments and their users as representing embedded resource to be mobilised in the field.

Work on the primacy of numbers, the professionalization of science, and science and the state respectively places the thesis in relation to current historical debates. For example, the dominance of numerical data was important from the 1830s but starting to be questioned in the early twentieth century. The professional calculators, map makers, and surveyors were able to exert some influence. The place of the RGS within the state was negotiated but subservient in WW1.

---

<sup>174</sup> Golinski (1998) p. 138, Bourguet, Licoppe and Sibum (2002) p.6

<sup>175</sup> Bourguet (2010) p. 120

<sup>176</sup> Golinski (1998) p. 139

<sup>177</sup> Burnett (2000) p.9, Raj (2002) p. 175

<sup>178</sup> Calder Wood (1943), <http://www.tandfonline.com/doi/abs/10.1179/sre.1943.7.48.50?journalCode=ysre19>

<sup>179</sup> Tresch (2010) p. 271

The tentative nature of the discipline of geography has been remarked on by several authors. The issue of trust in the field and the behavioural codes this requires has received some attention. This thesis demonstrates how behavioural codes worked in the reception of results from RGS travellers. Maps have received considerable attention, and this work illustrates their arguments, the immutability of these maps as mobile being challenged. Empire is a constant backdrop for controversies over 'centre and periphery' and 'self and other'. The 'centre and periphery' model is found to work well for instrumental results, and the relationships between 'self and other' have been shown to affect, and be affected by, the instruments themselves.

Instruments can have agency in ANT, but there has not been a study of the multiple agencies of a collection of institutional instruments over time. The RGS has been the focus of several studies which have addressed particular aspects such as instruction and the production of *Hints*. Not until now has there been an opportunity for an in-depth study of the role of the instruments in that institution.



## Chapter 3:

### Patterns of Activity

*When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind... you have scarcely advanced to the stage of science.<sup>1</sup>*

#### Introduction

In keeping with the systematic approach described in chapter 1, this chapter presents much of the basic empirical data accumulated from the archives, thus demonstrating the extent of the Society's engagement with mathematical instruments. This data provides the backdrop for chapters 4 to 8. The chapter contains information on acquisition and the management of instruments, the make-up of borrowers, the number and destinations of expeditions, what types of measurement were made, and the outputs which can be quantified.

#### Instrument Acquisition

Before 1879, information on acquisition can be deduced from the Council and Committee minutes and the RGS in-house journals. During this period the instruments were not always identified individually but could be listed as a set: there are 336 records of instruments or sets being acquired, which can be regarded as a minimum figure for instruments as each set contained at least one instrument. From 1879, acquisition data was recorded systematically providing date, source and, usually, cost.<sup>2</sup> Between 1879 and 1930 the Society acquired 1156 individual instruments. In the century from 1830 to 1930 the Society acquired about 1500 instruments. This figure includes a small number of items not related to exploration: watches as presents, clocks, barometers and globes for the Library and Map Room, and instruments with special provenance for the Museum which to they were usually donated.

---

<sup>1</sup> Kelvin (1883)

<sup>2</sup> AP 52 CI

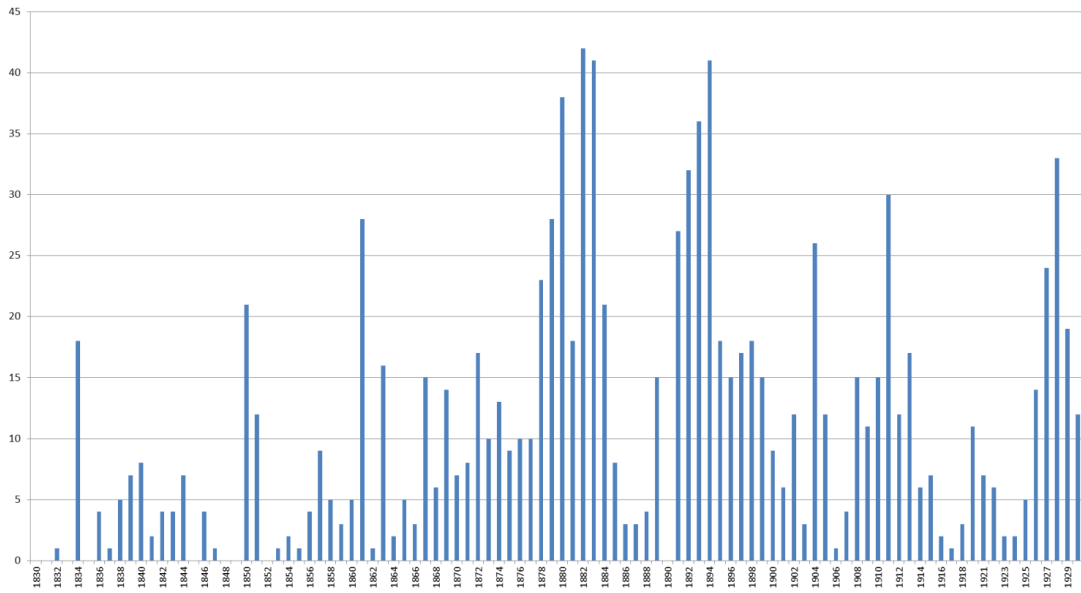


Fig 3.1: Number of instruments acquired by year 1830- 1930.<sup>3</sup>

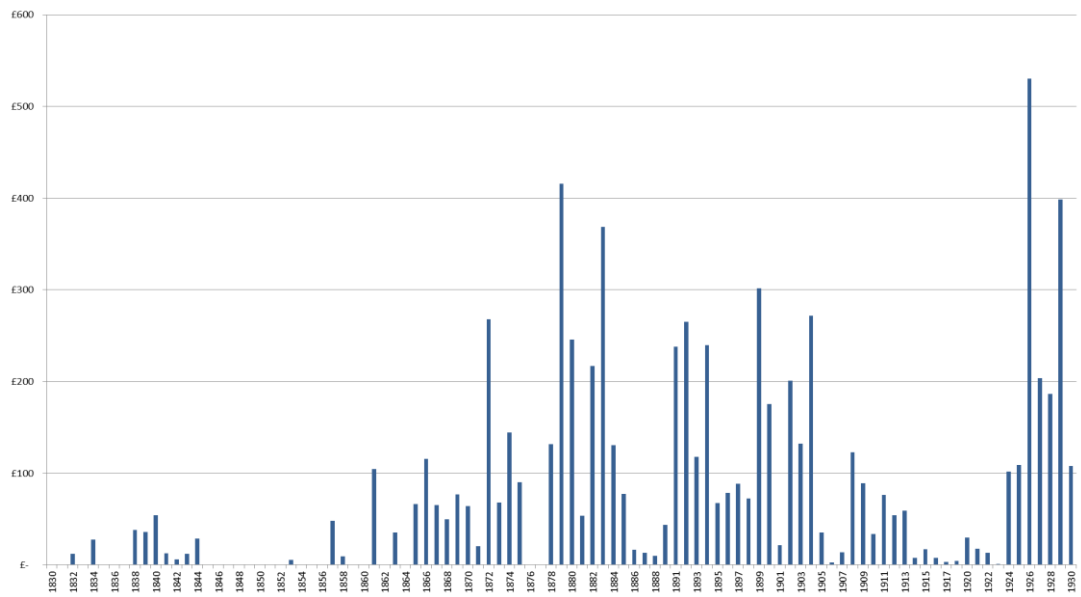


Fig 3.2: Expenditure on purchase of instruments by year 1830-1930.<sup>4</sup>

<sup>3</sup> CMs, FCs, AP 52 CI

<sup>4</sup> CMs, FCs, AP 52 CI

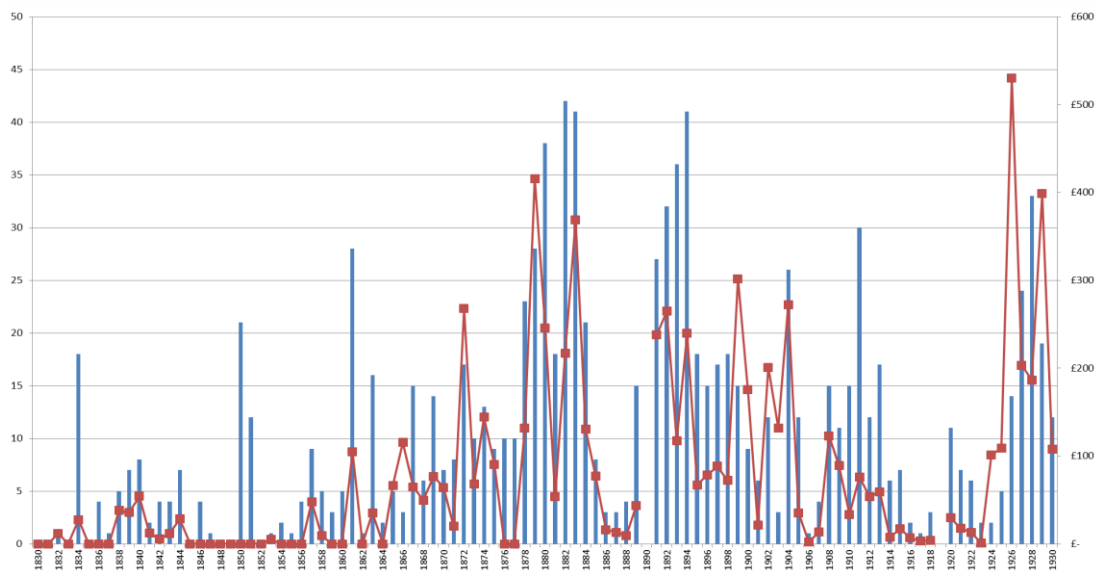


Fig 3.3: Comparison of acquisition and expenditure 1830-1930.<sup>5</sup>

Figure 3.1 reveals the activity of 1834, and fallow years in the late 1840s. The 1890s was the decade of maximum volume of acquisition. The mismatch between spending and acquisition in the early years, by a comparison of figures 3.1 and 3.2, indicates the level of borrowing from other institutions. The large donation by Robert Shedden in 1850 and 1851 is apparent. Figure 3.2 demonstrates an increase in spending from 1861 when money from the Petherick fund was assigned to instruments.<sup>6</sup> The cost of the Wild photo theodolite in 1926 accounts for the high spending that year.

Acquisition appears to follow cycles of expansion and contraction. As a result of losses sustained in 1872 travellers applying for the loan of instruments in the late 1870s were often disappointed, which probably accounts for a drop in purchasing between 1875 and 1878.<sup>7</sup> Between 1860 and 1872 instruments on loan to expeditions were listed in the *JRGS*, but no audit of the instruments in the Society's possession was kept. Between 1872 and 1879 there was a further decline in record keeping in that no information was provided regarding individual instruments, merely a list of the expeditions to which they were lent.<sup>8</sup> While purchasing was more established in the 1870s, borrowing was still preferred if possible. In short, the Society's collection of instruments was not consistently developed.<sup>9</sup>

Figure 3.3 demonstrates a diminishing dependence on borrowing and donation as purchasing became a routine activity. Between 1879 and 1930 the Society purchased about ninety percent of its instruments. As the acquisition of instruments became systematised it

<sup>5</sup> CMs, FCs, AP 52 CI

<sup>6</sup> CM. Jan 28<sup>th</sup> 1861, Mar 25<sup>th</sup> 1861, June 16<sup>th</sup> 1862. *JRGS* 28 (1858) p.169, CM Nov 11<sup>th</sup> 1861, Sub-Committee on Instruments Nov 12<sup>th</sup> 1861

<sup>7</sup> CM Mar 13<sup>th</sup> 1876, African Committee July 8<sup>th</sup> 1878, July 15<sup>th</sup> 1878

<sup>8</sup> CM Apr 8<sup>th</sup> 1861, June 10<sup>th</sup> 1861

<sup>9</sup> CM Dec 9<sup>th</sup> 1872

became less commonly the subject of debate. The figures exhibit various peaks; in the early 1880s, the early 1890s, the 1910s and the late 1920s. The first peak can be accounted for by the initiative for a scientific geography from 1876 onwards permeating into observational practice, and the responsibility of Coles for the instruments in his new role as Map Curator.<sup>10</sup> The second reflects the high volume of expeditions at that time; in particular large numbers of instruments were acquired for Harry H. Johnston and an Antarctic whaling expedition.<sup>11</sup> The peak of 1902 is explained by the equipping of the National Antarctic expedition, and that of 1909 in part by a Balkan expedition.<sup>12</sup> The last peak reflects a desire to re-establish traditions after WW1.<sup>13</sup>

---

<sup>10</sup> SPC June 27<sup>th</sup> 1879

<sup>11</sup> CM Feb 23<sup>rd</sup> 1891, FC Oct 3<sup>rd</sup> 1892

<sup>12</sup> CM June 29<sup>th</sup> 1908

<sup>13</sup> CM Nov 14<sup>th</sup> 1892

Traveller's Name	Year	Place of Expedition	Instruments Lent	Value	Value	Books of Observations	Books published	Books returned	Remarks
Mr J. T. Hearshy	1877	West Coast of Africa	East. Ast. Bar. 18.5 inch etc.	21	21	1 Paper. 2000 pages.	2ulligum Report	1 Paper & Observations	Returned to England
.. F. B. Croxon	1877	East Coast of Africa	East. Ast. Bar. 18.5 inch etc.	60	45	none	none	none	This gentleman had to return having caught the fever on the coast in Africa.
.. Wm. Johnson & Joseph Thomson	1878	East Africa	1 East. Ast. Bar. 18.5 inch etc. 2 Ast. Bars. 18.5 inch etc. 2 Ast. Bars. 18.5 inch etc. 2 Ast. Bars. 18.5 inch etc.	171	100	5 Papers, 10 Maps, 2 Books and Observations	Observations	Observations	Mr Johnson did not return having died in Africa.
.. Henry Forbes	1878	Belgian Congo	1 Ast. Bar. 18.5 inch etc.	9	not returned	1 Paper & Map by Capt. Forbes	none	none	Still abroad
.. F. H. S. Simons	1878	U. S. of Columbia	1 Ast. Bar. 18.5 inch etc.	16	16	none	none	none	Returned to England
.. J. L. Comber	1879	Congo District	1 East. Ast. Bar. 18.5 inch etc. 2 Ast. Bars. 18.5 inch etc. 2 Ast. Bars. 18.5 inch etc.	27	not returned	1 Paper, 1 Map and several Geographical Notes.	1 Paper & Map by Capt. Comber	Observations	This gentleman is still at work.
Rev J. Mullens D.D.	1879	East Africa	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	101	96	none	none	Observations	Died soon after leaving the Coast.
Capt W. H. Murchison R.N.	1879	Arctic Regions	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	5	5	1 Paper & Map.	2 in his books	none	Returned to England
Mr W. P. Johnson	1879	East Africa	1 East. Ast. Bar. 18.5 inch etc. 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	85	not returned	1 Paper & Map.	1 Paper & Map by Capt. Johnson	Observations	Still at work.
Mr S. D. M. Morgan	1880	Central Asia	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	76	not returned	1 Paper	none	Observations	Returned to England
Surgeon Major Nicholson	1880	Afghanistan	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	24	not returned	none	none	none	Returned to England
Mr F. M. Call	1880	Congo	1 East. Ast. Bar. 18.5 inch etc. 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	55	not returned	none	2 in his books	none	Died in Africa
Mr W. H. P. Eden	1880	East Africa	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	86	not returned	none	none	none	Still abroad
Capt. T. L. Whiston R.N.	1880	East Africa	1 East. Ast. Bar. 18.5 inch etc. 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	110	87	1 Paper & Map.	1 Paper & Map by Capt. Whiston	Observations	Died in Africa
Commander M. Drummond R.N.	1880	Borneo	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	76	not returned	none	several Articles in local papers, London.	none	Returned to England
Rev W. G. Lewis	1880	New Guinea	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	52	not returned	1 Paper	London Mission Society New Guinea	none	Still abroad
D. S. Slesher	1880	East Africa	1 East. Ast. Bar. 18.5 inch etc. 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	20	not returned	1 Paper & Map	none	Observations	Died in Africa
Mr W. M. G. Miles	1880	Greece	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	4	not returned	none	none	none	Returned to England
Mr Joseph Thomson	1881	East Africa	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	106	106	2 Papers & Maps.	many articles illustrated in "Good Words".	none	Returned to England
.. Jas. Stuart Esq.	1881	East Africa	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	34	not returned	1 Paper & Map & many valuable Geographical Notes.	none	Observations	Still abroad
.. J. H. Colquhoun	1881	China	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	8	not returned	1 Paper & Map.	2 in his books in 2 vols.	none	Returned to England
Commander O. L. Cameron R.N.	1881	West Africa	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	15	not returned	1 Paper	none	none	Returned to England
Lord Mayo	1882	S. W. Africa	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	3	not returned	1 Paper	none	none	Returned to England
Mr W. H. P. Eden	1882	Congo	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	56	56	several Geographical Notes	1 Paper in "Regions Beyond"	none	Died soon after his arrival in the Congo.
Capt. W. Dawson R.N.	1882	Circumpolar Expedition	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	100	not returned	none	none	none	This gentleman is still at work.
Rev H. M. Wakefield	1882	East Africa	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	54	not returned	several Geographical Notes	none	none	Still abroad
Mr J. V. East	1882	East Africa	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	21	not returned	1 Paper & Map	none	none	Still abroad
.. W. S. O'Neill	1882	East Africa	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	90	not returned	2 Papers & Maps	Consular Report	some sets of papers	Still abroad
.. W. H. Whiteley	1882	British Guiana	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	10	not returned	none	none	none	Still abroad
.. Joseph Thomson	1882	East Africa	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	145	not returned	none	none	none	Still abroad
.. E. D. Archibald	1883	For use at Home	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	25	not returned	none	none	none	For special purposes
.. W. Owen Bowen	1883	Madagascar	1 3 inch Transit theodolite, 1 Barometer, 1 Ast. Bar. 18.5 inch etc.	31	not returned	none	none	none	Still abroad
				Total value £1894					

Note:- No account has been taken in the above list of the depreciation of the instruments returned, as they have (in many cases) been again supplied to travellers, and entered at their original cost.

4/6/83

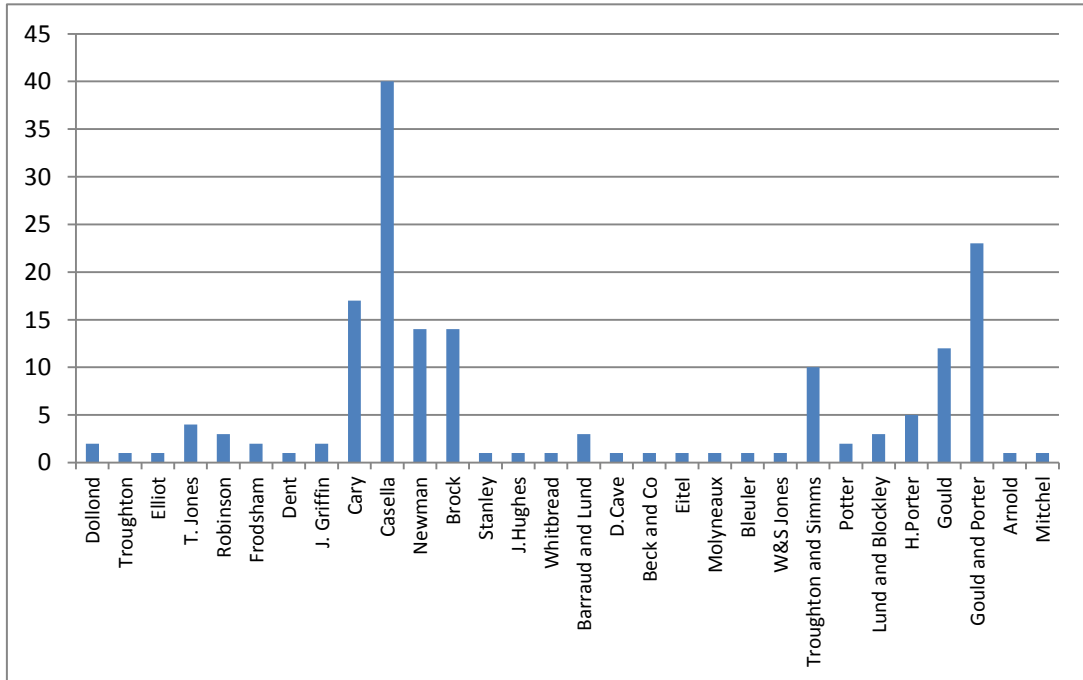
Fig 3.4 Report listing travellers, expeditions, and instruments lent to expeditions between 1879 and 1883.<sup>14</sup>

The 'Catalogue of Instruments,' listing when each individual instrument was bought, from whom, and usually the cost, was started in 1879.<sup>15</sup> As instrument purchases began to be recorded systematically, and the volume of acquisitions increased, it was decided that the interest on the legacies of both George Back and Murchison would be spent on the scientific

<sup>14</sup> AP 52 IIR

<sup>15</sup> AP 52 CI

outfit of travellers.<sup>16</sup> A detailed list was produced in connection with Coles' in-house training, which includes the instruments lent out, and their value, between 1877 and 1883, as shown in figure 3.4.<sup>17</sup>



<sup>16</sup> SPC 14<sup>th</sup> Mar 1876, Nov 28<sup>th</sup> 1879

<sup>17</sup> AP 52 IIR

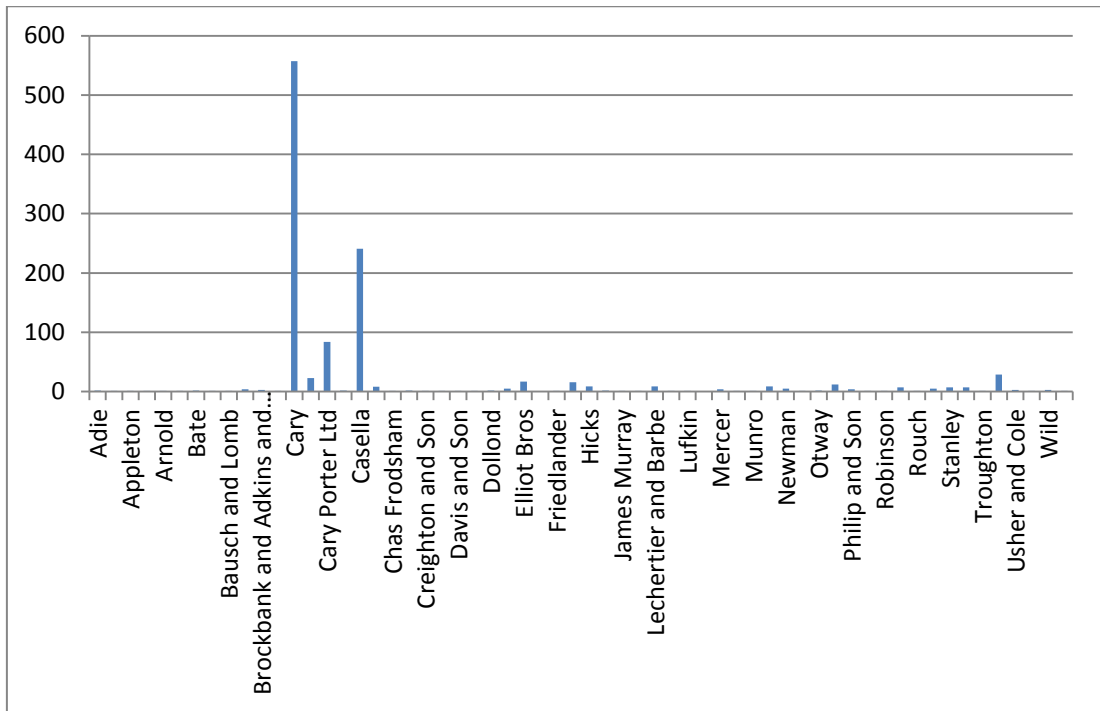


Fig 3.5 a and b: Number of instruments purchased from individual makers 1830-1879, and 1879-1930.<sup>18</sup>

The data collected on instrument makers seen in figures 3.5 a and b demonstrates that apart from the infrequent exceptions, for which no reasons were given, the Society retained the same suppliers, and that this conservatism became more pronounced in the second half of the period.<sup>19</sup> The vast majority of thermometers and hypsometrical sets were bought from Casella. 'Cary', which became 'Gould, late Cary', then 'Gould', then 'Gould and Porter' had a near monopoly on sextants and artificial horizons. 'Brock' supplied most chronometers and watches until 1884 after which 'Barraud and Lund', which became 'Lund and Blockley', took over. Spencer, Browning and Rust were chosen as purveyors of aneroids for a time in the 1860s. Troughton and Simms were used for a large range of type but a small number of individual instruments. Some firms such as Robinson and Newman went out of business, but the principal suppliers were remarkably long-lived.<sup>20</sup> The RGS was conservative in its choice of makers over the entire period.

<sup>18</sup> CMs, FCs, AP 52 CI

<sup>19</sup> FC July 15<sup>th</sup> 1861

<sup>20</sup> Clifton (1995)

## Instruments Deployed

Illustrations of the principal types of instruments have been provided. Whenever possible, these instruments are from the RGS Collection, but if none are now extant, images of similar instruments from other collections have been substituted.

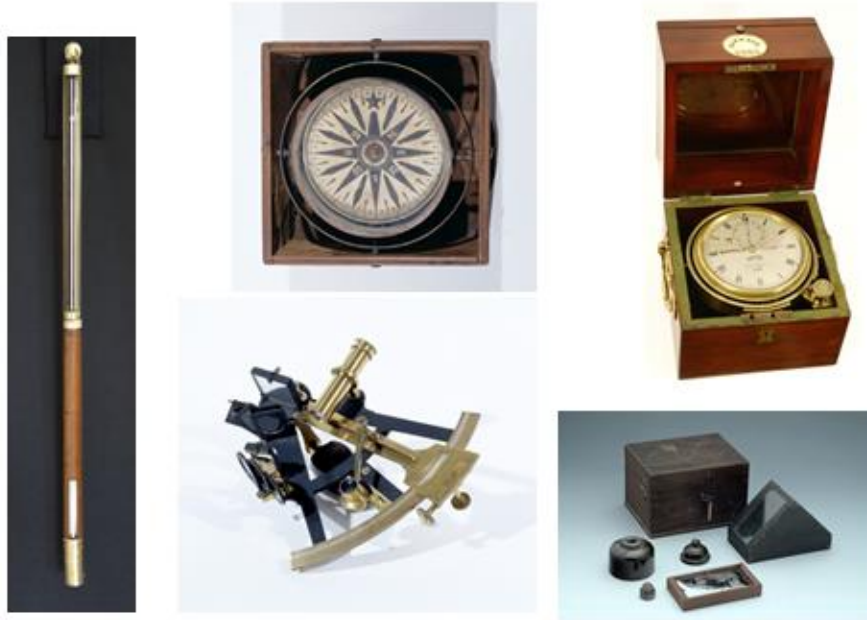


Fig 3.6: Instruments Commonly Used c.1830-c.1860: Clockwise from left: mountain barometer, boat compass, box chronometer, artificial horizon, eight-inch sextant.<sup>21</sup>

By the 1860s there had been some changes in the type of instruments lent. On January 14<sup>th</sup> 1863 Bedford Pim was one of the first to be granted an aneroid rather than a mountain barometer.<sup>22</sup> By the 1860s the box chronometer had been largely replaced by the pocket chronometer and the compass by the prismatic compass. The hysometer, or boiling point apparatus, was becoming popular. The choice of instruments provided became established in the 1860s and 1870s. Whenever individual instruments are mentioned for loan in the next three decades, they are almost always of this small group.

---

<sup>21</sup> <https://www.bidsquare.com/1/97/brass-mountain-barometer-cary> March 2017, Artefact E/213 (1), [http://www.tobiasbirch.com/barraudlondonno3045\\_55.php](http://www.tobiasbirch.com/barraudlondonno3045_55.php). March 2017, MHS Oxford Inv No 41159, Artefact E 3 (1)

<sup>22</sup> CM Jan 14<sup>th</sup> 1863





Fig 3.7: Instruments Commonly Used c.1860-c.1900: From left to right: hypsometer, prismatic compass, box sextant, and aneroid.<sup>23</sup>

Some instruments became obsolete as will be shown. On the other hand some instruments devised centuries earlier were still being acquired; an hour glass in 1900, a Gunter scale in 1908, and a Marquois rule for scale drawing in 1928. Plane tables only started to be popular after 1885. Prismatic compasses, aneroids, and theodolites made up very similar proportions of the whole between 1879 and 1930. Seismographs, subtense rods, transit instruments and tide machines barely featured. The acquisition of watches was notable during the 1880s and 1890s peaks of acquisition, but did not feature in those of the twentieth century peaks when longitude could be found by telegraphy.<sup>24</sup>

<sup>23</sup> RGS hypsometer no 44 Artefact A 13 (3), Prismatic compass RGS no 7 Artefact E 27] (1), Box sextant Artefact 4.1 (1), Aneroid used by Albert Markham on the Arctic Expedition of 1875-6 Artefact G 1 (4) (1)

<sup>24</sup> Bertrand (1900)



Fig 3.8: Instruments Commonly Used 1900-1930: From left to right: theodolite, tape measure, and plane table.<sup>25</sup>

In spite of interest in new technologies, the Council continued to be asked for instruments which had had only minor design changes since 1830.<sup>26</sup> New materials had been introduced but little else. For example in 1904 the Expeditions Committee asked for an estimate for the complete apparatus for measuring baselines with invar tape.<sup>27</sup> Transit theodolites and occultation telescopes became sought after in the period before WW1, but their principles of use were not innovative.<sup>28</sup>

Established and innovative technologies were used simultaneously in the 1920s. One instrument which incorporated both was the photo-theodolite, which the Society purchased in 1926. The twentieth-century expeditions tended to be more differentiated in their aims than the earlier ones, and occasionally required specific and expensive instruments such as tide gauges and seismographs. By the end of the period the Society was lending out instruments

<sup>25</sup> Artefact D 3, Artefact D 1, Plane table <http://www.ck3llc.net/Archives/2012/2ndQtr/MainArticle.html> March 2017

<sup>26</sup> EC Dec 5<sup>th</sup> 1904

<sup>27</sup> Scientific Research Committee Nov 16<sup>th</sup> 1911

<sup>28</sup> CM Feb 24<sup>th</sup> 1913, Dec 4<sup>th</sup> 1911, Mar 27<sup>th</sup> 1911, June 24<sup>th</sup> 1912

to the value of around £900 annually.<sup>29</sup> Keeping up with the increasing remit of geography entailed expending resource on expensive instruments for specific uses.

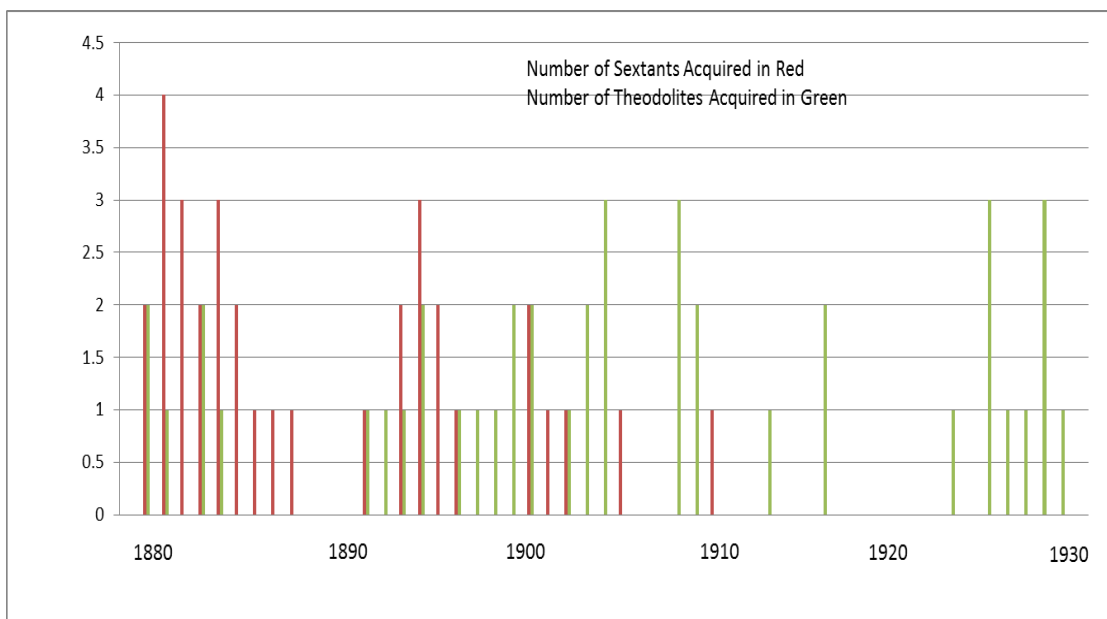
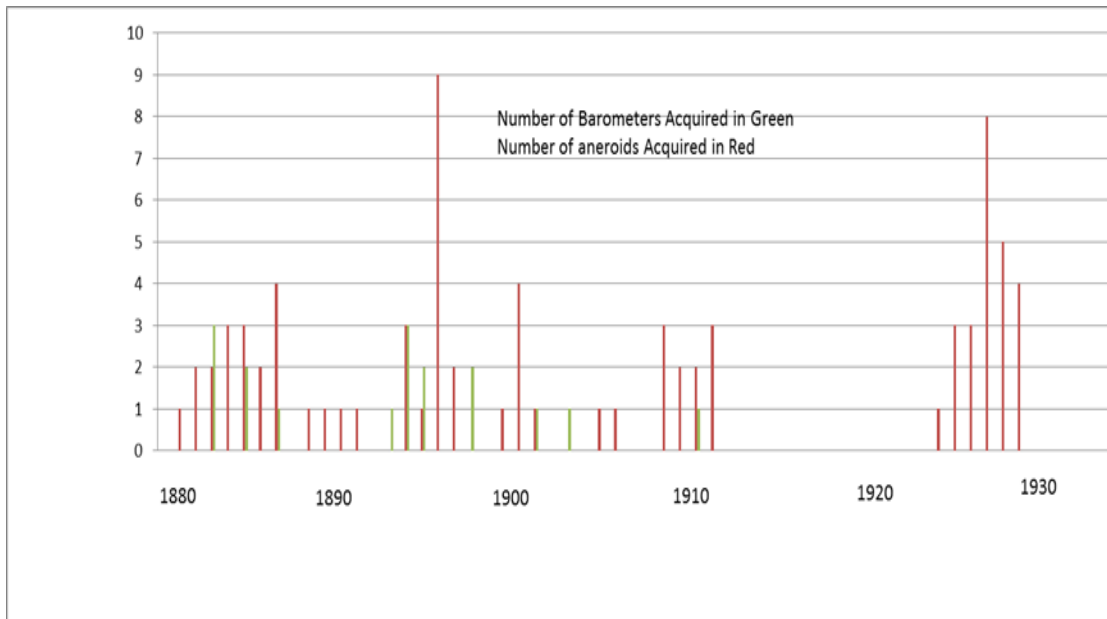


Fig 3.9 a and b: Choice of Instrument: A comparison of the number of barometers and aneroids acquired, and a comparison of the number of sextants and theodolites acquired, 1879-1930.<sup>30</sup>

<sup>29</sup> EC Mar 6<sup>th</sup> 1933

<sup>30</sup> CMs, FCs, AP 52 CI

In figures 3.9a and b the choice of instruments over time is demonstrated by comparing the acquisition of those which perform the same function. Only three mountain barometers were acquired in the twentieth century and non after 1910, by which time they had been superseded by aneroids. Sextants were popular until the mid- 1890s but were not purchased after 1910 when they were superseded by smaller theodolites with telescopic sights. It is argued in chapter 4 that choice of instruments reflected tensions within the Society and played a major role in defining ‘exploration.’

### Management of Instruments

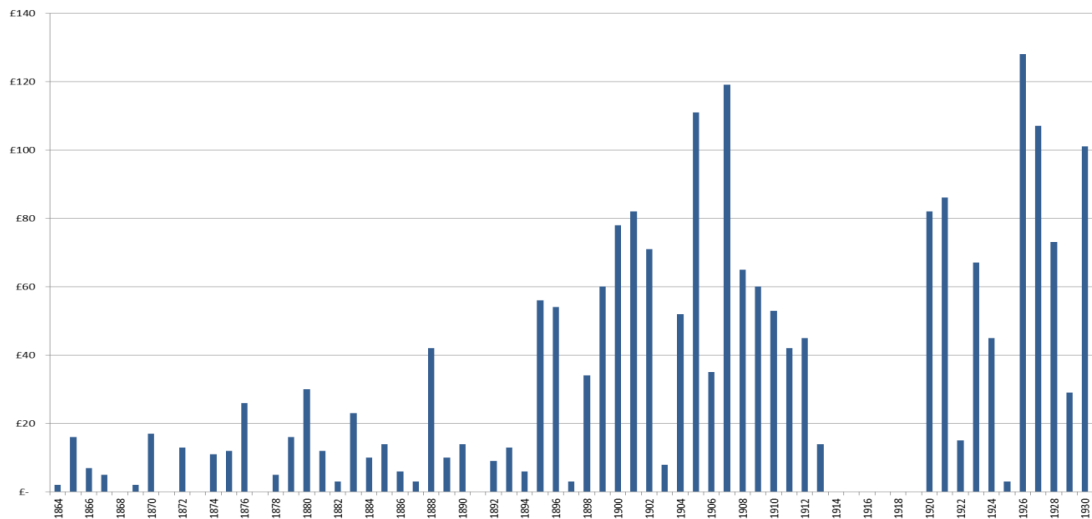


Fig 3.10: Expenditure on instrument repair 1864-1930.<sup>31</sup>

One of the ways in which the Society augmented the value of its instruments was by managing them as a collection. An aspect of this activity which can be expressed numerically was the provision of repairs as seen in figure 3.10. The Finance Committee minutes frequently recorded expenditure on repairs, although sometimes repair and acquisition were listed together.

<sup>31</sup> CMs, FCs

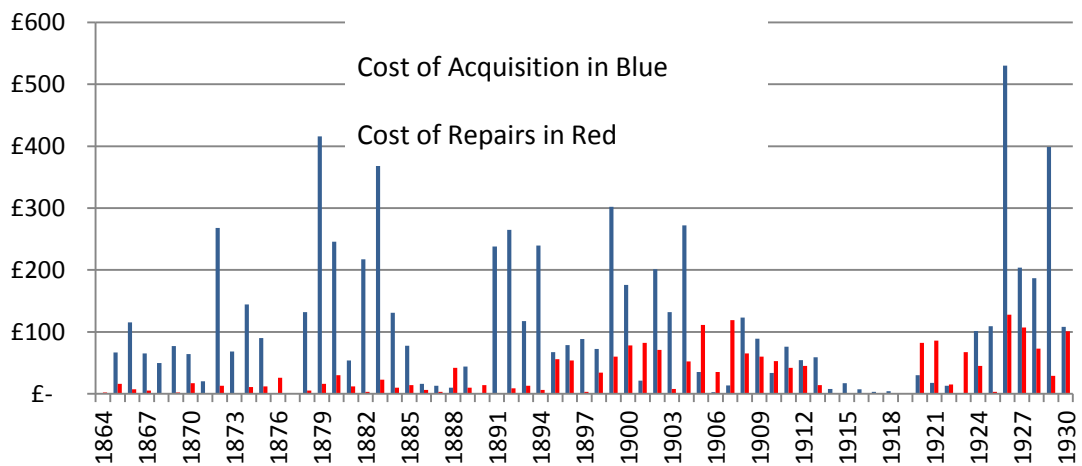


Fig 3.11: Comparison of spend on acquisition and repair 1864-1930.<sup>32</sup>

The increasing reliance on repairs after 1894 can be argued represents better management of the collection and an appreciation of its value.

### Borrowers and Their Training

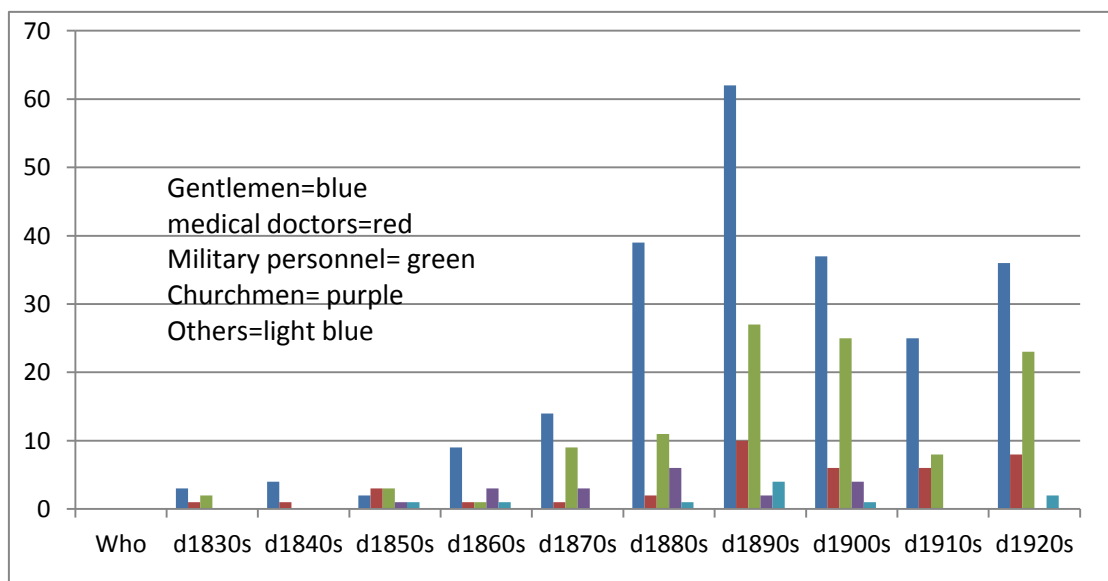


Fig 3.12: Composition of borrowers.<sup>33</sup>

Borrowers may be described as gentlemen of private means (blue), medical doctors (red), military personnel (green), churchmen (purple) and others (light blue), as seen in figure 3.12. The 'others' were diplomats in the 1850s and 60s, a lady of private means in the 1880s,

<sup>32</sup> CMs, FCs, AP 52 CI

<sup>33</sup> CMs, ECs, ICs, AP 52 ILT

three professors and a lady of private means in the 1890s, a professor in the 1900s, and a lady of private means and a professor in the 1920s.

Instruction was performed in two principal ways by the Society. The first was by the publication of an advisory text *Hints to Travellers* which went through ten editions during the century 1830-1930. The second was to provide tuition. This began in 1869 and was undertaken by successive map curators; George, Coles and Reeves. Jones has provided figures spent on education during part of the period. From virtually nothing in the 1830s the RGS was spending the equivalent of about £30K annually in the 1890s. By the 1920s the figure had increased to the equivalent of £66K.<sup>34</sup> A third, minor, way in which the RGS was indirectly involved in training was by the loan of instruments to pedagogical establishments such as Oxford University. This is not investigated in the thesis.

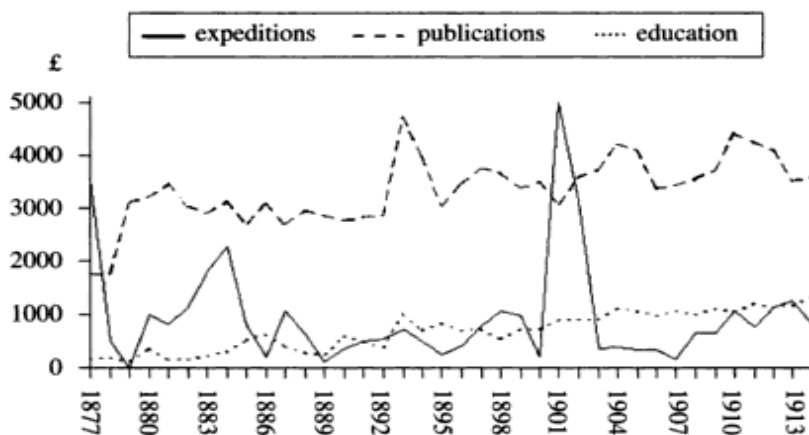


Figure 3.13: Annual expenditure on expeditions, publications and education, 1877-1914, from Jones M. (2005).<sup>35</sup>

While there is considerable evidence that George was frequently called upon to give instruction, it is impossible to quantify results. In 1879 Coles began to undertake instruction as a specific task. Records of monthly payments to Coles were kept at Finance Committee and show a considerable outlay on behalf of travellers and the Society. For example Coles was paid £8 and 5s for instruction for July and August, and £7 10s for October in 1879.<sup>36</sup> Between October 1879 and December 1880 he had worked for 232 hours and had 24 students.<sup>37</sup> From these lists it is possible to compare Coles' list with a record of who borrowed

<sup>34</sup> Estimated receipts 1924-5 in FC Jan 9<sup>th</sup> 1925, Jones (2005) p. 327

<sup>35</sup> Jones M. (2005) p.327, sourced from RGS ledgers vols 1-4

<sup>36</sup> FC Nov 3<sup>rd</sup> 1879

<sup>37</sup> JMS/21/ 48

instruments during the eighteen months and shortly afterwards from 'Instruments Lent to Travellers'.<sup>38</sup> Discussion of data on tuition features in chapter 6.

### Expeditions

The total number of expeditions supplied with instruments by the RGS between 1830 and 1930 was 436. Annual figures were low until the 1870s when they began to rise, peaking in the 1890s. WW1 caused a hiatus, with the numbers only starting to recover in the 1920s.

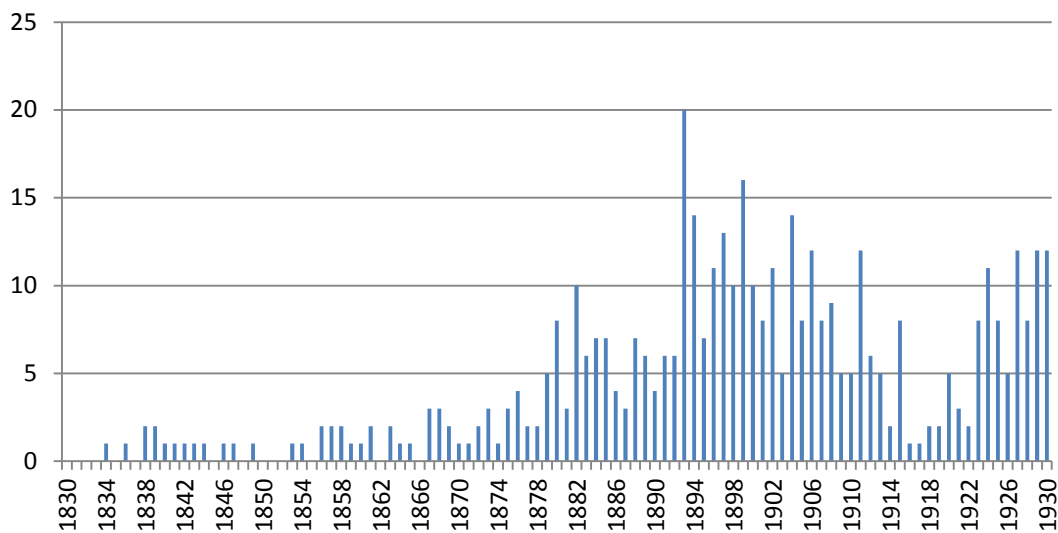
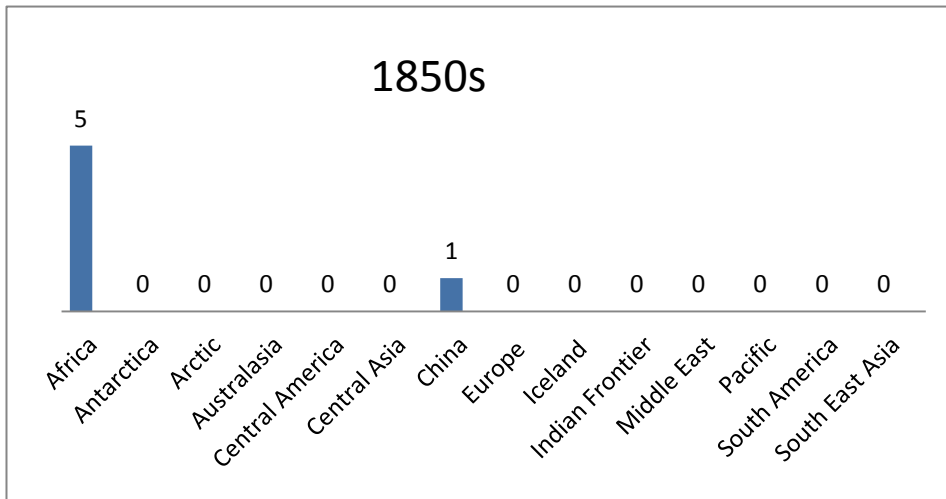
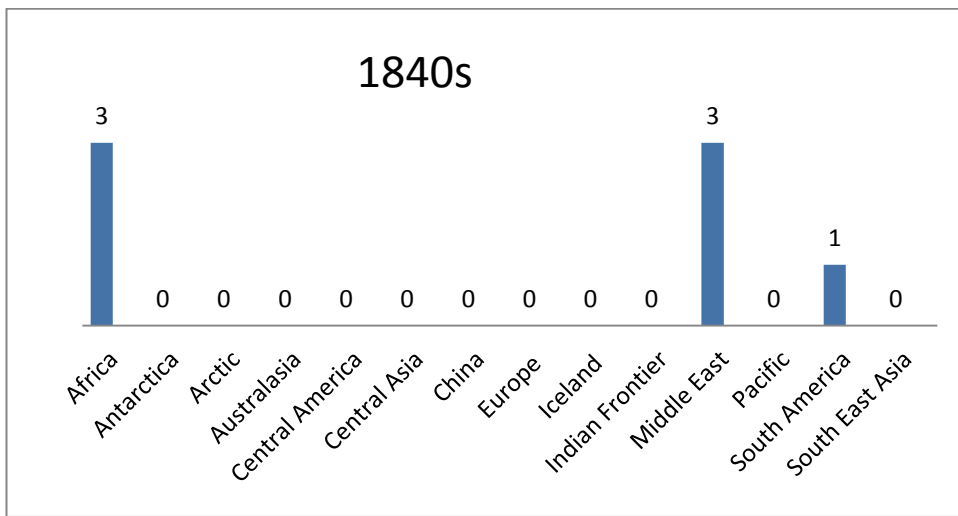
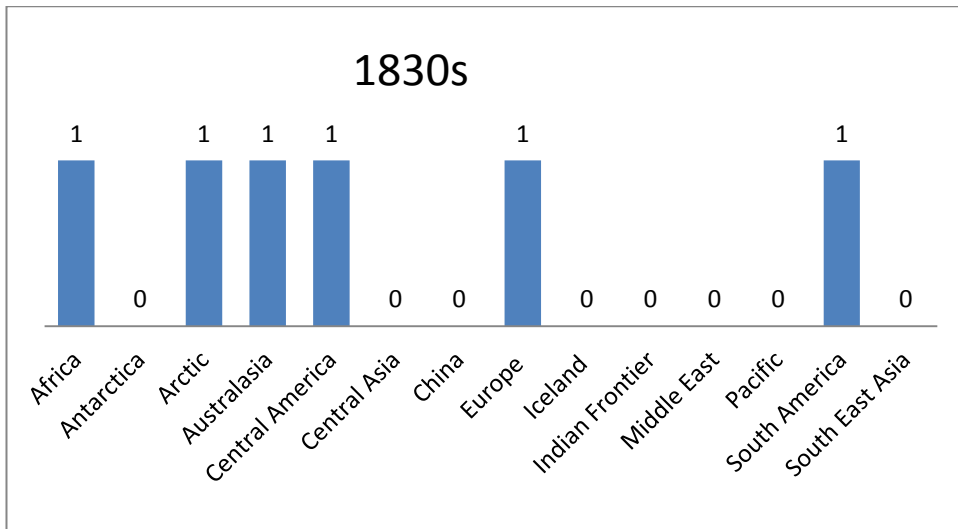


Fig 3.14: Number of expeditions by year supported with instruments 1830-1930.<sup>39</sup>

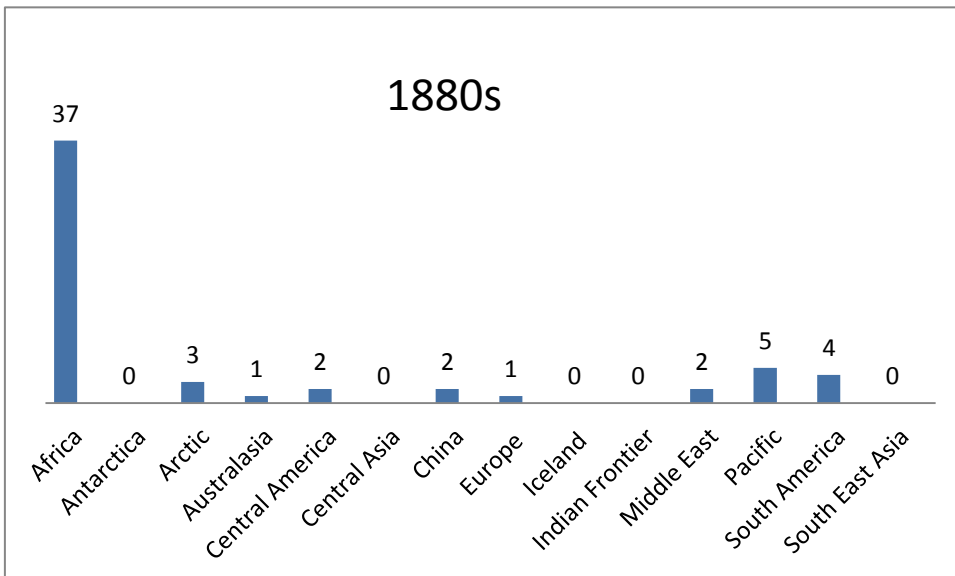
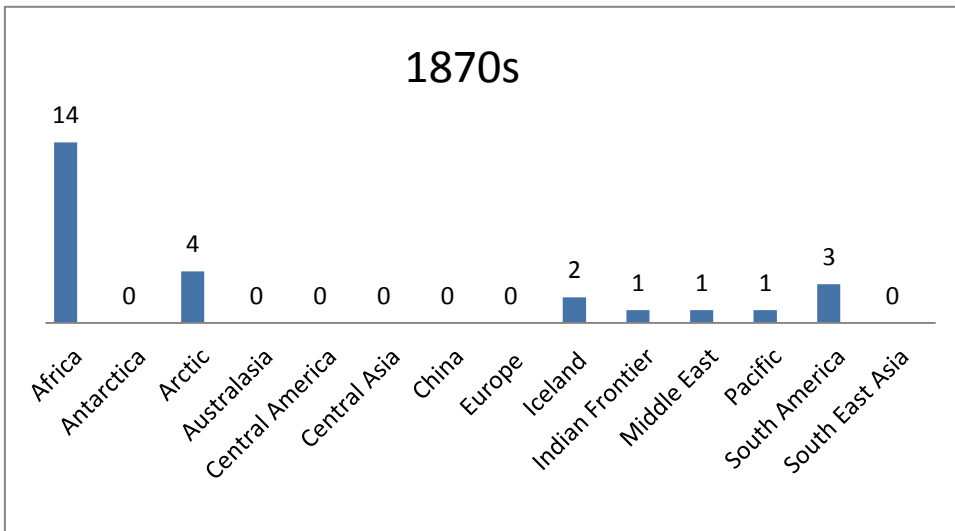
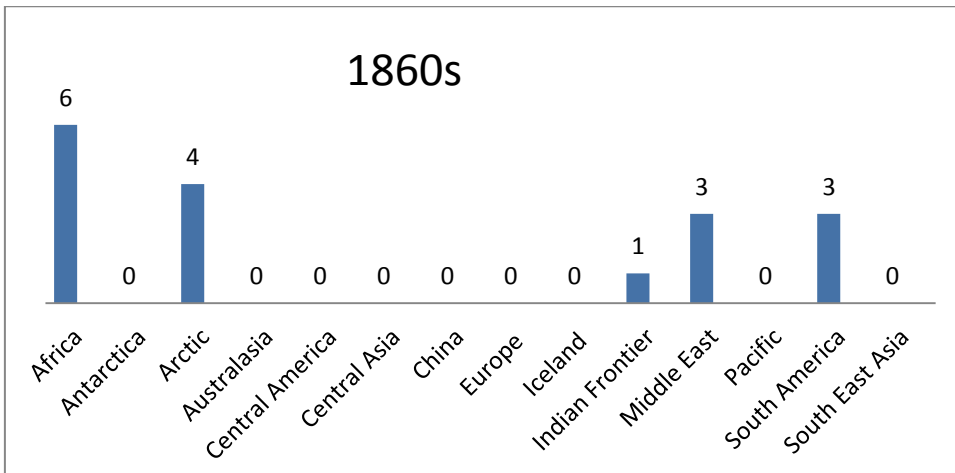
The early expeditions were 'open-ended', that is, aimed at filling in 'blanks' on maps. From the 1880s they became increasingly differentiated, concentrating on specific aspects of physical geography, natural history, ethnography, or historical geography. Africa emerged as the principal destination in the 1850s and remained so. By the 1890s the RGS had to look harder for blank spaces on the map, and in the twentieth century the area of interest became more dispersed with the Middle East becoming the destination of significant numbers.

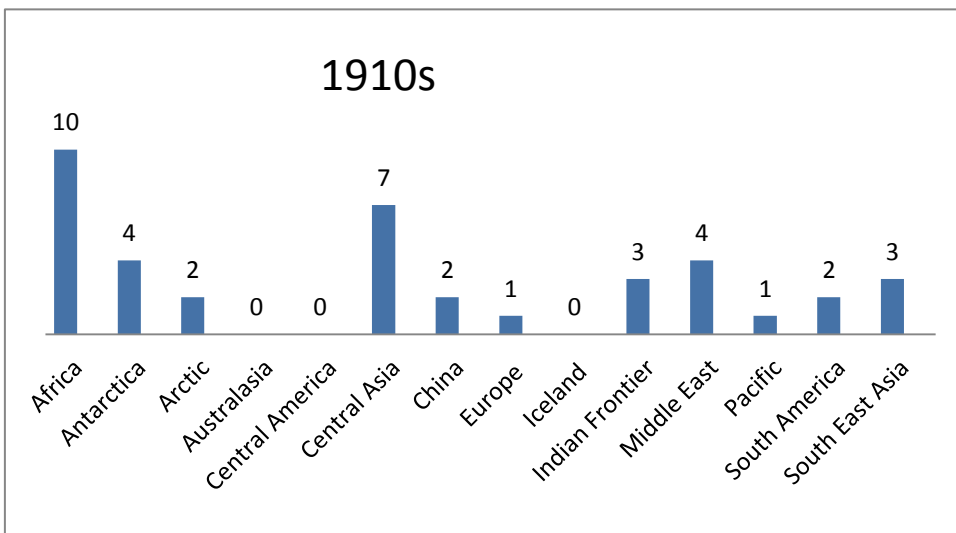
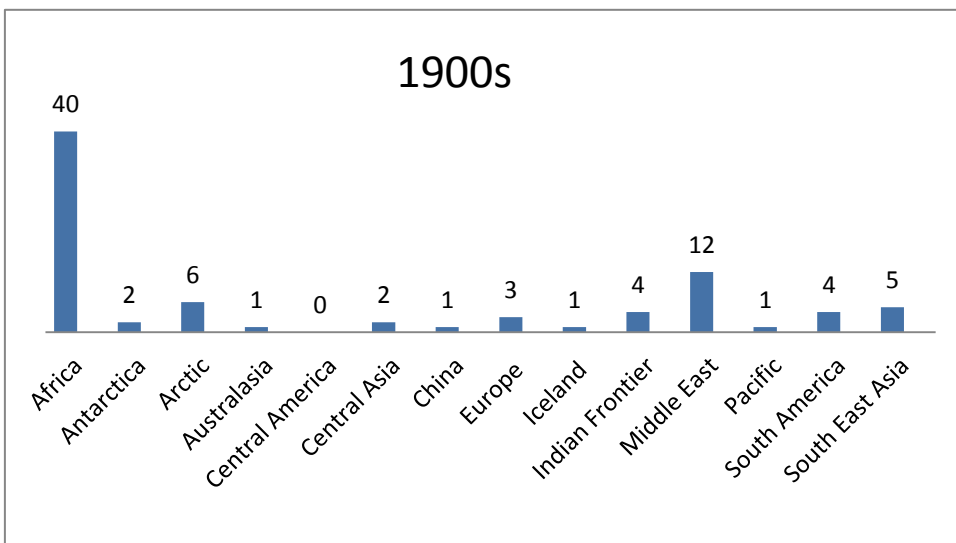
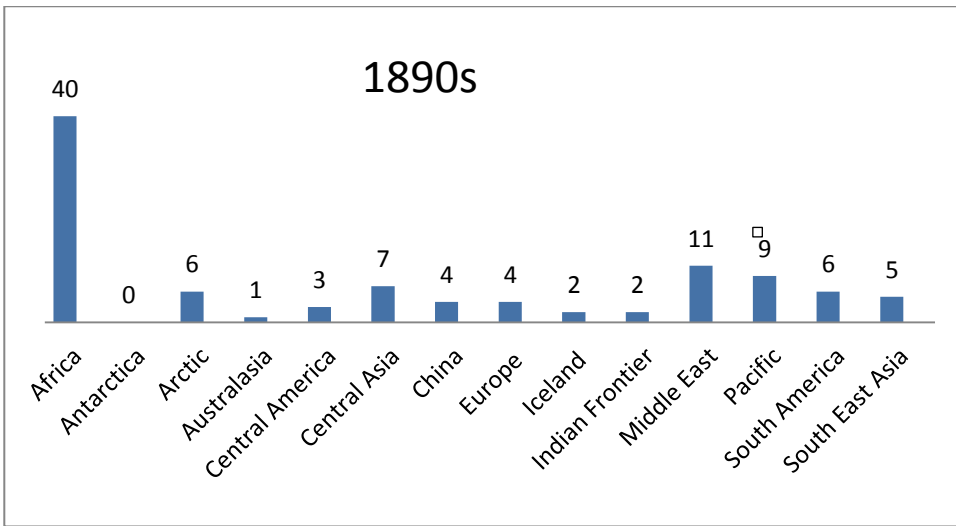
<sup>38</sup> AP 52 ILT

<sup>39</sup> CMs, ECs, AP 52 ILT









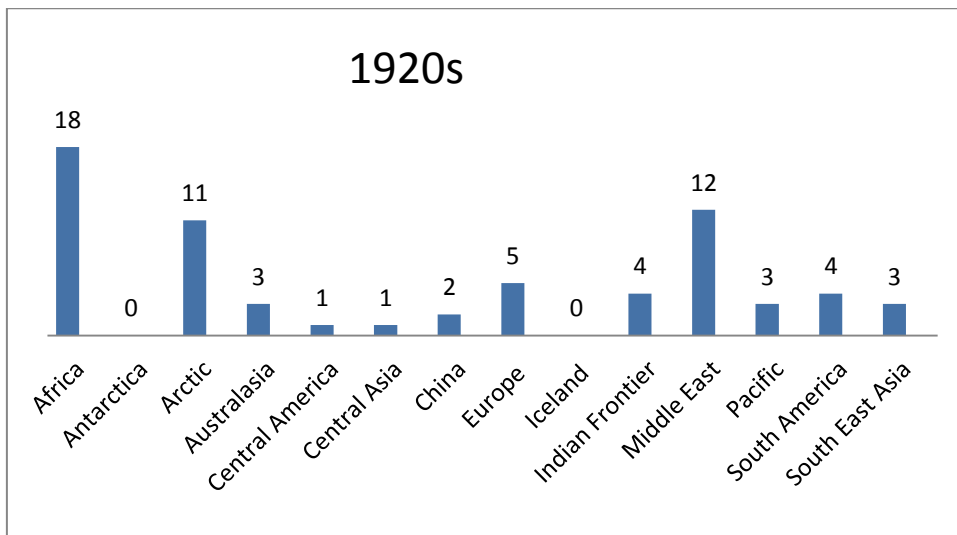


Fig 3.15 a to j: Destinations of expeditions by decade 1830-1930.<sup>40</sup>

Throughout the period the same types of instruments were sent indiscriminately to all parts of the World. Data on instrument itineraries show that, while a small minority of instruments were not mobilised, many were sent out repeatedly. The maximum number of expeditions by one object was eighteen, and the mean between three and four.<sup>41</sup> Figure 3.16 is a transcript of the itinerary of watch 9, a well-travelled instrument, taken from the Catalogue of Instruments. All the instruments have had their itineraries documented in this way.

<sup>40</sup> AP 52 CI, CMs, ECs

Explorer(s)	Place(s)	Date(s)
Commander Gitting	East Africa,	1883-1885
W.J. Last	East Africa	1885-1887
H.G.C. Swayne	East Africa	1888-1889
H.Ridley	Malay	1890-1892
R.S. Swan	South East Africa	1893-1896
R.J. Turley	China	1896-1898
S. Vanderleur	Egyptian Sudan	1899,
Maj W.C. Daniels	New Guinea	1902-1905
J.Evershed	Spain	1905-1906
G.W Bury	Arabia	1908-1909
Grant Peterkin for Mrs Bullock Workmen's expedition	Himalayas	1912-1912
Kingdom Ward	N.E India trans-frontier expedition	1913-1923
St J. Philby	Arabia	1924-1925
Major R.E. Cheesman	Abyssinia	1925-1927
H.G. Watkins	Greenland	1930-1931
R.Churchward	Brazil	1932-1932

Fig 3.16: Itinerary of watch 9.<sup>42</sup>

### Types of Measurement or Activity

Analysing the data by the phenomena measured reveals that more instruments were acquired to measure height than any other physical phenomenon. The next most popular phenomenon was temperature, followed by position-finding, direction-finding and drawing. Length measurement, meteorology and calculating are represented by a relatively small number of artefacts. The emphasis on height may be interpreted as a feature distinguishing land exploration, for which the Society became established, from sea navigation. The large number of thermometers can be explained by their fragility but also their ease of use and

---

<sup>42</sup> AP 52 CI

general applicability, which included height measurement. Length was often measured by speed of human or animal walking, and aspects of meteorology were frequently a lesser consideration.

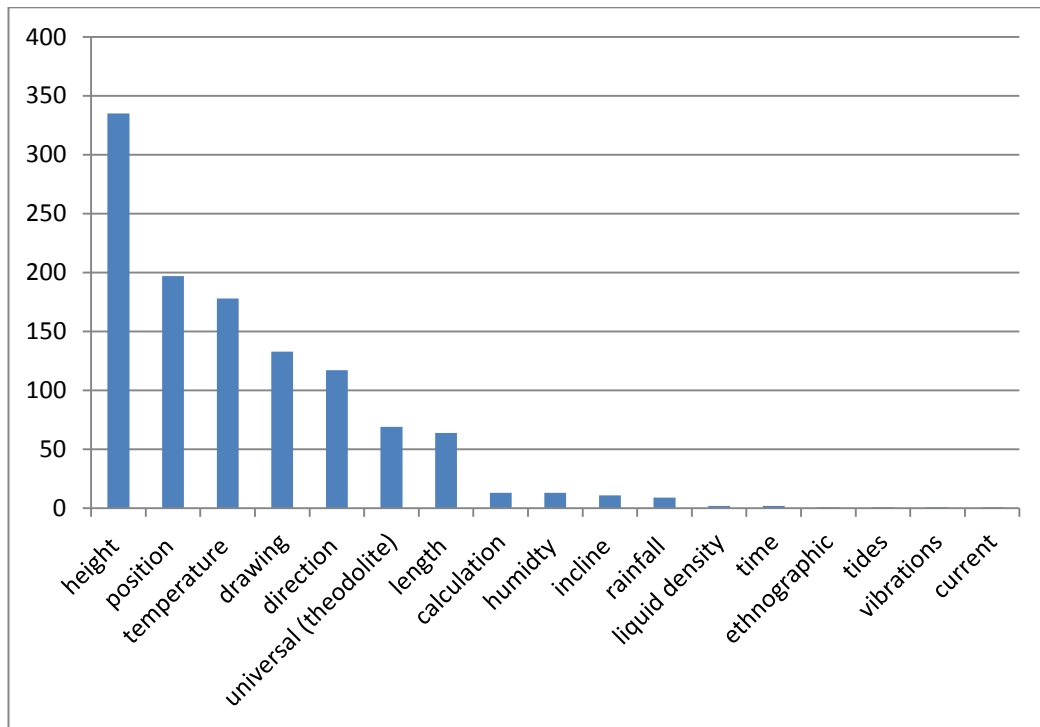


Fig 3.17: Number of instruments by type of measurement or activity 1879-1930.<sup>43</sup>

### Outcomes

The relationship between the loan of instruments and publishing has been studied as a mark of success of the Society's instrumental activities in the production of geographical knowledge. Publication was expected, even assumed, but was not a consistently explicated requirement of the Society.<sup>44</sup> Of the 436 exploratory expeditions that procured instruments from the RGS during the century 1830 to 1930, 252, or 58%, resulted directly in publications in a peer-reviewed journal. The rate varied to some extent over the period: the decrease in the rate in the twentieth century is significant. Alongside this decrease was an increase in papers from travellers who published on topics other than those directly concerning the expeditions for which instruments were provided. This usually preceded the loan, indicating

<sup>43</sup> CMs, FCs, AP 52 CI

<sup>44</sup> AP 52 CI

<sup>44</sup> Youngs (1994) p.87

the advantage of a publication record for the bestowing of this particular mark of approval, and the diminished interest in the actual mobilisation of the instruments subsequently.

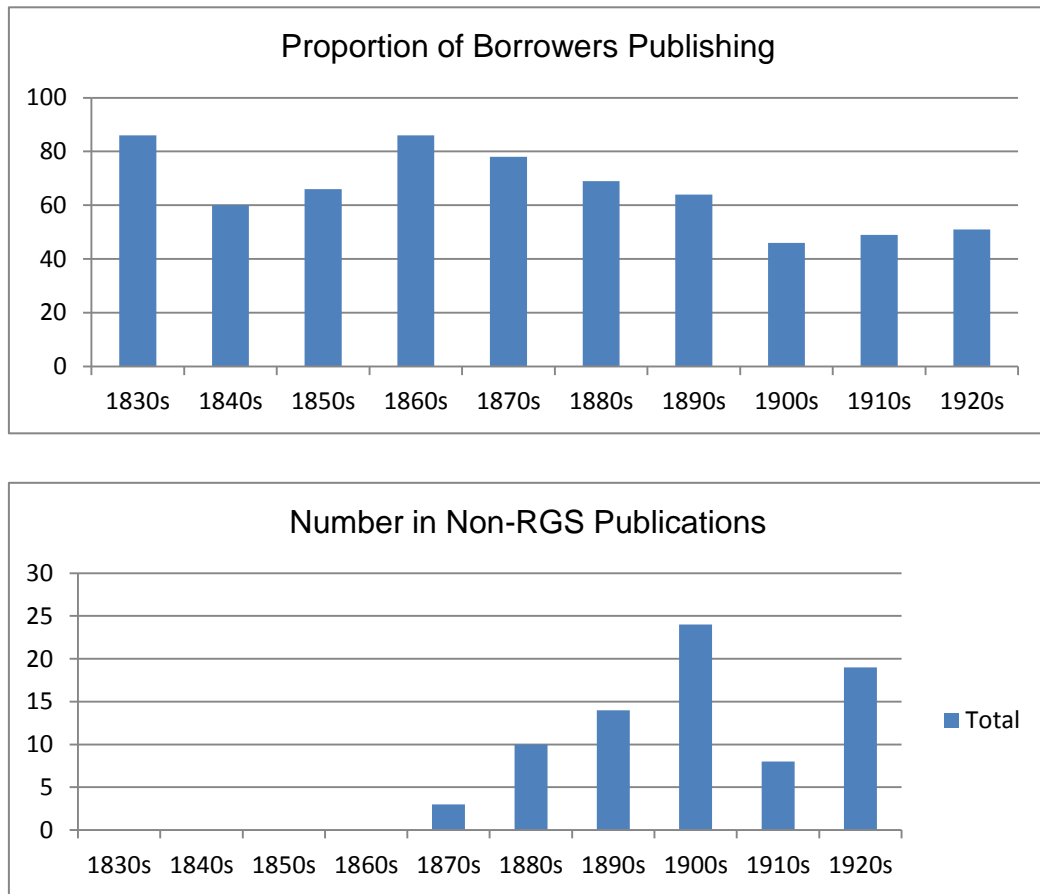


Fig 3.18 a and b: Proportion of borrowers publishing by decade, and number publishing in non-RGS publications.<sup>45</sup>

Another mark of success for travellers was the awarding of medals. Those borrowers receiving the Founder's or Patron's medal have been compared with the number of new borrowers in each decade, assuming that it was highly unlikely if not impossible to receive a medal more than once. It can be seen that the proportion of borrowers becoming medallists was far greater in the early decades when there were fewer expeditions. From 40 per cent in the 1830s the proportion dropped to less than ten per cent in the 1880s, before picking up at the end of the period.

<sup>45</sup> JRGS, PRGS, GJ, AP 52 ILT, CMs, ECs, Jstor database

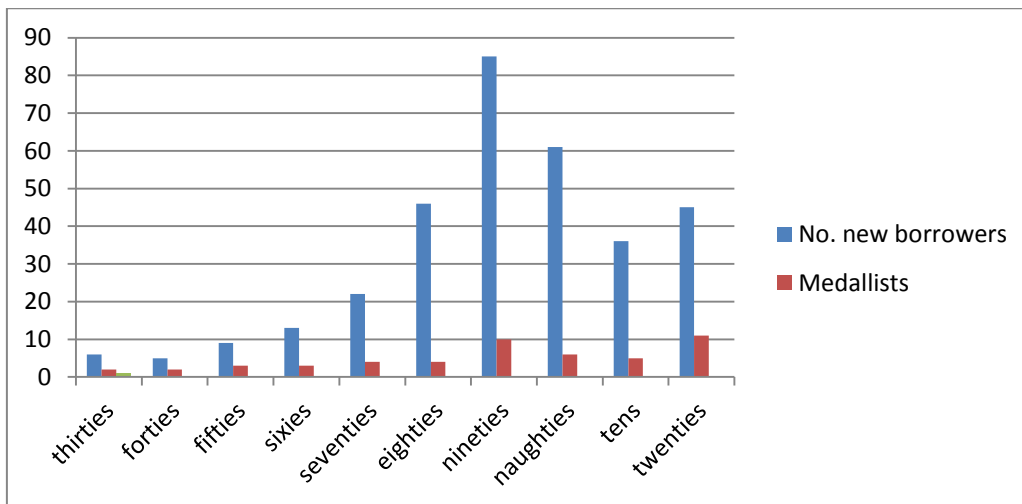


Fig 3.19: Borrowers who became medallists 1830-1930.<sup>46</sup>

### Conclusion

The RGS provided instruments for loan to travellers from 1834 until the end of the period and beyond. An early reliance on borrowing and donations was gradually superseded by an increased willingness to purchase. The types of instruments acquired changed little although more convenient forms; the box sextant, prismatic compass, aneroid and watch became more popular after the mid nineteenth century. The theodolite and plane table were widely used in the twentieth century. Measurement of temperature, height, direction and position were most frequently observed. The RGS was conservative in its choice of maker, adhering to a small group throughout the period. Increasingly it undertook repairs as part of its management of the collection.

The majority of travellers were gentlemen, but military personnel were increasingly represented in the second half of the period. Instruction was provided in two principal ways: by texts and by tuition. The first edition of *Hints to Travellers* was produced in 1854; the tenth edition of 1921 was the last in the century under consideration. While personal tuition was carried out by the Map Curator George, it only became a recognised aspect of the activities of the Society in 1879 when Coles was appointed to provide it in addition to his other duties.

The number of expeditions supported by provision of instruments was small in the first four decades, and only started to climb in the 1870s. The decade of maximum activity was the 1890s, although numbers were increasing again by 1930 following the lasting impact of WW1. The most popular destination was Africa which dominated the energies of the Society in the second half of the nineteenth century. Itineraries of objects show virtually no specificity with regard to destination except in the case of alcohol thermometers and a few

<sup>46</sup> CMs, ECs, AP 52 ILT, JRGS, PRGS, GJ

instruments designed for the polar expeditions or the more specific requirements of later projects.

Nearly sixty per cent of travellers who borrowed instruments subsequently published, the majority in the Society's publications, so the activity was successful on this level, in that the embedded resource produced results in terms of knowledge creation. Another relationship lending itself to quantification, and hence inclusion in this chapter of data, is the awarding of medals to borrowers, where it is noted that just under 10 per cent of borrowers were awarded medals over the period, with the rate higher in the early and later years but lower in the middle period.



## Chapter 4:

### Instruments and their Embedded Value

*To procure specimens of such instruments as experience has shown to be most useful, and best adapted to the compendious stock of a traveller, by consulting which, he may make himself familiar with their use.*<sup>1</sup>

#### Introduction

The chapter involves a comprehensive survey of instrumental practise at the RGS in preparation for mobilisation in the field. The above epigram states the third of six objects of the Society promulgated in the first edition of the *JRGS* in 1831. Yet the Society never fulfilled its ambition for a collection for perusal, but instead acquired instruments for loan to expeditions. This, while never a stated aim of the Society, nevertheless took place consistently and became an enduring activity.

When acquired, the instruments already represented a 'hinterland' of knowledge, both physical and intellectual, relating to their physical construction and the mathematical principles on which they were based.<sup>2</sup> It is argued, however, that their intrinsic worth for exploration was enhanced by their association with the Society, whose discourses served to focus the competing aspirations of various groups to mould the concept of appropriateness. The instruments benefitted from the resource invested in their management, and from the interactions between the Society and instrument makers concerning their modification and design, and from the interaction between the Society and the mathematical community concerning the latest mathematical constructs supporting their function.

The first part of the chapter provides the context for the instrumental culture at the RGS, investigating the arguments brought to bear on behalf of factions within the Society which shaped the concept of 'proper' instruments for exploration, and, in turn, the concept of exploration.<sup>3</sup> The second part traces the actual acquisition and provision of instruments for expeditions from archival evidence. The third part examines how the RGS managed its instruments, and how this activity enhanced value. The final parts address the design of instruments and the supporting mathematical relationships, when the Society engaged with instrument makers and mathematical practitioners respectively.

#### Defining 'Proper' Instruments

The word 'instrument' was often preceded by the word 'proper' at this time; what constituted 'proper' was a constant subject of debate, influenced considerably by the financial

---

<sup>1</sup> *JRGS* 1 (1831) p.viii

<sup>2</sup> Livingstone (2010) p.7

<sup>3</sup> Edney (1997) p.64

environment but also by factions within the Society. As Rae, Souch and Withers, have shown, the consensus within the RGS was that instruments were ‘key features associated with the advance of geographical science.’<sup>4</sup> However, deliberations over the choice of ‘proper’ instruments reveal internal conflicts.

The epigram which prefaces chapter 3 from Lord Kelvin in 1883 represents the attitude of the RGS as a whole during the period.<sup>5</sup> As several authors have shown, numerical values were esteemed; they lent objectivity to the quest for information. There was an aspiration for exploration to be based on ‘scientific’, which meant numerical, data, and measurement was seen as fundamental to the control of space and of society. This assigning of morality to precision underlay the acquisition and use of instruments.<sup>6</sup> Space was geometricized by instrumental measurement.<sup>7</sup> However, within this culture there remained a tension within the society between those who saw little or no distinction between the role of the RGS and that of government surveying, and those who fought to retain the image of the heroic explorer. The RGS used instruments as a vehicle to carve out their niche; therefore resource was expended on defining what constituted ‘proper.’

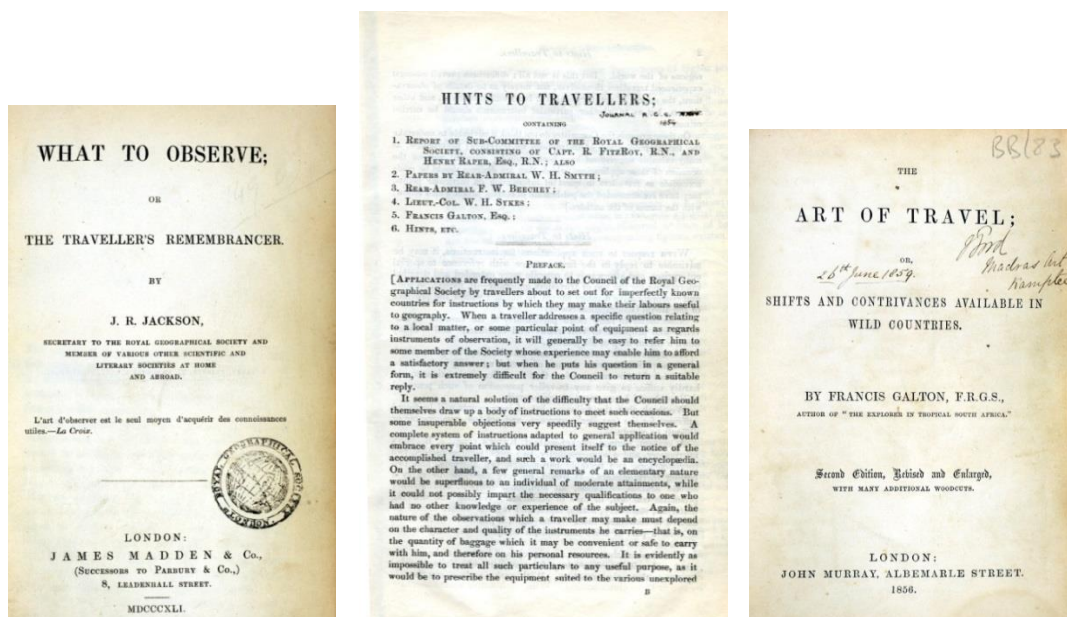


Fig 4.1 a, b and c: Title pages from left to right: *What To Observe* (1841), *Hints To Travellers*, (1854) and *The Art of Travel* (1856).<sup>8</sup>

<sup>4</sup> Rae, Souch, and Withers (2015) p 158

<sup>5</sup> Kelvin (1883) p.73

<sup>6</sup> Herschel (1849) p.9

<sup>7</sup> Alexander (2002), Smith and Wise (1989) p.724, Baron (2013)

<sup>8</sup> Jackson (1841), *Hints* (1854), Galton (1856)

Following in the genre of Harriet Martineau, Julian Jackson, then Secretary, set out the instruments he considered essential in *What to Observe*, (1841).<sup>9</sup> These were: a sextant and artificial horizon, prismatic compass, pocket compass, pocket chronometer, portable or mountain barometers, Rutherford's maximum and minimum thermometers, barometric or boiling point thermometer, hygrometer and clinometer. Other instruments were advised: soil thermometers could be made by surrounding bulb in non-conductor, actinometers, (which measured radiation) were considered good but heavy and expensive, so could be substituted with a blackened thermometer, Daniel's dew point hygrometer and Leslie's wet bulb thermometer were recommended, and a clinometer for the inclines of rock strata described by the geologist De La Beche with a spirit level and graduated arm. Further instruments regarded as desirable were Nicholson's hydrometer, a diaphanometer consisting of highly reflective spherical balls for the measurement of the purity of sea or fresh water, a log line and sand glass, a rain gauge, an atmometer for measuring evaporation, an anemometer, (Lind's being more portable than Osler's,) a drosometer for measuring dewfall, de Sussure's cyanometer, a dipping needle variation compass, and Hansteen's compass. Prospective travellers could be relieved that a 'graduated basin for measuring earthquakes and a photometer' were 'not strictly necessary for the traveller' and a eudiometer, which measured air quality, 'may be dispensed with.'<sup>10</sup>

---

<sup>9</sup> Martineau (1838), Jackson (1841), Withers (2013), Driver (2001) p. 51

<sup>10</sup> Jackson (1841) p. 454- 455

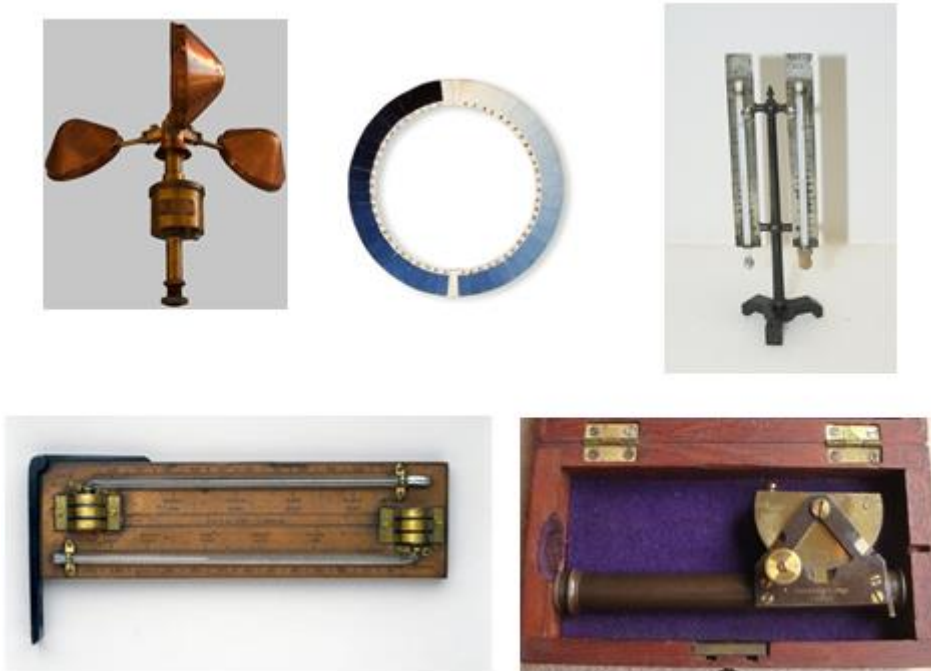


Fig 4.2: Some instruments listed by Jackson: Clockwise from top left: anemometer, cyanometer, wet and dry bulb thermometer, clinometer, Rutherford maximum and minimum thermometer.<sup>11</sup>

These instruments helped to mark out the 'scientific' traveller. The aspiration to produce 'scientific' travellers can be traced to several authors, but in particular to von Humboldt and Herschel. It was not a long tradition and was actively constructed. Cannon reproduces Humboldt's remarkable instrument list from 1797 which includes thirty six different types of instrument by leading makers.<sup>12</sup> She describes a 'new regime of knowledge, grounded in empirical trials and the use of instruments'.<sup>13</sup> Humboldt received a premium medal from the Society in 1839, and thirty years later there was a monument erected to him.<sup>14</sup>

In 1854 the RGS produced a report which became the first edition of its own advisory pamphlet; *Hints to Travellers*.<sup>15</sup> The authors could not agree on which instruments were 'proper', so the report took the form of a collection of sometimes contradictory papers. For example, Henry Raper, a textbook writer, and Robert FitzRoy a trained navigator,

<sup>11</sup> [http://www.starmuseum.org/weather\\_exhibit/page15.html](http://www.starmuseum.org/weather_exhibit/page15.html) January 2017, *Bibliothèque de Genève*, Switzerland, ScM 1915-421, <http://www.fleaglass.com/ads/a-19th-century-clinometer-by-troughton-simms/> February 2017, . RGS maximum and minimum thermometer no 6 Artefact A 33

<sup>12</sup> Cannon (1978) pp.75-76

<sup>13</sup> Cannon (1978) p.74, Bourguet, Licoppe and Sibum (2003) p. 3

<sup>14</sup> CM Apr 22<sup>nd</sup> 1839, 8<sup>th</sup> Nov 1869

<sup>15</sup> Driver (1998) p. 21

advocated Rochon micrometers, but Frederick William Beechey did not.<sup>16</sup> Raper and FitzRoy used chronometers, but Admiral William Smyth of the Navy, and Galton, an independent traveller, did not.<sup>17</sup> Beechey recommended an achromatic telescope for the satellites of Jupiter, but Smyth considered the necessity of a large telescope as ruling out longitude by this method.<sup>18</sup> It is apparent that the choice of instruments was being used to define the meaning of exploration and the requirements of the potential explorer.

Raper and FitzRoy wrote how the following list 'will be found sufficient': sextant, horizon, pocket sextant, Kater's compass, Rochon's micrometer, sympiesometer, two pocket chronometers, two thermometers, two portable barometers, two aneroids and two boiling thermometers. It would be very desirable to carry a second sextant or circle, an additional horizon, and another prismatic compass in case of accidents..... Sextants are better than circles. Dark or inky water can replace mercury in an artificial horizon. Barometers can give good comparable results but are not strictly accurate'.

Smyth was more pragmatic: 'The first duty of a geographical traveller is the accurate determination of the route, the fewer instruments to be encumbered with the better'. In an appeal to the heroic aspect of exploration he advocates 'the observations of an intelligent mind'. Chronometers cannot be trusted but also 'lunar distances are mischievous under unpractised hands'; leaving no reliable absolute measurement of longitude. Boiling point thermometers are 'liable to serious errors.' Galton's section on outfit is forthright on some topics: 'I cannot recommend an explorer to have anything to do with a chronometer or mountain barometer.' *Hints* (1854) did not give a definitive description of what constituted 'proper', as in 1856 Captain Richard Burton asked the RGS Expedition Committee for the proper instruments for making observations without specifying what these were.<sup>19</sup>

Galton produced his own advisory book in 1855.<sup>20</sup> The title begged the question of whether exploration was to be considered an art or a science. The work devoted only ten pages to instruments in the last of twenty-five chapters. Galton recommended a 'common strong silver watch', with black hands, 'the performance of the watch is a very secondary matter. £4 is quite enough to give for it. Have another two of the same character wrapped up in old stockings.' For hypsometrical measurement 'common water does just as well as distilled water'. Galton was principally concerned with getting by without instruments.

Galton was convinced this 'art' could be taught 'here in civilised England', by means of illustrated lectures which he had been endeavouring to establish at Aldershot, and field practice for two hours a day for three months. His 'instruments' included an axe, saw, chisel, sail needle, and hammer. At the end of his work Galton reproduced the list of

---

<sup>16</sup> *Hints* (1854) p. 7 and p.11

<sup>17</sup> *Hints* (1854) p. 8 and p.21

<sup>18</sup> *Hints* (1854) p. 8-9 and p.11

<sup>19</sup> EC June 23<sup>rd</sup> 1856

<sup>20</sup> Galton (1856), Withers (2013)

mathematical instruments previously published in *Hints* (1854), emphasising their simplicity in contrast to the 'many instruments designed by the Astronomer Royal of Scotland', Charles Piazzi Smyth, which he deplored.<sup>21</sup> The list appeared an afterthought as the body of the work did not concern its contents.

Galton then discussed substitutes for instruments: for length .... 'A horse.... takes pretty nearly 1000 steps to a mile... The habit of counting paces in a mechanical way is soon acquired by a traveller, who should make use of rosary beads to record them.' 'A traveller, when the last of his watches breaks down, has no need to be disheartened...' He then described how to observe occultations using a swinging stone to mark seconds. 'A native who is taught to throw a pebble into a bag at each beat will record it. If it is 39 inches long it will beat seconds very nearly indeed'. 'Inscribe a scale of inches on your gunstock'. 'Use outstretched hand and arm for a sextant. Middle finger and thumb subtends 15 degrees, and the Sun travels 15 degrees each hour.'<sup>22</sup> Galton's work was not appropriated by the Society as Jackson's had been, or provided to travellers.

A compromise had to be reached between the unrealistic expectations of Humboldt and Herschel, and the minimal survivalist approach of Galton. Instruments were crucial but they needed to be portable, robust, convenient, simple, and sufficiently precise. The first half of the nineteenth century witnessed the development of several 'compromise' instruments, which were introduced into the RGS during its first thirty years. These were the pocket or box sextant, prismatic compass, hypsometer, aneroid, and watch, which replaced the larger ordinary sextant, the ordinary compass, the mountain barometer, and the box chronometer. The desire for cheapness, compactness, and robustness dictated an amended instrument, which could mean a sacrifice in accuracy and a delineation between explorers' instruments and those used by state projects such as national triangulations.

One instrument which combined reduction in size with increased robustness was the box or snuff-box sextant, was very convenient and sufficiently accurate, but which was frequently not properly adjusted and could not be readjusted. Meanwhile angle-measuring instruments became smaller. The six-inch sextant; the standard instrument for astronomical observation in the mid nineteenth century, was gradually replaced by smaller versions, and by increasingly smaller theodolites by the turn of the century. It could be argued that accuracy did not suffer in proportion because of improvements in the production techniques, but, in principle, larger instruments are capable of more precise readings.

---

<sup>21</sup> Galton (1856) p. 239

<sup>22</sup> Galton (1856) p. 243-244

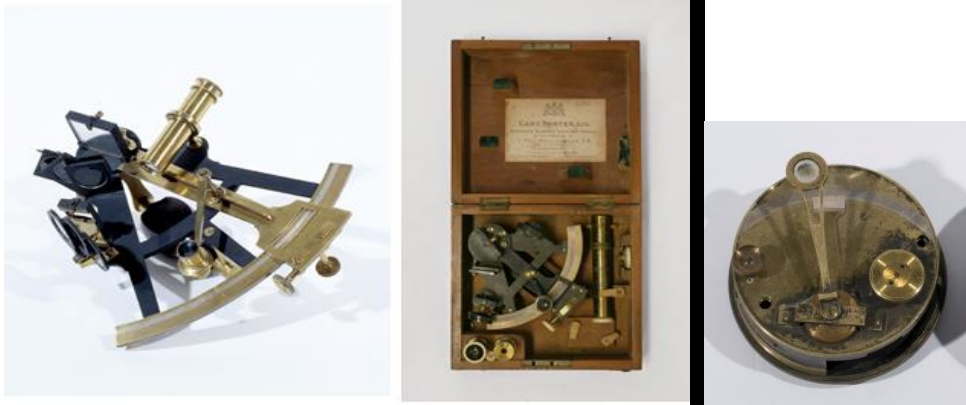


Fig 4.3: Changes in Sextants: From left to right: eight inch sextant used by Livingstone, three inch sextant from the late nineteenth century, and the more compact box sextant.<sup>23</sup>

The prismatic compass, patented by Charles Schmalcalder in 1812 incorporated a sturdy and durable right-angled prism attached to the rear sight; this prism could be positioned over the compass card's rim. When the patent expired in 1826 this type of compass became widely available. While not intrinsically less accurate than a surveyor's compass, the fact it was smaller and hand-held mitigated against precision. 'The main difference between the two instruments is that the surveyor's compass is usually the larger and more accurate instrument, and is generally used on a stand or tripod. The prismatic compass on the other hand is often a small instrument which is held in the hand for observing, and is therefore employed on the rougher classes of work.'<sup>24</sup>

<sup>23</sup> 8 inch sextant by J. Dalton, Hartlepool, c.1850, RGS No. 5 Artefact E 3 (1), 3 inch sextant no 5 by Cary Porter RGS no 5, 1884, Artefact A 21, Box sextant c.1995 Artefact 4.1

<sup>24</sup> [http://www.sage.unsw.edu.au/currentstudents/ug/projects/f\\_pall/html/s33.html](http://www.sage.unsw.edu.au/currentstudents/ug/projects/f_pall/html/s33.html) December 2016.



Fig 4.4: Changes in Compasses: Left, a surveyor's compass, right, prismatic compass used by Livingstone.<sup>25</sup>

Mountain barometers, singled out for their vulnerability, were primarily used for establishing heights rather than for meteorological purposes. By 1854 aneroids were part of the lexicon of travellers. Portability had been gained but accuracy was a concern; aneroids were known to drift over time. Accuracy was also an issue with hypsometers. In 1838, William Sykes argued that hypsometrical measurements could be used when 'great accuracy is not required,' and referred to 'barometric observations which I consider to be the true heights.'<sup>26</sup> While the positions of the instruments were later reversed, it was recognised that travellers could sacrifice accuracy for convenience. John.T. Walker, who wrote in the 1871 edition of *Hints* gave typical advice; 'the instrument I would recommend for geographical exploration, as being well-adapted for astronomical and terrestrial observations, and not very bulky, is the 6 inch transit theodolite by Troughton and Simms... sufficiently accurate,... not too heavy.'<sup>27</sup> The RGS did not procure these until the 1890s.

The underlying tension between the desire to be authoritative and scientific, and the romantic desire of the heroic individual was not normally spelled out. When it was, the arguments became heated. At the end of the nineteenth-century the 'scientific,' 'professional' aspirations of Thomas Holdich and Henry Thuillier clashed with the more quixotic ideals of

<sup>25</sup> <http://www.skinnerinc.com/auctions/2600M/lots/195> January 2017, Prismatic compass c.1860 RGS no 7 Artefact E 27 (1)

<sup>26</sup> Sykes (1838)

<sup>27</sup> Walker (1871) p. 34



Markham. While the central concern was training, the type of instrument chosen was crucial for the definition of exploration and the role of the RGS. Markham directly associated certain instruments- the sextant and the aneroid- with the work of the 'lone explorer.'<sup>28</sup> On the other hand, Holdich had strong opinions regarding the propriety of the plane table: 'I observe a growing tendency in this country to purely graphic surveying. Rather more than 20 years ago I found it difficult to persuade our English surveyors that plane table methods furnished the true key to rapid geographic mapping. Now, however, this instrument has become so popular that it is advisable to remind people that in hot and moist climates plane tabling must be regarded as the end not the beginning of practical field map making. It can never be a substitute for the far more accurate and trustworthy preliminary processes of triangulation by theodolite combined with subsequent computation and a mathematical record.'<sup>29</sup> Here we see a hierarchy of instruments with the plane table relegated to use only for secondary work.

The choice of instruments also played a part in national identity, particularly after WW1. The 'astrolabe a prisme' had been introduced in 1910 and according to a letter from Arthur Hinks to John Ball, was very popular with both the French and English officers.<sup>30</sup> It was, however, seen as a French contrivance notwithstanding its support. Harold Knox Shaw wrote to Hinks in 1919; 'amidst many greatneses of the French, I don't like their attempt to ignore any instrument such as the zenith telescope, to which they can make no national claim; this is a littleness'. 'The Z T will beat the astrolabe any time for latitude and the portable transit will beat it for time. For field use a good universal instrument (theodolite) will beat a field astrolabe for time and latitude'.<sup>31</sup> Ball and Knox Shaw offered a paper on the astrolabe a prisme which Ball wanted to call 'Surveying for Babes and Soldiers'.<sup>32</sup>

---

<sup>28</sup> CM May 28th 1900

<sup>29</sup> Holdich (1891a) pp 602-3

<sup>30</sup> Claude and Driencourt (1910), Ball CB8/9 Letter Hinks to Ball 14th Mar 1917

<sup>31</sup> Ball CB8/9 Letter Shaw to Hinks 14th April 1919

<sup>32</sup> Research Committee 17th Feb 1919

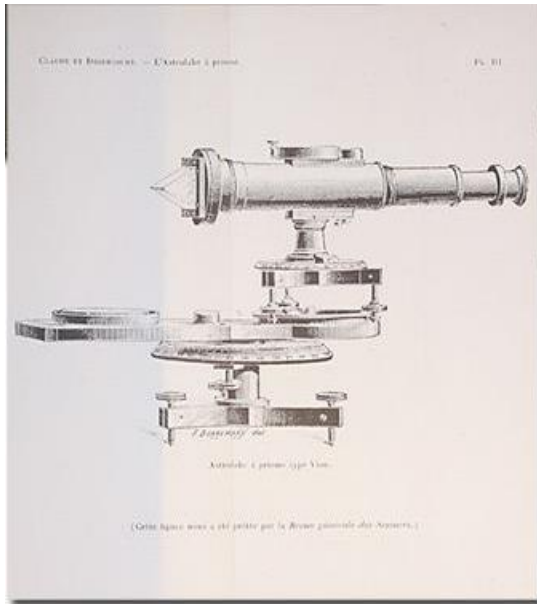


Fig 4.5: National Instruments: Left, astrolabe prism, and right, six inch transit theodolite by Troughton and Simms.<sup>33</sup>

The instruments possessed and mobilised by the RGS worked to define the role of the institution. Tensions within the RGS dictated how many and what instruments were considered ‘proper’; that is what was affordable, portable, usable, ‘scientific’ yet distinctive from government science, and later representing British nationality. The choice of instruments constituted a part of creating the concept of British exploration. Further to the arguments of Collier and Inkpen, and later Collier, it is argued the *instruments* changed to redefine exploration.<sup>34</sup>

### Acquisition Practice

Despite the third object of the Society as was set out in 1831, no purchase was made until the end of the following year: it was a pantagraph, an instrument for enlarging or reducing drawings, acquired for the draughtsman in London, and so was unrelated to the aim.<sup>35</sup> In 1834 Jackson, then Secretary, was justified in expressing his frustration; ‘after three years, the procuring of approved instruments, that travellers may be familiarised with their use has been completely neglected.’<sup>36</sup>

<sup>33</sup> ‘L’astrolabe a prisme’ Claude and Driencourt (1910), Six inch theodolite by Troughton and Simms c. 1890 <https://www.pinterest.com/mvillikka/surveying-instruments/> Mar 2017

<sup>34</sup> Collier and Inkpen (2002), Collier (2014a)

<sup>35</sup> CM 10th November 1832, 15th Dec 1832, Instrument no 12 *JRGS* 21 (1851) p. xlv, CM 9th Mar 1833, Jones M. (2005) p. 326 mistakenly claims the first draughtsman was appointed in 1873

<sup>36</sup> AP 7, 2. AP 8, 8. Rae, Souch, and Withers (2015) p. 143

Supplying instruments for use in the field became necessary in 1834 when the Society began to support expeditions. Captain James Alexander, in charge of an expedition to South Africa, was provided with an allowance specifically for instruments which bought him a pocket sextant, two artificial horizons, a mountain barometer, a syphon barometer, a Daniel's hygrometer, a reflecting compass, two thermometers, two measuring tapes, a telescope, a pocket chronometer, a Schmalcalder (prismatic) compass, several pocket compasses and two or three small thermometers.<sup>37</sup> This generous provision, emulating the practice of von Humboldt and Herschel, has been cited as partly responsible for the financial collapse of the 1840s.<sup>38</sup> Provision overall was generally patchy. When instructions were given to the Guyana expedition under Schomburgk in 1834, the RGS borrowed an Englefield barometer from a Mr. Hillhouse, a surveyor resident in Demerara.<sup>39</sup> Schomburgk also used his own barometer, demonstrating the multiple sources of instruments in the rather amateur arrangements of the early years.<sup>40</sup> The same Council meeting that agreed the first expeditions also established the first Instrument Committee, but no minutes of the latter survive.<sup>41</sup>

The generosity afforded to travellers was short lived. In 1838 the RGS spent only £33 on a sextant and barometer for an expedition to Kurdistan, which was advised to approach the East India Board for £150 towards other instruments.<sup>42</sup> A parsimonious attitude became prevalent; only six guineas were spent on an expedition in Durango, Mexico in 1839.<sup>43</sup> The RGS would merely 'furnish the common instruments for determining Charles Beke's position' in Africa in 1840, similarly for Layard two years later.<sup>44</sup> Ironically this allocation was substantially less than Jackson considered essential.<sup>45</sup> A discrepancy was appearing between stated ambitions and actual practice.

For the first twenty years of the Society's existence, acquisition was carried out in a haphazard and reactive manner.<sup>46</sup> The original stated aim of instrument acquisition was overlooked. By the late 1840s the financial situation had deteriorated to the extent that the Society's lending to travellers virtually stopped.<sup>47</sup> The first listing of instruments in the *JRGS* in 1851 demonstrates that, in spite of some limited previous acquisition, the majority of the instruments had been recently donated; gifts by Mansfield Parkyns in 1846, and especially by

---

<sup>37</sup> CM October 18th 1834, Fialovszky (2013) p.207, Schmalcalder's patent of 1812 (Patent No 3545) [http://www.sage.unsw.edu.au/currentstudents/ug/projects/f\\_pall/html/s33.html](http://www.sage.unsw.edu.au/currentstudents/ug/projects/f_pall/html/s33.html) Feb 2017

<sup>38</sup> Markham (1881) p. 112

<sup>39</sup> CM Nov 24th 1834, Rivière (2006), Martin (1809)

<sup>40</sup> CM Feb 27<sup>th</sup> 1837, Feb 12<sup>th</sup> 1838

<sup>41</sup> Bridges (2007) p.46-47, overlooked by Rae, Souch and Withers (2015)

<sup>42</sup> CM Feb 12<sup>th</sup> 1838, May 28<sup>th</sup> 1838

<sup>42</sup> CM June 11<sup>th</sup> 1838, June 25<sup>th</sup> 1838

<sup>43</sup> CM. Nov 11<sup>th</sup> 1839

<sup>44</sup> CM June 8<sup>th</sup> 1840. Barnett (1998) Goren (2011) p 227-228, Taylor CB3/742, CM Apr 3<sup>rd</sup> 1840, Apr 27<sup>th</sup> 1840, May 9<sup>th</sup> 1842, 22<sup>nd</sup> Dec 1845

<sup>45</sup> Jackson (1841) pp.454-455, Keighren, Withers, and Bell (2015) p. 62

<sup>46</sup> Rae, Souch and Withers (2015) p.142

<sup>47</sup> CM Nov 23<sup>rd</sup> 1846

the executors of Robert Shedden in 1850, provoked the Society into viewing its instruments as a collection.<sup>48</sup>

Galton, despite an enthusiasm for 'roughing it', was a consistent advocate of improvement, pointing out the want of proper instruments for travellers in 1852. His suggestion for procuring these in a formal manner was referred to a newly-formed Expedition Committee. This initiative did not lead to acquisition.<sup>49</sup> A ship's chronometer was replaced by a pocket chronometer in 1854 by the makers Barraud and Lund in the first updating of the collection, but instruments that were over twenty-years- old continued to be used.<sup>50</sup> The high mortality rate of travellers meant many of the instruments listed in the Journals of the 1850s as being lent out were lost. Even in financially buoyant times the RGS continued to borrow whenever possible. Travellers were frequently referred to government departments for instruments.<sup>51</sup>

As a result of the discussion regarding instruments to be lent to Charles Lewell for his expedition to Suakin, a second instrument committee was formed, re-visiting the initial aim of a collection for perusal.<sup>52</sup> This committee suggested that a letter be circulated to the following instrument makers: Troughton and Simms, Newman, Casella, Adie, Negretti and Zambra, and Elliot, inviting them to forward various meteorological instruments for inspection.<sup>53</sup> The letter read: 'A committee .... has been appointed to report upon the instruments which it is desirable should be supplied to travellers proceeding to different parts of the world...., as you may consider best suited to tropical, temperate or arctic regions'. The response from the makers was partial. Only one example was provided for the majority of instrument types specified, and none in some cases.<sup>54</sup>

This initiative provides a rare example of the consideration of the physical environment by the Society. It might be expected that climate and terrain would dictate modifications in the instruments, which could detract from the universality of their measurements, but there is little evidence of modification in the procuring of instruments, and the same instruments were lent to expeditions going to different physical environments. Only when the Society undertook polar expeditions was the specificity of provision apparent.

While these discussions of 1859 had no immediate effect on acquisition, there was an increase in spending from 1861.<sup>55</sup> One beneficiary was Captain George, the Map Curator since 1857, who received a set of drawing instruments in 1865. Clearly George had been using his own until then as he asked that his instruments 'be fresh pointed and cleaned

---

<sup>48</sup> *JRGS* 21 (1851) p.xlv, RSH, CM Nov 10<sup>th</sup> 1851

<sup>49</sup> CM June 14<sup>th</sup> 1852, EC Nov 15<sup>th</sup> 1852, EC December 20<sup>th</sup> 1852, EC Jan 17<sup>th</sup> 1853

<sup>50</sup> CM Jan 9<sup>th</sup> 1854, Serial no 825, No 1 in 1851 list

<sup>51</sup> CM Jan 30<sup>th</sup> 1860, Feb 27<sup>th</sup> 1860, Mar 12<sup>th</sup> 1860, Mar 26<sup>th</sup> 1860, FC May 1860, CM Mar 26<sup>th</sup> 1860, Feb 14<sup>th</sup> 1859, Rae Souch and Withers have misread Lewell as Sewell

<sup>52</sup> Rae, Souch and Withers are misinformed, CM Jan 24<sup>th</sup> 1859, Feb 25<sup>th</sup> 1859

<sup>53</sup> IC Feb 18<sup>th</sup> 1859, Works of the Society no.50

<sup>54</sup> IC Feb 25<sup>th</sup> 1859

<sup>55</sup> See Chapter 3

before he took them away as he had spent 8 years using them on behalf of the Society.'<sup>56</sup>  
This request was granted.

The relaxing of finances was short lived. From 1867 there was another financial tightening following Samuel Baker's expedition, the expensive loss of Paul Du Chaillu's instruments, and in 1872 the writing off of the instruments lent to William Winwood Reade.<sup>57</sup> Such expense on instruments was considered excessive. Although purchasing was becoming more established, the Society would borrow if possible: for example at the end of 1872 ten guineas was paid as a deposit to the Meteorological Office for instruments.<sup>58</sup> That year the Expedition committee also suggested that Captain George provided his own watch as it was recognised the Society's chronometers were inadequate, but there was no suggestion of replacing them.<sup>59</sup> Applicants were referred to the instrument committee which had only met twice in five years.<sup>60</sup> An exception was the 1875 Arctic expedition which was well supplied, and was unusual in being provided with specifically-designed instruments due to Markham's backing.

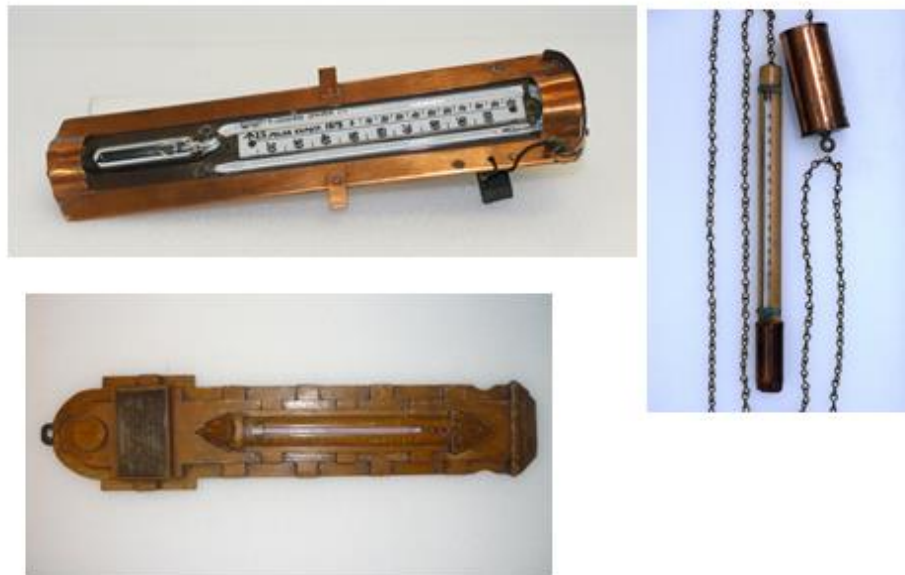


Fig 4.6: Instruments from the Arctic Expedition of 1875: Clockwise from top left: Deep sea thermometer from the 'Alert', Anderson's ice thermometer, and Markham's sledge thermometer.<sup>61</sup>

<sup>56</sup> FC March 20<sup>th</sup> 1865, June 19<sup>th</sup> 1865

<sup>57</sup> CM, Mar 12<sup>th</sup> 1866, 24<sup>th</sup> June 1867, June 8<sup>th</sup> 1868, 13<sup>th</sup> Dec 1869, Mar 13<sup>th</sup> 1871, EC Dec 9<sup>th</sup> 1872

<sup>58</sup> CM Dec 9<sup>th</sup> 1872

<sup>59</sup> CM Nov 26<sup>th</sup> 1872

<sup>60</sup> Special Committee Feb 6<sup>th</sup> 1874

<sup>61</sup> Deep Sea thermometer c.1875 Artefact G 10, Anderson's ice thermometer.1875 Artefact G 2 (2) Thermometer on piece of sledge c.1875 Artefact 7.0

The change remarked on in 1879 appears to have been driven by a need to limit spending on instruments and on the instruction given to travellers. The requirement to provide satisfactory instruments had often been declared but rarely acted upon until this point. In deciding to spend more on instruments from legacies, and in the meticulous recording of expenditure, instruments became acknowledged items of worth rather than objects grudgingly provided if they could not be sourced elsewhere.<sup>62</sup> As their purchase became a routine aspect of the Society's activities they were discussed less frequently. The 1880s was a decade of repetition rather than innovation; the number of expeditions, instrument requests, and loans increased considerably but little else changed. The nature of the instruments also remained largely unchanged.

One exception was the introduction and growing popularity of the plane table which thus requires further study. In 1834 Frederick Simms wrote: 'The plane table is now being taken over by the theodolite but still used for sketch maps.'<sup>63</sup> However, it was taken up increasingly by the RGS towards the end of the century.<sup>64</sup> Godwin Austin wrote a piece for the 1883 edition of *Hints* extolling its virtues.<sup>65</sup> One reason given for its popularity was that 'a plane table can always be carried by a native. It is seldom a European is called on to carry anything in a tropical country.'<sup>66</sup> Holdich's comments in 1891 have been cited.<sup>67</sup> The popularity of the plane table must be accounted for by the proliferation of rapid surveying by those not requiring precise results.

In 1883, again under the direction of Galton, the instrument committee was re-instated, having fallen into abeyance.<sup>68</sup> It would 'have control over the purchase and testing of instruments, and the granting of loans of instruments to travellers.' The Committee enquired of the Meteorological Office as to the cost of thermometers suitable for travellers.<sup>69</sup> As in 1859, a selection of makers was asked 'what pieces they will furnish that may be required by the Society?' This time the list included Troughton and Simms, Dollond, Elliot, Barrow, and Cooke of York. It is not clear what the result of this initiative was, apart from the purchasing of a plane table for the map room.<sup>70</sup>

The 1890s was another decade of repetitive activity with little innovation. The measurement of length by tape, pedometer or wheel became more common: A perambulator was requested in 1893, a measuring wheel in 1902, a tape measure in 1906.<sup>71</sup> A new arrival for the measurement of length was the subtense rod- a rigid bar usually six feet in length with

---

<sup>62</sup> SPC 14<sup>th</sup> Mar 1876, Nov 28<sup>th</sup> 1879

<sup>63</sup> Simms (1834) p.16

<sup>64</sup> IC Oct 26<sup>th</sup> 1883

<sup>65</sup> *Hints* (1883) pp. 107-115

<sup>66</sup> *Hints* (1883) p. 110

<sup>67</sup> Holdich (1891a), p. 602-3

<sup>68</sup> CM June 11<sup>th</sup> 1883

<sup>69</sup> IC June 21<sup>st</sup> 1883

<sup>70</sup> IC Oct 26<sup>th</sup> 1883

<sup>71</sup> SPC Nov 23<sup>rd</sup> 1893, EC Dec 1<sup>st</sup> 1902, Feb 2<sup>nd</sup> 1906

markers at each end- which would be mounted on a distant point. Using a good quality theodolite the bearings could be taken at both ends and the distance found by trigonometry. The measurement of length had been less instrumentally based than other types of measurement until this point.<sup>72</sup> Another instrument to become popular was the transit theodolite which could measure direction, position and height. For Reeves in 1905, 'The most important instrument for the geographical surveyor is doubtless the transit theodolite.'<sup>73</sup> These minor changes were due to new materials which, together with improved scales, enabled instruments to become smaller without losing precision.



Fig 4.7: The Wild photo-theodolite, 1926.<sup>74</sup>

The photo-theodolite was a combination of a transit theodolite and camera; an expensive instrument requiring back-up.<sup>75</sup> Not until 1925 was the RGS able to examine the new photo-theodolite by Wild when it was decided that the 'new apparatus by Wild was 'probably the best and certainly the least expensive' and should be purchased, and so was

---

<sup>72</sup> FC Feb 3<sup>rd</sup> 1890, EC May 8<sup>th</sup> 1900

<sup>73</sup> Reeves (1905)

<sup>74</sup> Phototheodolite no 1.by Henrich Wild 1926 Artefact A

<sup>75</sup> Reeves (1905)

bought from Heinrich Wild for £98 10s and arrived by January 1926.<sup>76</sup> While the photo-theodolite cost about £100, the stereo-cartograph, which reduced the results, cost £2400. The RGS decided to purchase a photo-theodolite but use the stereo- cartograph at Flums if possible. The phototheodolite was to be an object of reverence and would be displayed at the next Research Committee meeting.<sup>77</sup> The seismograph and tide machine were mathematical instruments taken up in 1901 and 1928 respectively. The widening remit of geography entailed considerable expenditure on instruments for specific purposes.

Study of the patterns of acquisition shows that obtaining instruments for expeditions, while not explicitly intended, became an important aspect of the Society's function. The early 'Humboldtian' aspirations could not be sustained however; from the 1840s the proportion of funds spent on instruments was consistently small, notwithstanding several peaks. Two donations prompted a change of attitude in 1850, when the concept of a collection became apparent, but initiatives to maintain and develop that collection had faltered by the 1870s. From 1879 the recording of the instrument purchases both directed and reflected an acknowledgement of their value on behalf of the Society. The usual types of instrument procured measured length, direction, height, position, temperature, and later drawing and general surveying with the plane table and theodolite respectively. Procuring instruments for use in the field had become routine by 1880, although it became less visible in inscriptions. New technology was introduced alongside the older instrument types without replacing them, affecting the numbers acquired, or altering their fundamental design.

### **Instrument Management**

Management of the instrument collection at the RGS was a distinct activity and contributed to its significance.<sup>78</sup> Activities included were routine repairs, calibration of the core types of instrument, listing, storage, weeding out and marshalling, recording of histories, inscribing, and insurance: these practices took place approximately in that chronological order. This section argues that management of the instruments by the RGS constituted an aspect of resource conferred, embedding within the objects added value in the form of institutional authority and a sense of belonging to the larger scientific establishment.

Rae, Souch and Withers have described the emergence of an instrumental culture within the RGS as a rather halting process involving ad hoc sub-committees of short duration. The first Instrument Committee was formed towards the end of 1834, three years after the Map Committee and two years after the Library Committee. It did not take responsibility for the provision of instruments for expeditions, as these were dealt with by Council.<sup>79</sup> It is only

---

<sup>76</sup> EC 9<sup>th</sup> Nov 1925, Research Committee 14<sup>th</sup> Dec 1925, Jan 18<sup>th</sup> 1926, AP 52 CI p.2A and 49B, serial number 304, EC 1925 Nov 9<sup>th</sup>

<sup>77</sup> Research committee 14<sup>th</sup> Dec 1925

<sup>78</sup> Rae, Souch, and Withers (2015) p. 142

<sup>79</sup> CM 14th May 1831, 5th Nov 1831, 10th Nov 1832, Oct 18th 1834, June 13th 1836



because they were recorded in the Council minutes that it is known a repair was organised for Schomburgk in 1836, and a mountain barometer was compared with the Royal Society standard for William Symonds in 1839.<sup>80</sup> Three repairs were mentioned in the Council minutes for the 1840s but without details of cost or provider.<sup>81</sup>

While the 1850s was a time of restored vibrancy within the RGS Council, achievement consistently lagged behind aspiration. The first listing of the Society's instruments occurred twenty-one years after the Society was founded.<sup>82</sup> Responsibility for the instruments was conferred on various persons or committees from time to time. The Expedition Committee was responsible for the instruments during 1854-55, which ensured they were listed in 1855.<sup>83</sup> As well as the object description, information on the borrowing expeditions was included for the first time.

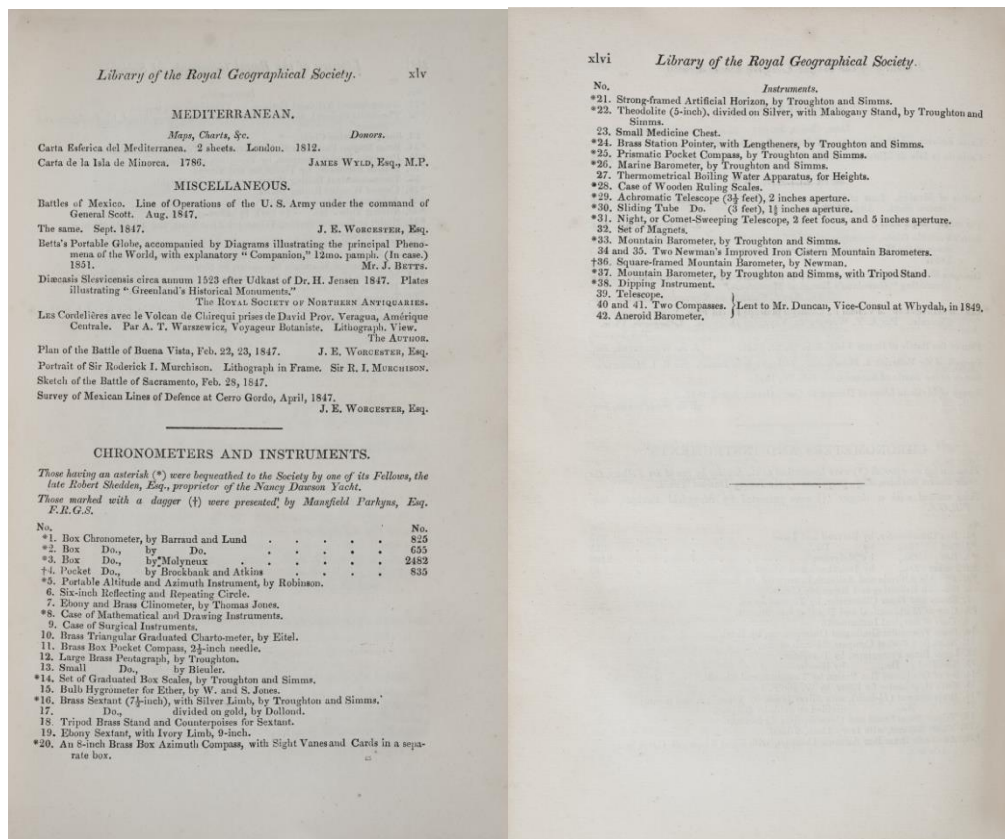


Fig 4.8: The first listing of instruments in the *JRGS* 1851.<sup>84</sup>

The *JRGS* for 1857 contained a list of instruments lent out, a practice which was repeated annually until 1873. However, unlike the two earlier lists, these were not complete

<sup>80</sup> CM June 27th 1836, June 10th 1839  
<sup>81</sup> CM 12th Feb 1844 10th Nov 1845, 22nd Nov 1847  
<sup>82</sup> *JRGS* 21 (1851) p.xlv  
<sup>83</sup> CM June 12th 1854, *JRGS* 25 (1855) p.lxvi  
<sup>84</sup> *JRGS* 21 (1851) p.xlv

audits of the Society's instruments.<sup>85</sup> In 1858 Galton asked George to prepare a list of instruments with remarks.<sup>86</sup> The resulting document, 'Works of the society no 50,' which comprised 'Notes on the Instrument Committee 1847-60,' has not been found.<sup>87</sup> The Secretary was formally put in charge of instrument purchase, use and management in 1858.<sup>88</sup> New printed regulations stated that the Honorary Secretary was 'to have charge of the scientific instruments advising as to their purchase, use and management. He be authorised to make suggestions and analyses of printed works'. In spite of this initiative and the recovering finances, there was no improvement in the recording of instruments.

The second instrument committee was to 'report upon instruments in the possession of the Society.'<sup>89</sup> It reported back promptly with the view that 'the instruments in the possession of the society were very defective.'<sup>90</sup> George Everest subsequently published on instruments for travellers in 1860.<sup>91</sup> The first attempt at quality control took place on Apr 23<sup>rd</sup> 1860 when a meeting was set up to decide which instruments to dispose of and which to retain.<sup>92</sup> The above-mentioned 'Works of the Society no 50' appeared on April 25<sup>th</sup> 1860. The instruments were numbered as per the 1851 list, except where they had been acquired since.<sup>93</sup> In spite of the recent assessment of the condition of the instruments as being poor, the committee recommended retaining thirty of them out of a total of thirty seven. A sliding-tube telescope, broken marine barometer, and a 'night glass' or astronomical telescope were to be disposed of, and an 8-inch azimuth compass and a case of surgical instruments were to be sold. The pantograph and a Chinese compass were referred to Mr. George and the Council respectively. In 1860 'Instruments Lent To Travellers' was started; while this manuscript provided a record of which expeditions were allocated instruments, it did not record the instruments themselves.

Instruments continued to be repaired and tested reactively for specific expeditions: for example, 'barometer number 36 to be tested at Kew in preparation for lending to Mr. Lewell'.<sup>94</sup> Troughton and Simms had repaired the theodolite for Galton, probably for his various travels in the early 1860s.<sup>95</sup> Instruments were also increasingly repaired before being returned, a more forward-looking approach.<sup>96</sup> The RGS used Frodsham as repairer of timekeepers and chronometers, the instruments which were most likely to need attention.

---

<sup>85</sup> *JRGS* 27 (1857), p. lxxxiv

<sup>86</sup> Works of the Society no 50; 'Notes on instrument committee 1847-60'. Feb 26th 1858, Markham (1881) p. 131

<sup>87</sup> A contributory list, to Works of the Society no 50, George, Feb 26th 1858

<sup>88</sup> CM Mar 8th 1858

<sup>89</sup> CM Feb 14<sup>th</sup> 1859

<sup>90</sup> IC Feb 25th 1859, CM Feb 14th 1859

<sup>91</sup> CM Apr 12th 1858, May 9<sup>th</sup> 1859, Everest (1860)

<sup>92</sup> CM April 23rd 1860

<sup>93</sup> Rae, Souch and Withers (2015) have not recognised the numbering from the 1851 list

<sup>94</sup> CM Feb 14th 1859. IC Feb 18th 1859

<sup>95</sup> CM April 11th 1859, Galton (1861) p.438

<sup>96</sup> CM April 11th 1859

More was spent on repairing chronometers than other types of instrument.<sup>97</sup> During the 1860s the RGS began to record payments to instrument makers specifically for repairs, although this was not consistent until 1870.<sup>98</sup>

In the language of ANT, it is essential for the construction of scientific knowledge that instruments are 'immutable mobiles', so they can replicate identical results at different times and places. In essence they all need to be the same instrument, so that any one is exchangeable for any other that measures the same natural phenomenon. This means that calibration by an agreed standard is a necessary pre-requisite to mobilisation and to achieving comparable results, although it is an ideal to be striven for rather than a reality. Instruments were assumed to have errors which could be established and mitigated against by testing.

In: TLW/4

BAR. FORM C.C. *Keifed and read in a horizontal position.*  
 KEW OBSERVATORY.—CERTIFICATE OF EXAMINATION.

ANEROID BAROMETER No. *760*

By *Camp. London.*

Compared with the Standard Barometer of the Kew Observatory  
 (reduced to 32° Fahr) with the following results.

Pressure. Inches.	Correction to Aneroid.
30	0.00
29	0.00
28	0.00
27	0.00
26	0.00
25	-0.04
24	-0.07
23	-0.05
22	-0.04
21	-0.02
20	0.00
19	0.00
18	+0.04
17	+0.05
16	+0.05

*Note:— These corrections were determined under diminishing pressure only.*

KEW OBSERVATORY,  
*May* 1880

*G. Whipple*  
 SUPERINTENDENT.

K. 500-9-75.

Fig 4.9: The Kew certificate for 2.5 inch aneroid RGS no 12.<sup>99</sup>

<sup>97</sup> FC Mar 5<sup>th</sup> 1866, Dec 21<sup>st</sup> 1870, Dec 30<sup>th</sup> 1872, July 3<sup>rd</sup> 1876, Nov 14<sup>th</sup> 1859

<sup>98</sup> CM Jan 23<sup>rd</sup> 1860, Nov 14<sup>th</sup> 1864 p.298, FC Apr 10<sup>th</sup> 1865, May 15<sup>th</sup> 186.

<sup>99</sup> TLW/4

In 1856 Galton mentioned Kew for the first time in connection with testing thermometers.<sup>100</sup> Kew Observatory had been suggested as a 'proper place for the comparison of standards of every description in which every steadiness of temperature and structure, light, retirement and security may be especially needed' and was to become central in the production of the Society's calibrated instruments.<sup>101</sup> A number of members of the BAAS, including Murchison, had put up the funding for the observatory to become a new site for science to enable Great Britain to take part in global initiatives with the 'new instruments'.<sup>102</sup>

In 1859 the energies of the instrument committee were directed at the essential subject of calibration. Kew had already provided a unique service on meteorological and magnetic instruments, but the RGS hoped they could be encouraged to extend this to sextants. Similar rhetoric was used to convince the Council to take this course as had been used when Kew was set up by the BAAS in the early 1840s: the threat of foreign supremacy was invoked. 'Numerous improvements of great value have been made by various instrument makers on the continent during recent years, little or no knowledge having reached English makers. If some of these could be procured and compared, instruments could be made superior to any yet known. An establishment where sextants could be sent for approval would be of very great service to geographical science. Instruments that were faulty could be condemned, small errors could be ascertained and corrections tabulated.'<sup>103</sup> While the manpower and machinery for calibration was beyond the RGS, the Society could have members on the Kew committee for £150 to £200 a year. Galton's efforts to organise calibration on behalf of the RGS bore fruit. In June 1861 Council reported that Galton had received a letter from the Kew Committee stating the 'outfit of the apparatus' would cost £30, and that the Kew Committee would undertake to test the instruments, the cost of testing being from 5 shillings to 10 shillings according to its class.<sup>104</sup>

In the memorandum by Charles Wheatstone mentioned by Robert Scott above, Wheatstone wrote that 'Attention need not be called to the increased value of observations made with calibrated instruments'. The desire to evaluate with the same instrument appears in The Memorandum for the Arctic Committee of the Royal Society July 3<sup>rd</sup> 1873. Another clear demonstration of how regular calibration was important comes in the case of Livingstone's instruments being passed to Verney Lovett Cameron.<sup>105</sup> The Council regretted that 'Unfortunately Cameron has taken command of his instruments which lessens their value' as they were not sent home to be verified.

---

<sup>100</sup> CM Nov 24<sup>th</sup> 1856, Jan 12<sup>th</sup> 1857

<sup>101</sup> Scott (1885) p. 48 quotes from The Report of the sub-committee of the RS in 1842

<sup>102</sup> Scott (1885) p. 51 cites the Memorandum signed by Charles Wheatstone in 1842

<sup>103</sup> Kew Committee on Instruments Dec 10<sup>th</sup> 1859

<sup>104</sup> CM June 25<sup>th</sup> 1860, June 10<sup>th</sup> 1861

<sup>105</sup> CM Feb 28<sup>th</sup> 1881

In 1866 there was another attempt at designating the instruments to the care of a specific person. In 1858 they had been allocated to the secretary, but now they were to be the responsibility of the map curator, Mr. George; the Map Curator's duties included responsibility for their care and preservation, and registering their accession and allocation to expeditions.<sup>106</sup> This appears to have had little impact. 'Instruments Lent to Travellers' was already in place and the 'Catalogue of Instruments,' which answers the brief, did not get underway for a further thirteen years. Instruments were dealt with by the Council or Expedition Committee; the Library and Map Committee did not discuss them for the remainder of the decade.<sup>107</sup> Ten years later George's list of instruments needing repair was referred to the Instrument Committee which had not met for many years.<sup>108</sup>

In 1872 William Grandy, a prospective traveller, opined that the chronometers furnished by the Society and made by Barraud and Co, and by Arnold, both old instruments, were worthless, 'The former having stopped altogether and the other varying largely in rate, and the watch made by Mr. Brock went very badly, and that the minute hand was not centrally mounted, nor the second hand long enough.'<sup>109</sup> No action appears to have resulted. Some attempt at marshalling instruments is apparent at this time, if only for financial reasons: Mr. Oswald Livingstone was asked to return the instruments belonging to the Livingstone Relief expedition and in 1872 the Expedition Committee wanted to know what had happened to the instruments supplied to Llewelyn Dawson.<sup>110</sup>

When arguing for government support for particular interests, deficiencies could be overlooked; in 1873 the Society felt the state of its instruments had improved to the extent they could now be claimed to be immutable mobiles.<sup>111</sup> The Memorandum for the Arctic Committee of the RS July 3<sup>rd</sup> 1873 stated how 'It would benefit geography... the coast of Greenland, hydrography, currents and (knowledge of) the bottom of sea, geodesy in the pendulum experiments that could be carried out with the same instruments used in India and verified at Kew, also magnetic experiments, meteorology. All previous experiments at depths are of doubtful value owing to imperfections of the instruments, but that defect has now been provided against.'

Yet another cycle of apportioning responsibility took place in 1877, reaffirming what had been decided in 1858 and 1866.<sup>112</sup> Point 7 of the duties of the map curator was to 'to have charge of the instruments belonging to the Society and see that they are kept in good repair'. However, the Library and Map committee postponed decisions on repair and disposal, referring the state of the chronometers to Captain Evans and Sir Leopold

---

<sup>106</sup> Library and Map Committee July 4<sup>th</sup> 1866, Map Committee 24<sup>th</sup> Aug 1866

<sup>107</sup> EC 3<sup>rd</sup> Jan 1867, CM Mar 23<sup>rd</sup> 1868, EC May 15<sup>th</sup> 1868, June 21<sup>st</sup> 1869

<sup>108</sup> EC Nov 20<sup>th</sup> 1876

<sup>109</sup> EC Nov 26<sup>th</sup> 1872

<sup>110</sup> CM Dec 9<sup>th</sup> 1872, EC Nov 15<sup>th</sup> 1872

<sup>111</sup> Memorandum for the Arctic Committee of the RS July 3<sup>rd</sup> 1873

<sup>112</sup> SPC June 20<sup>th</sup> 1877

McClintock.<sup>113</sup> Evidence for the perceived need for change comes in a letter from Coles to Galton: ‘The Society have some watches and chronometers but none fit for the use of a traveller, they are old, their cases anything but tight, all have seen much hard service, and now keep a very poor rate, please can we have two new watches....as those we have now would only mislead any one trusting them.’<sup>114</sup> Two days later in March 1879 Coles was given responsibility for the instruments by the Scientific Purposes Committee.<sup>115</sup> That year the Society finally began to record the purchase of individual instruments.<sup>116</sup> The Reverend Thomas Comber’s instruments, requested in March 1879, were the first to be recorded as routine in the ‘Catalogue of Instruments’; the thirty-sixth expedition to have borrowed instruments since 1860.<sup>117</sup> This represents a change in the Society’s attitude towards its instruments.



Fig 4.10: Watch RGS no 21 by Friedlander 1892 showing engraving.<sup>118</sup>

In 1881 two more features of instrument management were introduced. The sum of thirty pounds was made available for their storage, although a store of sorts existed previously, and from now on they would be inscribed with the initials ‘R.G.S.’<sup>119</sup> The latter meant that their added value was tangible and visible, distinguishing them from other

<sup>113</sup> Library and Map Committee Nov 21<sup>st</sup> 1877

<sup>114</sup> Coles CB6/502 letter Coles to Galton Mar 11<sup>th</sup> 1879

<sup>115</sup> SPC June 16<sup>th</sup>

<sup>116</sup> SPC Nov 28<sup>th</sup> 1879

<sup>117</sup> CM Mar 10<sup>th</sup> 1879

<sup>118</sup> <http://www.antiquewatchstore.com/archive/939-fridlander-london-no-52743-royal-geographical-society-watch-no-21.html> by permission of David Penney

<sup>119</sup> CM May 2<sup>nd</sup> 1881

instruments. This added value is still having agency today in that instruments inscribed with 'R.G.S' are prized by collectors. As the same instruction was made the following year by the Scientific Research Committee it is likely no immediate action was taken.<sup>120</sup> In 1883 the Instrument Committee was set up yet again: It 'will have control over the purchase and testing of instruments, and the granting of loans of instruments to travellers'. All applications for grants were to be referred to this committee.<sup>121</sup>

The Committee met in June when it considered a list of instruments lent between 1877 and 1883, and the instrument makers listed above were approached to ask 'what pieces they will furnish that may be required by the Society.'<sup>122</sup> All sextants were to be graduated on platinum and all instruments to have first class certificates from Kew. Again, this is unlikely to have had an effect because the same stipulation was made at the Scientific Research committee two years later.<sup>123</sup> There was also a new emphasis on repair from the late 1870s from when the sum spent each year increased markedly.<sup>124</sup> The state of the chronometers continued to be a problem, however. In May 1879 a Special Committee was set up to inspect the chronometers and watches in store when it was decided to ask the Astronomer Royal, George Biddell Airy, for his opinion as to whether the instruments were salvageable.<sup>125</sup> Finally, Coles was asked to dispose of the unwanted watches, selling them for not less than £10 each in 1888.<sup>126</sup> The council and Committee minutes show significant money spent on repairs each year from 1879 until 1927 with the exception of WW1 and its aftermath.

Instrument management lapsed, however, and in 1894 the Instrument Committee met for the first time in six years.<sup>127</sup> Coles prepared a report on the instruments which was also presented at the Scientific Purposes Committee.<sup>128</sup> It was decided to write off instruments lent to people known to have died; people who had retained instruments were to be contacted. This was undertaken with varying success.<sup>129</sup> In this more proactive phase it was decided to include instruments in the Yearbook for 1897.<sup>130</sup> A form for loaning instruments was also introduced, but has not been traced.<sup>131</sup>

Coles prepared a catalogue of instruments for the Expedition committee of April 20<sup>th</sup> 1899 which was audited by Holdich and Thuillier to produce a comprehensive report.<sup>132</sup> They found that 'The instruments were correct according to the Catalogue- however, there are

---

<sup>120</sup> SPC Mar 22<sup>nd</sup> 1882

<sup>121</sup> IC June 11<sup>th</sup> 1883

<sup>122</sup> IC June 21<sup>st</sup> 1883

<sup>123</sup> SPC 14<sup>th</sup> May 1885, CM Feb 11<sup>th</sup> 1889

<sup>124</sup> CM Feb 20<sup>th</sup> 1878 Mar 4<sup>th</sup> 1878, June 11<sup>th</sup> 1878, July 1<sup>st</sup> 1878, July 15<sup>th</sup> 1878, Dec 2<sup>nd</sup> 1878

<sup>125</sup> Special Committee Mar 24<sup>th</sup> 1879

<sup>126</sup> IC Mar 1<sup>st</sup> 1888, Markham (1881) p. 131

<sup>127</sup> IC Feb 28<sup>th</sup> 1894

<sup>128</sup> Mr. Garratt's Instruments Report, SPC and Education Committee May 8<sup>th</sup> 1894

<sup>129</sup> SPC and Education Committee 1<sup>st</sup> June 1894, CM Jan 7<sup>th</sup> 1895

<sup>130</sup> CM Dec 6<sup>th</sup> 1897

<sup>131</sup> EC May 19<sup>th</sup> 1898

<sup>132</sup> EC Apr 20<sup>th</sup> 1899, Thuillier and Holdich 'Special Report on Instruments' 13<sup>th</sup> May 1899 p. 127-8

some returned by travellers in a broken and useless state. They should be disposed of and written off'. Holdich added a memorandum: 'All theodolites should have a graduated level attached, value to be determined before the instrument goes out. Clinometers should be added to the list. The Watkins aneroid needs to be tested for efficiency through the agency of the Alpine or other Mountaineering club'. At the following Expedition committee meeting, it was decided this audit of instruments should take place every two years, but there is no evidence this was undertaken.<sup>133</sup> In 1901, as on three previous occasions, it was decided that instruments should be under the charge of the Map Curator, now Mr. Reeves, who was to get £10 a year extra for this duty, and he would have the services of a boy at £1 a month.<sup>134</sup>

A new initiative from 1901, showing an appreciation of the instruments, was the introduction of annual insurance.<sup>135</sup> In 1914 the instruments were valued at £2,426, greater than the sum for the library and museum contents which were each valued at £1,500.<sup>136</sup> The maps were valued at £21,803. WW1 caused an inevitable demise in the activities of the Society which did not recover until the early 1920s. In this period the expeditions were considered and instruments allocated on an annual basis rather than individually.<sup>137</sup> In 1925 the society's photo-theodolite was immediately insured for £325.<sup>138</sup> Insurance remained a live issue; sometimes the borrower insured, sometimes Society did if the cost was great.<sup>139</sup> It was eventually decided to insure all the instruments 'en bloc'.<sup>140</sup> Features of instrument management were incorporated in the financing of expeditions so that the Oxford Arctic Expedition's funds included £25 for testing the seismograph.<sup>141</sup>

There is evidence that the RGS undertook many reforms with regard to management of the instruments which were never totally effective.<sup>142</sup> For Rae, Souch and Withers 'Their rhetoric in this regard, which dates from 1831, was not supported in a formal way until 1859 and the appointment of an Instrument Committee. Only from 1866 was the Society's map curator given managerial oversight of the instrument collection and a loan policy developed'.<sup>143</sup> This gives an impression of a period of inactivity followed by a turning point. The apportioning of responsibility in 1866 was one of many such proclamations before and after, all with limited effect. The rhetoric was not supported in a formal way in 1859 because the collection for perusal was never acquired. There was never a consistently-applied loans policy. The pattern as regards management was one of slow, stuttering progress rather than idleness for thirty years followed by action.

---

<sup>133</sup> EC May 16<sup>th</sup> 1899

<sup>134</sup> EC October 9<sup>th</sup> 1901, Nov 11<sup>th</sup> 1901

<sup>135</sup> FC Dec 16<sup>th</sup> 1901

<sup>136</sup> Library and Map Committee Feb 26<sup>th</sup> 1914

<sup>137</sup> Report of the Council 15<sup>th</sup> June 1925

<sup>138</sup> EC 9<sup>th</sup> Nov 1925

<sup>139</sup> Memorandum by Secretary on Insurance of Instruments 6<sup>th</sup> Feb 1933

<sup>140</sup> CM 9<sup>th</sup> Mar 1914

<sup>141</sup> EC 6<sup>th</sup> Mar 1933

<sup>142</sup> AP 8 p.8, Jackson 2<sup>nd</sup> May 1837

<sup>143</sup> Rae, Souch, and Withers (2015) p. 158



The RGS instrument collection was associated with the foremost institution in the field. While the actual practices of the RGS fell well short of its intentions, it is important that there was continuous activity on behalf of the instruments which gave that association meaning and enhanced their embedded value.

### Instrument Design

It is argued the RGS enhanced the value of their instruments by engaging with debates concerning their design. The Society approved, improved, tested, and filtered out various types. This was particularly so in the first half of the period. ANT distinguishes between ‘ready-made science’ which is designated to be in the ‘black box’, and ‘science-in-the making’.<sup>144</sup> Latour argues that the construction of facts or machines is a collective process. In ‘science in the making’ facts are constructed through various stages from an original statement towards tacit knowledge, and are finally incorporated into instruments.<sup>145</sup> Golinski writes: ‘When an instrument assumes the status of an accepted means of producing valid phenomena then it can be said to have become a ‘black box.’<sup>146</sup> It will be shown that, in spite of the instruments having attained the status Golinski describes, many of them continued to be the subject of active discussion and experiment. The buying of a ‘machine’ - represented in this case by an instrument- did not indicate an acceptance of it representing ‘ready made science.’ especially before the 1870s.

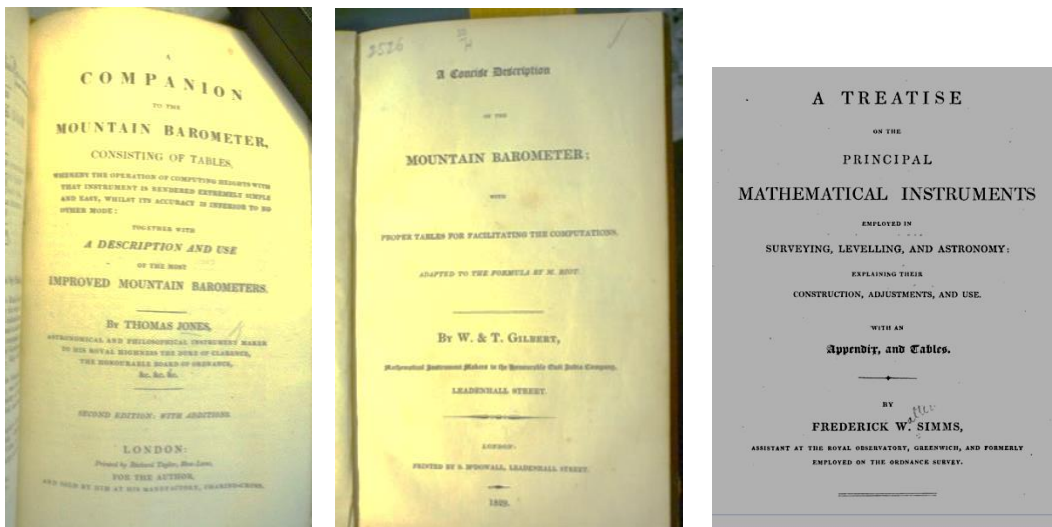


Fig 4.11: Frontispieces of advisory works on instruments by makers: Jones (1830), Gilbert (1829), and Simms (1834).

<sup>144</sup> Latour (1987) p.4, 29

<sup>145</sup> Latour (1987) p.44

<sup>146</sup> Golinski (1998) p. 140

The Society was in communication with various instrument makers. In the first decade, Thomas Jones, a London barometer maker, was involved in two discussions regarding design. The first concerned a barometer which could be used as a mountain or marine instrument, about which he wrote in 1831.<sup>147</sup> He recommended a syphon barometer on the basis of that suggested by James Adie in 1818, but with a tube entirely of metal.<sup>148</sup> The second concerned a design of sextant. In 1833, William Desborough Cooley suggested a modification and gave a mathematical demonstration of its accuracy and principle. Jones was asked to 'examine and report on its supposed advantages'.<sup>149</sup> However, it was reported from Cooley that Jones had undertaken the work so badly that it ought not to be accepted.<sup>150</sup> Unfortunately a record of Cooley's suggestions has not been traced, but it appears that they failed to gain support.<sup>151</sup> Jones admitted imperfections and agreed to re-construct the sextant.<sup>152</sup> The Council was ultimately reliant on the skills of the makers and could only acquire what they could supply.

The Society was able to lend prestige to a certain designs of instrument by recording its 'acceptance' or approval, and could publish test results which delineated a particular instrument's authority. An important development in the barometer was the introduction of the aneroid form which avoided the problematic use of long columns of mercury. In 1851 the Council received a paper from Captain Philip Yorke FRS comparing Newman's standard barometer with the new aneroid.<sup>153</sup> Yorke remarked that the portability and practicality of the aneroid had 'induced' travellers to substitute it for the mercurial form. Undertaking observations on 115 days during the summer of 1850 in Hereford and France, Yorke found considerable variation in pressure readings between the two. He concluded that the aneroid was suitable for measuring sudden changes in pressure and differences of level, but that it should not be relied on for any length of time as an independent instrument.

Immediately following Yorke's paper a similar one by George Buist compared a collection of barometers in Poona.<sup>154</sup> Buist was impressed with the aneroid: 'At home it has been underrated, because of the ridiculous legends'. By this he was referring to the words 'Stormy', 'Rain', 'Change', 'Fair' and 'Very dry' which suggested domestic or amateur use. A further paper from Captain Allen R.N recommended the aneroid as 'a handy little instrument' and 'a very agreeable and instructive companion,' encapsulating the general view.<sup>155</sup>

---

<sup>147</sup> JMS/21/3, 24th March 1831

<sup>148</sup> McConnell (2005) [http://www.antique-horology.org/\\_editorial/sympiezometerfontijn](http://www.antique-horology.org/_editorial/sympiezometerfontijn) Dec 2016

<sup>149</sup> CM 21st Dec 1833, 18th Jan 1834

<sup>150</sup> CM October 18th 1834

<sup>151</sup> Cox (2017)

<http://www.rgs.org/OurWork/Research+and+Higher+Education/AHRC+Collaborative+Doctoral+Awards/Completed+projects/Armchair+geography.htm>

<sup>152</sup> CM 24th Nov 1834, Feb 27th 1843, Mar 14th 1843

<sup>153</sup> CM Jan 13th 1851, *JRGS* 21 (1851) pp 35-42

<sup>154</sup> Buist (1851), CM Mar 10th 1851, Adie (1850)

<sup>155</sup> JMS/9/94 Allen, CM Feb 9<sup>th</sup> 1852, April 26<sup>th</sup> 1852, Dec 13<sup>th</sup> 1852

Different types of barometer were still being compared forty years later.<sup>156</sup> These papers demonstrate that buying an instrument could not be assumed to place it in the 'black box' of ANT, but rather that it could be tested, compared, criticised, and approved or rejected.

Magnetic variation was a constant difficulty. One of several interventions was from Messrs Mathiesen and Ritter who wrote in 1856 on an improved variation and azimuth compass: 'Many imperfections still remain, and one of the most serious difficulties exists in finding the amount of variation of the magnetic needle frequently, easily and with exactitude'. They proposed a device which could be used when the sky would not allow astronomical observations. Several strategies were mobilised to make their point: the problems were accentuated; 'Several hundred vessels of these two flags (GB and USA) perish annually'. The voice of authority was incorporated; 'the Certificates of competent naval officers show...'<sup>157</sup> The instrument was very straightforward, however, some sunlight would have been necessary to obtain a shadow on which it depended.

Some instruments submitted claimed to simplify calculation, others to simplify observation, others to be sturdier or more precise. In 1855 Jonas Radford sent a drawing of a geographical clock, or watch, or a 'universal time keeper'. Radford had exhibited at the Great Exhibition.<sup>158</sup> Two years later Finlayson reported on an instrument for taking latitude by one observation on land or at sea 'with but little calculation'.<sup>159</sup> The same drive for simplicity is seen in Mr. Gearing's submission of an instrument of his invention for determining the latitude by inspection thirteen years later.<sup>160</sup> During the 1860s and early 1870s, the Society continued to receive papers on the design of instruments ranging from deep sea thermometers, spirit levels, hydrographs, compasses and cards, and the shape of magnetic needles.<sup>161</sup> A Loftus sundial is in the present collection.<sup>162</sup>

Galton was an innovator with a desire for simplicity. In 1859 his paper on sun signals was accepted for reading, and the following year for publication in the *PRGS*.<sup>163</sup> Galton's idea of using a mirror to reflect a point of sunlight was extremely straightforward, and taken up in later trigonometric surveys, although he saw it 'simply to attract attention at great distances or to convey a few simple signals.' His compass clinometer, which could be used as either instrument, was produced by Casella from 1864. Galton's small instrument for finding the

---

<sup>156</sup> EC Nov 18<sup>th</sup> 1897

<sup>157</sup> Mathiesen and Ritter CB4/1158, CM June 9<sup>th</sup> 1856

<sup>158</sup> CM Dec 10<sup>th</sup> 1855, 1851 Great Exhibition Official Catalogue: Class X.: Jonas Radford.

<sup>159</sup> CM Mar 23<sup>rd</sup> 1857

<sup>160</sup> CM June 13<sup>th</sup> 1870

<sup>161</sup> ScM Inv no. 1876-817, CM Jan 13<sup>th</sup> 1862

[http://webcache.googleusercontent.com/search?q=cache:zc78MOIT00oJ:maps.nls.uk/os/6inch/os\\_info4.html+spirit+levels+ordnance+survey+Scotland+1860s&cd=1&hl=en&ct=clnk&gl=uk](http://webcache.googleusercontent.com/search?q=cache:zc78MOIT00oJ:maps.nls.uk/os/6inch/os_info4.html+spirit+levels+ordnance+survey+Scotland+1860s&cd=1&hl=en&ct=clnk&gl=uk) Jan 2017, CM Nov 15<sup>th</sup> 1870, Nov 29<sup>th</sup> 1870, Hints Committee Mar 8<sup>th</sup> 1871, Apr 26<sup>th</sup> 1871

<sup>162</sup> <https://www.search.birminghamimages.org.uk/Details.aspx?&ResourceID=3306&SearchType=2&ThemeID=65> January 2017 Artefact 238

<sup>163</sup> CM Nov 28<sup>th</sup> 1859, Jan 9<sup>th</sup> 1860, Galton (1859)

artificial nadir point was discussed at a meeting of the *Hints* committee in 1871.<sup>164</sup> He also devised a hand-held anemometer made by Hicks from 1882, which incorporated a sandglass to time the reading.<sup>165</sup>



Fig 4.12: Galton and his instruments: Clockwise from top left: carte-de-visite, illustration of sun signal, illustration of sundial, sun signal, compass clinometer, anemometer, and whistle.<sup>166</sup>

The RGS overestimated its ability to effect improvement. In 1860 Richard Collinson recommended that a medal or premium should be given to the maker of the best reflecting instrument.<sup>167</sup> Collinson believed that many improvements had been devised but not incorporated into a single design. In addition to general accuracy the prize would be awarded for portability, capability for large angles, independence of horizon, distinctness in reading off,

<sup>164</sup> Hints Committee April 26<sup>th</sup> 1871

<sup>165</sup> ScM Inv no. 1994-116

<sup>166</sup> <https://www.dnalc.org/view/11950-Francis-Galton-carte-de-visite-portrait-standing.html> Copyright UCL, Galton (1859-60) p.16, NMM in no NAV0945, ScM inv no 1996-227/2, ScM inv no 1894-116, ScM inv no 1983-148

<sup>167</sup> EC Jan 10<sup>th</sup> 1860, CM Feb 13<sup>th</sup> 1860, Galton CB4/680

convenience of handling, adaptability for use in field, efficiency of adjustments and power of measuring faint objects. The RGS was forced to postpone the 'Premium for Best Sextant', however, as no instruments were submitted. In the *JRGS* in 1861 the prize was advertised as being 'still open for competition.'<sup>168</sup> Three years later it was noted that: 'Up to this date no instrument of adequate merit has been shown to the Society.'<sup>169</sup>

In 1861 Everest wrote to Dr Norton Shaw regarding his perambulator for measuring road distances, which he had devised 'many years ago', and described in his book.<sup>170</sup> 'Any creature between a human and a donkey can be employed for the purpose of trundling it.' 'It can give differences of longitude with far greater accuracy than can be obtained by any observation of the Moon's motion.' In spite of its use in the Survey of India it was seemingly unfamiliar to Shaw. Certainly a large instrument such as the perambulator would not have suited the smaller parties exploring unknown terrain in the mid nineteenth century. On the other hand some travellers were well-read. Peter Sutherland, who will be considered in chapter 5, was aware of Ure's aneroid recently published in 1853.<sup>171</sup>

Some of the instruments placed before the Society were rejected. On June 10<sup>th</sup> 1861, Mr. Hedgecock wrote respecting his quadrant.<sup>172</sup> His theory was 'simply ridiculous, and the language, printed and spoken, in which the claim has been asserted, as unintelligible nonsense; and the whole subject, therefore, as unworthy of the further attention of the Academy'.<sup>173</sup> Collinson and Galton reported on a paper on the errors of a sextant by Major J.F. Kennard in 1865.<sup>174</sup> Kennard wrote that 'A circle could be used instead of a sextant; the weight has hitherto prevented their use, but modern workmanship is capable of making them lighter'. Galton and Collinson believed that circles were ingenious and simple, but only in theory; they had never been perfected although they had promised to be useful.<sup>175</sup> Thus the Society played a part in maintaining a firewall for the preservation of reliability.

George made improvements to surveying instruments which are known today as 'George's Pattern'. One was a double sextant, and the other an artificial horizon.<sup>176</sup> George's double sextant could be used to measure two altitudes of celestial bodies almost simultaneously. The salient improvement to the artificial horizon was the incorporation of a storage container for the mercury which was tested and approved.<sup>177</sup> The RGS acquired twenty five George pattern artificial horizons between 1879 and 1925. Galton congratulated George on having improved on the capricious nature of the instrument 'which has hitherto

---

<sup>168</sup> CM Mar 11<sup>th</sup> 1861, *JRGS* 31 (1861) p. vii

<sup>169</sup> *JRGS* 34 (1864) p. xvi

<sup>170</sup> CM Jan 28<sup>th</sup> 1861, Raj (2000) p.132, Everest (1851) p.78

<sup>171</sup> Ure (1853) vol 1 part 1 p.322

<sup>172</sup> [http://archive.org/stream/surveyinglevelli00stanuoft/surveyinglevelli00stanuoft\\_djvu.txt](http://archive.org/stream/surveyinglevelli00stanuoft/surveyinglevelli00stanuoft_djvu.txt) May 2017, CM June 10<sup>th</sup> 1861, Nov 25<sup>th</sup> 1861, Hedgecock (1859)

<sup>173</sup> American Academy of Arts and Sciences, (1857)

<sup>174</sup> CM Jan 23<sup>rd</sup> 1865, Feb 13<sup>th</sup> 1865

<sup>175</sup> *JMS*/20/23

<sup>176</sup> <http://collections.rmg.co.uk/collections/objects/43351.html> May 2017

<sup>177</sup> Hints Committee Feb 15<sup>th</sup> 1871

been so disheartening'.<sup>178</sup> George received a medal for these instruments at the International Geographical Congress in Paris in 1875.<sup>179</sup>



Fig 4.13: George's pattern double sextant and artificial horizon.<sup>180</sup>

The above examples illustrate the lively interest that the RGS took in instrument design in the first half of the century under consideration. After about 1880 there was a sharp decline in discussions on this topic, when the construction of mathematical instruments was largely accepted as 'closed'. The relatively new technologies of photography, telegraphic communication and aerial survey became the foci of attention.<sup>181</sup> The design of the plane table represented an exception. Between 1889 and 1891 Henry Godwin-Austen reported on various modifications to its design: a cavalry sketching case, an improved plane table, a rolling-up plane table, and a 'service' tripod stand.<sup>182</sup> In July 1894, Coles also reported on a cavalry sketching instrument and plane table, which would be considered for publication in *Hints*. In 1896 Mr Ralph Sadler asked for assistance to help him improve the plane table, and Major Willoughby Verner of the Rifle Brigade sent a sketching instrument for inspection.<sup>183</sup> Another exception was that of the instruments designed by Reeves, map curator between 1900 and 1933. Reeves was an enthusiastic improver, inventing several drawing instruments and a micrometer.<sup>184</sup> He published papers on his instruments in 1905, 1908, 1911 and 1912, working closely with Casella, who publicised his designs in their book *Surveying and Drawing Instruments* (1911).<sup>185</sup> 'Mr. E.A. Reeves, FRAS, curator and instructor in practical astronomy and surveying at the Royal Geographical Society,.... a micrometer for theodolites, which, while giving considerable accuracy of reading, is simpler, not so liable to be put out of

<sup>178</sup> Galton CB6/864 letter to George Aug 18<sup>th</sup> 1871

<sup>179</sup> <http://collections.rmg.co.uk/collections/objects/43351.html> Feb 2017

<sup>180</sup> Artefacts 34 and 66

<sup>181</sup> IC 1<sup>st</sup> June 1894, June 21<sup>st</sup> 1894

<sup>182</sup> JMS/19/26

<sup>183</sup> Expedition and Instrument Committee Apr 17<sup>th</sup> 1896, June 19<sup>th</sup> 1896, CM Nov 23<sup>rd</sup> 1896, EC Dec 10<sup>th</sup> 1896

<sup>184</sup> Map Committee July 4<sup>th</sup> 1889, IC Feb 28<sup>th</sup> 1894

<sup>185</sup> Reeves (1905), Reeves (1908a), Reeves (1908b), Reeves (1911)

adjustment and less expensive .... Sole makers: C.F. Casella & Co Ltd.' The Reeves set of drawing instruments had been 'designed particularly to meet the requirements of explorers and geographical surveyors'. There was also a Reeves pattern set of proportional dividers.<sup>186</sup>



Fig 4.14: Reeves and his instruments: Clockwise from top left: Reeves, proportional dividers, folding alidade, and astronomical compass.<sup>187</sup>

This evidence demonstrates that there was continuous debate as to the best design of various instruments, and assessments made which could bestow credibility on various new ideas. After the 1870s this became less frequent, although there was a surge of interest in sketching in the 1890s. It is argued that the resource spent engaging with instrument makers regarding design added value to the RGS collection. The members of Council and the referees of the papers submitted 'maintained' the conceptual black boxes through these debates.

<sup>186</sup> Reeves (2013) pp. 50-1, <http://www.etsesseract.com/C100.pdf> : Catalogue 63 Reeves's Pattern Folding Telescopic Alidade, No.8062 Apr 2017, Abraham (1926) p.202

<sup>187</sup> Portrait photograph, photographer unknown PR/051916 Artefacts A 3 , A23 , and A 29 (1)

## Supporting Mathematics

As for the physical design, the inherent mathematics within the instruments was frequently in ANT's 'black box', but was sometimes the subject of debate, as the instruments were based both on previously-agreed knowledge and that which was being constructed. As the Society relied on instrument makers, it also relied on mathematical practitioners. The RGS was dependent on hydrographic charts, the *Nautical Almanac*, meteorological tables, and tidal calculations.

The Society recommended a variety of books and tables in its instructional text *Hints to Travellers*. In the second edition (1865) the list included Raper's *Navigation*, Inman's or Norie's *Tables*, Shadwell's *Cards of Formulae*, the *Nautical Almanac*, and tables for boiling points.<sup>188</sup> In the third edition (1871) it also recommended logarithmic tables, and Chauvenet's *Astronomy*.<sup>189</sup> All these tables and texts represented considerable resource, as they required considerable manpower to compile, without which the instruments would have had no operational value.<sup>190</sup>

Several different aspects of mathematics were involved, notably trigonometry for dead reckoning, traverse surveys, and trigonometric surveys, the theory of the Moon's motion for longitude calculations, celestial mechanics for longitude by other astronomical observations, which included perturbation theory and the calculation of refraction and parallax. The relationships between heights of barometer tubes, boiling points, elevation for topographical survey, meteorological calculations, tidal calculations which included interpolation, and magnetic data were necessary. Projections for map creation are discussed in chapter 7. Occasionally other tangential areas were touched on such as the four-colour theorem which appeared in the *JRGS* in 1879.<sup>191</sup>

Various texts can illuminate what was required in terms of trigonometry: Raper's *Navigation* was particularly acclaimed.<sup>192</sup> Texts by Butler Williams, Simms, Ralph Smyth and Thuillier, were all quite similar, relying on Euclid almost exclusively; 'To Euclid's elements alone, of all other human productions, belongs the glory of having survived the dismemberment of Empires, the changes of opinion, ... after the lapse of 2000 years....'<sup>193</sup> Some texts went beyond Euclid to consider spherical triangles for geodetic surveying.<sup>194</sup>

With respect to longitude, the considerable 'hinterland' of resource is equivalent to that invested in the construction of the instruments and is similarly beyond the scope of the thesis.<sup>195</sup> However, the RGS kept abreast of current work. In addition to regular up-datings of

---

<sup>188</sup> *Hints* (1865) p.8, *The Nautical Magazine and Naval Chronicle* April 1863 p. 224

<sup>189</sup> *Hints* (1871) pp. 10-11, Chauvenet (1863)

<sup>190</sup> Croarken (2003)

<sup>191</sup> CM Jan 27th 1879

<sup>192</sup> *Hints* (1854) p.3

<sup>193</sup> Tate (1848) p. vi, Butler Williams (1842), Raper (1849), Simms (1834), Jeans (1849), Firebrace Roorkee (1868), Jackson (1853), Smyth and Thuillier (1855)

<sup>194</sup> Butler Williams (1842) pp.107-109, Smyth and Thuillier (1855) p.381

<sup>195</sup> Newton (1737) preface, Kollerstrom (2000), Iliffe (2007), Westfall (1981), Laplace (1799-1827)



the Admiralty tables and *Almanac*, in 1847 the RGS received a *Table of Astronomical Predictions* from Captain Charles Shadwell of the Royal Naval College at Greenwich.<sup>196</sup> J.M. Share RN submitted a prospectus of his work on great circle tables.<sup>197</sup> In 1877 the Council requested a list of occulted planets for the following two years from Greenwich, on which much resource had been spent.<sup>198</sup>

152 HINTS TO TRAVELLERS.

TABLE IV.—MEAN PLACES OF 44 OF THE PRINCIPAL FIXED STARS FOR JANUARY 1ST, 1883.

Name.	Mag.	Right Asc.			Ann.Var	Declination.			Ann.Var.
		h.	m.	s.		°	'	"	
α Andromedæ . . . . .	2	0	2	20.434	+3.09	+28	26	39.99	+19.90
γ Pegasi . . . (Algenib) . . . . .	3.2	0	7	12.679	3.08	+14	31	58.21	20.02
α Cassiopeæ . . . . .	2.3	0	33	52.403	3.37	+55	53	43.49	19.79
β Ceti . . . . .	2	0	37	42.872	3.01	-18	38	45.05	19.80
α Ursæ Minoris . . . (Polaris) . . . . .	2	1	15	30.214	22.09	+38	41	5.88	18.96
α Eridani . . . (Achernar) . . . . .	1	1	33	21.260	2.24	-57	49	53.45	18.38
α Arietis . . . . .	2	2	0	34.694	3.37	+22	54	30.49	17.10
α Persei . . . . .	2	3	15	58.418	4.25	+49	26	36.05	13.11
α Tauri . . . (Aldebaran) . . . . .	1	4	29	12.442	3.44	+16	16	22.30	7.57
α Aurigæ . . . (Capella) . . . . .	1	5	8	2.822	4.42	+45	52	38.05	4.08
β Orionis . . . (Rigel) . . . . .	1	5	8	54.867	2.88	-8	20	17.30	4.41
β Tauri . . . . .	2	5	18	53.816	3.79	+28	30	25.03	3.38
α Columbæ . . . . .	2	5	35	24.791	2.17	-34	8	14.78	2.11
α Orionis . . . (Betelgeuse) . . . . .	1	5	48	50.251	3.25	+7	23	1.70	0.98
α Argis . . . (Canopus) . . . . .	1	6	21	21.199	1.33	-52	37	55.84	1.87
α Canis Majoris . . . (Sirius) . . . . .	1	6	39	59.518	2.65	-16	33	23.82	4.72
ε Canis Majoris . . . . .	2.1	6	54	1.665	2.36	-28	48	49.70	4.70
α² Geminorum . . . (Castor) . . . . .	2.1	7	27	8.073	3.84	+32	8	37.76	7.52
α Canis Minoris . . . (Procyon) . . . . .	1	7	33	10.646	3.14	+5	31	24.05	9.01
β Geminorum . . . (Pollux) . . . . .	1.2	7	38	9.317	3.68	+28	18	27.13	8.39
ι Argis . . . . .	2	9	13	57.416	1.61	-58	47	4.12	15.02
α Hydriæ . . . . .	2	9	21	50.213	2.95	-8	9	8.09	15.43
α Leonis . . . (Regulus) . . . . .	1.2	10	2	8.399	3.20	+12	32	18.65	17.45
η Argis . . . . .	1.6	10	40	31.399	2.31	-59	4	10.58	18.86
α Ursæ Majoris . . . . .	2	10	56	29.965	3.75	+62	22	55.86	19.38
β Leonis . . . . .	2	11	43	5.453	3.06	+15	13	33.79	20.10
γ Ursæ Majoris . . . . .	2.3	11	47	40.397	3.18	+54	20	42.27	20.02
α¹ Crucis . . . . .	1	12	20	5.827	3.29	-62	27	0.89	19.99
α Virginis . . . (Spica) . . . . .	1	13	19	1.725	3.15	-10	33	0.92	18.91
η Ursæ Majoris . . . . .	2	13	42	55.833	2.37	+49	53	50.61	18.09
β Centauri . . . . .	1	13	55	34.519	4.18	-59	48	28.01	17.61
α Bootis . . . (Arcturus) . . . . .	1	14	10	19.503	2.73	+19	47	32.98	18.81
α² Centauri . . . . .	1	14	31	39.101	4.01	-60	21	14.15	15.38
α Corona Borealis . . . (Alphecca) . . . . .	2	15	29	44.079	2.54	+27	6	33.39	12.10
β Scorpil . . . . .	2	15	58	38.050	3.47	-19	29	3.03	10.15
α Scorpil . . . (Antares) . . . . .	1	16	22	14.060	3.67	-26	10	15.83	8.33
α Trianguli Australis . . . . .	2	16	36	17.199	6.29	-68	48	37.49	7.75
α Ophiuchi . . . . .	2	17	29	30.331	2.78	+12	38	46.54	2.86
α Lyrae . . . (Vega) . . . . .	1	18	32	58.614	2.03	+38	40	31.09	+3.15
α Aquilæ . . . (Altair) . . . . .	1.2	19	45	4.467	2.91	+8	33	36.56	9.25
α Pavonis . . . . .	2	20	16	23.014	4.78	-57	6	29.28	11.20
α Gruis . . . . .	2	22	0	51.173	3.81	-47	31	36.91	17.25
α Piscis Australis . . . (Fomalhaut) . . . . .	1.2	22	51	10.909	3.32	-30	14	32.23	18.97
α Pegasi . . . (Markab) . . . . .	2	22	58	55.944	2.98	+14	34	33.71	19.38

In this table North Declination is denoted by +, South Declination by -; to reduce the declination to any other date the corrections must be applied algebraically.

Fig 4.15: *Hints* (1883) p.152

As for physical design, the RGS modified previously-agreed mathematical knowledge. In 1860 and 1861 papers were published on longitude by Everest and William Spottiswoode respectively, and a Mr Brown submitted a paper in 1866 which was not accepted.<sup>199</sup> William Chauvenet, an American professor of mathematics at Annapolis, was

<sup>196</sup> CM April 12th 1847

<sup>197</sup> CM April 23rd 1855

<sup>198</sup> African Exploration Fund Committee July 4th 1877

<sup>199</sup> CM Nov 14<sup>th</sup> 1859, JMS 19/14, Everest (1860), CM Jan 14<sup>th</sup> 1861, Mar 11<sup>th</sup> 1861, Spottiswoode (1860 – 1861) pp. 234-237, CM Nov 12<sup>th</sup> 1866

referred to for his calculation of meridian altitudes, which were simplified by Shadwell.<sup>200</sup> As in the case of discourse on physical improvement, the debates on mathematical issues decreased markedly after the 1870s. There were no further references to longitude in the Council minutes and only one further paper on the topic in the Journal.<sup>201</sup>

Ideas on tides were submitted to the RGS in 1845, 1846, 1857, 1877 and 1909, although a tide machine was not purchased until 1928.<sup>202</sup> William Whewell became the best-known writer on tides, and organiser of the 'great tide experiment' in 1835 when thousands of people in nine nations and colonies on both sides of the Atlantic took part in synchronized tidal measurement.<sup>203</sup> Whewell's work was referred to in the Journal in 1852, as was that of John Lubbock, who being concerned with the actual situations in various British ports, modified the work of Laplace to fit empirical data.<sup>204</sup> While the mathematics behind the tides was not decided, the RGS were able to discern valuable material from the claims of cranks by examining mathematical basis to the material submitted. In 1846 the Council received a paper from Captain J. Debenham who asked pertinent questions, but by miscalculating the square of 95 million, the distance in miles from the Earth to the Sun, which he did by logarithms, he came up with the argument that the Sun exerts a stronger influence than the Moon.<sup>205</sup>

---

<sup>200</sup> *Hints* (1871) p. 14

<sup>201</sup> Scott, (1908) p. 65-69

<sup>202</sup> CM 12<sup>th</sup> May 1845, 9<sup>th</sup> Nov 1846, Jan 26<sup>th</sup> 1857, Nov 12<sup>th</sup> 1877, Nov 26<sup>th</sup> 1877, Harris (1909) p. 549-550, Reidy (2008) p. 41

<sup>203</sup> Reidy (2008) p. 8 <http://blogs.scientificamerican.com/guest-blog/victorian-era-citizen-science-reports-of-its-death-have-been-greatly-exaggerated/> Apr 2017, Whewell (1836), Ducheyne (2010)

<sup>204</sup> *JRGS* 22 p.lxxxvii, Lubbock (1839) p. viii

<sup>205</sup> Debenham (1846) p. 20

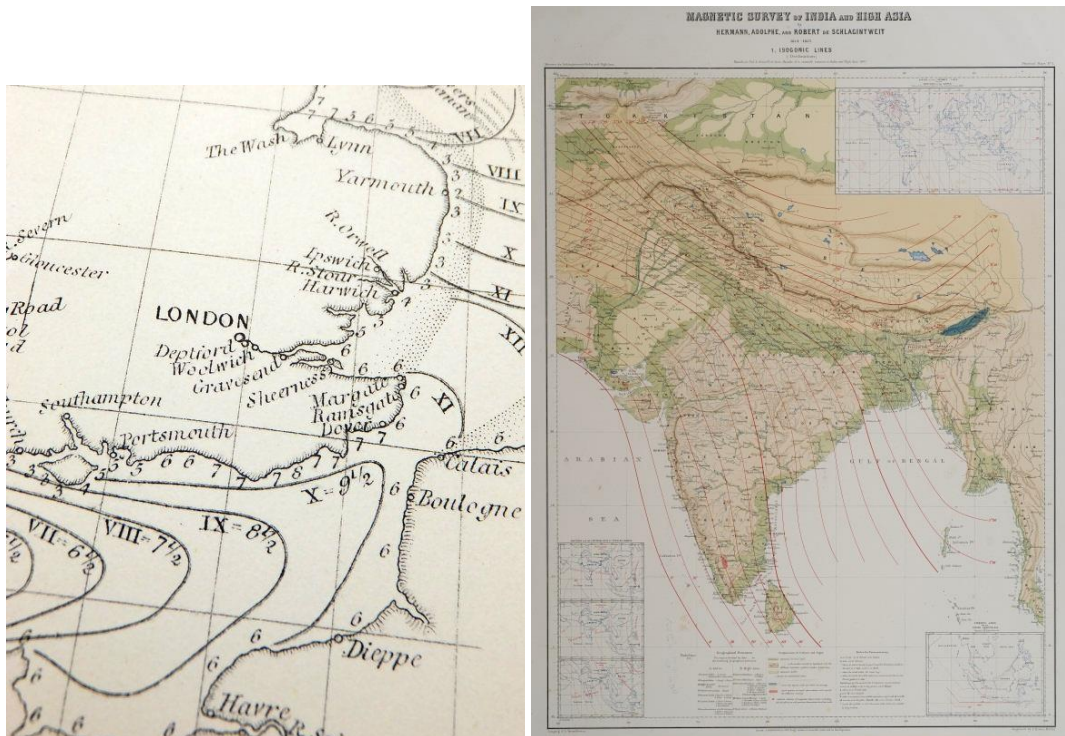


Fig 4.16 a and b: Detail from Whewell's tidal isomap, and a magnetic isomap of 'India and High Asia' by Hermann and Robert Schlagintweit.<sup>206</sup>

Magnetic compasses were essential for dead reckoning, and in order for them to be reliable over large distances, a great deal of resource external to the society was devoted to the Earth's magnetic field. In an equivalent project to Whewell's on tides, Edward Sabine organised a 'magnetical crusade,' which in 1839 established iron-free observatories in far-flung places, and collected data from naval ships.<sup>207</sup> Magnetometers were developed based on the initial work of Carl Friedrich Gauss and Wilhelm Weber, and Christopher Hansteen who introduced a bifilar instrument for absolute measurement in 1832.<sup>208</sup> Gauss's work was referred to by Humboldt. He described a 'new apparatus furnished with a mirror... which requires greater skill and instruction on the part of the observers'.<sup>209</sup> Substantial resource was devoted to find the laws of recalcitrant nature which would then be mathematised in order for the instruments to have foundation.

Again the council filtered out unhelpful submissions. In 1843 it declined to sponsor a new theory of terrestrial magnetism.<sup>210</sup> In 1846 it received a paper from J. Davey Hailes on

<sup>206</sup> Whewell (1868), Schlagintweit(s) (1861), X0253(1)

<sup>205</sup> Collier (2014b), Ennebak (2014)

<sup>208</sup> Collier (2014b) p. 310, Sabine CB3/675, Locher (2007)

<sup>209</sup> Humboldt (1838)

<sup>210</sup> CM Nov 13<sup>th</sup> 1843

magnetic variation.<sup>211</sup> He believed that latitudes were changing rather than the variation. Sabine recommended that; '(Hailes should)... take 50 to 100 geographical positions fairly distributed, and the variations from those positions, and place them side by side with the variations computed by his formula... that is what Gauss has done as the test of his mathematical formula.'<sup>212</sup> The formulating of mathematical relationships with respect to the entire globe required considerable resource.<sup>213</sup> Sabine clung to a Humboldtian belief in eventual patterns even though the magnetic variation was known not to remain constant: 'There will soon be a fixed and unchanging unit so we can compare the data now with epochs in future'.<sup>214</sup>

In spite of these activities, there was still a great deal of uncertainty as to the Earth's magnetism at the end of the nineteenth-century. A memorandum of a conference of delegates from British geographical societies held in 1899 stated; 'The question whether the magnetic poles are at rest or revolve is of the greatest importance but is undetermined.'<sup>215</sup> As for the tide machines, the magnetometers had allowed empirical measurements to be taken, based on agreed mathematics, but were not empowered to give the underlying long-term mathematical relationships, which remained obscure.

Finding elevations was central to the work of the RGS as its attention became focused on land exploration. The relationship between height, pressure and boiling point of water had been a matter for investigation since the start of the nineteenth century. Francis John Hyde Wollaston had provided a description of the thermometric measurement of altitude in 1817.<sup>216</sup> In 1820 he published a table in *Philosophical Transactions* based initially on the results of Andrew Ure, a Scottish chemist. Using logarithms Wollaston obtained the differences per degree for temperatures between 214F and 202F. He then produced a table with columns of temperature of boiling water, parts on the scale of the 'barometric thermometer', height in feet, and length of a mountain barometer tube. He undertook his experiments on the summit of Snowdon in Wales, having previously boiled his instrument on the floor of the Vicarage in Caernarvon on the coast. His readings agreed well with those of Roy's trigonometric observations.<sup>217</sup>

Francis Baily, a leading astronomer and a founder of the Royal Astronomical Society, published his tables of barometric readings versus heights above sea level in 1827. This was reproduced in W & T Gilbert's description of the mountain barometer in 1829, without which the instrument would have been pointless.<sup>218</sup> The formulae used by Jones the following year were corrected for the expansion of mercury using the resources provided by

---

<sup>211</sup> CM Nov 23<sup>rd</sup> 1846, Hailes CB3/345

<sup>212</sup> Sabine to Jackson letter July 20<sup>th</sup> 1846, in Sabine CB3/345, Mawer (2006)

<sup>213</sup> Sabine in Herschel (1851) pp.14-16

<sup>214</sup> Herschel (1851) p. 18 and p. 24, Haines (1854), Evans (1877)

<sup>215</sup> CM June 6<sup>th</sup> 1899 Special Report p.223

<sup>216</sup> Wollaston (1817), Wollaston (1820) p.295

<sup>217</sup> Wollaston (1820)

<sup>218</sup> Gilbert (1829)

Neville Maskelyne and George Shuckburgh.<sup>219</sup> Sykes' 1838 paper presupposed that the technique was not widespread.<sup>220</sup> By the mid-century, Baily's formula for calculating heights by the barometer was no longer considered accurate: it was henceforth to be produced with a warning, and a recommendation that hypsometrical measurements should be used if more accuracy was required.<sup>221</sup> The relative positions of the instruments had changed. In 1852 the tables were still under discussion. William Smyth considered a Mr. Hewlett's table for determining altitudes for publication, together with a new edition of Colonel Sykes 'boiling temperature tables.'<sup>222</sup>

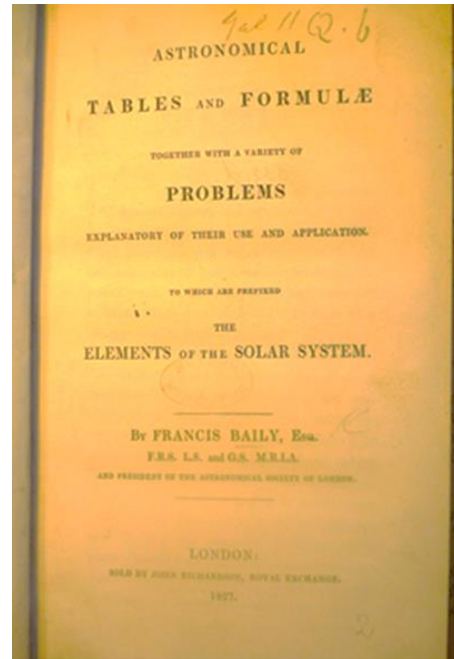


Fig 4.17 a and b: Baily, frontispiece from Baily (1827).<sup>223</sup>

With the introduction of the aneroid, not only did the relation between barometric height and elevation have to be agreed, but also the relationship between the new aneroid barometers and the old mountain barometers had to be negotiated.<sup>224</sup> Hewlett sent tables comparing aneroid and mercurial barometers to the RGS in 1859.<sup>225</sup> In successive editions of *Hints* these tables were replaced by the latest agreed version.<sup>226</sup> The preparation of these

<sup>219</sup> Jones (1820)

<sup>220</sup> Sykes (1838)

<sup>221</sup> EC Jan 17<sup>th</sup> 1853

<sup>222</sup> EC Nov 15<sup>th</sup> 1852

<sup>223</sup> Francis Baily c.1829, by Thomas Phillips, by permission of the RAS via the Science Photo Library, Baily (1827)

<sup>224</sup> Hints Committee Nov 4<sup>th</sup> 1871

<sup>225</sup> CM Feb 28<sup>th</sup> 1859.

<sup>226</sup> CM May 8<sup>th</sup> 1865, Hints Committee Nov 4<sup>th</sup> 1871

tables was labour intensive and therefore represents embedded value. The last iteration was submitted in 1875.<sup>227</sup>

The first reference to meteorological tables occurs in 1833 when it was decided to print an abridged form of those provided by Smyth.<sup>228</sup> According to the preface of Arnold Guyot's *Meteorological Tables* (1852), the calculations involved 'the reduction of the observations and extensive comparisons, without which meteorology can do but little, requiring an amount of mechanical labour which renders it impossible for most observers to deduce for themselves the results of their own observations.' 'To relieve the meteorologist is to save his time and in favour of science.'<sup>229</sup> Other types of measurement also required specialist tables; In 1861 Harvey Simmonds published a *Meteorological Tables* for 45 degrees latitude, including a comparison of results on dew points by James Glaisher and the conversion of the height of water in a Lind anemometer to wind speed.<sup>230</sup>

## Conclusion

This chapter has followed the debates within factions of the Society over what constituted a 'proper' instrument of exploration at the RGS. While the actual acquisition did not fully reflect these ideals, this chapter has demonstrated that the production of small, robust, portable mathematical instruments from the early nineteenth century was embraced by the RGS and became the Society's staple inventory. The instruments were supplied in increasing quantity but with little qualitative change during the century under consideration. It is argued that the embedded resource was enriched by their association with the RGS, and while the management was inefficient, it had some leverage. Design improvements and modifications to the mathematical foundations, relying on instrument makers and mathematical practitioners respectively, were subjects of discourse particularly in the first half of the period. It has been demonstrated that the RGS Council provided a filter ensuring the maintenance of credibility. Bought instruments were not necessarily in the 'black box' of ANT, but were frequently tested and compared.

Rae, Souch and Withers rightly note that 'The RGS took instruments and their correct use to be key features associated with the advance of geographical science.'<sup>231</sup> The loan of instruments to expeditions was an enduring and important activity for the Society, but it was never a stated aim. The acquisition of instruments was reactive for several decades and never systematised.

All these activities enhanced the authority of the RGS instruments. The resource bestowed on behalf of the Society constitutes part of the solution to the paradox of authority

---

<sup>227</sup> CM Apr 12<sup>th</sup> 1875

<sup>228</sup> CM 12<sup>th</sup> Jan 1833

<sup>229</sup> *Hints* (1871) p.29, *Hints* (1878) p.97

<sup>230</sup> Harvey Simmonds (1861)

<sup>231</sup> Rae, Souch, and Withers (2015) p.158

versus fallibility set out in chapter 1. Having conferred this resource, the Society was bound to continue to support instrumental measurement in the field whatever the rigour with which it was performed.

## Chapter 5:

### The Preparation of Travellers

*Upon the careful and efficient training of explorers depends the value and accuracy of their work.*<sup>1</sup>

#### Introduction

Preparation of travellers in the use of instruments was complementary to the provision of instruments themselves. Users would mobilise the considerable instrumental resource in the field. The RGS endeavoured to discipline its travellers in order that they might establish best practice with respect to the care and transport of the instruments, observational methods, data collection, calculation, and representation. Livingstone describes this process as creating 'Protocols for the management of scientific space.'<sup>2</sup>

This chapter concerns the resources expended on the preparation of users including the utilisation of external expertise through building networks. It addresses the work done by the RGS to guide exploration through training, and the effectiveness of the training process, the latter involving comparison of alternative texts. The chapter argues that a considerable resource was embedded in the instruments and their potential users before mobilisation in the field took place. As for the choice of instruments, the type of training was a product of conflicting attitudes within the Society, although the preference for instrumental measurement over other forms of observation was consistent. While on some levels the training was effective, it is argued that it could be undermined by various privileges in which the intended ambition was thwarted.

#### Recognition of Need

The RGS was founded at a time of vocal frustration with government support for science and mathematics. Baily's remarks in 1829 are particularly pertinent. He lamented the 'scanty funds' for the Ordnance Survey noting that 'the government believes nothing more is necessary than to provide instruments.'<sup>3</sup> While the value of instrumental expertise was appreciated at the RGS, little was done to provide it until the 1850s.

From the outset in 1830 the RGS council suggested that a standing committee be appointed to communicate with intending travellers to give them advice on what to examine - 'Geographical Desiderata.'<sup>4</sup> Macdonald and Withers point out that the second volume of the *JRGS* contained an ambition for a 'Travellers' Manual' but as for other intentions, this was not

---

<sup>1</sup> Markham (1881) p. 109

<sup>2</sup> Livingstone (2010) p.4

<sup>3</sup> Baily (1829) p.8 and 10

<sup>4</sup> CM 4<sup>th</sup> Dec 1830



fully realised for several decades.<sup>5</sup> In 1834, the instructions given to Alexander stated that the seven or eight months in reaching his destination would be spent 'acquiring expertness in the use of the astronomical and other instruments' as well as acquiring language skills.<sup>6</sup> The hands-on aspect of his tuition was to be received from the officers on the ship.<sup>7</sup> As was seen with regard to the acquisition of instruments, the Society did not act to implement its ambitions with respect to instruction during this period. Formal training was not provided, but naval expertise was exploited.

In 1837 Mr. Lewis Tonna of the United Services Museum offered to give instruction 'to travellers going abroad on the manner of making observations for longitude and latitude', which was not taken up.<sup>8</sup> The following year £100 was requested on behalf of Baron Karwinski on the understanding that 'he should prove himself capable of taking latitude astronomically and laying down his route correctly before he goes.'<sup>9</sup> However, the RGS did not provide the means to obtain this expertise. The third expedition the RGS supported, to Kurdistan in 1839, became a subject of frustration for Richard Sheepshanks who was dismissive of the competence of the travellers, William Ainsworth and Christian Rassam. He asked 'if they could not take latitude and longitude in England, how could they do it in Kurdistan?' Sheepshanks was dismayed that the men had not been given proper training and did not want to take responsibility if they failed.<sup>10</sup> There was no institutional response on behalf of the Society.

### **Advisory Texts**

From 1854 until 1935 the RGS published *Hints To Travellers*, which has been discussed in the previous chapter for its role in defining which instruments were 'proper' for exploration. Here *Hints* and other publications will be considered from the point of view of the preparation of the traveller.

The need for Jackson's advisory text '*What to Observe*' (1841), a precursor of *Hints*, was spelt out clearly in its preface; 'When we consider the total absence of anything like solid information given to us by the legion of those who quit their native country to roam for a while over the various parts of the globe, we cannot but think that some good must result from pointing out how their peregrinations may be turned to better account than they have hitherto been.'<sup>11</sup> It was clear that exploring was a moral obligation, not merely a physical undertaking; 'The intending traveller, it is hoped, will, from a perusal of the present work see what an

---

<sup>5</sup> *JRGS* 2 pp v-viii, MacDonald and Withers (2015) p.7

<sup>6</sup> CM 18<sup>th</sup> October 1834

<sup>7</sup> *Hints* (1854) p. 19

<sup>8</sup> CM June 12<sup>th</sup> 1837

<sup>9</sup> CM Mar 26<sup>th</sup> 1838

<sup>10</sup> Sheepshanks CB2/484 July 22<sup>nd</sup> 1838

<sup>11</sup> Jackson (1841) Preface iv, Driver (2001) pp 58-61, Withers (2011) pp.45-46

immense field of physical and moral research lies open to his investigation'.<sup>12</sup> Thus the training made clear of the duties of the European male explorer.

*What To Observe* may be considered in relation to other similar contemporary texts. It was concerned principally with survival techniques and general advice; only Division XI was entitled 'Instruments and Operations'. In spite of evidence throughout the century under investigation that the ability to use instruments to find latitude and longitude was not widespread, for example Butler Williams' remarked in 1842 that 'the subject of longitude is not generally understood,' Jackson dismissed the description of the use of the sextant, artificial horizon, prismatic and pocket compass as being unnecessary: 'Of the first four we shall say nothing presuming they are well-understood by those who intend using them.'<sup>13</sup> While it could be said the compasses were straightforward if variation was known, the use of the sextant and artificial horizon to find longitude involved the most difficult observations and calculations. Jackson ruled out topics for inclusion by declaring that 'The scientific traveller needs no instruction from us,' begging the question of where the scientific traveller would get his information.<sup>14</sup> *What To Observe* did not emulate the mathematical texts, nor could it replace the hands-on instruction provided to travellers by navigators on route.<sup>15</sup>

Jackson referred to George Landmann, (also Landmann), professor of fortification and artillery at Woolwich, who had written a practical geometry for the Royal Military Academy in 1805.<sup>16</sup> Landmann's novelty was 'practical geometry *on the ground*'. He advocated inscribing geometrical exercises directly on to the land that was to be measured: 'Your spade becoming your pencil, a rod or chain becoming a scale,' hence cutting out the sketching stage.<sup>17</sup> Jackson was using resources designed for the military, and while catering for those who were not deemed scientific travellers, failed to equip them to gain support from the RGS.

Numerous other texts were available at the time which gave detailed instruction on the use of instruments; Butler Williams' work *Practical Geodesy* (1842) was aimed at 'surveyors, students of civil, military and naval engineers'.<sup>18</sup> His description of surveying in the colonies is not that of exploration but of marking out plots for sale to settlers, but he does describe the use of the barometer for heights and lunar distances for longitude. Janet Taylor's *Nautical Astronomy* (1833) was highly mathematical taking into account the oblate nature of the Earth.<sup>19</sup> Simm's *A Treatise on the Principal Mathematical Instruments Used in Surveying* (1834) claimed to fill a gap for the young surveyor: 'The want of a work containing a concise and popular description of the principle instruments of surveying has long been

---

<sup>12</sup> Jackson (1841) Preface iii

<sup>13</sup> Butler Williams (1842) preface v, Jackson (1841) p. 455

<sup>14</sup> Jackson (1841) p. 478

<sup>15</sup> Withers (2013)

<sup>16</sup> Landmann (1805), Adams (1813)

<sup>17</sup> Adams (1813) p. 426

<sup>18</sup> Butler Williams (1842)

<sup>19</sup> Taylor (1833)

felt.' The book contained detailed descriptions of the instruments with instructions on how to correct and set them up with worked examples.<sup>20</sup> Raper's *Navigation* (1840) was recommended in later RGS publications. It was thorough with an awareness of appropriate numbers of significant figures, but was more concerned with marine than land surveying.

*What To Observe* was therefore a companion to *travellers*, rather than the more mathematical tomes available for trainee surveyors or navigators. *What To Observe* was dispatched to the RGS travellers each year from 1841 until 1844, copies being sent out after that date at the direction of the Secretary.<sup>21</sup>

*Hints* (1854) was the outcome of Galton's failed attempt to procure instruments in a systematic manner. It became a trade mark publication of the RGS, going through seven editions before 1900.<sup>22</sup> In 1853 the Expedition Committee resolved that a document 'Hints for Collecting Geographical Information' would be published, and that it would include both Sykes' and Baily's tables for barometric heights, both representing considerable inherent resource.<sup>23</sup> Driver has remarked that the first edition of *Hints* (1854) was a hesitant publication, remaining as merely the Report of the Committee.<sup>24</sup> It supposedly answered questions of a general nature from explorers as to how they could make their expeditions 'useful to geography.'<sup>25</sup> The fact that it was not a formal publication but a collection of papers demonstrates not only the uncertainty as to which instruments were 'proper', but the uncertainty as to who would participate in this relatively new undertaking.<sup>26</sup> In this case then, the harnessing of networks which involved a multiplicity of figures of authority- Smyth, Beechey, Raper, FitzRoy and Galton- did not serve to strengthen the credibility of *Hints*, but acted to undermine it. As Latour wrote; "it is not simply a question of the number of allies but of their acting as a unified whole."<sup>27</sup>

The contradiction between the authors regarding instruments was matched on the question of the audience for the publication. While Galton was addressing 'a man, (who) for the first time in his life proposes to explore a wild country,' for Raper and FitzRoy 'It is understood that he has already travelled, and has given proofs of his acquaintance with the use of several necessary instruments. Were this not the case, we fear that the fullest

---

<sup>20</sup> Simms (1834)

<sup>21</sup> CM May 8<sup>th</sup> 1843

<sup>22</sup> CM June 14<sup>th</sup> 1852, Rae, Souch, and Withers (2015) p.145-150

<sup>23</sup> EC Nov 15<sup>th</sup> 1852, Sykes (1838), Baily (1827), EC Jan 17<sup>th</sup> 1853

<sup>24</sup> *Hints* (1865) p. 3, Driver (2001) pp 58-61

<sup>25</sup> EC Nov 15<sup>th</sup> 1852, Jan 17<sup>th</sup> 1853

<sup>26</sup> *Hints* (1865) p.3 Driver (2001) pp 58-6

<sup>27</sup> Latour (1987) p.131

instructions would hardly suffice to give any traveller possession of such practical skill as should be acquired experimentally.<sup>28</sup>

Instructions as to how to use the instruments received little attention except from Galton. General methods were advocated such as laying down the points trigonometrically between stations which should be determined astronomically, without revealing how this should be done. Many of the recommendations concerned the care and transport of instruments, on which topics there were fewer alternative avenues to information. Raper and FitzRoy wrote that 'Writing and drawing materials, scales, tapes, and register books should be kept in watertight containers. All instruments should be in leather or canvas cases painted *white*. Chronometers should be worn night and day to keep them warm. Barometers are better on men's backs.'<sup>29</sup> Smyth wrote 'Quicksilver will be lost in the sand and nothing of wood can be used in Africa.'<sup>30</sup> Journey times by camel were estimated.<sup>31</sup> Unsurprisingly, Raper advocated his own work for the mathematical instruction, but this was a heavy textbook not a companion for travellers.

*Hints* (1854) was thus even more tentative than *What to Observe* (1841). It demonstrated clearly the emerging, but far from confident or established, category of 'scientific traveller.' These were neither trained surveyors, nor were they totally ignorant. There was a perceived lack of appropriate instruction manuals for them, but who exactly they were was contested. Driver has described the early production of *Hints* as 'an unsettled attempt to resolve some fundamental questions,' a view supported by this thesis.<sup>32</sup> On eight occasions the minutes recorded that *Hints* (1854) had been supplied to travellers, and it was also printed in the *JRGS*.<sup>33</sup>

Galton's advisory text *The Art of Travel* (1855) was not directly associated with the Society notwithstanding Galton's position on the RGS Council.<sup>34</sup> Arguably, Galton's ambitions in writing this book were not compatible with the intentions of the RGS. Galton's audiences were 'travellers, missionaries, emigrants or soldiers' requiring advice on survival. *The Art of Travel* was intended for those who may have to 'rough it', very much Galton's personal style.<sup>35</sup> Nevertheless, it is helpful to consider these different texts in order to appreciate the niche the RGS was creating with respect to its travellers.

In 1865 the RGS Council decided to establish a committee to 'compile formulae and numerical elements useful to scientific travellers with a view to publication in a pamphlet.'<sup>36</sup> The committee consisted of Collinson, Galton and Back, all of whom were listed as authors:

---

<sup>28</sup> *Hints* (1854) p. 2, p.18

<sup>29</sup> *Hints* (1854) p. 6

<sup>30</sup> *Hints* (1854) p. 9

<sup>31</sup> Rennell (1791)

<sup>32</sup> Driver (2001) p. 50

<sup>33</sup> *JRGS* 24 (1855) pp. 328-359

<sup>34</sup> Galton (1856), Driver (2001) p. 63

<sup>35</sup> Galton (1856) preface iii

<sup>36</sup> CM May 8<sup>th</sup> 1865

other text was provided by a range of contributors. The product was not materially different from the earlier edition, although it was twice as long. The resulting second edition was a more disciplined work than the first; while there was still a multiplicity of authors, the strident contradictions had been largely removed. This edition was to be ‘understood to be addressed to a person who, for the first time in his life, proposes to explore a wild country and who asks “what astronomical and mapping instruments and other scientific outfit should I take? What are the observations for latitude and longitude on which I should rely?”’ The questions were not specific to the contributions of individuals but appeared in the introduction as pertaining to the whole work.

It was now recommended that instruments were tested at Kew to provide calibration, that Norie’s, Raper’s or Inman’s tables for navigation could be used, Shadwell’s cards of formulae were suggested, logarithmic tables and boiling point tables were provided and the *Nautical Almanac* advocated.<sup>37</sup> Longitude to quarter of a degree was deemed sufficient, for which lunar distance remained the preferred method. Because stopping at noon was inconvenient and the artificial horizon not easy to use when the sun was high, it was recommended to use stars for latitude. A small section on photography was introduced.<sup>38</sup> There remained a lack of detail about how actually to take the observations except from Galton whose contribution was reproduced from the first edition.<sup>39</sup> This work was distributed ‘gratis’ to intending travellers, and published in the *JRGS*.<sup>40</sup>

By early 1871 the 1865 edition of *Hints* was out of print. Council resolved that a third edition would be compiled with the previous committee augmented by Edward Whymper.<sup>41</sup> They had discretion to add to their number so that Captain Pratt R.E. could suggest improvements in compasses and the use of the Abney level, and Captain Evans R.N. could suggest improvements in the shape of compass needles and sketches. This furthered networks with the Navy and the Royal Engineers.<sup>42</sup> It was agreed that John T. Walker would contribute on the transit instrument and theodolite and Pratt would write on their adjustments.<sup>43</sup> There were four further contributors including George. The proof slips were sent to twenty-two people to check for errors in a strategy to build support and authority: the multiple authors had been disciplined to present a common message.<sup>44</sup> Clowes was paid £39 1s and 2d for publication of the 1871 *Hints*, but it is not known how many were printed.<sup>45</sup> Again, the work was distributed free to intending travellers.<sup>46</sup>

---

<sup>37</sup> Norie (1839), Raper (1849), Inman (1821), Cotter (1968) Shadwell’s cards: RAS Cat. No.335

<sup>38</sup> Ryan (2010) p.226

<sup>39</sup> *Hints* (1854) p.11, *Hints* (1865) p. 22

<sup>40</sup> *JRGS* 34 (1865) pp. 272-317

<sup>41</sup> CM Jan 9<sup>th</sup> 1871

<sup>42</sup> Hints Committee Apr 26<sup>th</sup> 1871

<sup>43</sup> Hints Committee May 4<sup>th</sup> 1871

<sup>44</sup> Hints Committee Feb 15<sup>th</sup> 1871

<sup>45</sup> FC Feb 5<sup>th</sup> 1872

<sup>46</sup> *JRGS* 41 (1872) p. viii

The third edition retained the introductory questions of the second edition, and similarly relied on resources from outside the RGS: for example tables were taken from Guyot's *Meteorological Tables* (1852), the *Admiralty Manual for the Use of Travellers* (1849), published under Herschel's editorship was cited, and Lendy was also recommended.<sup>47</sup> By now there were several textbooks available describing instruments and practices in greater mathematical detail, such as *Spherical and Practical Astronomy* (1863) by Chauvenet. However, in *Hints* (1871) it was thought necessary to simplify Chauvenet's formulae by substituting the work of his British counterpart: Shadwell the President of the Royal Naval College at Greenwich.<sup>48</sup> As with the earlier editions, the RGS was nurturing the concept of an explorer who was not a professional surveyor. The focus on the sextant and artificial horizon was justified by the availability of expertise on route: 'The prospective traveller can practice himself in their use under the tuition of the officers on the ship.'<sup>49</sup> This is an example of the invisibility of vital aspects of the resource invested in instruments provided by those outside the RGS.<sup>50</sup>

In June 1877 reprinting *Hints* was considered.<sup>51</sup> At the Scientific Purposes Committee, Galton was asked to decide whether there were any new matters which could be added, and to take into account the desirability of altering its size and shape and the price at which it should be sold.<sup>52</sup> The following year it was decided to print 750 copies of *Hints* at 2s and 6d, which could be presented to travellers at the discretion of the assistant secretary.<sup>53</sup> The fourth edition, which appeared in 1878, was similar to the third and also attributed to Galton, Collinson and Back. The additional authors did not change appreciably. Coles appeared for the first time, as did Richard Strachan, who was responsible for the instruments at the Meteorological Office, who was brought in to provide a section on meteorology. There were few pages devoted to the complex calculations needed for longitude: the reader was referred to Shadwell's modification of Chauvenet. Markham summarised the first four editions in his 'Fifty Years' Work.'<sup>54</sup>

The fifth edition of *Hints* (1883), a page of which is illustrated in figure 5.1, was attributed to Douglas Freshfield, Godwin- Austen and Knox Laughton, and was the first to reflect the 'scientific turn', and constituted a distinct raising of the technical level.<sup>55</sup> Jones rightly sees this as a break from the past.<sup>56</sup> This edition was acknowledged as a remodelling and was produced by an entirely new sub-committee. The portion on surveying was the

---

<sup>47</sup> *Hints* (1871) p. 11, Lendy (1869)

<sup>48</sup> Chauvenet (1863), *Hints* (1871) p. 11 and p.14

<sup>49</sup> *Hints* (1871) p. 7

<sup>50</sup> Driver and Jones (2009)

<sup>51</sup> CM June 11<sup>th</sup> 1877

<sup>52</sup> SPC June 18<sup>th</sup> 1877

<sup>53</sup> CM May 13<sup>th</sup> 1878

<sup>54</sup> Markham (1881) pp.106-107

<sup>55</sup> CM Mar 13<sup>th</sup>, Mar 14<sup>th</sup> 1876

<sup>56</sup> Jones, M. (2005) p. 321

responsibility of Coles the 'Map Curator and Instructor in Practical Astronomy and Surveying.'<sup>57</sup> Other sections comprised: Meteorology by Strachan, Geology by William Blandford, Anthropology by Edward Tylor, Photography by William Donkin, professor of chemistry at St George's Hospital, Medical Hints by George Dobson and Hints on Outfit by Whympere, James Grant and Joseph Thomson.<sup>58</sup> The introductory questions had gone and there was a new intended audience: this edition claimed to meet the 'higher requirements of a new generation of young travellers, many of whom receive instruction before they leave England from the Society'. The *Hints* were now seen as complementary to the recently-introduced in-house instruction. The prospective traveller would have 'already been at some pains to acquaint himself with use of instruments.' It was also more outward-looking as it included tables for the comparison of English and metric measures, and comparisons of thermometer scales.<sup>59</sup>

---

<sup>57</sup> *Hints* (1889) preface iv

<sup>58</sup> Hints Committee July 1<sup>st</sup> 1881

<sup>59</sup> *Hints* (1883) p. 33

70

*Lunar (Raper's Rigorous Method)*

	Latitude .. .. 51 31 11 N.
	Thermometer .. 49
	Barometer .. .. 30 inches.

Date November 22nd, 1879, P.M. at place of observation, Mars and ☿. Mars East of Meridian.

<table border="0" style="width: 100%;"> <tr><td>Time by Watch ..</td><td>H. M. S.</td><td>7 45 33</td></tr> <tr><td>Accumulated Rate of Watch ..</td><td></td><td>- 29</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Error of Watch ..</td><td></td><td>7 45 4</td></tr> <tr><td>G. M. T. Nov. 22nd ..</td><td></td><td>7 45 56</td></tr> </table>	Time by Watch ..	H. M. S.	7 45 33	Accumulated Rate of Watch ..		- 29	<hr/>			Error of Watch ..		7 45 4	G. M. T. Nov. 22nd ..		7 45 56	<table border="0" style="width: 100%;"> <tr><td>☿ Semid. (table 40) ..</td><td>H. M. S.</td><td>15 2 5</td></tr> <tr><td>Augmentation (42) ..</td><td></td><td>9 2</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>☿'s Aug. Semid ..</td><td></td><td>15 11 7</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Mar's Declination ..</td><td>H. M. S.</td><td>17 28 23 N.</td></tr> <tr><td>Mar's Polar Dist. ..</td><td></td><td>72 31 37</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Mar's R.A. ..</td><td>H. M. S.</td><td>2 56 15</td></tr> </table>	☿ Semid. (table 40) ..	H. M. S.	15 2 5	Augmentation (42) ..		9 2	<hr/>			☿'s Aug. Semid ..		15 11 7	<hr/>			Mar's Declination ..	H. M. S.	17 28 23 N.	Mar's Polar Dist. ..		72 31 37	<hr/>			Mar's R.A. ..	H. M. S.	2 56 15	<table border="0" style="width: 100%;"> <tr><td>☿'s Hor. Par. Noon ..</td><td>H. M. S.</td><td>55 28 9</td></tr> <tr><td>Mid. ..</td><td></td><td>55 11 2</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Variation in 12 hours ..</td><td></td><td>00 17 7</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Correction (table 21) ..</td><td></td><td>00 11 4</td></tr> <tr><td>Hor. Par. Noon ..</td><td></td><td>55 28 9</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Hor. Par. corr. for G.D. ..</td><td></td><td>55 17 5</td></tr> <tr><td>Corr. for Lat. (41) ..</td><td></td><td>- 6 7</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Reduced Hor. Par. ..</td><td></td><td>55 10 8</td></tr> </table>	☿'s Hor. Par. Noon ..	H. M. S.	55 28 9	Mid. ..		55 11 2	<hr/>			Variation in 12 hours ..		00 17 7	<hr/>			Correction (table 21) ..		00 11 4	Hor. Par. Noon ..		55 28 9	<hr/>			Hor. Par. corr. for G.D. ..		55 17 5	Corr. for Lat. (41) ..		- 6 7	<hr/>			Reduced Hor. Par. ..		55 10 8
Time by Watch ..	H. M. S.	7 45 33																																																																														
Accumulated Rate of Watch ..		- 29																																																																														
<hr/>																																																																																
Error of Watch ..		7 45 4																																																																														
G. M. T. Nov. 22nd ..		7 45 56																																																																														
☿ Semid. (table 40) ..	H. M. S.	15 2 5																																																																														
Augmentation (42) ..		9 2																																																																														
<hr/>																																																																																
☿'s Aug. Semid ..		15 11 7																																																																														
<hr/>																																																																																
Mar's Declination ..	H. M. S.	17 28 23 N.																																																																														
Mar's Polar Dist. ..		72 31 37																																																																														
<hr/>																																																																																
Mar's R.A. ..	H. M. S.	2 56 15																																																																														
☿'s Hor. Par. Noon ..	H. M. S.	55 28 9																																																																														
Mid. ..		55 11 2																																																																														
<hr/>																																																																																
Variation in 12 hours ..		00 17 7																																																																														
<hr/>																																																																																
Correction (table 21) ..		00 11 4																																																																														
Hor. Par. Noon ..		55 28 9																																																																														
<hr/>																																																																																
Hor. Par. corr. for G.D. ..		55 17 5																																																																														
Corr. for Lat. (41) ..		- 6 7																																																																														
<hr/>																																																																																
Reduced Hor. Par. ..		55 10 8																																																																														

<table border="0" style="width: 100%;"> <tr><td>Mars, Observed Alt. ..</td><td>Art. Hor.</td><td>80 21 30</td></tr> <tr><td>Index error ..</td><td></td><td>+ 3</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>2) 80 21 33</td><td></td><td></td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>App. Alt. ..</td><td></td><td>40 10 46 5</td></tr> <tr><td>Refraction - 1' 9" ..</td><td></td><td>- 0 56 1</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Par. in Alt. + 13" ..</td><td></td><td></td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Mars True Alt. ..</td><td></td><td>40 9 50 4</td></tr> </table>	Mars, Observed Alt. ..	Art. Hor.	80 21 30	Index error ..		+ 3	<hr/>			2) 80 21 33			<hr/>			App. Alt. ..		40 10 46 5	Refraction - 1' 9" ..		- 0 56 1	<hr/>			Par. in Alt. + 13" ..			<hr/>			Mars True Alt. ..		40 9 50 4	<table border="0" style="width: 100%;"> <tr><td>Observed Alt. ☿ ..</td><td>Art. Hor.</td><td>78 30 54</td></tr> <tr><td>Index error ..</td><td></td><td>+ 3</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>2) 78 30 57</td><td></td><td></td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Augt. Semid. ..</td><td></td><td>39 15 28 5</td></tr> <tr><td>☿'s App. Alt. ..</td><td></td><td>39 30 40 2</td></tr> <tr><td>☿'s corr. in Alt. (39) +</td><td></td><td>41 25</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>☿'s True Alt. ..</td><td></td><td>40 12 5 2</td></tr> </table>	Observed Alt. ☿ ..	Art. Hor.	78 30 54	Index error ..		+ 3	<hr/>			2) 78 30 57			<hr/>			Augt. Semid. ..		39 15 28 5	☿'s App. Alt. ..		39 30 40 2	☿'s corr. in Alt. (39) +		41 25	<hr/>			☿'s True Alt. ..		40 12 5 2	<table border="0" style="width: 100%;"> <tr><td>Sidereal Time at Mean Noon Nov. 22nd ..</td><td>Day.</td><td>H. M. S.</td><td>16 4 24 24</td></tr> <tr><td>Acceleration for G.D. (21) ..</td><td></td><td>7 hours ..</td><td>1 9</td></tr> <tr><td></td><td></td><td>45 mins ..</td><td>7 39</td></tr> <tr><td></td><td></td><td>56 sec. ..</td><td>15</td></tr> <tr><td colspan="4"><hr/></td></tr> <tr><td>Mean ☿'s R.A. ..</td><td></td><td></td><td>16 5 40 78</td></tr> <tr><td colspan="4"><hr/></td></tr> <tr><td>Observed Distance F.L. ..</td><td></td><td></td><td>53 30 10</td></tr> <tr><td>Index error ..</td><td></td><td></td><td>+ 2 00</td></tr> <tr><td colspan="4"><hr/></td></tr> <tr><td>☿'s Semid. Augmented ..</td><td></td><td></td><td>53 32 10</td></tr> <tr><td>☿'s Apparent Dist. ..</td><td></td><td></td><td>53 16 58 3</td></tr> </table>	Sidereal Time at Mean Noon Nov. 22nd ..	Day.	H. M. S.	16 4 24 24	Acceleration for G.D. (21) ..		7 hours ..	1 9			45 mins ..	7 39			56 sec. ..	15	<hr/>				Mean ☿'s R.A. ..			16 5 40 78	<hr/>				Observed Distance F.L. ..			53 30 10	Index error ..			+ 2 00	<hr/>				☿'s Semid. Augmented ..			53 32 10	☿'s Apparent Dist. ..			53 16 58 3
Mars, Observed Alt. ..	Art. Hor.	80 21 30																																																																																																															
Index error ..		+ 3																																																																																																															
<hr/>																																																																																																																	
2) 80 21 33																																																																																																																	
<hr/>																																																																																																																	
App. Alt. ..		40 10 46 5																																																																																																															
Refraction - 1' 9" ..		- 0 56 1																																																																																																															
<hr/>																																																																																																																	
Par. in Alt. + 13" ..																																																																																																																	
<hr/>																																																																																																																	
Mars True Alt. ..		40 9 50 4																																																																																																															
Observed Alt. ☿ ..	Art. Hor.	78 30 54																																																																																																															
Index error ..		+ 3																																																																																																															
<hr/>																																																																																																																	
2) 78 30 57																																																																																																																	
<hr/>																																																																																																																	
Augt. Semid. ..		39 15 28 5																																																																																																															
☿'s App. Alt. ..		39 30 40 2																																																																																																															
☿'s corr. in Alt. (39) +		41 25																																																																																																															
<hr/>																																																																																																																	
☿'s True Alt. ..		40 12 5 2																																																																																																															
Sidereal Time at Mean Noon Nov. 22nd ..	Day.	H. M. S.	16 4 24 24																																																																																																														
Acceleration for G.D. (21) ..		7 hours ..	1 9																																																																																																														
		45 mins ..	7 39																																																																																																														
		56 sec. ..	15																																																																																																														
<hr/>																																																																																																																	
Mean ☿'s R.A. ..			16 5 40 78																																																																																																														
<hr/>																																																																																																																	
Observed Distance F.L. ..			53 30 10																																																																																																														
Index error ..			+ 2 00																																																																																																														
<hr/>																																																																																																																	
☿'s Semid. Augmented ..			53 32 10																																																																																																														
☿'s Apparent Dist. ..			53 16 58 3																																																																																																														

<table border="0" style="width: 100%;"> <tr><td>Mars (+13 5") ..</td><td>App. Alts.,</td><td>40 11 00</td></tr> <tr><td>☿'s (+19 8") ..</td><td></td><td>39 31 00</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Sum ..</td><td></td><td>79 42 00</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>180 00 00</td><td></td><td></td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Apparent Zenith Dist. ..</td><td></td><td>100 18 00</td></tr> </table>	Mars (+13 5") ..	App. Alts.,	40 11 00	☿'s (+19 8") ..		39 31 00	<hr/>			Sum ..		79 42 00	<hr/>			180 00 00			<hr/>			Apparent Zenith Dist. ..		100 18 00	<table border="0" style="width: 100%;"> <tr><td>Mars (+13 5") ..</td><td>True Alts.,</td><td>40 10 3 9</td></tr> <tr><td>☿'s (+19 8") ..</td><td></td><td>40 12 24 8</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Sum ..</td><td></td><td>80 22 28 7</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>180 00 00</td><td></td><td></td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>True Zenith Dist. ..</td><td></td><td>99 37 31 3</td></tr> </table>	Mars (+13 5") ..	True Alts.,	40 10 3 9	☿'s (+19 8") ..		40 12 24 8	<hr/>			Sum ..		80 22 28 7	<hr/>			180 00 00			<hr/>			True Zenith Dist. ..		99 37 31 3	<table border="0" style="width: 100%;"> <tr><td>App. Dist. ..</td><td></td><td>52 17 00</td></tr> <tr><td>App. Zenith Dist. ..</td><td></td><td>100 18 00</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Sum ..</td><td></td><td>2152 35 00</td></tr> <tr><td>Sum ..</td><td></td><td>76 47 30</td></tr> <tr><td>Sum - App. Dist. =</td><td></td><td>23 30 30</td></tr> <tr><td>Logarithmic difference ..</td><td></td><td>9 988156</td></tr> <tr><td></td><td></td><td>9 60845</td></tr> <tr><td></td><td></td><td>9 99311</td></tr> </table>	App. Dist. ..		52 17 00	App. Zenith Dist. ..		100 18 00	<hr/>			Sum ..		2152 35 00	Sum ..		76 47 30	Sum - App. Dist. =		23 30 30	Logarithmic difference ..		9 988156			9 60845			9 99311
Mars (+13 5") ..	App. Alts.,	40 11 00																																																																											
☿'s (+19 8") ..		39 31 00																																																																											
<hr/>																																																																													
Sum ..		79 42 00																																																																											
<hr/>																																																																													
180 00 00																																																																													
<hr/>																																																																													
Apparent Zenith Dist. ..		100 18 00																																																																											
Mars (+13 5") ..	True Alts.,	40 10 3 9																																																																											
☿'s (+19 8") ..		40 12 24 8																																																																											
<hr/>																																																																													
Sum ..		80 22 28 7																																																																											
<hr/>																																																																													
180 00 00																																																																													
<hr/>																																																																													
True Zenith Dist. ..		99 37 31 3																																																																											
App. Dist. ..		52 17 00																																																																											
App. Zenith Dist. ..		100 18 00																																																																											
<hr/>																																																																													
Sum ..		2152 35 00																																																																											
Sum ..		76 47 30																																																																											
Sum - App. Dist. =		23 30 30																																																																											
Logarithmic difference ..		9 988156																																																																											
		9 60845																																																																											
		9 99311																																																																											

<table border="0" style="width: 100%;"> <tr><td>Mars App. Alt. ..</td><td>Sec.</td><td>0 116916</td></tr> <tr><td>☿'s App. Alt. ..</td><td></td><td>0 112698</td></tr> <tr><td>Mars True Alt. ..</td><td></td><td>0 883164</td></tr> <tr><td>☿'s True Alt. ..</td><td></td><td>0 822933</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Logarithmic Difference ..</td><td></td><td>9 995733</td></tr> </table>	Mars App. Alt. ..	Sec.	0 116916	☿'s App. Alt. ..		0 112698	Mars True Alt. ..		0 883164	☿'s True Alt. ..		0 822933	<hr/>			Logarithmic Difference ..		9 995733	<table border="0" style="width: 100%;"> <tr><td>App. Dist. ..</td><td></td><td>52 17 00</td></tr> <tr><td>App. Zenith Dist. ..</td><td></td><td>100 18 00</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Sum ..</td><td></td><td>2152 35 00</td></tr> <tr><td>Sum ..</td><td></td><td>76 47 30</td></tr> <tr><td>Sum - App. Dist. =</td><td></td><td>23 30 30</td></tr> <tr><td>Logarithmic difference ..</td><td></td><td>9 988156</td></tr> <tr><td></td><td></td><td>9 60845</td></tr> <tr><td></td><td></td><td>9 99311</td></tr> </table>	App. Dist. ..		52 17 00	App. Zenith Dist. ..		100 18 00	<hr/>			Sum ..		2152 35 00	Sum ..		76 47 30	Sum - App. Dist. =		23 30 30	Logarithmic difference ..		9 988156			9 60845			9 99311	<table border="0" style="width: 100%;"> <tr><td>Are ..</td><td></td><td>76 38 52</td></tr> <tr><td>True Zenith Dist. ..</td><td></td><td>99 37 31 3</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Sum ..</td><td></td><td>176 16 23 3</td></tr> <tr><td>Difference ..</td><td></td><td>22 58 39 3</td></tr> <tr><td>Sum ..</td><td></td><td>88 8 11 6</td></tr> <tr><td>Difference ..</td><td></td><td>11 29 19 6</td></tr> <tr><td>Approx. True Dist. ..</td><td></td><td>52 59 50"</td></tr> <tr><td>Seconds added ..</td><td></td><td>1 7</td></tr> <tr><td>Time Dist. ..</td><td></td><td>52 59 48 3</td></tr> <tr><td>N.A. at VL hours ..</td><td></td><td>52 55 19</td></tr> <tr><td>Difference ..</td><td></td><td>55 30 7</td></tr> <tr><td>Time of Dist. by N.A. ..</td><td></td><td>52 55 19</td></tr> <tr><td>Correction for 2nd difference (57) ..</td><td></td><td>7 45 54</td></tr> <tr><td>G. M. T. by Lunar ..</td><td></td><td>7 45 50</td></tr> <tr><td>Time by Watch ..</td><td></td><td>7 45 33</td></tr> <tr><td>Watch fast of G. M. T. ..</td><td></td><td>17</td></tr> </table>	Are ..		76 38 52	True Zenith Dist. ..		99 37 31 3	<hr/>			Sum ..		176 16 23 3	Difference ..		22 58 39 3	Sum ..		88 8 11 6	Difference ..		11 29 19 6	Approx. True Dist. ..		52 59 50"	Seconds added ..		1 7	Time Dist. ..		52 59 48 3	N.A. at VL hours ..		52 55 19	Difference ..		55 30 7	Time of Dist. by N.A. ..		52 55 19	Correction for 2nd difference (57) ..		7 45 54	G. M. T. by Lunar ..		7 45 50	Time by Watch ..		7 45 33	Watch fast of G. M. T. ..		17
Mars App. Alt. ..	Sec.	0 116916																																																																																																
☿'s App. Alt. ..		0 112698																																																																																																
Mars True Alt. ..		0 883164																																																																																																
☿'s True Alt. ..		0 822933																																																																																																
<hr/>																																																																																																		
Logarithmic Difference ..		9 995733																																																																																																
App. Dist. ..		52 17 00																																																																																																
App. Zenith Dist. ..		100 18 00																																																																																																
<hr/>																																																																																																		
Sum ..		2152 35 00																																																																																																
Sum ..		76 47 30																																																																																																
Sum - App. Dist. =		23 30 30																																																																																																
Logarithmic difference ..		9 988156																																																																																																
		9 60845																																																																																																
		9 99311																																																																																																
Are ..		76 38 52																																																																																																
True Zenith Dist. ..		99 37 31 3																																																																																																
<hr/>																																																																																																		
Sum ..		176 16 23 3																																																																																																
Difference ..		22 58 39 3																																																																																																
Sum ..		88 8 11 6																																																																																																
Difference ..		11 29 19 6																																																																																																
Approx. True Dist. ..		52 59 50"																																																																																																
Seconds added ..		1 7																																																																																																
Time Dist. ..		52 59 48 3																																																																																																
N.A. at VL hours ..		52 55 19																																																																																																
Difference ..		55 30 7																																																																																																
Time of Dist. by N.A. ..		52 55 19																																																																																																
Correction for 2nd difference (57) ..		7 45 54																																																																																																
G. M. T. by Lunar ..		7 45 50																																																																																																
Time by Watch ..		7 45 33																																																																																																
Watch fast of G. M. T. ..		17																																																																																																

<table border="0" style="width: 100%;"> <tr><td>Mars True Alt. ..</td><td></td><td>40 9 50</td></tr> <tr><td>Lat. ..</td><td></td><td>51 31 11</td></tr> <tr><td>P.D. ..</td><td></td><td>72 31 37</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Sum ..</td><td></td><td>2 164 12 38</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Sum ..</td><td></td><td>82 6 19</td></tr> <tr><td>Sum - Alt. ..</td><td></td><td>41 56 29</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Hour ..</td><td></td><td>7 45 16</td></tr> <tr><td>Mars RA + 24 hours ..</td><td></td><td>25 56 15</td></tr> </table>	Mars True Alt. ..		40 9 50	Lat. ..		51 31 11	P.D. ..		72 31 37	<hr/>			Sum ..		2 164 12 38	<hr/>			Sum ..		82 6 19	Sum - Alt. ..		41 56 29	<hr/>			Hour ..		7 45 16	Mars RA + 24 hours ..		25 56 15	<table border="0" style="width: 100%;"> <tr><td>Sec.</td><td>0 206039</td></tr> <tr><td>Cosec.</td><td>0 1020516</td></tr> <tr><td colspan="2"><hr/></td></tr> <tr><td>Cosin</td><td>9 137839</td></tr> <tr><td>Sin.</td><td>9 825017</td></tr> <tr><td colspan="2"><hr/></td></tr> <tr><td>Log Sin sq. =</td><td>9 189411</td></tr> </table>	Sec.	0 206039	Cosec.	0 1020516	<hr/>		Cosin	9 137839	Sin.	9 825017	<hr/>		Log Sin sq. =	9 189411	<table border="0" style="width: 100%;"> <tr><td>☿'s R. A. of Merid. ..</td><td></td><td>2 56 59</td></tr> <tr><td>Mean Sun's R. A. ..</td><td></td><td>16 5 41</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Mean Time at Place. ..</td><td></td><td>7 45 18</td></tr> <tr><td>G. M. T. by Lunar. ..</td><td></td><td>7 45 50</td></tr> <tr><td colspan="3"><hr/></td></tr> <tr><td>Long. in Time ..</td><td></td><td>8 00 West.</td></tr> </table>	☿'s R. A. of Merid. ..		2 56 59	Mean Sun's R. A. ..		16 5 41	<hr/>			Mean Time at Place. ..		7 45 18	G. M. T. by Lunar. ..		7 45 50	<hr/>			Long. in Time ..		8 00 West.
Mars True Alt. ..		40 9 50																																																																				
Lat. ..		51 31 11																																																																				
P.D. ..		72 31 37																																																																				
<hr/>																																																																						
Sum ..		2 164 12 38																																																																				
<hr/>																																																																						
Sum ..		82 6 19																																																																				
Sum - Alt. ..		41 56 29																																																																				
<hr/>																																																																						
Hour ..		7 45 16																																																																				
Mars RA + 24 hours ..		25 56 15																																																																				
Sec.	0 206039																																																																					
Cosec.	0 1020516																																																																					
<hr/>																																																																						
Cosin	9 137839																																																																					
Sin.	9 825017																																																																					
<hr/>																																																																						
Log Sin sq. =	9 189411																																																																					
☿'s R. A. of Merid. ..		2 56 59																																																																				
Mean Sun's R. A. ..		16 5 41																																																																				
<hr/>																																																																						
Mean Time at Place. ..		7 45 18																																																																				
G. M. T. by Lunar. ..		7 45 50																																																																				
<hr/>																																																																						
Long. in Time ..		8 00 West.																																																																				

71

Fig 5.1: Mathematical calculation from *Hints* (1883).<sup>60</sup>

At the outset the fifth edition stipulated that the reader must be acquainted with the instruments and plane trigonometry, and have a knowledge of how to do latitude and longitude observations; very different to the earlier editions. Augmented by forty-five pages of tables, a substantial section was by Coles and contained fairly complex mathematics. Paradoxically there was an enlarged section on the plane table; an instrument which did not rely upon knowledge of supporting mathematics to produce results, indicating an ambiguity with respect to readership.<sup>61</sup>

The fifth edition 'having met with general approval,' the editors of the sixth claimed not to have 'attempted to make any material alteration', but the sixth edition of 1889 was

<sup>60</sup> *Hints* (1883) pp 70-71

<sup>61</sup> *Hints* (1883) p. 111



marketed at a wider readership. It acknowledged changes in the make-up of its travellers and reflected the different, more technical, world the Society now inhabited. 'As the results of the rapid multiplication of the lines of ocean steamers, and of railways, makes it easy for men of comparatively brief leisure to undertake a share in exploration in the course of a vacation tour, so the goal of ten years ago has become a starting point. However, tourists are plentiful, opportunities great, but their power of profiting is far from commensurate.'<sup>62</sup> Again the tuition at the RGS was advertised. While it was asserted that there was no shortage of new land- New Guinea, Tibet, Formosa, Borneo- and Africa was 'still far from being exhausted,' it was emphasised by Freshfield that 'Geography is no longer the simple business of surveying and mapping but the production of a picture of the Earth's surface in relation to its inhabitants.'<sup>63</sup> This edition reflected the new challenges to the nineteenth century heroic ideal of exploration, and formed part of the expressions of modernity in geography in this period.<sup>64</sup>



Fig 5.2 a, and b: Hypsometers from *Hints* (1865) and *Hints* (1906) respectively, demonstrating the more professional approach of the later editions.

Although it acknowledged a wider readership, the content of the sixth edition was slightly more technical than that of the fifth edition. Better quality plates of the instruments were provided, as can be seen in figure 5.2. Coles covered trigonometry, the use of the compass, hypsometer, aneroid, barometer, sextant, pocket sextant, artificial horizon, and theodolite, and included a very detailed description of the use of the plane table. Godwin-

<sup>62</sup> *Hints* (1889) p.1

<sup>63</sup> *Hints* (1889) p.4

<sup>64</sup> Withers (2010b) p.96

Austen's text was reproduced from the previous edition. Both the fifth and sixth editions retained a section on 'extempore measurement' when instruments were not available.

In 1889, the same year as the sixth edition of *Hints*, the RGS published *Hints To Lady Travellers* which although having little technical content, possibly because of assumptions as to the abilities of women, advised that 'a small compass should always be carried'.<sup>65</sup> It is noted that the advertisements were for sextants, binoculars and watches even if the text omits these items.

The seventh edition (1893) was the last of the nineteenth century. A notable addition to the target audience was 'Englishwomen.' It was edited by Freshfield and William Wharton, and consisted of essays by various authors. The single greatest contribution was that by Coles on surveying and astronomical observation. No reduction in technical content was considered necessary to accommodate the new audience. A thousand extra copies of this edition were printed, but the initial print run is not known.<sup>66</sup> In his 'Preliminary Hints,' Freshfield warned of the dangers of becoming an 'exact topographer', but failing as a 'geographer in the highest sense of the word.'<sup>67</sup> This piece, which reflected a more romantic, contemplative attitude, was removed by Coles in the eighth edition, which returned to drier instruction.

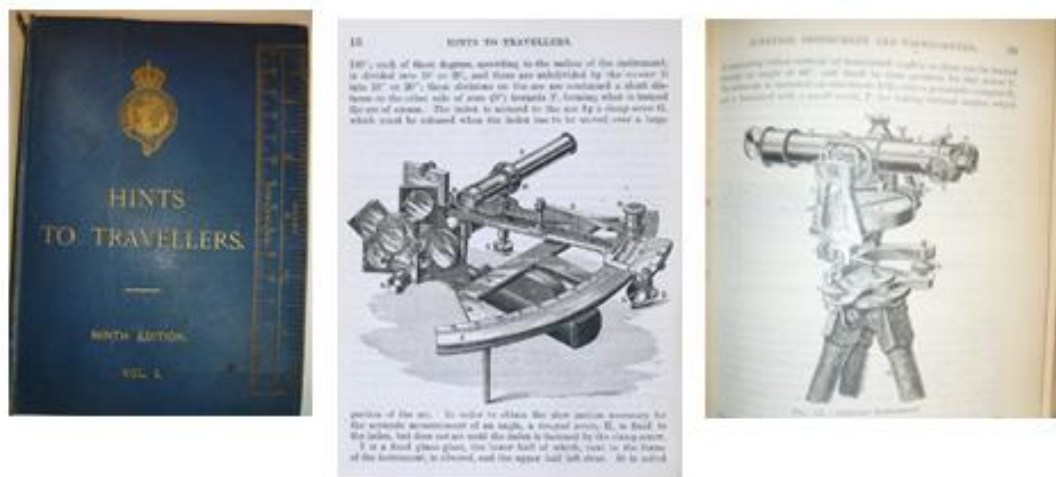


Fig 5.3: Illustrations from the ninth edition of *Hints* (1906): From left to right: the ruler on the cover, sextant, and theodolite

<sup>65</sup> Campbell Davidson (1889) p.121

<sup>66</sup> FC Dec 21<sup>st</sup> 1893

<sup>67</sup> *Hints* (1893) p.7

The early twentieth-century editions of *Hints* which appeared in 1901, 1906 and 1921, occupied two volumes: this compromised portability. The first volumes comprised the advice on surveying, and the second volumes the other areas of interest. They were supported by advertising from the eighth edition onwards, which was also the first to incorporate a ruler on the cover, both harking back to Galton's gun barrel and reminding the travellers of their moral obligation to measure. *Hints* (1901), edited by Coles, made reference to him as the 'late Instructor,' as he had recently resigned. Coles wrote nearly all the first volume. The ninth edition (1906) was edited by Reeves, Coles' successor. While Reeves provided new material, Coles' work was dispersed in the text without acknowledgement.<sup>68</sup> The ninth edition's preface opined that 'the days of the pioneer explorer of old are fast drawing to a close and more exact surveys are required': this was fast becoming a familiar trope.<sup>69</sup> The text book supplied by the War Office, *Text Book of Geographical and Topographical Surveying*, was mentioned as having been an important resource.<sup>70</sup>

While no edition of *Hints* was produced during WW1, a discussion on the mental preparation of travellers took place in 1915.<sup>71</sup> War-weariness contributed to an approach by Lord Bryce which was resonant with Freshfield's attitude expressed in the preface of the 1893 edition. Bryce advocated knowledge of language and local customs, and an ability to see 'beautiful things' and remember them; measuring instruments were not mentioned.

The lengthy delay before the appearance of the tenth edition of *Hints* (1921), largely the effect of WW1, was presented as a virtue: 'The ninth edition has stood the test of years.'<sup>72</sup> In keeping with the lack of change in the principles of the measuring instruments under consideration during the intervening period, it was decided by the *Hints* committee to retain the first volume with no major alterations.<sup>73</sup> The final edition (1935) dismissed editions preceding the ninth in a lazy, inaccurate resume, and its weight was increased by the addition of blank pages, a feature which may have contributing to its demise.<sup>74</sup>

### **The Role of *Hints* from 1883**

It has been noted that the first four editions of *Hints* were not in competition with more serious surveying texts. From the fifth edition, however, *Hints* addressed itself to a better-educated audience, therefore its specific role from this point requires investigation. There was a considerable literature on general surveying available by this time; a number of works have been consulted.<sup>75</sup>

---

<sup>68</sup> *Hints* (1906) p. 212 reproduces *Hints* (1901) p. 135

<sup>69</sup> *Hints* (1906) preface iii, Withers, Finnegan and Higgitt (2006) p.441

<sup>70</sup> *Hints* (1906) preface iv

<sup>71</sup> Bryce (1915)

<sup>72</sup> *Hints* (1921) preface

<sup>73</sup> *Hints* (1921) preface

<sup>74</sup> *Hints* (1935) preface

<sup>75</sup> Lendy (1869), Drayson (1869), Paterson (1873), Richards (1873), Roberts (1878), Jackson (1880), Holloway (1881), Johnson (1885), Usill (1888), Nesbit (1889), Middleton (1894), Stanley (1895), Merriman (1899),

None of these competing texts included survival techniques, which alone placed *Hints* in a special category. Still relevant for the fifth edition was Lendy (1869), which had been cited in the third edition, a fairly mathematical work but only in connection with geodesy and map drawing, and there was no reference to latitude or longitude. Drayson (1869) was one of a number of simple texts aimed at the military, which focused on baseline surveys and route marches, with a description of the simple instruments. Longitude was assumed to be by chronometer. Paterson (1873) claimed he had been forced to renew his work because of the adoption by the British army of the new 'scale of shade'. He did not include finding latitude or longitude.<sup>76</sup> Richards (1873) was very similar to Peterson, and he also complained of the new guidelines on scale of shading. Roberts (1878) superseded Drayson but included a 'scale of shade' and 'horizontal equivalents.'<sup>77</sup> He also included a section on sketching without instruments. Jackson (1880) was comprehensive, detailed and heavy, including everything from astronomical observation to railway curves. Holloway (1881) was concerned with fields and area calculation. It can therefore be said that at the time of the fifth edition *Hints* was compact, informative, specialised, and most importantly, distinctive.

Johnson (1885) belonged to the genre of topographical surveying similar to Holloway. Usill (1888) was a text book for students preparing for exams or for survey work in the colonies; while it was detailed there was no latitude or longitude. Nesbit (1889) was again concerned with fields and railway lines. So the sixth edition, following rapidly after the fifth, maintained its position. The seventh edition continued to fill the space occupied by the fifth and sixth as there were no publications to challenge it.

A number of related texts appeared between the seventh edition of 1893 and the eighth of 1901. Middleton (1894) acknowledged Usill and help from Stanley in reproducing images of the instruments, his work was concerned with levels, chains and theodolites, with no longitudes. Stanley (1895) described in detail the instruments he sold but without instructions on their use. Merriman, a professor of engineering at Lehigh University, Pennsylvania, produced a work in 1899 which differed from *Hints* in a distinctive way. Without any preamble it launched into error theory and least squares, incorporating advanced mathematics and dismissing chronometers for longitude. Again, the eighth edition of *Hints* was distinctive and relevant.

By the time of the ninth edition more detailed works were available, but little had changed otherwise. Dixon (1902) updated an earlier work by Baker, mainly focusing on fields and railways. Skrimshire (1901) was more thorough, but nevertheless only included longitude

---

Wilson (1900), Skrimshire (1901), Nugent (1902), Baker (1902) Tracy (1907), Park (1911), Close (1913), Adams (1913), Earl Davis (1915), Popplewell (1915), Lowring Webb (1917), Salmon (1918), Higgins (1920), Parry (1920)

<sup>76</sup> Paterson (1873) p. 67

<sup>77</sup> Robertson (1878) p. 29

by dead reckoning, with considerable space devoted to mines, levelling, railways and apportioning land. Nugent (1902) echoed Skrimshire (1901).

The considerable time which elapsed before the tenth edition saw the publication of Tracy (1907) which was similar to Skrimshire and Nugent, and did not include longitude. Park (1911) produced a more thorough version of the same issues, with longitude only as dead reckoning, and including areas, apportioning lines, levelling and railway curves. Close (1913) was comprehensive and included error theory, and a comparison of longitude by several methods; it was a tome unsuitable for accompanying travellers. Adams (1913) was another simple text in the style of Drayson, Johnson, Middleton and others. Davis (1915) was similar to *Hints*, but included levelling and apportioning of land and excluded survival techniques. Popplewell (1915) was in the civil engineering vein, and Webb (1917), being similar to Davis, was close to *Hints*. Webb claimed to have made the 'detailed directions so complete that the student can go through the routine without verbal instructions....so the instructor may be free to watch carefully the performance of each student.'<sup>78</sup> Salmon (1918) and Parry (1920) wrote in the simpler genre not including longitude other than by dead reckoning: Higgins (1920) gave a thorough account without being any more advanced.

This survey suggests that after an unpromising start represented by the first four editions, *Hints* fulfilled a need not otherwise addressed. The great majority of surveying texts were aimed at those apportioning land, working on railway projects, or undertaking rough military reconnaissance. A smaller number were mathematical tomes for higher precision than required was by travellers. From WW1 other texts started to come on the market, which were similar in level of content, but they were not aimed at travellers. The thoroughness and scope of *Hints* from the fifth edition made it a valuable product of the Society.

The publication strategy of the RGS for advising travellers was successful in terms of a constant production of editions of *Hints*. While the networks were extensive, in the earlier editions public disagreements undermined the authority of the work. From the fifth edition of 1883 the product was assured and *Hints* survived with no fundamental change from this point. Paradoxically, as the intended audience widened the technical level increased, possibly reflecting improvements in education received from the Society and other sources. The publication made extensive use of external resources such as tables, references, manuals and textbooks. Each edition cited the 'exhaustion' of the previous version within five to fifteen years, on average within eight years, as a reason for its later imprint. Depletion of print runs appears to have necessitated new editions rather than any pressing need for revision. To what extent its readership benefitted from *Hints* is difficult to ascertain.

---

<sup>78</sup> Webb (1917) preface vi

## In-House Instruction

The RGS used competence in instrument use as a criterion for its support, and in particular to confer a loan. On numerous occasions travellers were asked to ‘qualify themselves to take astronomical positions.’ It was on this condition that Robert Walker was granted £100 and instruments for a trip to Africa in 1865.<sup>79</sup> In 1868 Winwood Reade’s request for instruments was agreed ‘when he has received the necessary instruction’<sup>80</sup> Winwood Reade got his instruments but pointed out the difficulty in finding instruction in their use.<sup>81</sup> This exchange led to the introduction of the second method of instruction provided by the Society: direct hands-on tuition.

At this juncture there was no distinct statement of intent regarding the provision of training by the Society. Its introduction was gradual. It frequently fell to the map curator George to provide assurances that the travellers were sufficiently capable, which increasingly entailed instruction. In 1869 George Hayward was lent instruments ‘on a favourable report from Captain George.’ In the same year a Reverend R.J. Hatchard was also lent a set of instruments ‘on a favourable report from Captain George.’<sup>82</sup> In 1870 the Council ‘felt it necessary to satisfy themselves that M. Angelo was capable of taking astronomical observations and of making maps. He should call on Captain George at Whitehall Place.’<sup>83</sup> In 1874 a missionary was required to ‘satisfy Captain George that he has competent knowledge of the use of instruments,’ and by default, as this stipulation became standard practice, Captain George took on the new role.<sup>84</sup> According to Markham, who wrote in 1879, ‘Captain George received many applications for information and in various instances gave instruction.’<sup>85</sup>

In 1877 Coles succeeded George as map curator on a salary of £200 per year, having first applied in 1872.<sup>86</sup> This was a period of innovation for the Society as ‘Scientific Geography’ was taking shape as an attitude and aspiration: in 1876 the Council proposed to take ‘a more strictly scientific direction.’<sup>87</sup> The ad hoc nature of the instruction can be seen from his job description, drawn up by Henry Bates the assistant secretary, point seven of which read; ‘To have charge of the instruments belonging to the Society and see they are kept in good repair, also to give advice to travellers and instruction in their use if required’.<sup>88</sup>

---

<sup>79</sup> EC Mar 15<sup>th</sup> 1865

<sup>80</sup> CM Mar 23<sup>rd</sup> 1868, Driver (2001) chapter 5

<sup>81</sup> CM Apr 27<sup>th</sup> 1868

<sup>82</sup> CM June 28<sup>th</sup> 1869

<sup>83</sup> CM Mar 28<sup>th</sup> 1870

<sup>84</sup> CM Feb 23d 1874

<sup>85</sup> CB6/502 Coles The Scientific Memorandum

<sup>86</sup> CM Mar 11<sup>th</sup> 1872, May 14<sup>th</sup> 1877, and June 11<sup>th</sup> 1877

<sup>87</sup> CM Mar 13<sup>th</sup> 1876, 14<sup>th</sup> Mar 1876

<sup>88</sup> CB6/502 Coles Duty of Map Curator 28<sup>th</sup> June 1877

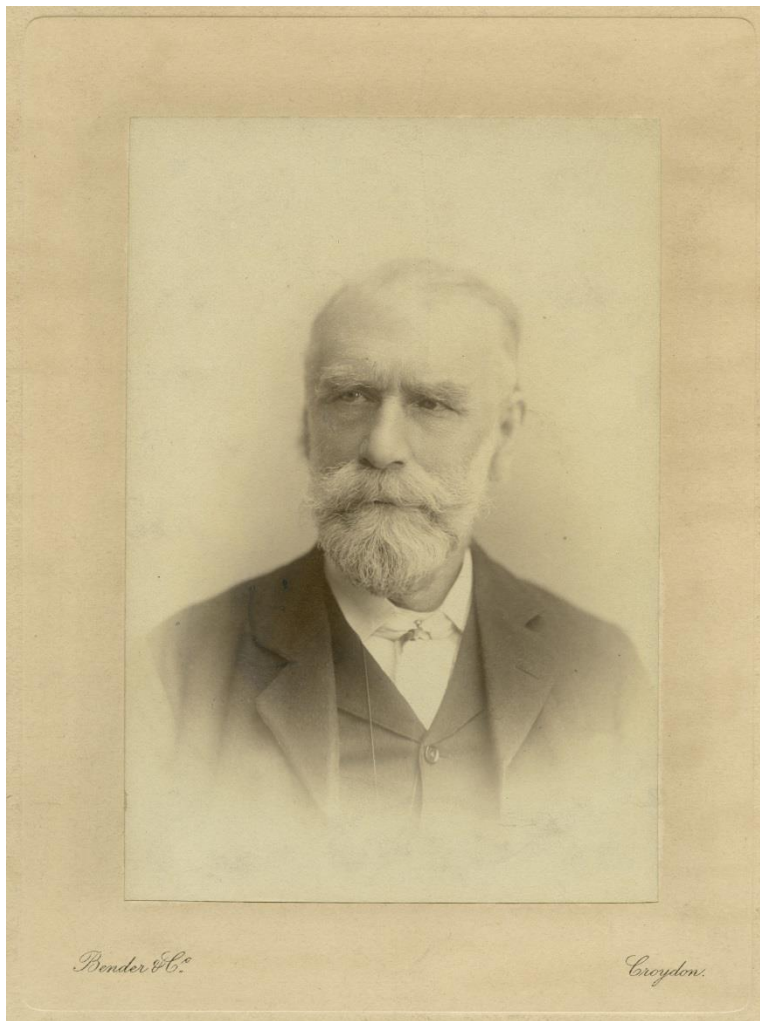


Fig 5.4: Portrait photograph of Coles <sup>89</sup>

The resource represented by Coles' expertise was considerable. His curriculum vitae read; 'I entered the Navy as a Cadet in 1848.... passed all the exams for Lieutenant.... employed on Vancouver Island under the Master of Surveying.... explored in British Columbia, ... worked for Hooper Telegraph as their nautical advisor from 1872, .....hydrography,..... submarine cables, ..... surveyed coast of island of Mauritius, ..... had surveyed in South Africa, Arabia, Egypt, France, Russia, and the USA'.<sup>90</sup> He claimed he could speak French, understand map projections, express himself in public, and paint in watercolour. He cited Admiral George Richards, and was proposed by Back and Collinson. The following year Reeves, then aged 16, also started at the Society as an assistant to

---

<sup>89</sup> Portrait photograph of Coles by Bender of Croydon, c.1900 rgs 022519

<sup>90</sup> Coles CB6/502 letter to Blakeney 23<sup>rd</sup> March 1877

Coles who taught him mathematics, geography, map drawing, astronomy, surveying, history and languages.<sup>91</sup>

Specific plans were made for instruction in instrument use only in 1879, but then there was rapid progress. An initiative of Council read: 'A memorandum on a plan for training travellers to make useful scientific observations to be submitted and printed,' was acted upon in a couple of weeks.<sup>92</sup> The memorandum was printed and submitted to the subsequent Council meeting on June 9<sup>th</sup>. It read: 'A very large number of Englishmen visit countries which have never been geographically described or correctly mapped...Every year these wanderers spread themselves out over every quarter of the globe, yet, for want of necessary training they travel and return without any, or with fewer, results that can be utilised for geographical purposes.'<sup>93</sup> An exam on 'physical geography and practical knowledge of manipulations' was suggested to address this shortfall.

The Memorandum also made clear who the intended travellers would be: Nine classes of traveller were listed for whom training would be beneficial:

1. Officers in the army, on leave or at home from India, and the colonies who 'often wished to strike out but are seldom competent'.
2. Officers in the navy who possessed these qualifications but when they undertake exploring journeys by land are in need of that 'special training on other points.'
3. Clerks in merchant's houses abroad who had opportunity but not the capability. They were often sent into the interiors of South America, Africa, the Levant, China, or Australia.
4. Planters and Settlers, though more stationary than mercantile men, had excellent opportunities for example in The Argentine, New Zealand, South Africa, Australia, India, Ceylon or North America.
5. Engineers who were now penetrating into every corner of the world and only need a few suggestions and instructions. These were 'just the men to catch eagerly at the idea of qualifying themselves as observant travellers'.
6. Missionaries who were 'pretty widely spread over the Earth's surface and would willingly qualify themselves for scientific work if opportunities offered before they left England'.
7. Consuls and consular agents; recently one had found difficulties in getting training and had 'ended up in the Minorities where mates of merchants ships were taught'.
8. Collectors of natural history.
9. Sportsmen and ordinary travellers who 'visited little known regions for their own amusement.'

The aim was to produce 'scientific' travellers. What was required was an instructor who would teach the use of instruments and computation and give a course of lectures.<sup>94</sup> The Memorandum suggested fifteen topics for inclusion including longitude by lunar distance and its computation. It also suggested a course of seven lectures on physical, comparative, botanical, and zoological geography, geology as applied to geography, meteorology, ethnography, and statistics. The upshot was a motion proposed by Markham and seconded by Broderick; 'that it is desirable that the council should organise a plan for the instruction of

---

<sup>91</sup> EAR Reeves 'Some Recollections of My Fifty years at The RGS'. (1928) p. 2

<sup>92</sup> CM May 26<sup>th</sup> 1879

<sup>93</sup> CM June 9<sup>th</sup> 1879 AP/51, Jones (2005) p. 319

<sup>94</sup> Jones M. (2005) p.319



geographical students and others about to visit unknown or little known countries so as to train them as scientific observers and a committee should consider and report on details.<sup>95</sup>

As for the choice of instruments previously discussed, there were tensions within the Society which affected the type of training proposed. At the Scientific Purposes Committee on June 16<sup>th</sup> Markham argued that the instruction provided should be limited to surveying and mapping including the fixing of positions by astronomical observations. His views held sway and the programme was scaled back.<sup>96</sup> He suggested that training must be geared to individuals, and those most pressed for time must take precedence.<sup>97</sup> Markham considered Savile Row to have been a 'central and convenient position,' for instruction, but argued that as travellers 'do not like others to see their ignorance' so 'classes may not always be feasible'. The learners must be treated individually.<sup>98</sup> It was decided that Coles would make a start, and from that point 'all travellers 'applying for the loan of instruments should be required to satisfy the Society's instructor that they can use them to advantage.'<sup>99</sup> Hence the bestowing of instruments for loan can be taken as a criterion of the success of the training.

In addition 'Council should be recommended to sanction a 'structure on the roof' for observing in 'the open air'. 'Mr. Coles, the curator of maps, be requested to conduct the instruction at any time before 10.30am, or after 3pm, the pupils paying a fee of 2/6 an hour.'<sup>100</sup> This was consistent with Markham's belief in the centrality and independence of the RGS; Colonel Taylor from the Royal Artillery Institution at Woolwich having offered the use of their observatory was presumably declined.<sup>101</sup>

There followed a series of resolutions at the next Scientific Purposes Committee on June 27<sup>th</sup>. The terms of the resolution with respect to the instruction of intending travellers should be placed in the *PRGS*. Coles should teach position finding and barometric and hypsometric observations only. Total payment to Coles would not exceed £15 in one month. He should receive five shillings an hour per pupil. Pupils were to be taught in classes not exceeding three. Coles was to report names of intending travellers who have received instruction.<sup>102</sup> Coles' reports were then used to control instrument loans, except when over-ruled by more influential council members.<sup>103</sup>

During this period Coles' position was temporary, so he was motivated to supply detailed accounts of his work. He was, nevertheless, in a position to demand no less than five shillings an hour for teaching individuals which, he argued, was necessary because of the extra 'tedious' work at home. Like Markham he was opposed to the idea of classes: 'Many

---

<sup>95</sup> CM June 9th 1879

<sup>96</sup> SPC June 16th 1879, Coles CB6/502, 16th June 1879

<sup>97</sup> AP/51

<sup>98</sup> AP/51

<sup>99</sup> AP/51

<sup>100</sup> SPC June 16<sup>th</sup> 1879.

<sup>101</sup> SPC June 16th 1879

<sup>102</sup> SPC June 23<sup>rd</sup> 1879, SPC June 27<sup>th</sup> 1879 SPC

<sup>103</sup> SPC Nov 12th 1880

highly educated gentlemen are quite ignorant of the very elements of nautical astronomy... and would not be induced to join a class as they had 'varied attainments.'" Coles also asked for clarification on his position.<sup>104</sup>

At the end of July 1879 Coles reported that he had taught Temple Phipson Wybrants for 25 hours. He had covered the construction of maps and map drawing, taking angles and plotting field work, undertaken 'in the country', computing latitude and longitude by traverse, finding latitude by meridian altitude, finding time and thence longitude, the variation of the compass, absolute altitudes of the Sun and stars East and West of the meridian, the use of the prismatic compass. 'Phipson Wybrants is a very apt pupil who can do any of the above and use a sextant in quicksilver. He has fixed his longitude to within a few seconds of that laid down by the Ordnance Survey.'<sup>105</sup> The following month Phipson Wybrants had learnt to fill barometers, calculate heights using Baily's formula, take hypsometrical measurement and use the relevant formulae. He had calculated heights and differences using trigonometry, taken longitude by two altitudes of the Sun and of different stars.<sup>106</sup>

Records of monthly payments to Coles were made at Finance Committee and show a considerable outlay on behalf of both travellers and the Society. Coles was paid £8 5s for instruction for July and August, and £7 10s for October 1879.<sup>107</sup> His earnings from tuition would have been twice that, equivalent to about £1,500 a month on top of his normal salary in 2017.

In November 1879 Coles complained about his facilities: 'The only telescope in the Society is not fitted with finder or rack motion its object glass is unsuited to astronomical observation. I would therefore ask the committee to authorise purchase of an astronomical telescope for £25 with finder, 3 inch objective, steadying rods, tangent screw adjustment to horizontal motion'. He had taken measurements from the roof with a six- inch transit theodolite; while there was no tremor it was dirty and the ladder was rotten. The artificial horizon would not work in wind. He argued that these issues 'would be remedied if an observatory was built.'<sup>108</sup> Coles was successful and the observatory was erected on the roof, which cost £151 16s and 6d, although the telescope came slightly later.<sup>109</sup>

By December 1879 Coles had three pupils; Edward Delmar Morgan and F.J. Rawson had joined.<sup>110</sup> Coles reported that Phipson Wybrants was a 'thoroughly practical observer and computer.'<sup>111</sup> He had been undertaking lunars, the error of a watch, finding latitudes by various methods. Rawson had been undertaking latitudes, and begun to

---

<sup>104</sup> CB6/502 Coles Report of Instruction April 16<sup>th</sup> to 12<sup>th</sup> Nov 1880

<sup>105</sup> Coles CB6/502 letter to the Assistant Secretary July 31<sup>st</sup> 1879

<sup>106</sup> Coles CB6/502 letter to the assistant Secretary Sept 1<sup>st</sup> 1879

<sup>107</sup> FC Nov 3<sup>rd</sup> 1879

<sup>108</sup> Coles CB6/502 letter to the Assistant Secretary 28<sup>th</sup> Nov 1879

<sup>109</sup> FC May 3<sup>rd</sup> 1880 and Oct 4<sup>th</sup> 1880

<sup>110</sup> Coles CB6/502 note 1<sup>st</sup> Dec 1879

<sup>111</sup> Coles CB6/502 letter to the Assistant Secretary Nov 28<sup>th</sup> 1879

calculate the time from the Sun's altitude. Delmar-Morgan had been taking altitudes for latitude and using the sextant and artificial horizon. By February 1880 Coles was teaching five men.<sup>112</sup> Coles used Ordnance Survey maps as 'the truth' and compared his students work to them.<sup>113</sup> After April 1880 his reports became increasingly perfunctory.<sup>114</sup>

Coles' quarterly reports listed the types of students. By April 1880 Coles had taught ten people, five of whom had a university education.<sup>115</sup> One was from Germany, one at Sandhurst, two were civil engineers and another was at Eton. Four of them were medical men, three missionaries, two engineers, and one a gentleman traveller. Coles asked again for a telescope for the observatory which was granted; £35 18s and 6d was paid to H. Porter in October 1880.<sup>116</sup> The following quarter Coles had taught the Bishop of Zululand. 'The observatory is in constant use and admirably suited'. Again he asked if his appointment could be confirmed.<sup>117</sup>

Towards the end of 1880, Coles was asked to provide a list of gentlemen he had trained so the Society could consider what to do on a more permanent basis.<sup>118</sup> Coles also prepared a paper for the *JRGS* where he summarised his work: Between October 1879 and December 1880 he had worked for 232 hours and had twenty-four students. The topics for instruction had been the use of the transit theodolite, the ordinary 5-inch theodolite, sextant and artificial horizon 'in the country' and 'at night in the observatory'. He had also taught plotting traverses, the use of the compass, barometer and hypsometer. Among the twenty four students were a bishop, a major, two doctors, two captains, a reverend, a commander, a German 'Herr', and fourteen misters. Coles assessed thirteen as having made excellent progress and eight a 'fair training.' Coles argued they had travelled subsequently to many locations.<sup>119</sup>

---

<sup>112</sup> Coles CB6/502 letter to the assistant Secretary Feb 29<sup>th</sup> 1880

<sup>113</sup> Coles CB6 letter to Assistant Secretary Apr 30<sup>th</sup> 1880

<sup>114</sup> Coles CB6 note to Mr. Bates Aug 24<sup>th</sup> 1880

<sup>115</sup> Coles CB6 Coles Report Jan-Apr 1880

<sup>116</sup> FC May 3<sup>rd</sup> 1880 and Oct 4<sup>th</sup> 1880, Coles CB6 letter Apr 26<sup>th</sup> 1880

<sup>117</sup> Coles CB6 Report Apr- Nov 1880

<sup>118</sup> SPC Nov 12<sup>th</sup> 1880

<sup>119</sup> JMS/21/48 early 1881



From the personal files of William McEwan and Phipson Wybrants, it is possible to establish what was taught.<sup>121</sup> The titles on the carbon-copied sheets appeared as follows:

1. Double Altitudes-Sun or Star
2. Short double Altitudes
3. Longitude by Chronometer (and Sun's true bearing?) and Latitude by double altitude, variation of compass.
4. Riddle's method for altitude of a star or planet/ latitudes by circumeridional method
5. Sun's equal altitude Riddle's Method
6. Lunar observation
7. Method of computing the difference in heights of two places by means of the barometer. Baily's table and formula.
8. Latitude and longitude by two observations of altitude, the result of each computation being at the time and place where the greater altitude as taken
9. Circumeridional altitudes of Sun and reduction to meridian
10. Star and moon Coleman's method
11. Longitude by altitude of star or planet
12. Longitude by chronometer, latitude by double altitude, variation of compass and bearing of any object by angular distance from Sun.
13. Latitude by circumeridional altitude of star or planet- or true bearing of a peak or any other object in the horizon by means of its observed angular distance from the Sun.
- 14 Latitude by two different stars taken at or near the same time.
- 14a Direct Method of double altitudes.

Two un-numbered hand-written sheets show him to have been issued with 'Longitude by the Occultation of a Star', and 'Raper's Rigorous Method'. Addition printed pages were titled: 'To find the Error of the Chronometer by Equal Altitudes of a Fixed Star'.

It appears that Coles drew up these sheets using established sources and methods. His selection of texts illustrates what was considered useful and what observations and calculations his students performed in the field. Edward Riddle wrote a navigational text in 1824 that went through several editions before the 1860s.<sup>122</sup> Coleman's work appeared in Norie (1860).<sup>123</sup> Raper's text, already mentioned, was so popular that it went through many editions.<sup>124</sup> Ivory had contributed papers to *The Philosophical Magazine* on various subjects in the 1820s.<sup>125</sup> His method for longitude was extended by Riddle and also appeared in

---

<sup>121</sup> TLW, SSC/107 McEwan

<sup>122</sup> Riddle (1824)

<sup>123</sup> Norie (1860)

<sup>124</sup> Raper (1840)

<sup>125</sup> Ivory (1822), (1825), (1828)

Harbord (1863).<sup>126</sup> The sheets encompass all the popular methods of position finding at the time, and require the ability to perform complex manipulations.

It is possible to assess the outcome of the direct tuition more readily than that of the advisory texts, as, from time to time, the Society endeavoured to measure its success. The loan of instruments can be regarded as a positive direct outcome of tuition. It is not possible to be sure of exactly whom George taught but it included Hayward, R.B. Shaw, St Vincent Erskine, Rev Q. Thomson, and Robert Walker, all of whom went on to borrow instruments. A fuller picture is available for Coles. On the basis of his report, the RGS granted Coles a permanent role so he would now be 'Instructor in Practical Astronomy and Surveying to the RGS.'<sup>127</sup> His hours were extended and instruments began to be bought specifically for training rather than to be lent out, starting with a 5 inch theodolite.<sup>128</sup> It has been possible to compare Coles' list with a record of who borrowed instruments during the eighteen months and shortly afterwards from 'Instruments Lent to Travellers'.<sup>129</sup> Eight were granted instruments by the Society, so the tuition was successful on this criterion.<sup>130</sup> Charles Gordon was refused without a reason.<sup>131</sup>

However, the scheme was undermined by those who were able to borrow instruments without the requisite training. Dr. E. J. Southon was awarded instruments by Galton who overruled the stipulation at a Scientific Purposes Committee on November 12<sup>th</sup> 1880.<sup>132</sup> The following month Colonel Henry Yule was allowed instruments for his daughter.<sup>133</sup> Lord Mayo, who does not appear to have received instruction, was lent instruments in January 1882.<sup>134</sup> It appears status could subvert the efforts to professionalise the Society.

After this initial period of Council scrutiny it becomes more difficult to know who had received instruction. However, it was revealed that twenty five people had completed the course by 1897.<sup>135</sup> Comparing this with the number of travellers who had borrowed instruments between 1879 and 1896, it suggests that only approximately 25 per cent accomplished the full course. The number who had completed basic instruction was far higher, but the stipulation that travellers must take instruction was undermined by the actions of the Council who persistently granted instruments to those who had not received training. In turn this undermined the value of the training.

---

<sup>126</sup> Harbord (1863)

<sup>127</sup> JMS/21/ 48, SPC Jan 27<sup>th</sup> 1881

<sup>128</sup> SPC Mar 21<sup>st</sup> 1881, FC Apr 4<sup>th</sup> 1881

<sup>129</sup> AP 52 IIR, AP/52 ILT

<sup>130</sup> CM May 31<sup>st</sup> 1880

<sup>131</sup> CM Nov 13<sup>th</sup> 1882

<sup>132</sup> SPC Nov 12<sup>th</sup> 1880

<sup>133</sup> CM Dec 13<sup>th</sup> 1880

<sup>134</sup> CM Jan 16<sup>th</sup> 1882

<sup>135</sup> CM Jan 4<sup>th</sup> 1897

The status of the instruction was enhanced in 1883 by Cuthbert Peek, a particularly prolific author following training, who provided an annual award to those who gained a thorough knowledge of instrument use. Coles defined 'thorough' as longitude by chronometer to within three minutes, and longitude by lunars to within ten minutes.<sup>136</sup> The first Peek Grant recipient was William McEwan, an engineer of the road under construction between Lakes Nyassa and Tanganika, 'because of his qualifying himself under the Society's instructor as a geographer and astronomical observer.'<sup>137</sup> Students of Coles could now be recognised for 'qualifying themselves'. In 1884 the limit on the number of students was lifted, and in 1885 Coles' pay was increased to £220 a year.<sup>138</sup>

The nature of the training became a forum where various approaches were contested. A central character in the promotion of in-house training at the RGS at this time was Markham. His report on the present state of geographical education was published in May 1882. Markham believed that all travellers should have the advantage of hands-on tuition. He advocated the teaching of geographical knowledge, applied maths and practical astronomy: 'The bane of this country has always been a want of continuity of purpose in official undertakings.'<sup>139</sup> In a familiar vein he compared other countries favourably with that of Great Britain, and Great Britain's past favourably with the situation at his time.

Markham opposed the endowment of a professorship at Oxford or Cambridge as not being compatible with the aims of the Society.<sup>140</sup> 'Lectures given at a distance from our usual place of meeting away from our control, would not be made available to the general body of the Fellows, and would not, therefore, come within the conditions which would justify expenditure'.<sup>141</sup> His aspiration for control was linked to the spatial centre at Savile Row. He suggested lectures on surveying methods to be made open to members, and that instruction be extended to geology, botany and photography. From 1886 the Society had an instructor in photography.<sup>142</sup>

When Markham became President in 1893 he could impose his views.<sup>143</sup> In 1894 the limit was lifted on the number of pupils Coles could teach at one time, but in recognition of the increasing cost, it was also decided that when a person could pay the whole fee he should do so. Markham was a staunch supporter of Coles's instruction. He asserted that it worked at minimal cost: 'This should be the true policy of the Society.'<sup>144</sup> In his Report 'Notes on the Educational Policy of the Society', he remarked that direct tuition cost only £1.2K per

---

<sup>136</sup> CM Nov 12<sup>th</sup> 1883

<sup>137</sup> CM May 12<sup>th</sup> 1884

<sup>138</sup> SPC and Education Committee 1st June 1894, FC Mar 2nd 1885

<sup>139</sup> Markham (1882), Jones M. (2005) p. 323

<sup>140</sup> AP 95

<sup>141</sup> AP 95 p.9

<sup>142</sup> CM 18<sup>th</sup> Jan 1886

<sup>143</sup> AP 95 Oct 1895

<sup>144</sup> AP 95 Education Committee Oct 1895

year.<sup>145</sup> Markham wanted the RGS to become the 'University of Geography'. In a 'Scheme for a system of Geographical Instruction' dated November 1895, Markham advocated a centralising policy which uneasily sought to incorporate the needs of disparate groups. The course would be in four sections: training of observers and travellers, cartography, physical geography and political geography. The mathematical and descriptive parts would produce observers and travellers respectively. The students of this University would obtain their mathematical instruction from Coles, but this would be different from that currently being provided for potential explorers. 'We already have an able and well-tried professor.'<sup>146</sup> Mackinder put forward a similar scheme for a London School of Geography which Markham supported; both unsuccessfully sought a government subsidy.

In 1896 it was decided that students should pay two guineas in full for instruction in the art and practice of observing, and Coles was to teach a full diploma. The Education Committee would now decide on the proficiency of students. The Diploma would be useful to the War Office and be used by other public bodies and parts of government. It would include: the use of the prismatic compass and plane table, the use of the sextant, transit theodolite and tacheometer, observations for finding time, azimuths, longitude by the Moon, occultations and eclipses of Jupiter's satellites, traverse surveying, heights and distances by trigonometry, computations, and the prediction of occultations in parts of the World. The Council noted that only twenty five people had completed the entire course; the majority learnt only the basics.<sup>147</sup> Coles responded that lunars were no longer much used. He provided a list of those who had gone through the whole course- three of whom had since died- and pointed out that Woolwich had shown an interest.

Diplomas continued to be awarded: six were gained in 1898.<sup>148</sup> In 1899, however, Coles came under direct attack. A special report by Thuillier and Holdich recommended a more advanced course for 'extended survey' with a rigorous exam. The old certificate would become a short course.<sup>149</sup> Thuillier and Holdich reiterated that nothing should be lent without the new diploma being gained. In an open reference to Coles's work they said that the means of instruction must be reconsidered: 'Plane-tabling Mitcham Common is hardly sufficient'. The teaching methods as well as the instruments had become a battleground and were defining the role of the RGS.<sup>150</sup> Holdich and Thuillier represented the professional class of surveyor against Markham's attachment to the heroic lone pioneer.

Coles responded justifiably that 'Holdich's suggestions do not point to any new departure'. He claimed forty one of those he taught had contributed maps, and that three had been awarded a Society medal, eleven others had received minor awards, and that nearly all

---

<sup>145</sup> AP 95 p. 8

<sup>146</sup> Education Committee Nov 14<sup>th</sup> 1895

<sup>147</sup> CM Jan 4<sup>th</sup> 1897

<sup>148</sup> CM Feb 28<sup>th</sup> 1898, Dec 12<sup>th</sup> 1898

<sup>149</sup> CM May 28<sup>th</sup> 1900

<sup>150</sup> EC's report: Survey Instruction p.2 CM 28<sup>th</sup> May 1900, Collier and Inkpen (2002)



officers who had worked on the boundary commissions have been trained by him. He disagreed with Holdich over the use of the sextant which Coles asserted was more accurate than a theodolite. He defended the use of Mitcham saying anything else was not feasible. He volunteered to resign and shortly afterwards did so.

The Holdich faction gained momentum. An announcement of the vacancy of the position of instructor was to be put in the *JRGS*. In addition to the certificate, a more advanced diploma should be issued to those in charge of extended survey in the field. There would be a rigorous exam. The diploma would be for a complete topographical survey. The old certificate would be awarded for a 'short course'.<sup>151</sup>

Markham overturned the new report with what became a tirade:

'The Council should understand that if the report is accepted it will mean the end of the present means of instruction, substitution of something quite different, with different methods and a different object. In 1897 the whole of my scheme was adopted in its entirety. The aim was to improve the efficiency of travellers who undertook the exploration of unknown and little known lands. It included fixing positions, finding bearings, compass error, surveying, plotting from the field book, and map projection. Mr. Coles' teaching was a complete success. 1898 there were twenty six civilians, twenty four military officers, two naval officers, nine members of the colonial service, and two missionaries and four civil engineers. Geographical results have been most satisfactory. Even foreigners have sought instruction. It is not far to seek the reason for this remarkable success; we have undertaken work which was within our power and was peculiarly the work of the Society.'

Of particular relevance to the salient tension of professional surveyor versus lone explorer was the following:

'We prepared travellers for first exploring work, our motto is 'ob terras reclusas' (To or for lands unknown), Instead of skilled travellers who are usually single-handed, we are to turn out men fit to take charge of survey operations on an extended scale with a trained staff under them. Base measurement for theodolite triangulation, longitude by telegraph, ... while the use of the instruments adapted for the single traveller; the sextant or aneroid, is discouraged. We are not to train travellers such as Coles does on Mitcham Common, but will be teaching skills 'only acquired after years'. This is not our business. This is the work of a government. We have not the means and it is not our business. The OS, Indian Survey and Colonial Survey Department should train their own men.'<sup>152</sup>

It has been suggested that this confrontation might be better seen as an argument between naval survey traditions, represented by Markham, and military – specifically Indian – survey methods represented by Holdich. Certainly the traverse survey of the lone explorer was more akin to the naval methods than the triangulation employed by professional surveyors in India, as discussed in chapter 6. However, from a perusal of the archival material, the actants viewed it as a battle between the lone gentlemen amateur explorer and the professional large scale enterprises of the O.S and India rather than as a conflict

---

<sup>151</sup> CM May 28<sup>th</sup> 1900 p.35a

<sup>152</sup> CM May 28<sup>th</sup> 1900 p. 35c

between the naval and the military. No reference was made to maritime surveying at this point



Fig 5.6 a and b: The lone explorer versus the professional surveyor in the mid-nineteenth-century: Speke with a sextant and watch, the Ordnance Survey with theodolite and staves.<sup>153</sup>

Coles's teaching ended with the nineteenth century, but despite the new initiatives, it is difficult to discern any fundamental changes when his successor Reeves took over.<sup>154</sup> This is unsurprising given that Reeves freely acknowledged that Coles had been responsible for his education.<sup>155</sup> Potential explorers continued to borrow sextants and aneroids, the instruments of the single traveller, but the tensions continued. The images in figure 5.6a and b encapsulate the different attitudes towards surveying.

By resolution of the President Holdich and Thuillier's report on instruction was not recommended to be accepted.<sup>156</sup> Markham decided that Reeves, who had been appointed pending filling the vacancy, should carry on until November when James McCarthy would be appointed.<sup>157</sup> McCarthy's tenure was short-lived; nevertheless, his comments reveal many of the difficulties that the Instructor met with. He had two good army officers who could now do longitude with the calculations. He used Hendon because 'Hendon affords facilities with clear atmosphere so that ten men can make observations at the same time'. McCarthy expressed

<sup>153</sup> Portrait of John Hanning Speke (1827-1864) by James Watney Wilson, Control number 700347  
<https://www.ordnancesurvey.co.uk/blog/2011/06/were-220-years-old-today/> March 2017, Owen and Pilbeam (1992)

<sup>154</sup> Library and Map Committee May 8<sup>th</sup> 1900, p. 35a May 28<sup>th</sup> 1900

<sup>155</sup> EAR Reeves Recollections(1928) p. 2

<sup>156</sup> CM June 18<sup>th</sup> 1900

<sup>157</sup> EC June 21<sup>st</sup> 1900, CM June 25<sup>th</sup> 1900, CM Nov 12<sup>th</sup> 1900

the concern that 'The tendency is for each individual to want something different, which will be impossible when numbers increase' and asked 'How far is the Society willing to allow practice without fees? They make observations under my supervision, but really they need to make independent observations too. The men belong to a class that can be relied upon. It would however be in a safer position following some order of the Council.'<sup>158</sup> He asked for a boy to carry the instruments to and from the field, and for preparing for the observations. It is likely that McCarthy's needs were not met as, at the end of 1902, he resigned and Reeves was appointed.<sup>159</sup> McCarthy's concerns highlighted the difficulties of providing individual tuition on such a scale, and the lack of the Society's support in allowing him to let the students work without direct supervision, or to provide means of transporting the instruments from central London to the appropriate suburb.

Reeves was successful in obtaining a new theodolite at a cost of £46 for teaching in 1903.<sup>160</sup> However, the problems associated with training were still apparent. In 1904 there were concerns raised that the course had become too long and expensive.<sup>161</sup> The War Office was considering no longer using the RGS course and efforts needed to be made to make it attractive to the army.<sup>162</sup> Funds were to be raised by selling copies of Reeves's *Manual of Trigonometry*, half the proceeds of which would go to Reeves.<sup>163</sup> This state of affairs was unsatisfactory as only one person was currently doing the diploma, five the certificate.<sup>164</sup> During the ensuing years diplomas were awarded but there is little correlation between diplomas and the loan of instruments.<sup>165</sup>

Possibly as a result of an enquiry by the surveyor of taxes, the Society again took stock of the situation with respect to training in 1913.<sup>166</sup> A memorandum was to be produced by Captain Lyons.<sup>167</sup> Since 1897 there had been seventy-three diplomas granted, all but two candidates having passed. In order to 'maintain high standards,' at least two members of the committee were recommended to be in attendance to examine candidates, and they must have had experience of modern topographical surveying. The committee on examining diplomas were to report to the council on the quality and standard of work. It was noted that the Colonial Office had in recent years sent officers for instruction, so the work needed to be seen by this committee before the men were reported to the Department as being efficient. At

---

<sup>158</sup> EC 1<sup>st</sup> Oct 1901

<sup>159</sup> CM Nov 11<sup>th</sup> 1902

<sup>160</sup> FC June 3<sup>rd</sup> 1903

<sup>161</sup> CM Mar 21<sup>st</sup> 1904

<sup>162</sup> CM Apr 25<sup>th</sup> 1904, EC Dec 5<sup>th</sup> 1904

<sup>163</sup> FC October 18<sup>th</sup> 1904

<sup>164</sup> CM May 10<sup>th</sup>-11<sup>th</sup> 1905

<sup>165</sup> CM Nov 12<sup>th</sup> 1906, Jan 11<sup>th</sup> 1909, Feb 12<sup>th</sup> 1912

<sup>166</sup> CM Jan 29<sup>th</sup> 1913

<sup>167</sup> CM Jun 23<sup>rd</sup> 1913

the same time new instruments were bought for the instruction room in the new premises at South Kensington.<sup>168</sup>

A further initiative took place in 1924 when the Research Committee urged the Council to recognise the urgent necessity of improving the instructional equipment. The Council was encouraged to allow a substantial grant for the purchase of chronometers, watches, a micrometer theodolite, and a new wireless apparatus for the field and for the instruction room.<sup>169</sup> The Finance committee expected to spend £220 on instruments in 1924, but had only spent £93 in 1923. It expected to spend £20 on repairs, but had spent nothing in 1923.<sup>170</sup> A report in May that year revealed seventeen gentlemen had been instructed by Reeves in field astronomy, topographical survey, and mapping, of whom one had received a diploma. Forty-three men from the Colonial Office had taken the elementary course.<sup>171</sup> These numbers were not substantially different to those of Coles a generation previously.

### **Conclusion**

The role of in-house training was primarily to enforce standards of practice among travellers, and especially those upon whom instruments would be bestowed. Training was costly and, latterly, only maintained by the government departments who used the course. The correlation between training and borrowing instruments was positive, but not all those who took the training courses went on to borrow instruments. Conversely, the ability of those with connections to borrow instruments without having had instruction undermined the status of the scheme.

The unlocking of the potential of instruments required significant resource in terms of training their putative users. The type of training, like the choice of instrument, became a source of conflict between those who saw travellers as professional surveyors versus those whose view was that of the lone pioneer. Disputes were over the types of instruments employed, not whether instruments were preferable to other forms of measurement; the instrumental culture remained dominant throughout the period, and 'roughing it' continued to feature on the periphery of the Society's interests.

In spite of early statements of intent, the Society was slow to provide any form of instruction. The first publication on behalf of the Society, *Hints To Travellers* (1854), was a tentative and contradictory affair, only stabilising in its content and purpose from 1883. The networks exploited by the Society in the engagement of multiple authors only served to undermine the authority of the product. From its fifth edition there is strong evidence that *Hints* (1883) supplied a niche, but its use was not itself sufficient for the practice of instrument

---

<sup>168</sup> FC July 8<sup>th</sup> 1913

<sup>169</sup> Research Committee 21<sup>st</sup> Jan 1924

<sup>170</sup> FC estimates for expenditure 11<sup>th</sup> Feb 1924

<sup>171</sup> Report of the Council presented on 26<sup>th</sup> May 1924. p. 5

use. The fact that the many editions each became out of print in between five and sixteen years suggests a utility which is nevertheless difficult to establish.

Hands-on training was not provided systematically by the RGS until 1879. The Society relied when possible on the various ships' crews who transported the expeditions, or, in an ad hoc manner, on the Map curator, Captain George. After training began, *Hints* was used to advertise it, so the publication was no longer a stand-alone product. Systematic training utilised considerable personnel resource and was expensive, but appears to have produced travellers with enhanced ability. Many of those trained went on to borrow instruments. The disciplining role of the instruction was undermined by influential Council members who could allow borrowing without training.

## Chapter 6:

### The Mobilisation of Instruments in the Field

*To scale the highest or second highest mountain in the world will possess a scientific interest..... What the exact measure of that value will be must...depend largely upon the character and weight of the instruments which it is possible to drag to the summit, and the capacity of the party to use them when they get there.<sup>1</sup>*

#### Introduction

This chapter concerns the mobilisation of the combined resource of instrument and user in the field, where the apparent 'fallibility' remarked on by Withers is most apparent. Curzon, quoted above, recognised two of the aspects of instrument use which were crucial to the production of valued data: the appropriateness of the instrument and the ability of the traveller in instrumental observation. This chapter considers these among other factors which affected observational practice, and investigates the extent to which the travellers overcame them, and the extent to which the instruments captured the aspect of nature to which they were applied. The chapter also examines whether these factors and responses differed over time and place. The question of immutable mobiles is relevant to ANT; to what extent can instruments be regarded as such? From the results of a survey of expeditions the thesis argues that actants had to work to maintain both the mobility and immutability of instruments.

In keeping with the approach of a general survey, fifty expeditions, just over 10 per cent of the total, have been selected, rather than a small number studied in detail. A wide range of dates and places, climates, terrains, type of measurement, forms of transport, and primary motives were chosen: they are therefore less focussed on Africa than a representative sample would be. The expedition dates and destinations were sourced from 'Instruments Lent to Travellers'. Unlike other factors, the nature of the interaction with indigenous people was not stated at the outset, so it is more difficult to use as a criterion, but it is shown to have had a considerable effect. In the archives for the period under consideration there is a lack of recognition of the contribution of indigenous people and their view of events, but they are not entirely hidden.<sup>2</sup> Diaries and correspondence were trawled whenever possible, being more revealing than journal articles, where problems were likely to be concealed, and the details of practice, possibly thought too tedious, omitted. The nature of the inscription and its intended audience is particularly pertinent.<sup>3</sup> A narrative form preserves the connection with the travellers.

The expeditions are categorised according to the particular aspect of practice which, it has been judged, had most effect on the mobilisation of the instrumental resource.

---

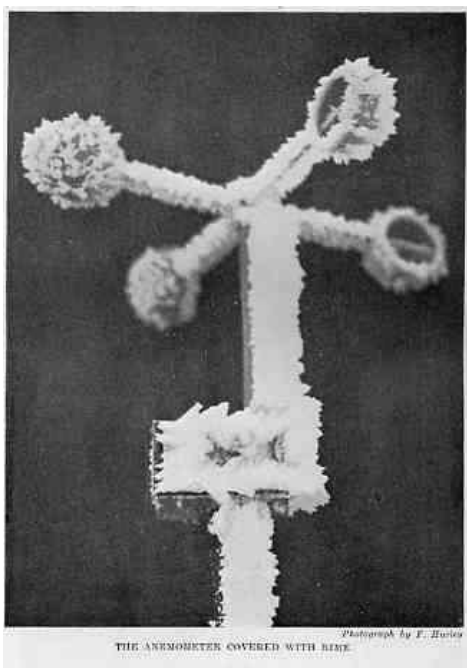
<sup>1</sup> Letter Aug 15<sup>th</sup> 1905 Curzon to Goldie, read CM Nov 6<sup>th</sup> 1905

<sup>2</sup> Bravo (1999) p.219, Driver (2015) p. 17

<sup>3</sup> McCarthy (2004) p. 141

Within each category the expeditions are dealt with chronologically. Reported difficulties are noted; if no difficulties were reported a judgement has to be made as to the credibility of the accounts. Particular strategies were apparent. Sometimes institutional authority was brought to bear; often care was taken to describe good practice in detail.<sup>4</sup> Occasionally a traveller misjudged the situation as in the case of Savage Landor. Ultimately an assessment relies on an informed but subjective decision.

While effective use of instruments relied on the success of the mission as a whole, the reverse was not the case; David Livingstone was the most honoured explorer associated with the RGS for half a century, but he was not proficient at the production of valuable data and maps. This chapter focuses on practice, not on the ultimate reception of the work produced which is investigated in chapter 8.



---

<sup>4</sup> Keighren, Withers and Bell (2015) p. 72



Fig 6.1 a, b and c: Common problems in the mobilisation of instruments: anemometer incapacitated by ice, terrain unsuitable for sight lines, maximum and minimum thermometer broken in transit.<sup>5</sup>

The pitfalls were various as can be seen in figure 6.1. In order to produce a working instrument on site, travellers had to arrange for transport to the starting point, guard against damage and breakages, loss and theft. They had to be vigilant in maintaining calibration: chronometers were particularly demanding in this respect. There had to be sufficient manpower, skill, and experience within the expedition. Daily schedules had to involve routine observations with various roles assigned for various gestures. Local physical circumstances had to be practicable; for example sight lines needed to be visible, the sky needed to be clear for astronomical observation, water had to be clean for hypsometric measurements, there needed to be landmarks. To avoid 'instrumentalism' it was necessary to know what was being measured. Indigenous peoples were often necessary for support and their local knowledge; the 'geographical gift.'<sup>6</sup> Systems were required to negotiate access and safe passages, provide communication, sustenance, and sometimes the repair or replacement of instruments.<sup>7</sup>

The affecting factors have been designated as follows: the ability of the traveller, the physical environment, the human aspect either locally or politically, logistic support, and systemic issues. In many instances there were multiple issues but an optimum method was necessary. Two travellers have been assessed as having been equally affected by both

<sup>5</sup> Photograph of anemometer by Hurley in Antarctica in 1914-16, rgs 053461, Forest in Brazil by Percy Fawcett in 1908, rgs 058339, Maximum and minimum thermometer by Newton Artefact E 9

<sup>6</sup> Bravo (1999)

<sup>7</sup> Schaffer (2011)



physical and human factors: Fanny Bullock Workman and Boyd Alexander. Samuel White Baker alone revealed nothing of his practice so could not be categorised; even his private diaries appeared to be 'sanitised.'<sup>8</sup> The evidence demonstrates that the ability of the individual traveller to make and to record observations was the most common factor determining the successful mobilisation of instruments.

### **Factors Affecting Instrumental Practice:**

#### *The Ability of the Traveller*

In over a third of expeditions studied the major determinant of instrumental success was the ability of the traveller. In the early years some travellers were not competent, but in the later part of the period gains through training were offset by those on specialist expeditions being disinterested in basic surveying.

The expeditions supported by instruments in the 1830s were crucial to the continuation of the practice, and the establishing of procedure. The first two, given approval simultaneously in 1834, were to Delagoa Bay in East Africa under Alexander, and to British Guyana in South America under Schomburgk.<sup>9</sup> These two represented extremes of failure and success in instrument mobilisation respectively.

Beaufort wrote with advice for Alexander: 'Give him instructions to keep all his rough observations in order to be worked hereafter and you can't emphasise this point too strongly. Let him have a good astronomical object glass, and he should lose no opportunity of observing eclipse occultations because he may not have an opportunity of working these.'<sup>10</sup>

Alexander's instructions were to: 'Keep an exact register of astronomical and meteorological observations and then you will note carefully the variation of the compass, with bearings and distance of every remarkable point in view. The natives recognise hospitality as a moral obligation. Travel by boat and canoe up river to 50 miles where oxen can be found'.<sup>11</sup> On his way south from Tenerife Alexander reported that barometrical and thermometric observations had been taken three times; an insufficient number, and, crucially, he left no record of when or where these observations had been taken, thus invalidating them. He 'looked at the snow through the Admiral's 'excellent Dollond telescope' while it was intended that he should make astronomical observations with his own.'<sup>12</sup> There is no mention of latitude, longitude or variation of the compass, never mind the eclipse occultations

---

<sup>8</sup> Baker Collection Journal 1, Baker (1861), Moore-Harell (2010) p.7

<sup>9</sup> CM June 21<sup>st</sup> 1834

<sup>10</sup> Beaufort CB2/50 Letter to MacConchie Aug 17<sup>th</sup> 1834

<sup>11</sup> JMS/2/5 Alexander

<sup>12</sup> JMS/2/6 6<sup>th</sup> of October 1834

advocated by Beaufort.<sup>13</sup> Alexander was giving longitude as 'circa', even though he was equipped with instruments sufficient to determine it to within a minute.<sup>14</sup>

Alexander was detained in the Cape during 1835 due to 'Kaffir Campaigns'.<sup>15</sup> The Council wrote 'reminding him that the resources were provided for an expedition from Delagoa Bay, for this purpose only'. The *Athenaeum* commented perceptively that Alexander's behaviour showed 'how slight a hold the RGS had of him, and the want of a proper understanding between that body and their traveller as to their reciprocal observations.'<sup>16</sup> Even without political setbacks, Alexander was incapable of undertaking the work that the RGS expected. The resource embodied in his considerable supply of instruments remained dormant.

In Schomburgk, however, the RGS had a convincingly able traveller. Many of Schomburgk's diaries from Guiana have been published by Pierre Riviere, and Burnett has studied his activities in considerable context.<sup>17</sup> Prior to his expedition to Guiana, Schomburgk submitted a paper concerning his techniques which remained unpublished. This demonstrates the preference for results rather than methods in published accounts, and emphasises the need to look beyond published papers.<sup>18</sup>

Schomburgk recognised, overcame, and demonstrated how he overcame pitfalls. He wrote:

I placed the graphometer and took a sight to the point where the beach took a turning having fixed a stave with a signal to it. I measured its subtense with the chain, making it a rule throughout my surveys to take the end of the chain myself. Well acquainted with the fallibility of the needle I measured a base line and took from both ends signals to the points where I had been previously, so I guarded against errors... using the rules of plain geometry. Manyfold were the difficulties; being obliged to fix my instrument in the (pond) and taking the angles from thence while standing up to my neck in stagnant water.<sup>19</sup>

In this he demonstrated personal responsibility, awareness of instrumental fallibility, knowledge of plain geometry and a willingness to go to extremes to get good measurements. Schomburgk was the first of a small number of travellers who attained the maximum value from their instruments in the manner concordant with ANT. Burnett has compared traverse surveys unfavourably with triangulation, but it is evident that while Schomburgk did not have the resources for the latter on a large scale, he performed both whenever possible, dispensing with the compass in favour of trigonometry.<sup>20</sup> Burnett emphasises the necessity of

---

<sup>13</sup> JMS/2/6 Alexander

<sup>14</sup> JMS/2/8 Alexander

<sup>15</sup> CM 19<sup>th</sup> Oct 1835

<sup>16</sup> *The Athenaeum* Sept 29<sup>th</sup> 1838 no 570 p.714

<sup>17</sup> Rivière (2006), Burnett (2000) chapter 3

<sup>18</sup> Riviere (2006) p.7 note 1, *JRGS* 2 (1832) p.152-170, JMS/5/2

<sup>19</sup> JMS/5/2

<sup>20</sup> Burnet (2000) p.88

good fixed points in a traverse survey when discussing Schomburgk's work.<sup>21</sup> He then goes on to argue the similarity of the role of the ship's navigator with that of a traverse surveyor. While they are similar in some respects, in particular in the types of instrument used and observations made, the centrality of landmarks to relate to the fixed points in a traverse survey is a significant departure from the practice of navigating oceans.

One of the few expeditions sponsored in the 1840s was that of John Duncan to West Africa in 1844. Derek O'Connor's assessment of Duncan is accurate; 'Duncan may have acquired navigational instruments but he evidently had little idea how to use them.'<sup>22</sup> Duncan was lent a prismatic compass, pocket compass, boiling point thermometer, ordinary thermometer and a good box sextant, portable horizon, and *What to Observe*.<sup>23</sup> He was given basic instruction in the use of the sextant by a Captain Johnston, and presented with Raper's *Navigation*.

When travelling, Duncan reported temperature only when it affected the expedition: 'Thermometer at 115 degrees, 95 in the shade. Actually I have to walk because I can't afford to ride.' He demonstrated ability as a travel writer, but not as an observer, by incorporating numerical observations only to heighten the reader's sense of empathy.<sup>24</sup> A few months later Duncan reported that his thermometer had broken. The RGS sent two at a cost of £18; as thermometers were £1 at this time, the conveyance was the principal expense.<sup>25</sup> The resource invested by the RGS was not repaid. Duncan's distances were always prefixed by 'about'. He used the words 'observation' and 'dip' in the wider sense of common speech.<sup>26</sup> In October 1845 he reported 'a gloriously successful traverse in the heart of the Kong Mountains' but does not describe how it was done.<sup>27</sup> Duncan used descriptive and numerical compass directions interchangeably, and magnetic and true bearings inconsistently. While appreciating the value placed on instrumental measurement by the Society he could not deliver it.<sup>28</sup> His subsequent journey to West Africa in 1849 was his last.

In a sad postscript, Lieutenant Alexander Becher wrote to Jackson in July 1850: 'I sallied down to the dockyard at Southsea where Mr. Jeans had a box of instruments returned from Africa that may possibly be those lent to Duncan.'<sup>29</sup>

While Galton's book advocated a pioneering approach, his personal papers testify to his constant application to observation and measurement, for example the discussion as to how to read maximum and minimum thermometers in figure 6.2.<sup>30</sup> In 1851 in Central Africa

---

<sup>21</sup> Burnett (2000) p.99

<sup>22</sup> O'Connor (2006) p. 115

<sup>23</sup> CM 26<sup>th</sup> June 1843., May 13<sup>th</sup> 1844

<sup>24</sup> Duncan April 19<sup>th</sup> 1845 JMS/1/18 , Duncan CB3/241

<sup>25</sup> CM 9<sup>th</sup> Feb 1846

<sup>26</sup> JMS 1/24

<sup>27</sup> JMS/1/29

<sup>28</sup> JMS/1/29, JMS/1/18, JMS/1/29

<sup>29</sup> Becker CB3/58 31<sup>st</sup> July 1850

<sup>30</sup> CM Mar 28<sup>th</sup> 1859, April 11<sup>th</sup> 1859, LMS g 1, Wright Gilham (2001) p. 68

he took longitude by various advanced methods, used a circle as well as a sextant, and rejected some readings as being too far apart; 'they do not mean well'. Galton measured anything possible. When his oxen 'would not face the thorns' he used a spring weighing machine and marked the number of pounds resistance at the moment the thorn broke. However, in spite of his efficient use of instruments Galton was reliant on a guide who 'lost his way more than once.'

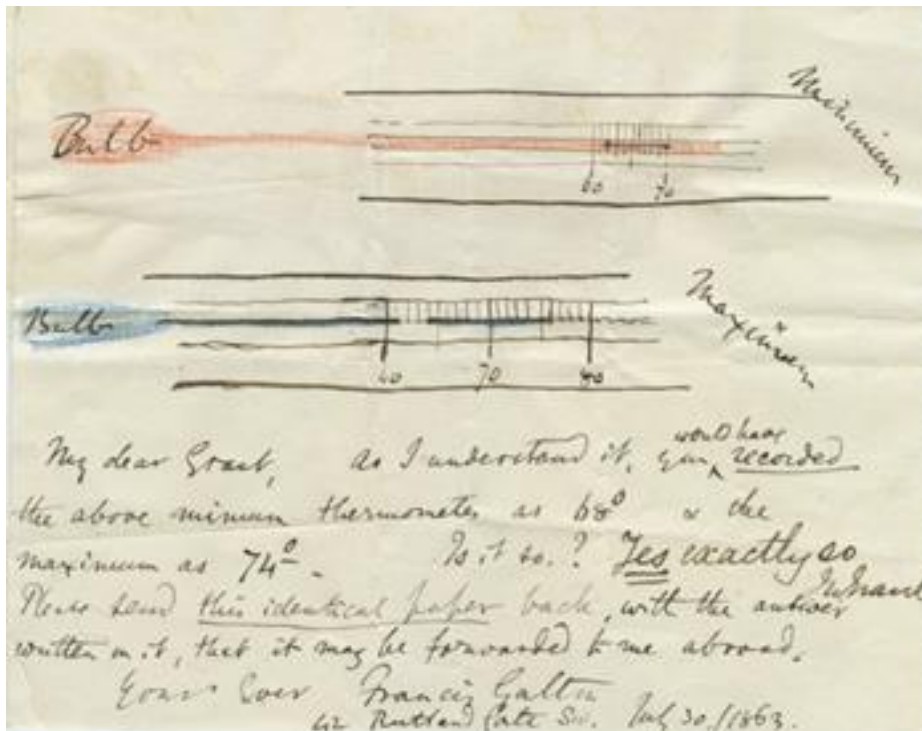


Fig 6.2 Note from Galton to Grant concerning how to read maximum and minimum thermometers in 1863.<sup>31</sup>

Galton used dead reckoning but incorporated multiple observations and then checked them astronomically. 'I have so many bearings that I had no difficulty in constructing many triangles so I could check one by the other. I then took the most trustworthy readings. I protracted the lines to find longitudes, then the scale of the map by latitudes. I compared these longitudes with those obtained astronomically. I am thus particular upon these matters.'<sup>32</sup> There was also a cost-benefit analysis: 'I would have been involved in endless computation had I attempted to do more on the map, but it is fairly accurate.' Sheer

<sup>31</sup> Galton (1853) p 102-103, Camel thorn GDG-2/C/14, JMS/3/58

<sup>32</sup> JMS/2/28 p.31

determination, the 'moral calibration' as Withers has it, allowed factors such as terrain and poor relations with the indigenous people to be overcome.<sup>33</sup>

Sutherland also engaged productively with his instruments. He took meteorological observations on a sea voyage from England to Algoa Bay in South Africa in 1853.<sup>34</sup> Sutherland took his observations regularly.<sup>35</sup> Glaisher, secretary of the British Meteorological Society, had compared Sutherland's 'Ure' aneroid with the standard instruments at the Royal Observatory, Greenwich, and found its index error, which Sutherland applied. Sutherland went to similar trouble with his thermometers. He also recorded wind direction and force on the Beaufort scale, noted prevailing cloud type according to Luke Howard's nomenclature, measured the density of the sea water, noted the depth in fathoms, and dredged for species. He determined the ship's position astronomically with latitude to one minute. Despite using a new instrument, the aneroid, which had not yet merited the confidence of the Society, Sutherland was effective. He involved the newly-emerging networks and the standard scales recently developed in meteorology.

Before he became famous, Livingstone was awarded a silver medal for his paper on the discovery of the 'Great South African Lake'.<sup>36</sup> He asked for his prize money to be spent on an inscribed 'Chronometer or watch,' thus acknowledging the status of instruments within the Society.<sup>37</sup> Subsequently Livingstone was lent a variety of instruments by the RGS in 1857.<sup>38</sup> As he became the most revered explorer of the nineteenth century it is worth investigating his use of these, as his biographers have focussed on his extraordinary reputation rather than his instrumental abilities.<sup>39</sup>

It is evident from Livingstone's diaries that observing and measuring were not of interest to him.<sup>40</sup> He prefixed his latitudes and longitudes with 'about'. He admitted they had not had time to examine Lake Shurwa, but 'think twenty or thirty miles may have to be cut off its length on the maps'. When their instruments were stolen, Livingstone expressed no great dismay. In a letter to the RGS dated January 1862, he related that he was taking latitudes, and soundings with a fishing line. He estimated that Lake Nyassa 'extended into the southern borders of the tenth degree of south latitude.' Livingstone wanted all his positions to be subject until they had been examined, presumably not feeling confident of them.<sup>41</sup> The resource in Livingstone's instruments did not contribute to his reputation or useful data.

---

<sup>33</sup> Schaffer (1997) p. 448, Withers (2011) p.45-46

<sup>34</sup> Gunn and Codd (1981) p. 410

<sup>35</sup> LMS S 45 Sutherland

<sup>36</sup> CM Feb 11<sup>th</sup> 1850, April 8<sup>th</sup> 1850

<sup>37</sup> CM April 7<sup>th</sup> 1851

<sup>38</sup> *JRGS* 27 (1857) p. lxxxiv

<sup>39</sup> MacNair (1976) p. 193, Driver (2001) p.81, Ross (2002) p.175 is aware of Livingstone's failings

<sup>40</sup> DL 3/13/2

<sup>41</sup> DL /10/2 p.121 Mar 10<sup>th</sup> 1856

Allen Young borrowed instruments in 1875, for an expedition in extreme cold, but overcame physical deprivations to produce new knowledge.<sup>42</sup> Young ensured his failed expedition to find Sir John Franklin had scientific benefits.<sup>43</sup> He took both true and magnetic bearings, latitude, longitude, barometer and temperature readings. He took soundings with a lead and constantly watched his barometer and observed dip. Young's ability both enabled data to be gathered from traditional instruments and extended the remit of geography into analysis, as he had ice samples analysed physically and chemically.

James Stewart, a member of the Indian civil service interested in spreading Christianity, borrowed instruments for an expedition to East Africa in 1881.<sup>44</sup> Stewart was forced to confront Livingstone's shortfalls: 'By the map our course should have been NE, but it was actually SE by steering' as Livingstone had made a mistake in the latitude of the north end of Lake Nyassa. Stewart categorised himself as belonging to a third class of observer: a 'humbler class of explorers, whose investigations are carried on for immediate practical purposes by patient and continued observation large blank surfaces are filled up with as much accuracy as human effort and instruments can effect.'<sup>45</sup> Stewart's results were used by McEwan and so contributed to the iterative process whereby knowledge was built incrementally.

Peek was chosen because he was an advocate of the training given by John Coles.<sup>46</sup> In 1880 he was in Iceland with Coles and Delmar Morgan fixing the northern extreme of the great larval flow of 1874.<sup>47</sup> 'We feared that a jog trot of 10 hours duration might have put the instrument somewhat out of adjustment, but we were pleasantly surprised'. Peek trusted the compass because 'the sun's azimuth taken at many stations gave us a variation in agreement with the Admiralty chart of curves of variation'. He demonstrated an awareness of tolerances: 'Any eccentricities (in dip) were absent or so small as to be inapplicable with ordinary travellers' instruments'. Like Young they sent back samples for analysis.

Peek's expedition suffered from physical setbacks: steam obscured the sight lines, staves could not be driven in, sulphurous vapour condensed on the sextant, the dust storms and the jog trots were 'very severe tests for the watches'. However, they took care: 'We procured a box about 3 inches larger each way than the theodolite case, after layering with rags the instrument in its case was placed in the box. Then clothes all round and on top before fastening it to a pack saddle. The instrument never got out of adjustment'. Peek was described as being 'adept with the sextant.'<sup>48</sup> Peek's good practice overcame physical factors to become the salient features in his success.

---

<sup>42</sup> Barczewski (2007) p. 23

<sup>43</sup> Mason (1908) p. 41

<sup>44</sup> JMS/2/196, Hokkanen (2007) p 108-114

<sup>45</sup> JMS/2/196 p. 2

<sup>46</sup> Peek CB6/1752 Letter to unnamed recipient RGS 24<sup>th</sup> Sept 1880

<sup>47</sup> JMS/15/87

<sup>48</sup> Slater (2005) p. 116

William McEwan, another beneficiary of tuition from Coles, borrowed instruments in February 1884 to go to Kilimanjaro.<sup>49</sup> McEwan had a copy of Stewart's map, and was constructing his own with bearings and positions. He used 'Observation Calculation Books' in which he recorded observations on a daily basis, including an assessment of the conditions. On 14<sup>th</sup> May 1884, the 'mosquitoes were somewhat distracting' and clouds prevented a North Star sight. On 20<sup>th</sup> a slight breeze disturbed the mercury. On the 24<sup>th</sup> moisture formed on the artificial horizon. On the 26<sup>th</sup> he used a 2-inch compass on Abney's level to find variation, recognising that the compass was too small to be accurate to more than 2 degrees.<sup>50</sup>

McEwan's chronometers were a constant source of trouble, gaining less while travelling, when they were carried by one of the porters. One chronometer stopped for a month, giving a worrying double tick when restarted.<sup>51</sup> By taking two observations and weighting the mean by how much he valued them he reached latitude to within five seconds of the 'truth'. This is the first time that readings were found to be not merely discarded, as Galton had done thirty years previously, but weighted according to reliability. McEwan's accounts revealed awareness of problems such as limiting factors of his instruments, and initiative in overcoming these difficulties.



Fig 6.3: Whymper descending the Pointe Des Ecrins in the 1860s.<sup>52</sup>

<sup>49</sup> IC Feb 11<sup>th</sup> 1884, SSC/107 McEwan

<sup>50</sup> SSC/107 McEwan observation book 5

<sup>51</sup> SSC/107 McEwan observation book 6 page 8

<sup>52</sup> Whymper (1900) Control number 340375 p. 204/205

Having displayed little engagement with instruments in the 1860s, Whymper was keen to show how he valued them by 1880, taking tuition from Coles.<sup>53</sup> Having been advised not to climb in the Himalayas for political reasons, Whymper decided upon Ecuador 'the most lofty remaining country available.'<sup>54</sup> His aims were to compare instruments rather than investigate the place: they were testing the robustness of mercurial barometers, comparing their readings with aneroids, and comparing mercurial barometers and hypsometers.<sup>55</sup> Three mercurial barometers, eight aneroids and ten boiling point thermometers were taken, all returning unscathed. Jean-Antoine Carrel, an Italian climber and porter: 'carried the mercurial barometers during the whole of my equatorial journey. He knew the importance of their preservation. And he displayed a most tender and loving care of them. He thus rendered service to science.'<sup>56</sup> Tender and loving care was a frequent approach to instruments; Henry tells of barometers being referred to as 'babies.'<sup>57</sup> Again Whymper's expedition demonstrated clearly that instruments were tested after purchase, so the actants were opening the conceptual black box.

Charles Woodford borrowed instruments to visit the New Hebrides in 1884 and the Solomon Islands in 1886.<sup>58</sup> He embraced the Humboldtian ideal of searching for long-term patterns in natural phenomena, hitherto largely absent from the RGS in practice if not in theory. A 'critical geographer', or a comparator of sources, he listed a history of expeditions to the Solomon Islands since 1764 comparing the latitudes and longitudes reported, and relating the flora and fauna and the habits of the indigenous people.<sup>59</sup> He gave results for soundings, latitudes and longitudes, but did not consider how they were taken to be important. Woodford saw himself as 'establishing and maintaining datum to afford to our descendants an opportunity of estimating in the future the changes that are taking place.'<sup>60</sup>

Alfred Maudslay, a leading authority on Mayan culture, borrowed instruments four times to go to Central America between 1884 and 1890.<sup>61</sup> He took many various advanced astronomical observations and compared chronometers.<sup>62</sup> He gave the impression of enjoying his instruments and of observing as a pastime.<sup>63</sup> Maudslay illustrates that effective engagement with instruments was necessary but not sufficient for effective knowledge creation as he had no proper system of routine observation or record.

---

<sup>53</sup> EWH/1

<sup>54</sup> Hansen (1996) p. 48-71, Whymper (1892) p.56

<sup>55</sup> Whymper CB6/2379 letter to Bates on Oct 1<sup>st</sup> 1880

<sup>56</sup> Whymper CB7/98 letter to Freshfield Oct 21<sup>st</sup> 1890, Henry (2011) p. 85

<sup>57</sup> Henry (2011) p. 291

<sup>58</sup> Tennant (1999) p.419

<sup>59</sup> Tennant (1999) p. 426

<sup>60</sup> JMS/18/90

<sup>61</sup> SSC 122/5, Graham (2002)

<sup>62</sup> SSC 122/5 12<sup>th</sup> May 1889, 5<sup>th</sup> June 1889

<sup>63</sup> Dym (2004) p. 350



H. H. Johnston's relationship with the RGS has been discussed by Amy Prior.<sup>64</sup> Johnston borrowed instruments from the RGS for five expeditions between 1884 and 1899. From the fourth expedition to Nyasaland he left a diary which included lists of times, rate of progress and compass degrees.<sup>65</sup> He is unusually explicit regarding length measurement: His map scale was an inch to the mile, and two minutes of time was reckoned as a unit. Dividing a mile into thirty parts, one mile an hour corresponds to one thirtieth of a mile. At the rate of 1.5 miles an hour two minutes corresponds to a twentieth of an inch, and so on: thus, in order to measure distance, he had to know speed. Johnston was equipped to use dead reckoning but like many others, was confined by his inability to check this procedure astronomically.

Freshfield, the subject of studies by Reuben Ellis and by Charles King, borrowed instruments in 1889.<sup>66</sup> He stated that he had selected Sikkim because 'I like scenery more than science.'<sup>67</sup> He wrote: 'While it was 'much more to my taste to be sitting drawing subjective details in a snug tent than scrabbling over moraine with a plane table..., however, ....we wanted to work out our results and prepare a map.'<sup>68</sup> Freshfield's companion Edmund Garwood appears to have done the surveying: 'Garwood used as a basis the Survey of India. He has filled in and corrected detail using the plane table observations, and photographs.'<sup>69</sup> Freshfield's delegation suggests the role of the instrumental observer had lost status as the surveying profession developed. Freshfield's preference for a comparative geography was reflected in the writings of other travellers such as Steers and Ramsay at this time.

---

<sup>66</sup> Prior (2013) pp.189-194

<sup>65</sup> SSC/86 Johnston

<sup>66</sup> King (2008) p.125, Ellis (2001) p. 11

<sup>67</sup> JMS/11/142, Steinmann (1998) p. 121

<sup>68</sup> JMS/11/142, Hansen (1996)

<sup>69</sup> JMS/11/142



Fig 6.4: Freshfield contemplating snow. <sup>70</sup>

Walter Harris borrowed instruments for use in the Atlas Mountains in 1896. His surviving manuscript refers to an earlier journey.<sup>71</sup> The paper was devoid of any measurements; he used phrases such as 'a couple of miles,' and 'A rough estimate of 450 square miles'. He gave a height to the nearest hundred feet, but another to the nearest ten. A letter of Feb 7<sup>th</sup> 1894 reports that 'a prismatic compass, boiling point tubes and aneroid being continually in use', but that 'Unfortunately the disguise in which I travelled - that of a donkey boy - did not allow of my carrying a sextant'. There was no indication at any point that Harris produced a single piece of instrumental data.

Haddon was an anthropologist who had set up a laboratory in Dublin modelled on Galton's in London.<sup>72</sup> A full account of his work in the Torres Straits is given by Anita Herle and Sandra Rouse.<sup>73</sup> He had absorbed the scientific attitude of the RGS, and wanted to apply it to an ethnographic study in the Torres Straits.<sup>74</sup> He was granted instruments in 1897.<sup>75</sup> Haddon wrote that he would be taking a naturalist, photographer, sociologist, phonographs and a cinematograph; an extremely early instance of the latter technology.<sup>76</sup> His proposal was taken up with enthusiasm. He found himself in the unique position of having instruments

---

<sup>70</sup> Photograph entitled 'Below zero' 1880s, Control number 026564

<sup>71</sup> JMS/1/149 W.B. Harris

<sup>72</sup> Stocking (1996) p. 104, Richards G. (1998)

<sup>73</sup> Herle and Rouse (1998)

<sup>74</sup> Haddon CB7/43

<sup>75</sup> EC Nov 18<sup>th</sup> 1897, Feb 28<sup>th</sup> 1898, Mar 2<sup>nd</sup> 1898

<sup>76</sup> Haddon CB7/43 Oct 20<sup>th</sup> 1897, Griffiths (2002) p.129-148

and money forced upon him, but was wary of taking on work for which his team was not equipped. He 'may be able to do some little geographical work and at all counts I can have a shot at it'.<sup>77</sup>

The RGS granted Haddon £150 on condition he was himself an observer and did not use a 'special geographer'.<sup>78</sup> He was concerned that 'none of them had experience, none had surveyed', but was assured not to worry but to do his best. In a subsequent letter he asked for a light plane table, and then a small box sextant.<sup>79</sup> The Society was keen to press traditional surveying on to specialist expeditions who were not necessarily competent in this technique.

The Rev Thomas Lewis borrowed instruments to visit the Congo region in 1902, and again to visit Angola in 1908.<sup>80</sup> He was interested in studying the customs and habits of the people, wanting to open up the 'dark continent to the light and blessing of civilisation'.<sup>81</sup> He did not relate how he took measurements, and used a route map. He was aware of rainfall records but without appearing to take measurements himself. While he took latitudes, the longitudes were based on the work of Reverend George Grenfell. Lewis had been lent a theodolite, an aneroid, and boiling point thermometers, but does not mention them, and does not appear to have been capable of taking longitude; a common shortcoming.<sup>82</sup>

There is some confusion over William Ramsay, as a namesake also based at Aberdeen was a well-known chemist who worked with spectroscopy to identify new rare gases around the turn of the nineteenth century. Some correspondence in the Gill collection is probably from the chemist: for example a Ramsay argued the aurora borealis was due to krypton with a wavelength of 5570a.<sup>83</sup> Ward Gasque writes about a Ramsay who was interested in Asia Minor.<sup>84</sup> A letter from this Ramsay to Scott Keltie read: 'Privately, not officially, I always live in the hope of something turning up by which I could retire from Aberdeen and devote myself for the conclusion of my life to the exploration of the history of Asia Minor.'<sup>85</sup> Fortunately from 1901, this Ramsay was able to make trips with RGS instruments nearly every year until 1908, and then for several years in the 1920s.

Ramsay described his inability to find a tacheometer, a form of waywiser attachable to cart wheels, in London, and 'the same fate awaited us in Paris. Everyone would make one to order but none ready-made. The want of a tacheometer would make the journey useless.'<sup>86</sup> The RGS provided pedometers at this time but not this type of length measurer.

---

<sup>77</sup> Haddon CB7/43 to Keltie Oct 17<sup>th</sup> 1897

<sup>78</sup> Haddon CB7/43 Keltie to Haddon Dec 13<sup>th</sup> 1897

<sup>79</sup> Haddon CB7/43 to Keltie Letters Feb 24<sup>th</sup> and July 1<sup>st</sup> 1898

<sup>80</sup> EC 9<sup>th</sup> Oct 1901, May 13<sup>th</sup> 1902

<sup>81</sup> JMS/2/341 1901

<sup>82</sup> EC May 13<sup>th</sup> 1902

<sup>83</sup> DOG/132

<sup>84</sup> Ward Gasque (1966)

<sup>85</sup> Ramsay CB7/99 1<sup>st</sup> October 1901

<sup>86</sup> Ramsay CB7/99 14<sup>th</sup> June 1902

In similar vein to Freshfield, Ramsay complained: 'I am filled full and overflowing with discoveries... about Asia Minor as well as with theories which need more study. I see a great deal more without surveying.'<sup>87</sup> Ramsay felt that the surveying required by the RGS inhibited his thinking about the wider issues. He called himself a historical geographer, an emerging category not primarily interested in instrumental results.<sup>88</sup>

Francis Rennell Rodd borrowed instruments for an expedition to the Sahara in 1927. Living in French military posts he had difficulties finding a good site for measurements.<sup>89</sup> 'The French have installed a meteorological station but have no barometer or aneroid, or wet and dry thermometer, and no sling or whirling thermometer.' He had a ruled book for barometer readings, magnetic bearings, and time which he filled in meticulously. Rodd was aware of the need to calibrate instruments with standards internationally. He was using a large range of instruments including a barograph, a wet and dry bulb thermometer and a thermogram.<sup>90</sup> Eventually Rodd managed to set up a station at Anderas from which readings from the maximum and minimum thermometers and the rain gauge were wirelessed to Dakar every morning. Rodd provided very detailed series of latitudes and longitudes.<sup>91</sup> He measured the ground with a tape, including corrections for inclination, temperature, sag and height above sea level. He listed his instruments which included four Chesterman steel tapes and a well thermometer, a whirling hygrometer, a densimeter, a prismatic sketching instrument and celluloid protractors.<sup>92</sup> His ability and determination meant he eventually overcame logistical problems.

---

<sup>87</sup> DOG/132 13<sup>th</sup> Mar 1903 letter to Keltie

<sup>88</sup> JMS/9/236, Koelsch (2013) p. 196-198

<sup>89</sup> Fisher (2002) pp 98-99, Fisher (2006) p.355, Collection FJR/17 1922

<sup>90</sup> Rodd FJR/6 May-August 1927

<sup>91</sup> Rodd FJR/6

<sup>92</sup> CM Feb 20<sup>th</sup> 1928



Fig 6.5: Photograph entitled 'Camel carrying a chronometer' by Rodd, 1927.<sup>93</sup>

#### *Physical Conditions*

On many occasions the physical conditions faced by the travellers impeded good instrumental observation. In seeking out increasingly inaccessible places in its search for blank spaces on the map, the RGS maintained this impediment throughout the period.

Whymper's expedition to Greenland in 1866 was chosen for study in the thesis because it arose from a commercial enterprise providing the telegraph to Alaska.<sup>94</sup> They recorded the lowest temperature then reached by an alcohol thermometer of minus 57 degrees Fahrenheit, in which thirty-six men were digging holes for telegraph poles: 'The work was no joke'. Whymper was using a chart drawn up by Lavrenty Zagoskin as the 'authority' for his latitudes and longitudes, even though he had borrowed a chronometer.<sup>95</sup> 'I tried to sketch out the river but so little varied that all my points were between N and E.' The intense cold sapped any enthusiasm for observation, and no new geographical knowledge appears to have added to that provided by Zagoskin.

Good observations could be lost due to physical disasters. Keith Johnston appears to have been an able observer, but much resource was lost due to an accident. Johnston was

---

<sup>93</sup> FJR/13

<sup>94</sup> CM July 9<sup>th</sup> 1866, 25<sup>th</sup> Feb 1867, FC Nov 5<sup>th</sup> 1866, 1<sup>st</sup> April 1867, JMS/4/73

<sup>95</sup> Coates (2010) cites Zagoskin (1847-8)

commissioned to make a survey of the boundary of Paraguay from the end of 1873, a project for which he and Charles Congreve were lent instruments in 1874.<sup>96</sup>

Johnston's ability as an observer and technician ensured that he overcame a variety of problems demonstrating 'heroic recuperation of disorderly hardware.'<sup>97</sup> Johnston reported that:

'the barometer which although carefully packed inside the tin tube and the tripod stand, had snapped off clear above the place where the tube and cistern join. I made some glue with Venice turpentine, and have joined the break in the tube putting on a metal cover with white lead; I think it will do very well. Two rain gauges which I had made in the Livingstone pattern have been stolen, probably to be used as bottle filters. I have had two more made, keeping the original in case of further deprivations. I have made a number of latitude observations with north and south stars and get results agreeing with one another to a few seconds. I have also found the variation with six or seven compasses and know my watch rate to the fraction of a second. For longitude here I have taken several lunars and as there is a difference of ten miles in the given positions of Asuncion.'<sup>98</sup> We have kept up a series of meteorological observations since March and they are still going on. We have 3 barometers: 2 of yours and one by Stanley of London, which I found here'. 'Leaving Congreve to do the usual 9am and 9pm observations, I took the India rubber stoppered barometer with me on the journey and read it as often as possible exactly at these hours'.

Johnston's descriptions of filling the mercury barometer over a hundred times gives a rare sense of the toil involved in the effectual use of instruments in the field.<sup>99</sup>

Unfortunately, however, a strong current upset their boat; 'she rolled over and out went all our baggage, instruments, maps, and provisions, sailing swiftly down the current...only a few boiling point observations have been saved'.<sup>100</sup>

William Watts was lent instruments for a primarily geological expedition to Iceland in 1876.<sup>101</sup> His principal instrumental difficulty was the inability to use the compass because of the large volcanic deposits: 'Throughout my journey I took the bearings using the variation for 1873 but their observation yielded no very accurate result'. 'The compass was utterly useless, the principal focus of attraction being west'. 'We were compelled to return due to the inability of our compass.' Watts described how he constructed his own instrument; a circular piece of card marked into quarters with which he steered by the wind. The resource imbedded in the beautifully-made compasses of the mid-nineteenth century could not be accessed in this location.<sup>102</sup>

---

<sup>96</sup> McCarthy (2004) p. 71, p. 85, Johnston CB6/1265, CM Mar 11<sup>th</sup> 1872

<sup>97</sup> Schaffer (2011) p. 709

<sup>98</sup> Johnston CB6/1265 letter to George 25<sup>th</sup> April 1874

<sup>99</sup> Johnston letter to George 3<sup>rd</sup> Dec 1874

<sup>100</sup> McCarthy (2004) p. 98

<sup>101</sup> Watts (1876) p. 88, CM Apr 26<sup>th</sup> 1875

<sup>102</sup> Watts (1876) p.90

Trevor Battye borrowed instruments to go to the Kolguyev Island in the Russian Arctic in 1894.<sup>103</sup> They were confined to their tents for ten out of sixteen days due to bad weather, taking a few latitudes, soundings and magnetic variations, although they had a chart which may have been Zagoskin's: 'According to our chart the island lay between 68 43 and 69 30 N and 48 15 to 49 55 E'. Of the River Pechora, Battye wrote: 'I do not for one moment pretend to have accurately mapped this river, but I crossed it near its source and at several points lower down.' It appears that, as for Whympers's expedition in 1866, poor weather exhausted them and frustrated the production of reliable new knowledge.

Boyd Alexander's expedition from Nigeria to the East coast of Africa by boat in 1904 has been described as 'tragic.'<sup>104</sup> His younger brother Claude had received the diploma from Reeves.<sup>105</sup> The project was beset equally by problems physical and human. The physical setbacks included insects, infection, and the changing water levels making mapping difficult.<sup>106</sup> While they were all affected by illness, Claude died and was irreplaceable. Alexander's eye suffered from theodolite work and 'Clouds and columns of insects made observing almost impossible; I have never seen anything to equal it.'<sup>107</sup> Nevertheless Alexander took barometric readings and temperatures, using a maximum and minimum thermometer for several months. 'One morning was spent measuring a subtense but the bush was very dense.' Alexander was severely hampered by physical factors but persisted to produce a sketch map whose existence belies the conditions of its making.

Fanny Bullock Workman has been discussed as a female mountaineer, but not specifically a user of instruments.<sup>108</sup> Ann Colley argues that 'above the snow line things were different' and gender no longer mattered.<sup>109</sup> Workman borrowed instruments for use in the Himalayas in 1912. As for Boyd Alexander, she was equally affected by physical and human issues.<sup>110</sup> While height was her principal interest, she reported the extraordinary differences between temperatures in the sun and at night, and used a solar radiation thermometer. Workman took the average of three sets of observations: 'We took two Watkin aneroids to 25,000 feet checked daily by the hypsometers.' Workman found the height of Lungma to be 23,394 feet.

Workman's physical challenges were demonstrated in another journal manuscript: 'There is a troublesome stretch of absolutely waterless desert, and as this 50 miles or so must be accomplished almost without a halt; it will be a serious obstacle to survey proper'.<sup>111</sup> The deep sand taxed the muscles of mules and camels. Workman had a dam

---

<sup>103</sup> JMS/15/99

<sup>104</sup> Bederman (2000)

<sup>105</sup> Bederman (2000) p.74

<sup>106</sup> GBG/3 p. 5

<sup>107</sup> GBG/3 p 6

<sup>108</sup> MacLachlan (2004), Colley (2010) p.115

<sup>109</sup> Colley (2010) p.136

<sup>110</sup> JMS/11/149

<sup>111</sup> JMS/11/114

constructed which provided water. She was sanguine about the prospects ahead: 'Plane table survey has been carried through two routes ... but what beyond that? Are there hills to help us along or not? She was using Talbot and Sanderson's maps and comparing her own observations: 'The present map is about 20 miles in error westward'. She checked their traverse by daily latitudes, and rounds of horizontal angles, to such distant hills as were visible; 'all we could do'. She described 'bitter blinding days of wind dust which prevented anything like accurate observation'. They were also impeded by 'extraordinary effects of (atmospheric) refraction'. Workman expressed frustration with the maps on which there was 'not a single place of importance even remotely accurate geographically'. However, she was impeded by the same physical difficulties as the previous cartographers.

The 'botanist- explorer' Frank Kingdon Ward borrowed instruments in 1913 and 1924 for expeditions to Tibet.<sup>112</sup> In January 1925 Ward related many of the common problems. He recalled 'watching the snow congeal to ice on the theodolite.' 'As it was still snowing on the third day we had to give up with that went our last chance of fixing our snow peaks, which was rather sad. We have names for some of them, but as we don't know where they are it is not much use'. Ward reported several latitudes and used a chronometer for longitude. 'Unfortunately the observations taken on the night of arrival had to be rejected being quite out probably on account of the high wind making observing difficult, and last night it was too thick to observe at all.'<sup>113</sup> By the 1920s these common setbacks had not been overcome, bad weather was an enduring obstacle.

#### *Human and Political Constraints*

The deterioration in relationships with indigenous people towards the end of the nineteenth century has been noted in chapter 2. As the century progressed, political situations also increasingly dictated where the RGS could operate.

The expedition of Colquhoun was selected because he was lent instruments to go to China in 1881, not hitherto a popular destination.<sup>114</sup> Nicholas Clifford claims the underlying reason for his journey was the possibility of a railway from Burma.<sup>115</sup> Colquhoun related a 'Vexatious delay caused by the difficulty in getting interpreters, servants and coolies on what they considered a wild journey, objectless and dangerous; we eventually found seven. Our medicines and instruments were packed in cases not exceeding 60 lbs, two for a mule and one for a coolie'. He complained of the 'constant labour of surveying and taking frequent angles,' but there is little to show for his efforts in the paper, with measurements usually given as 'about'. His interpreter became insubordinate; one was too fatigued to walk. The principal

---

<sup>112</sup> Waller (1990) p. 140

<sup>113</sup> Ward CB9/151 letter to Hinks 19<sup>th</sup> Jan 1925

<sup>114</sup> JMS/10/85

<sup>115</sup> Clifford (2001) p. 36



impression of this journey is of frustration with indigenous people and disinterest with measurements.<sup>116</sup>

Sir Martin Conway borrowed instruments for six expeditions between 1892 and 1901 to mountainous regions. Two of his journal manuscripts have been studied. 'The RGS will hear more of mountains because the great bulk of the hospitable part of the world has been explored.'<sup>117</sup> As this terrain could only be accessed on foot he stressed the need for light equipment; 'then the mountains will be mapped'. He relied on indigenous people to a great extent, noting both 'the unwillingness of the coolies' and their 'excellent' method of using staves to measure angle of slope.<sup>118</sup>

Conway took temperature readings when it was hot, but not regularly, noting the weather but with no numerical data. He 'made many necessary stops for surveying and collecting', concluding that after two days of sketching, surveying and cataloguing 'all our work was satisfactorily done.'<sup>119</sup> He used a barometer to measure the height, being the pertinent dimension for him. He recounted that they travelled from Skardo to Leh to verify their instruments, but again does not reveal how.<sup>120</sup> He considered surveying was 'necessary', his work 'satisfactory', and the attitude of the coolies an impediment. Conway demonstrated frustration with the 'coolies' as his imperialist culture clashed with that of the indigenous people, as ANT predicts.<sup>121</sup>

Isabella Bird Bishop was the second woman to have borrowed instruments from the RGS; the first, Miss Yule, did not leave inscriptions. Prior to her better-known journeys in China, 'Mrs Bishop' went to Korea in 1894.<sup>122</sup> Here she described various 'hardships and difficulties,' mostly with the indigenous people she relied on. Contrary to RGS stipulations she used 'li' as a unit of length, presumably because she was relying on a Chinese interpreter. Like Duncan and Conway she used the thermometer only when temperature affected the expedition: 'The mercury was at 24 degrees at 6am. In a strong north-easterly wind, the cold was intense'. Mrs Bishop was using her height-measuring instruments but does not mention taking latitude or longitude. She was interested in global physical features such as snow and tree lines and the girths of trees: 'Captain Gill found the snow line to be 13000 feet, and the line of perpetual snow to be 14000 to 15000 feet. The timber line must lie at about 12500 feet.' They climbed a peak which she claimed was 13,017 feet; a coolie was bleeding because of altitude and they declined to carry her and wanted to leave her there.<sup>123</sup> Bishop's poor relations with indigenous people proved a substantial obstacle.

---

<sup>116</sup> Brailey (1999) p. 522

<sup>117</sup> JMS/11/130

<sup>118</sup> JMS/11/129

<sup>119</sup> JMS/11/129 p.12

<sup>120</sup> JMS/11/130, Jones (2014) pp.319 -321

<sup>121</sup> Latour (1987) p. 190

<sup>122</sup> Park (2002) p.515, Clifford (2001) p. 2

<sup>123</sup> JMS/10/102

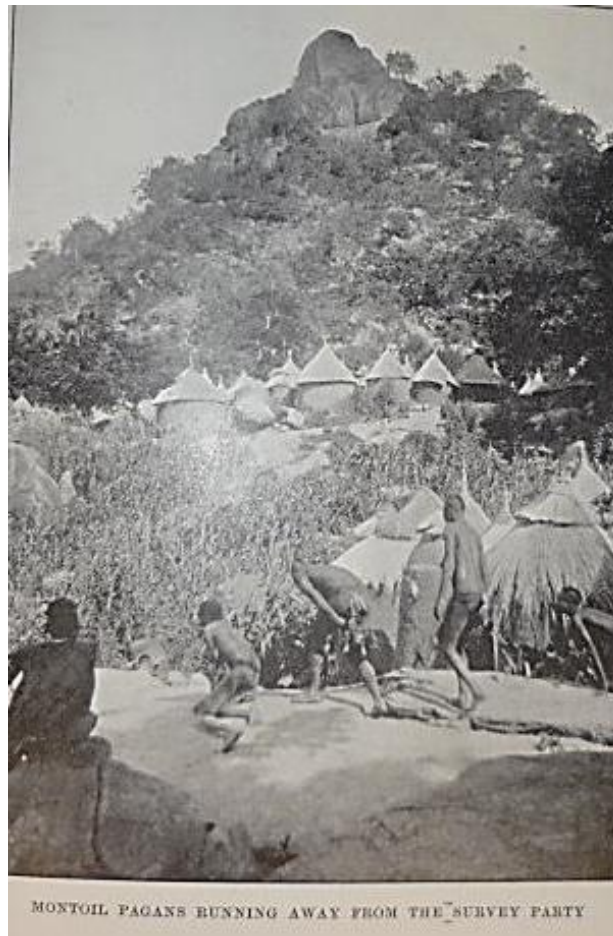


Fig 6.6: 'Montoil Pagans Running Away From The Survey Party' from Joan Alexander <sup>124</sup>

Boyd Alexander's expedition was equally affected by physical and human factors. He did not acknowledge the support of Jose Lopes, a childhood friend from Cape Verde Islands, who was 'absolutely vital to whatever success the expedition experienced,' according to Bedeman.<sup>125</sup> Talbot, a member of the party, got lost in the bush without his compass, but found 'a friendly village where they pointed him in the right direction.'<sup>126</sup> After benefitting from these under-acknowledged human interventions, on his second and last expedition Boyd Alexander ignored political advice not to proceed from Wadai and was murdered in April 1910.

Henry Savage Landor was chosen for assessment in this thesis because, unusually, his work was criticised by the Society.<sup>127</sup> He approached the RGS in November 1896 to

---

<sup>124</sup> Alexander (1977) Control number BG/155D

<sup>125</sup> Bedeman (2000) p. 69

<sup>126</sup> GBG/3 p. 5

<sup>127</sup> EC Dec 10<sup>th</sup> 1896.

borrow instruments for use in Central Asia.<sup>128</sup> On May 28<sup>th</sup> 1897 Savage Landor wrote; 'I am taking 4 men with me and hardly any luggage except instruments. I will follow 30 degree latitude in east direction.'<sup>129</sup> However, by the end of June there had been a disaster: 'The scientific instruments I had at the time of my capture nearly cost me my head! However, I was able to save my diary, and all notes and maps and sketches. All records of astronomical observations are still in my possession.'<sup>130</sup> He had a ransom of 500 rupees on him, with two servants, one with leprosy, but he had pushed on 'unable to light a fire and camping on snow'. They were marching at night and hiding by day.<sup>131</sup>

Savage Landor's colourful exploits were being serialised in the *Daily Mail*, but he was keen to emphasise the RGS would get scientific results. The following April he was still at work on the map: 'Observations so numerous...I have done it with very great accuracy.....daily meteorological observations and the altitudes constantly and carefully measured.'<sup>132</sup> In May he wrote defensively how 'I went through a long additional course with Mr Coles who certified to the Council that I was well up in the use of all the instruments. When worn out half-starved and frozen I had to sit up to register the tedious observations and (with the) trouble of carrying the Society's instruments I spent some £200'.<sup>133</sup> On June 1<sup>st</sup> Savage Landor wrote how 'the box of drawing instruments belonging to the Society is still in the hands of the barbarians'. On the 20<sup>th</sup> he wrote: 'I saved nearly all the instruments belonging to the RGS but they are somewhat damaged. The Tibetans (sic) handled them very carelessly.'<sup>134</sup> Savage Landor recognised the value of the instruments to the RGS but this resource was rendered useless by a variety of factors resulting from his disastrous human interactions both with indigenous people and the Council of the RGS.

Workman's travels were considerably affected by human interventions as well as physical ones, so her expedition has been included in both sections. She relied on others for the instrumental work: she hired two surveyors to triangulate Huascarán to prove she had climbed higher than her rival Annie Peck.<sup>135</sup> She used a topographer and two Italian guides to measure the inclination of the Hoh-Lumba glacier and how much it moved in twenty four hours. On her journey in the Himalayas she gave her own assessment of which factor had affected her most: 'Transport coolies are the great obstacle to high exploration of the Himalaya,' and more bluntly; 'Coolies are lazy dogs'.<sup>136</sup>

---

<sup>128</sup> CM Nov 23<sup>rd</sup> 1896

<sup>129</sup> Savage Landor CB7/55 to Keltie 28<sup>th</sup> May 1897

<sup>130</sup> Hopkirk (1982) p. 118-135

<sup>131</sup> CM June 28<sup>th</sup> 1897

<sup>132</sup> Savage Landor CB7/55 April 20<sup>th</sup> 1898

<sup>133</sup> Savage Landor CB7/55 May 14<sup>th</sup> 1898

<sup>134</sup> CM June 20<sup>th</sup> 1898

<sup>135</sup> Ellis. (2001) p. 133

<sup>136</sup> JMS/11/149 p.1 and p.19



Fig 6.7 a and b: Mrs. Bishop's photograph of her baggage coolies at Chekiang, and a ladies' sedan chair, probably hers, 1895.<sup>137</sup>

Mackinder, described by Ellis as 'one of the most influential geopolitical theorists of the early 20<sup>th</sup> century', borrowed instruments for an expedition to Mount Kenya in 1899.<sup>138</sup> There were six Europeans, including an Alpine guide, ostensibly leaving Mackinder free for observation and survey. Porters were in short supply because of other expeditions. 'We arranged with Major Souttar that the 59 Zanzibarians should be marched to the fort and be isolated for the night. Then they were sent by train to Nairobi. At Nairobi we recruited local porters. With the aid of the Eastern Telegraph Company I fixed longitude telegraphically. The sky was overcast on two successive days selected for the operation. Small pox compelled us to leave Nairobi 170 strong'. 'The 170 comprised '6 Europeans, 66 Swahilis, two tall Masai guides and the rest were naked Wakikuyu'. 'We steered by a mountain. I tried to get shots of sun and stars but it was too overcast'. Hansen has described Mackinder's uneasy relationship with local populations, and while weather and disease played a significant part in obstructing his ambitions, his dictatorial attitude towards the various indigenous people is the most remarkable aspect of his expedition.<sup>139</sup>

William Mersh Strong, who was later Chief Medical Officer and Government Anthropologist, borrowed instruments for expeditions to New Guinea in 1905 and 1907.<sup>140</sup> Strong's instrumental abilities were above average; he took bearings, boiling point readings, barometer readings, temperatures, and longitude by chronometer. He drew sketch maps including contour lines. However, his relationships with humans detracted from his efficacy; his notebook recorded a series of confrontations with indigenous people. A bag with

<sup>137</sup> Control numbers 074054, 077558

<sup>138</sup> EC Feb 6<sup>th</sup> 1899, CM Feb 13<sup>th</sup> 1899, FC Apr 14<sup>th</sup> 1899, Kearns (2009,) Gray (2004), Ellis (2001) p.53, *GJ* (2004) no 4 is devoted to Mackinder

<sup>139</sup> Hansen (1996)

<sup>140</sup> Lawrence (2006), [http://history.prm.ox.ac.uk/collector\\_seligman.html](http://history.prm.ox.ac.uk/collector_seligman.html) May 2017

observing instruments was left behind 'owing to lack of concern' on their behalf.<sup>141</sup> He was held up by fighting between groups. Later he was forced to pay off his thirteen carriers due to food shortages.<sup>142</sup> In the continuation to the paper written with Seligmann, Strong admitted 'all the heights are incorrect' due to an error with the barometer.<sup>143</sup> Barometers were usually carried by porters which may have caused this particular problem.

Mark Aurel Stein explored ancient remains in Central Asia in 1906. Two years previously he expressed regret at the difficulties of obtaining access into Tibet.<sup>144</sup> In June 1905 he had hatched a plan. Writing from the 'North West Frontier' he asked for the loan of 'a few simple instruments without the object or even the fact of my journey becoming public.'<sup>145</sup> Keltie agreed but suggested that 'The Indian Government should supply your native surveyor,' possibly indicating the RGS believed they were only responsible for equipping Europeans.<sup>146</sup>

Stein's expedition suffered deprivations common to many: 'trying conditions of ground and climate', principally shifting sand and intense cold. 'Over the sea of sand there was nothing to guide us except the compass. Never before had ground been so confusing.'<sup>147</sup> They used timed marches for length, did not take astronomical observations, but felt they had improved on the Russian's charts.<sup>148</sup> More remarkable was that Stein's expedition required considerable human support in the form of labourers to supply water from thirty miles away, as the expedition was to spend considerable time in areas without sufficient cultivation to sustain them.

By October 1906 Stein had dispatched an Indian surveyor, Ram Singh, to cover the snowy range about Karlik Darwan which had never been fully surveyed, and to the upper Karakash from whence access might be gained to the 'last bit of terra incognita remaining here'. 'While I was busy.... Rai Ram Singh has under my instruction carried out a systematic survey by plane table and theodolite through a still unexplored section of Tashkurgan River Valley.'<sup>149</sup> Ram Singh's plane table survey covered 24,000 square miles. The positions of numerous stations were fixed astronomically by theodolite and heights by mercurial barometer and clinometer. Unfortunately, Ram Singh lost his eyesight to disease and was replaced by Lal Singh, another experienced surveyor.<sup>150</sup> Stein's setbacks included all those associated with uninhabitable country. With substantial and expert human intervention Stein was able to overcome these.

---

<sup>141</sup> WMS Obs 76 (1905)

<sup>142</sup> WMS Obs 76 Additional data Nov 8<sup>th</sup> 1905

<sup>143</sup> Mersh and Seligmann (1906) p.347

<sup>144</sup> Stein CB7/81 letter to Keltie Aug 10<sup>th</sup> 1904

<sup>145</sup> Stein CB7/81 letter to Keltie June 15<sup>th</sup> 1905

<sup>146</sup> Stein CB7/81 letter Keltie to Stein Feb 6<sup>th</sup> 1906

<sup>147</sup> JMS/7/127 Letter July 5<sup>th</sup> 1908.

<sup>148</sup> Stein CB7/81 Letter to Keltie July 10<sup>th</sup> 1906

<sup>149</sup> Stein CB7/81 Letter to Keltie Oct 10<sup>th</sup> 1906

<sup>150</sup> JMS/7/127 Letter 10<sup>th</sup> Dec 1907 p. 11, Raj (2002) discusses earlier 'pundits', Waller (2015)

Douglas Carruthers, vicar at Holbrook, and ornithologist, borrowed instruments for an expedition to Ruwenzori, Africa in 1905-06 where he climbed Mount Kiyanja.<sup>151</sup> Carruthers reveals the deterioration of relations with indigenous people: When in Congo in 1906 he complained; 'When the natives see us they run away so we can't get food. We have to have a guard of about 20 soldiers'. Carruthers set out on another expedition in 1909.<sup>152</sup> He noted the advance of 'civilisation' had adverse effects: 'The railway hinders the traveller because the tribes are hostile to the line. I had to make friends with some powerful Bedouin tribe.' Like many others he measured length by timing paces of animals, in this case camels, however, he spent 14 days waiting for them. 'I now kept my observations as best I could with compass and watch, noting every hour I rode as well as the pace and direction. On camels one travels very straight at a very even pace'.<sup>153</sup> Like others he compared his results with those gathered previously: 'At the edge of the dunes the aneroid registered 2300 feet, which corresponded with Blunt's observations but Mr. Doughty's readings were much higher.'

Carruthers was dependent on his guide: 'Having travelled a whole day without knowing where we were', his guide picked up his bearings. At night they travelled by the stars. He related that he was nearly killed and would have been if his guide had not been there. His possessions were stolen but he was fortunate not to have died. In Carruthers' case it appears that a good relationship with his guide saved his life.

#### *Logistical Issues*

Several expeditions were affected predominantly by issues concerning supply lines and communication networks.

William Ainsworth was lent instruments in 1838 for his journey to Kurdistan, the particular focus of which was magnetic observations with the newly-designed magnetometer of Gauss and Weber along the route through Europe.<sup>154</sup> He wrote that 'The observations on the intensity of the horizontal force were made with two pairs of cylindrical needles vibrated in small arcs similar to the apparatus of Mr. Heemsteen; and differences of strength in supporting silk avoided'.<sup>155</sup> The second pair of needles had been 'brought to a steady, although with regard to each other, unequal force by immersion in boiling water.' While Ainsworth was aware of the need for calibration, he was not totally successful in achieving it.

Ainsworth and his colleague Bushell were careful to keep the observer and teller the same for each observation, but had difficulties with maintaining immutable mobiles.<sup>156</sup> Unfortunately the dipping needle was 'rudely examined' by Customhouse Officers at the Sardinian frontier and therefore the observations at Isella were deemed not good. Ainsworth

---

<sup>151</sup> JMS 9/248

<sup>152</sup> JMS 9/248

<sup>153</sup> Rennell (1791)

<sup>154</sup> CM June 11<sup>th</sup> 1838, Ainsworth and Sabine (1838)

<sup>155</sup> Enebak (2014) p. 593

<sup>156</sup> Mercer (1972) <http://www.marinechronometers.co.uk/archive.html>

sent his needles back to Sabine for checking. Sabine asserted their magnetism unchanged, and had a card case made for them, 'such as will protect them.'<sup>157</sup> The chronometers were more troublesome: at Milan the chronometer was losing eight seconds per day and changing rate. By the time they were in Therapia, they had substituted the Molyneux chronometer for one by Bent which was losing three seconds a day. In 1840 Ainsworth was caught up in the battle of Nezib and lost his instruments.<sup>158</sup> His journey was disrupted because the replacement instruments did not arrive. His artificial horizon had no cover and was too much disturbed by wind to allow more than an occasional observation.

I regret to say that the instruments have arrived mashed to pieces, notwithstanding that I went to the expense of a post messenger. They were probably put upon camels and the consequences that might have been anticipated have occurred. The barometer is broken in two places and the thermometer attached to it. The beautiful thermometer you were so kind as to send me was smashed to pieces....., and the artificial horizon which is too good for this country....the warping of the wood by heat no longer allows the glass to fit. I shall however be able to set it right..... I shall now soon get the chronometer mended.<sup>159</sup>

He argued that it would have cost double their value if he had fetched them, as they had arrived at Alexandria not Beirut, where the shippers, Messrs Laird and Co, had a boat going. By late August Ainsworth was desperate.<sup>160</sup> In October he wrote from Constantinople that 'I have not been able to do anything worthy of the Society.'<sup>161</sup>

Ainsworth failed to mobilise instruments successfully due to circumstances beyond his control. Political difficulties had intervened, but more importantly systems were not in place to provide instruments. Neither the RGS nor Ainsworth had no control over shipping, could ensure the provision of undamaged instruments, or instruments appropriate for the particular location.

Richard Burton and John Hanning Speke travelled to the great interior lakes of East Africa between 1856 and 1859.<sup>162</sup> A range of issues facing them was communicated by Speke to Norton Shaw in letters containing detailed accounts during their travels. While a range of problems beset them, logistical problems were paramount.

In August 1857 Speke wrote to Shaw complaining that 'the barometer ordered from Dixey had not come to hand nor even been heard of.'<sup>163</sup> In November, he complained 'You will express my regret from incapacity at not having taken many observations for latitude. I had a sharp stroke of fever.'<sup>164</sup> However, 'by careful observation of distance by time taking

---

<sup>157</sup> Sabine CB2/471 letter to Washington Oct 20<sup>th</sup> 1838

<sup>158</sup> Ainsworth CB2/10 letter to Washington July 11<sup>th</sup> 1840

<sup>159</sup> Ainsworth CB2/10 letter to Washington July 20<sup>th</sup> 1840

<sup>160</sup> Ainsworth CB2/10 letter to Washington Aug 30<sup>th</sup> 1840 from Mosul

<sup>161</sup> Ainsworth CB2/10 letter to Washington Oct 16<sup>th</sup> 1840

<sup>162</sup> Burton and Speke (1858), Wisnicki (2008), Carnochan (2006), Finkelstein (2003)

<sup>163</sup> JHS/1/1 Letter to Shaw 20<sup>th</sup> May 1857

<sup>164</sup> JHS/5 Nov 20<sup>th</sup> 1857

into account the curvature of the track' he had measured distance. 'Another source of great regret is the destruction by a fall whilst boiling of our last thermometer. I am now reduced to a bath with a thermometer by Newman...it is cut to degrees but readable closer'. The post between them and Zanzibar was poor so communication of data was slow.

The following July Speke wrote again to Shaw; 'what torments me most in this journey is the inability to take lunars and fix the longitude'. He was despairing of getting them because of want of an assistant to take the time, as Burton had always been ill:

When we have an opportunity for a lunar his eyes become bad. I took one but then my eyesight was very bad so I had much doubt concerning it. I sent its elements for you to work out as I have not got the Moon's semi-diameter for this month.<sup>165</sup> At Zanzibar where I had adjusted the pedometer to show distances at the initial marching pace of laden porters, believing then we should travel with oxen, but arrived at Kaolay to find that there were nothing but donkeys procurable. These animals require so much attention, travel at such various rates and so the pedometer was rendered next to useless. The watch also was of no avail for timings....the compass bearings have been done by guess work...I judged as well as possible what the direct distance would be of the zig-zag path, and applied it to the latitude'.<sup>166</sup>

Over twenty years after its first sponsored expeditions, the RGS had failed to provide delivery of functioning and appropriate instruments or current data, and the use of the artificial horizon was damaging to the eyes in low latitudes. The Society had no control over local transport; length measurement was virtually impossible; instrumental resource was squandered in such ways.

Dr Ogilvie Grant proposed a zoological expedition of Dutch New Guinea in 1908.<sup>167</sup> Wollaston, who had previously travelled with Carruthers, decided within days that he would join it.<sup>168</sup> However, this expedition became a battleground between surveying, the focus of the War office, and various forms of collecting as championed by Ogilvie Grant. Grant stipulated that men would not be available for surveying if doing collecting work; Cecil Rawling from the War Office wanted the survey party to be separate from the collectors as he needed carriers specifically for the survey.<sup>169</sup> Rawling was granted instruments in July 1908.<sup>170</sup> Wollaston was engaged to look after the 'heart' of the expedition and to collect specimens. He was required to take the RGS diploma.<sup>171</sup>

At that time Dutch New Guinea was the site of six Dutch expeditions.<sup>172</sup> The RGS expedition was arriving at the height of the rainy season and the sea was too rough for a relief ship to land. Keltie responded: 'You wont (sic) have trouble getting ahead of the Dutch

---

<sup>165</sup> JHS/1/2 Letter to Shaw 2<sup>nd</sup> July 1858

<sup>166</sup> JHS/1 letter to Shaw 2<sup>nd</sup> July 1858, Rennell (1791)

<sup>167</sup> LMS B 46, 1<sup>st</sup> Dec 1908

<sup>168</sup> LMS B 46, 11<sup>th</sup> Dec 1908

<sup>169</sup> LMS B 46 Rawling to Keltie 15<sup>th</sup> May 09

<sup>170</sup> EC July 15<sup>th</sup> 1909

<sup>171</sup> LMS B 46 letter Keltie to Wollaston 30<sup>th</sup> Jan 1909

<sup>172</sup> LMS B 46 Rawling to Keltie Dec 3<sup>rd</sup> 1909, Overweel (1998) p. 455



expeditions.<sup>173</sup> Rawling wrote on the same day saying that the chronometer had been mended but 'does not keep as good time as formerly'. By 1910 the half chronometer watches were 'behaving very badly. They gain eight or ten seconds a day, then lose that much. This wont help our longitudes very much.'<sup>174</sup> Rawling reported 'practically no information of geographical importance'. He had met up with Wollaston, but the coolies had all departed as they had only been engaged for six weeks. The Ghurkas, however, were 'invaluable'. Progress was extremely slow and difficult: 'nothing can be seen as solid growth hems one in on every side'.<sup>175</sup> Rawling also wrote to Reeves;

The map is slowly growing but you would faint with disgust at its size if you saw it. We have never been able to get a measured base, of any sort, no amount of cutting would enable us to make one. Instead our base is a latitude base lying nearly due north and south and as the latitudes at either end have been taken several times they are pretty accurate. The distance between is 22 miles. To obtain a view of the mountains from the north end we had to clear 14 acres of forest, which took three and a half months,.... This is not the country for theodolite work in any form. No star was visible for 3 months. Dense jungle everywhere, no open ground, incessant rain, and all hope of reaching snows given up. The country supplies no food whatsoever. The natives assist a bit or we should have done nothing. We can't get exact heights as we can't see the foot of the precipice or reach it.... Only Wollaston, Marshall and 6 Ghurkas are left. 20 have died and 83% invalidated.<sup>176</sup>

Even by the twentieth century the Society could exhibit a lack of forethought. Rawling stated clearly that 'This is not the country for theodolite work', and yet theodolites had been lent. Acceptable quality surveying in this terrain required teams of people employed for months in clearance work, and the necessary resources were not provided. While the indigenous people were crucial, nothing had been organised to sustain the personnel.

Steers applied to join the RGS expedition of 1928 to Australia.<sup>177</sup> He was one of the first travellers to use the phototheodolite; the expensive instrument which the RGS had purchased in 1926. On June 30<sup>th</sup> he discovered a defect in the camera which made him 'much worried', sending a wireless message at Socotra; 'The two stereo plates of Gibraltar were bad failures'. On July 27<sup>th</sup> at Sydney he was able to have his instruments repaired; however, when he called for the camera, the reflex lever broke. Through careless navigation they ran into a mud bank on August 11<sup>th</sup>; 'Things not going too well as far as the expedition is concerned' he reported. Steers took stereopairs and made arrangements with Kodak for developing them. On 27<sup>th</sup> August Steers recorded that 'The photos taken yesterday were not a success, somehow they were blurred and two of them miss fired altogether. Two tiny

---

<sup>173</sup> LMS B 46 Keltie to Rawling 3<sup>rd</sup> Jan 1910

<sup>174</sup> LMS B 46 Rawling to Keltie 3<sup>rd</sup> Jan 1910

<sup>175</sup> LMS B 46 Rawling to Keltie 8<sup>th</sup> March 1910

<sup>176</sup> LMS B 46 Rawling to Keltie Dec 15<sup>th</sup> 1910

<sup>177</sup> JAS/1

holes found in the shutter. I do hope the camera is all right'. On August 30<sup>th</sup> he was 'worried about results- but best not to think about that now.'<sup>178</sup>

During September the frustrations continued: Sept 1<sup>st</sup> was spent triangulating the area for a photo-survey. Like Ramsay he was sceptical of the value of a survey for larger questions: 'The more I think about the reef the more I am convinced one needs to think in general or abstract lines rather than by adopting survey methods to certain areas.' The following day 'We were busy with the photo theodolite.... ..we were very heavily laden and it was almost more than we could do to get the stuff from place to place. We have decided to finish it in the morning and after that I think we shall confine ourselves to geographic work and general physiographic work and get about more.'<sup>179</sup> There was a change of plan, however, the reasons for which were not clear but must have resulted from instructions from London: 'I have decided to do survey work during the time I am here. It means cutting down on activities very much and also preventing our seeing the coastal features in general'. By late September Steers was surveying as much as possible with a plane table and levelling staff.<sup>180</sup> 'Rather steep slopes made carrying apparatus rather risky. Spender got stuck and I must not risk the apparatus in this way'.<sup>181</sup> The tide gauge was held up by a strike.<sup>182</sup>

Steers' expedition has been described as a fiasco, and it is difficult to see results in comparison to the resources invested. Steers was not an enthusiastic surveyor, and appears to have had surveying thrust upon him. He was impeded by heavy apparatus without appropriate transport, thus demonstrating a disadvantage of untested technology.<sup>183</sup>

Major Robert Cheesman borrowed instruments for Northern Arabia in 1923, and then for Abyssinia in 1925, 1927 and 1929. In 1920 he had been 'fixed up with a course of instruction with Mr Reeves.'<sup>184</sup> In a letter to Hinks of 1921 he described borrowing instruments in Bursa; 'the chronometer was a ship's and was rather like travelling with a grandfather clock'. I had to carry it myself as 'a ship's chronometer on a camel is not of much account.' The result was six pairs of observations, 'thanks to Mr. Reeves.'<sup>185</sup> In a more candid letter to Reeves, Cheesman wrote that: 'The atmosphere is not conducive to good map making' as the thermometer was reading 120F.<sup>186</sup> In 1923 his instruments arrived unscathed but he was charged by customs £12.<sup>187</sup> 'I took prismatic readings all the way; I am plotting them myself before sending them to Reeves'.

---

<sup>178</sup> JAS/1 June 30<sup>th</sup> 1928

<sup>179</sup> JAS/1 2<sup>nd</sup> Sept 1928

<sup>180</sup> JAS/1 Sept 20<sup>th</sup> 1928

<sup>181</sup> JAS/1 Sept 23<sup>rd</sup> 1928

<sup>182</sup> JAS/1 October 1<sup>st</sup> 1928, October 10<sup>th</sup> 1928

<sup>183</sup> Bowen and Bowen (2002) p. 274

<sup>184</sup> Cheesman CB9/38 Letter to Hinks May 9<sup>th</sup> 1921

<sup>185</sup> Cheesman CB9/38 letter to Reeves July 4<sup>th</sup> 1921

<sup>186</sup> Cheesman CB9/38 letter to Reeves July 4<sup>th</sup> 1921

<sup>187</sup> Cheesman CB9/38 letter to Hinks 30<sup>th</sup> Mar 1923



Fig 6.8: Cheesman with his camel boy and camel near the Dohat Salwa Coast, 1921.<sup>188</sup>

For his 1927 expedition Cheesman was supplied with a very cumbersome wireless receiving apparatus at a total cost of £192 15s.<sup>189</sup> Unfortunately the high tension batteries were damaged on arrival, and the spare battery had run down. Following that, the wireless set was not allowed into Abyssinia: 'The important thing now is to get a few, even one or two, wireless longitudes but how to do it I don't know.'<sup>190</sup> It was explained by the Consul at Dangila that it was unwise to take accumulators to a place where re-charging was impossible.<sup>191</sup> Writing from Khartoum the following October, Cheesman stated: 'Maps are of little use for this route between Gallabat and Lake Tana'. The distances are given as marching hours for loaded mules at 2.5 miles an hour although 'Distances must not be considered accurate.'<sup>192</sup> 'Altitudes were taken daily by aneroid and frequently by boiling point thermometer. When worked out they will give altitude with a fair degree of accuracy', notwithstanding Cheesman's later claim that both these methods were inaccurate.<sup>193</sup> Other setbacks included a chronometer which had not been rated since Khartoum, the theodolite box falling off a mule, and having to guess rainfall. Cheesman recognised that what was needed was 'a few longitudes' to 'strayhten' (sic) the map.<sup>194</sup> In general there had been no

---

<sup>188</sup> Control number 092709

<sup>189</sup> Cheesman CB9 list attached to letter Nov 24<sup>th</sup> 1927.

<sup>190</sup> Cheesman CB9 Letter to Hinks Jan 29<sup>th</sup> 1928

<sup>191</sup> Cheesman CB9 20<sup>th</sup> Jan 1928

<sup>192</sup> SSC/18 REC 23 Oct 24<sup>th</sup> 1928 letter to Hinks

<sup>193</sup> Cheesman (1936)

<sup>194</sup> SSC/18 REC 23 Letter to Reeves 6<sup>th</sup> Dec 1906

recognition of the maintenance issues of recently- introduced apparatus. While his letters were peppered with numbers, each and every measurement was suspect.

### *Systemic Issues*

Probably the most inconspicuous aspect of collecting instrumental data was the underlying supporting measurements on which the observations were based.

The Arctic explorer John Rae undertook several expeditions and was involved in the search for Franklin. He was beset by many categories of difficulty: the ability of his team was dubious, there were substantial physical challenges, and the logistical issues took their toll. Rae was able to overcome these by his stoicism and perseverance, and by good relations with the esquimaux. However, much of Rae's instrumental work was invalidated by systemic failures.

Rae received instructions in 1846 from George Simpson of the Red River Settlement to map the northern shoreline of America following the work of Peter Dease and Thomas Simpson.<sup>195</sup> 'You will obtain latitude and longitude of all the remarkable points....but also botany, geology, zoology, temps of air and water, atmosphere, ice, winds, currents, soundings, magnetic dip and variation, the aurora and refraction, and the esquimaux, and interesting features of the long night. Keep a diary and collect any interesting specimens. Rae complained of the ability of his team and the inadequacy of his instruments: 'Richardson has almost entirely forgot the mode of taking observations.' 'The sextants supplied by the Government are neither of them any good, and are not at all well suited for taking the most accurate observations-such as Lunar Distances.'<sup>196</sup>

The first detailed accounts of his expeditions sent to the RGS were those of his journey through the Great Bear Lake and Victoria Land in 1851 which were in diary form.<sup>197</sup> Writing from a provision station on Kendall River in June 1851 he described how he took latitude, time, temperature and direction. Latitude was understandably of more interest than longitude, although, one without the other did not constitute finding position. Occasionally Rae took longitude by a lunar, although 'one of the men got rather deeply frost bitten in the face' so taking lunars was 'rather unpleasant.'<sup>198</sup> From then they took latitude and longitude 'by account'; i.e. by dead reckoning. Rae measured length by an estimate of walking speed.<sup>199</sup>

In his second paper Rae took latitude without longitude frequently, although he had a chronometer.<sup>200</sup> He reported the variation was sluggish so not reliable. 'The compass was useless because it was being acted upon by pyrites'.<sup>201</sup>

---

<sup>195</sup> JMS/4/27 Letter from George Simpson to Rae 15<sup>th</sup> June 1846

<sup>196</sup> Rae to Simpson from Portage la Loche, 5 July 1848 PAC microfilm HBC 4M22/E.15/5, Levere (1993) p. 206

<sup>197</sup> JMS 17/21

<sup>198</sup> JMS 17/21 paper 1 p.4

<sup>199</sup> JMS/17/21 paper 1 p. 5 and paper 2 p.18

<sup>200</sup> JMS/17/21 paper 2 p.11

A later expedition for which Rae borrowed instruments was in the yacht 'Fox' in 1860.<sup>202</sup> Rae took heights but the aneroid and mountain barometer did not agree, so he 'stuck to the mountain barometer'<sup>203</sup>. The weather was too foggy for any but barometrical measurements.<sup>204</sup> He took soundings but lost the lead so the soundings were 'not certain.'<sup>205</sup> Rae took heights and latitudes when possible, but if the fog was too thick only altitudes, so he was taking heights at points he could not locate. He did not usually take longitudes on land, using the chronometer when on board the Fox. Occasional longitudes enabled them to position themselves on the chart, but the chronometer was giving measurements thirty miles further east.<sup>206</sup> Rae suffered most types of problem but the uncertainty of his soundings, and the fact did not integrate latitude and longitude, and therefore did not know where he was taking his height measurements, rendered all these observations useless.

The Arctic expedition of 1875-6 suffered from physical effects, but the underlying cause was principally because of a lack of adequate knowledge of the coast of Greenland. Having not attempted the high Arctic since the loss of Franklin, Clements Markham was keen to revisit by the 1870s.<sup>207</sup> The expedition team was led by George Nares. 'Success' or 'failure' depended on latitude reached; the scientific work was for appearances' sake.<sup>208</sup> They decided 'not to risk failure by pushing away from land, if the Alert could winter in 84 (degrees) there is the certainty of reaching a very high latitude by sledge travelling.' Every opportunity was taken to emphasise the new knowledge that would be gained: Four men 'were all fully occupied with magnetic observations during several days, obtaining satisfactory, independent results for dip and variation.' 'There will be plenty of scientific work for the officers, and instruction.'<sup>209</sup>

---

<sup>201</sup> JMS/17/21 paper 2 p. 16

<sup>202</sup> LMS 387c

<sup>203</sup> LMS 387c 4<sup>th</sup> Aug 1860

<sup>204</sup> LMS 387c 6<sup>th</sup> Aug 1860

<sup>205</sup> LMS 387c 7<sup>th</sup> Aug 1860

<sup>206</sup> LMS 387c 24<sup>th</sup> Sept 1860

<sup>207</sup> Berton (1988) p. 411

<sup>208</sup> CM June 14<sup>th</sup> 1875

<sup>209</sup> JMS 17/90



Fig 6.9: A sketch by A.H. Markham entitled 'Commander Markham's farthest north' in 1875  
210

Another aspect of the expedition was taking deep sea soundings between fifty seven and sixty degrees north with the *Valourous*, an old paddle-wheel steamer 'not really fitted to the ice'. Dredgings and soundings were taken twice a day at sixty seven degrees north, and sea temperatures at the surface and the sea bed taken throughout Davis Strait and in the Atlantic. Tables were kept of latitude and longitude by chronometer. Nares did not want to take the responsibility of departing from the coast of Greenland in case the ice did not remain stationary and unbroken.<sup>211</sup> However, unless the coast of Greenland extended beyond eighty three degrees they would not get further than previous expeditions. Nares continued with his measurements in deteriorating conditions.<sup>212</sup> He measured the depth of ice as being 7.5 feet, and made a rough calculation of the volume of mobile ice. The physical aspect of Arctic sledging had a considerable impact on the ability of the men to provide reliable and consistent instrumental observations, but the underlying issue faced was the lack of knowledge of the coast of Greenland which made the expedition all but futile.

Expeditions using new instruments to measure phenomena not previously the subject of scientific study were especially vulnerable to systemic problems.

---

<sup>210</sup> Rgs 0214-021498

<sup>211</sup> JMS 17/90

<sup>212</sup> Nares (1876-7), JMS/17/96

In 1878 Henry Forbes asked the RGS Council for instruments to visit the Cocos and Keeling Islands in order to monitor changes since the time of Ross and Darwin.<sup>213</sup> His observations were devoid of measurements. He recorded instrumental results only if they affected the expedition in the manner of a travelogue. There was no apparent attempt to take heights despite borrowing the appropriate instruments, he did not use numerical compass bearings, and recorded only one sounding.<sup>214</sup>

Forbes had further opportunity following the 1883 eruption of Krakatoa when he was in Batavia. On 26<sup>th</sup> August the date of the catastrophe, Forbes recorded that:

Abnormal atmospheric and magnetic displays were observed. The barometer rose and fell many tenths of an inch in a minute, the compass needle rotated violently. The waves came and went across the oceans four times before they became inscrutable to our instruments. While the tide gauges have recorded this story, the delicate fingers of the barometrical registers of the World have also borne uninfluenced testimony to a force which caused the barometers in the neighbourhood to rise and fall with unparalleled rapidity. 'General Strachey has now examined a large number of barographs from which he has been able to fix the dates of the atmospheric undulations.'<sup>215</sup>

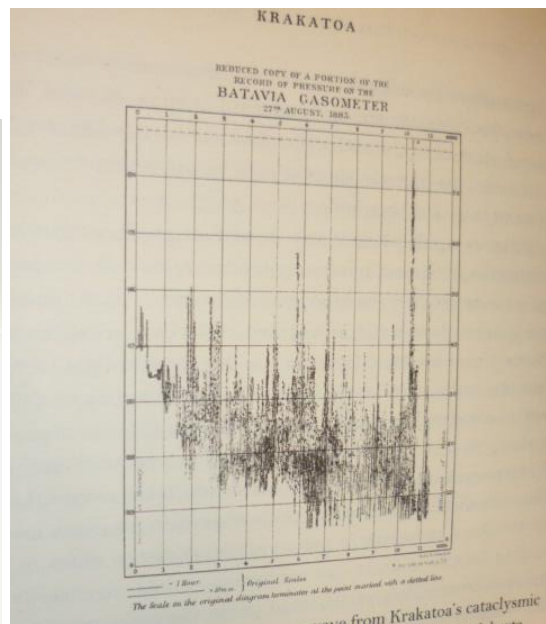


Fig 6.10 a and b: Barograph by Casella and recording of tremors for the Krakatoa eruption of 1883 from pressure on the Batavia Gasometer 27<sup>th</sup> August 1883.<sup>216</sup>

<sup>213</sup> Forbes CB6/ 814 letter 5<sup>th</sup> Oct 1878, CM Nov 11<sup>th</sup> 1878, Darwin (1874)

<sup>213</sup> JMS 18/17

<sup>214</sup> JMS/8/64

<sup>215</sup> JMS/8/65

<sup>216</sup> Artefact A 32, Symons (1888) plate iX

'Uninfluenced testimony' was now being gathered of global phenomena by instruments spanning the Earth in an extension of the systems that science relied on. In particular self-recording instruments were seen as free from human subjectivity.<sup>217</sup> The systems of science were being constructed to extend the spatial remit of local knowledge in the way Schaffer describes (see chapter 2).

Dr. John Milne was chosen for inclusion in this chapter because of his interest in seismology.<sup>218</sup> He contributed to the design of seismographs, being credited with the invention of the horizontal instrument in 1880.<sup>219</sup> He refers to work in Japan; a popular destination for those interested in this topic.<sup>220</sup> In 1896 he remarked that seismography had been little studied. Taking sea level as static it could be seen 'that certain rocks are now above it, sometimes ten feet'. 'We need to know the rate of formation of these hills'. Milne chose Yedo because it was a 'nearly closed bay', which, he believed, would allow a study of height variation.

Milne divided Japan into fifteen seismic districts and recorded 9000 shocks. He suggested examining how the shocks were affected by barometric pressure and tides. He assigned 'weights' to previous measurements according to their accuracy, and looked for periodicity. 'The knowledge of the intensity of our Earth is chiefly based on the revelations of the thermometer and plumb line, but the records of seismographs may throw a flood of light that the quantities are real has been verified by numerous experiments, in which columns of brick work have been rocked back and forth'. During the afternoon of April 17, 1889, he saw his pendulum swing in a strong, regular movement. A few months later he realised his instrument had recorded a powerful earthquake in Japan. 'Two of the latter instruments placed 1000 feet apart have synchronised in the direction of displacements, first in one direction for about ten days and then in the other. It is premature to assume that what is being measured is change in the inclination of the Earth's crust.'<sup>221</sup> Milne had encountered a problem not previously met with by the RGS travellers under investigation. He had measurements but could not interpret them.

Frederick Selous, an elephant hunter and later member of Cecil Rhodes' British South African Company, borrowed instruments in 1888 and in 1895 for expeditions to South Africa.<sup>222</sup> A letter from him to the RGS on his first expedition in the Transvaal revealed common pitfalls. Selous was comparing his measurements with previous maps. 'I had to twist the whole thing to the West in order to bring my map to agree with Mr. Ravenstein's.' He suffered from a lack of landmarks, an inability to use the compass due to iron deposits, a lack

---

<sup>217</sup> Bourguet, Licoppe and Sibum (2002) p.7

<sup>218</sup> Musson, (2013) Agnew (2002) p.6-7 Warner (2015) p.166

<sup>219</sup> Clancey (2006)

<sup>220</sup> JMS/20/66

<sup>221</sup> <http://seismo.berkeley.edu/blog/seismoblog.php/2010/04/17/title-8> Mar 2017

<sup>222</sup> JMS/2/258, JMS/2/274, Mandiringana and Stapleton (1998) p.199



of knowledge of the error of the compass, and a common problem for heights; 'I took aneroid readings all over the country but will not answer for their starting point.'<sup>223</sup>

In 1895 Selous obtained much information from indigenous peoples for which he was appreciative. He got his sketch maps to agree using bearings and distances, although, in some places he was prevented from taking bearings because; 'the country was hilly and always thickly wooded, without there being any conspicuous land marks'. He reckoned that the compass error was about twenty degrees; presumably he meant variation, but this is high. He was honest about the uncertainties of his measurements: 'As to any altitudes I suppose they are not worth much.'<sup>224</sup> Selous produced details but without an underlying system of reference, such as the starting point for height differences, these were worthless.

The first of the large-scale twentieth-century expeditions was the British National Antarctic Expedition, 1901–4, generally known as the *Discovery* Expedition.<sup>225</sup> This was led by Captain Robert Scott. Its remit was wide: 'To carry on meteorological, oceanographic, geological, biological and physical investigations' in addition to magnetic survey.<sup>226</sup> The total cost of the expedition was £92K, over half of which was the commissioning of the ship, which has been noted was a 'throwback' being made of wood and primarily meant to sail.<sup>227</sup>

The outlay in instruments for Scott's *Discovery* expedition was considerable: nearly £783 was spent between July 1899 and Oct 1902.<sup>228</sup> The Admiralty also supplied some instruments.<sup>229</sup> A complete list of these was published in a small pamphlet; apart from the routine ones it included four thermographs, a sunshine recorder, three anemometers, two earth thermometers, a polariscope, five sounding machines, three spectroscopes, a wedge photometer, a Fox dip circle, Barrow's dip circle, a Lloyd-Creak (L.C.) instrument for inclination and intensity of the magnetic field and a Milne seismometer.<sup>230</sup> New developments were introduced such as the Petterson-Nansen insulating water bottle to maintain the temperature of water samples.

Before starting there were attempts to calibrate the instruments, although this appears not to have been comprehensive.<sup>231</sup> The barometers were compared at Christchurch, New Zealand, and corrections were applied to index error, capacity and capillarity, but not for temperature and altitude.<sup>232</sup> A barometer by Negretti and Zambra to be used on gravity observations had no corrections applied. Time was signalled electrically from Wellington, New Zealand, and the Molyneux chronometer was tested against it and found to

---

<sup>223</sup> Göttsche (2013), <https://books.google.co.uk/books?isbn=1571135464> Mar 2017

<sup>224</sup> JMS/2/274

<sup>225</sup> British Antarctic Expedition (1903 a,b and c)

<sup>226</sup> Instructions to the Commander March 1901, bound in CM

<sup>227</sup> NAE Account, bound in CM Dec 902-Jan 1903, Barczewski (2007) p.23

<sup>228</sup> NAE Account, bound in CM Dec 902-Jan 1903

<sup>229</sup> AA/9/1/1-34 3<sup>rd</sup> Feb 1900

<sup>230</sup> AA 9/1/25

<sup>231</sup> AA/10/2

<sup>232</sup> Hicks no 895 Marine pattern

be 12.56 seconds slow. The navigator Cuthbert Armitage wrote to Scott: 'As the *Discovery* is lively in a moderate sea I find that it requires considerable amount of practice to attain that degree of celerity, confidence and accuracy with the Fox and L.C. circles which is desirable. It is impossible to use the statical weighted needle supplied with the L.C for it acts as a pendulum and swings entirely out of the field. I regret to inform you that the fine point of the axis of the needle in use with the Fox has been broken, and that all the needles were found to be slightly rusted when taken out of their cases.'<sup>233</sup> Armitage advised Scott to take spare needles.

The following year Creak remarked on the magnetic observations made on the *Discovery* between the Cape and Lyttleton. 'The observations have been much hampered by the bad weather and lively character of the ship in any leeway.' The variation measurements were not reliable because of 'heavy lurching'. Also there were no base observations for the Fox dip circle at the Cape. 'Those taken at Christchurch when they arrived will not be sufficient to calculate anything like reliable results.'<sup>234</sup> Markham wrote to William Farr at Christchurch Observatory in March 1902: 'Some excellent observations were made on board but the copy we were sent has no record of whether they were made at the standard compass position or the Fox position.'<sup>235</sup> The bearing was worthless without knowing where it was taken.

When the relief ship *Morning* returned with news of the party, the longitudes, which were not far from 180 degrees, were not known to be East or West.<sup>236</sup> Creak revealed doubts: 'I propose to tackle the *Discovery's* observations and calculate the results... I shall then be able to see what is the full value of them.'<sup>237</sup> The expedition's observations eventually became the subject of financial wrangles between the RGS and RS.<sup>238</sup>

The physical deprivations of the expedition made the scientific outcome less of a focus of attention, but as the basis for much of the instrumental data was flawed, so the considerable resource was squandered. The RGS was unable to provide calibrated instruments which would perform effectively in the inadequate transport it had procured. Even if the Society had provided these, the results were undermined by lack of basic information.

Vaughan Cornish was described as 'an aesthetic, political historical and physical geographer, prominent activist for countryside preservation, mystic, writer on waves, eugenist, and family historian'.<sup>239</sup> His strategic geography has also received attention, and his work on physical geography connected with wave phenomena has been described.<sup>240</sup> He had a very distinct set of interests compared with other explorers, being fascinated by waves of

---

<sup>233</sup> AA/10/2

<sup>234</sup> AA/10/2 remarks to Wharton from Creak Mar 1902

<sup>235</sup> AA/10/2 Letter to Farr 21<sup>st</sup> Mar 1902

<sup>236</sup> BAE (1903a) p.440

<sup>237</sup> AA/10/2 letter to Markham from Creak 3<sup>rd</sup> July 1902

<sup>238</sup> AA/10/2 Letter from Scott 31<sup>st</sup> Dec 1903 to Markham

<sup>239</sup> Matless (1991)

<sup>240</sup> Dodds (1994) p. 85-99, Goudie (1972)

various forms: sand dunes, ocean waves, and seismology. He occupied a position between physics and geography, but was supported by the RGS without question. He borrowed instruments in 1900, 1901, 1907 and 1913. In 1907 he was studying the earthquake in Kingston, Jamaica.<sup>241</sup>

Cornish was comparing seismograph readings with storms at sea. He had to construct the fundamentals of his science: 'The distant swell measures the total force at the focus, not its destructive violence'. He used the Rossi-Forel scale of earthquake intensity. Mr. Maxwell Hall had sent him the report of the observations made at Washington, but the results did not agree with the theory. Cornish was not convinced that the traverse waves could predominate when, in Jamaica, the direct vibrations had predominated. Cornish also consulted the Bremmens-Gray-Milne (BGM) pendulum seismograph.<sup>242</sup> He was given the results from this instrument together with a description, and a series of elongated oval curves scratched by the oscillating needle on the lamp-black coating of the horizontal glass plate. Unfortunately the BGM seismograph constructed at Chapelton was 'rendered imperfect' by the needle having left the plate: 'I was unable to agree with Bremmer's opinion on the direction of vibration. Only one certain compass bearing from the records of both seismographs has been published regarding the theory of transverse waves. These two records are hopelessly at variance as can be seen from an inspection of the map.'<sup>243</sup> As with seismic measurements by Milne, Cornish had instrumental results but these did not correlate, and there was no theory that could accommodate them.

John Gregory was a geologist, physical geographer and ethnographer whose life has been comprehensively documented.<sup>244</sup> He borrowed instruments for expeditions to the West Indies, China and Peru in 1899, 1922 and 1931 respectively. Gregory undertook training as in his papers there are printed sheets first supplied by Coles and presumably continued by Reeves.<sup>245</sup>

Gregory's expedition of 1922 to Yunnan was with his son.<sup>246</sup> He wrote to Hinks as follows:

I took very few boiling points on the way North. Our best thermometer was smashed the day we left Rangoon, and it gave me such a fright that I hardly used the boiling point thermometers for fear an accident might deprive us of them.' He recommends adding 'a couple of hundred feet' to previous measurements because Old Atuntze had been overtaken by a landslide. 'Halving the difference between that result and Davies (and ignoring the fact that Davies' station was probably 200 feet lower)...' 'It seems to me better to agree as nearly as possible with the generally accepted

---

<sup>241</sup> JMS 5/79

<sup>242</sup> Galitzin (1904), Fremd (1997) p.91

<sup>243</sup> JMS/5/79 p. 49

<sup>244</sup> Leake (2011)

<sup>245</sup> SSC 60 Gregory

<sup>246</sup> Gregory (1923)

results'. 'I am quite happy to add on 300 feet'. 'A new Casella aneroid gave good results until a fall upset the internal mechanism of both of us'.<sup>247</sup>

Gregory tested his instruments as he used them: 'The Cary no. 10 gave unreliable results but the no 15 gave better results and was used to check the Casella, though I have always taken the Casella results except for a day or two until the Casella had recovered from the incident.'<sup>248</sup> Gregory was undermined fundamentally by simultaneously using and testing his instruments, and by subjective guesses as to base heights which invalidated all his measurements.

Ralph Bagnold borrowed instruments for an expedition to the Libyan Desert in 1930. Unlike previous travellers he used motorised transport which had logistical issues as petrol was not available en route, however it was 'very hard going for cars.'<sup>249</sup> He believed his latitudes and longitudes were too low, but did not say why. He took dip and wet and dry bulb readings; the latter of particular interest in the desert. He had to make a detour with another car as 'ours was stationary on the road.'<sup>250</sup> He found 'certain discrepancies between true position marked and as plotted and those given in the typed lists'. 'The road is a dead reckoning course starting each day from astronomically fixed positions. Final positions and true starting position are not quite the same but the error is small.' Bagnold took altitudes with Paulin aneroids and also took pocket aneroid readings every ten miles, adjusting them to correspond with each other. 'The actual altitude positions can be interpolated from them.' The systemic issue from which Bagnold suffered was that a milometer built in to the car, gave 'numbers (which were) only ciphers,' 'as distances they are valueless as the cars ran back on their tracks etc.'<sup>251</sup> Bagnold gives the impression of a meticulous observer but had to contend with a lack of features, unsuitable transport and most tellingly, a systemic inability to measure length meaningfully.

---

<sup>247</sup> SSC 60 Gregory to Hinks 12<sup>th</sup> Feb 1923

<sup>248</sup> SSC 60 Gregory letter to Hinks 12<sup>th</sup> Feb 1923

<sup>249</sup> LMS B 3 p.12

<sup>250</sup> LMS B 3 p. 16

<sup>251</sup> LMS B 3 letter Bagnold to Milligan of the Sudan Survey Dept Dec 18<sup>th</sup> 1932

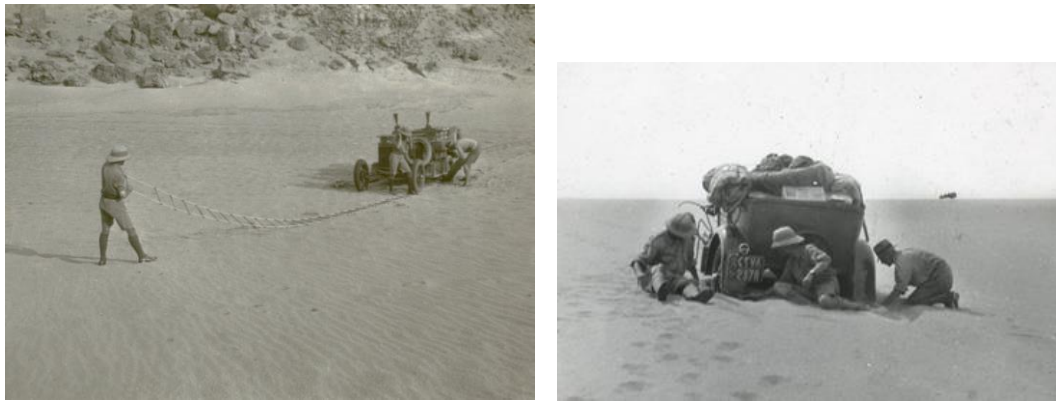


Fig 6.11 a and b: Bagnold and colleagues in the Libyan desert in 1929-30: 'Car stuck in sand' and 'Extricating car from sand' <sup>252</sup>

### Conclusion

The evidence assembled here suggests that mobilisation of the considerable resources invested in the instruments and their users was fraught with difficulties, many of which remained similar over the century in question and across all parts of the globe. While early expeditions constituted open-ended 'filling in blanks' on maps, later expeditions tended to have specific aims and focused less on basic surveying. Some later travellers even argued that surveying prohibited 'seeing.' The ability of the individual traveller was the most common cause of instrumental success or failure. While the instruction from the late 1870s improved the skill of some, an increased differentiation of expeditions meant that many individuals continued not to exploit the potential of their instruments as they might have done.

The evidence from these expeditions concurs with many writers whose work demonstrates deteriorating relationships with indigenous people by the late nineteenth-century. Human intermediaries were omnipresent but frequently taken for granted: indigenous people were expected to provide food, give directions, and carry baggage including instruments. It was in this last respect that indigenous agents were frequently blamed for poor levels of care resulting in poor instrumental performance. Some later travellers suffered the result of decades of maltreatment of indigenous people which frustrated freedom of movement. Political factors often dictated where expeditions went, and the instruments sometimes played a role in increasing danger, as in the case of Savage Landor. The correlation of the assignation of various instruments and roles to social hierarchies is not as apparent in exploration as in the larger triangulation projects, but as surveying as a profession extended around the globe it became more common to delegate instrumental practice.

---

<sup>252</sup> LS/713 - 22, LS/713 - 04

The instruments supplied were not always adapted to their use in foreign locations: there were constant complaints about wood in dry climates, theodolites in dense undergrowth, artificial horizons in low latitudes, and chronometers which changed their rates when moved. The provision of instruments across the globe was hampered by a lack of control as to where shippers went, and who handled the instruments. Their maintenance and repair were usually not possible except by sending them back to London. Their re-issue was time-consuming, expensive, and could further the risk of breakage. New technology was not always helpful; Bagnold in his car had the same trouble measuring length as earlier travellers with traditional transport; Carruthers regretted the railway; steam ships with iron hulls were no use in extreme cold. As Schaffer puts it: 'To sustain normal functions new systems of repair and maintenance had to be developed.'<sup>253</sup> Facilities for charging batteries and accumulators were absent; petrol had to be carried for any motorised expedition. The RGS pursued increasingly challenging terrains in high latitudes or altitudes, which introduced new logistical and physical problems, but difficulties remained in all types of physical environments.

Systemic failure also occurred with the measurements themselves, and, if applicable, totally invalidated results. Differences between heights were useless if the height of the base was not known. Accurate heights were useless if the position was not known. Latitude was useless without longitude. Compass bearings were useless without variation being known. The beautifully-crafted angle-measuring instruments were frequently used in conjunction with timing of marches, or by pacing, for length; the failure to apply the same tolerances across the range of dimensions undermined the integrity of the whole.<sup>254</sup> As noted in *Hints*; 'Unless the results that are carefully recorded be those of observations made on correct principles, all the time and pains they have cost are thrown away.'<sup>255</sup>

Later travellers frequently compared their work with that of their predecessors in order to get closer to 'the truth', and to provide data which could be accepted as knowledge until the next circulation of inscriptions. This is in accordance with ANT. In many instances, however, calibration took place simultaneously with measurement of phenomena, thus undermining the 'scientific method': the instruments were not 'immutable mobiles.' Field science involved so many uncontrollable factors: weather, local contingencies, and even changing physical circumstances such as water levels or shifting sand. The model supposed by ANT works well in situations of repeating cycles of accumulation and improvement, but in some cases the instruments' potential could not be mobilised and no knowledge was gained.

---

<sup>253</sup> Schaffer (2011) p. 710

<sup>254</sup> Schaffer (1994) p. 7, Outram (1999), Robinson (1852) p. 228

<sup>255</sup> *Hints* (1854) p. 5

## Chapter 7:

### The Management of Data

*It is quite indispensable that the writing, and more particularly the figures, should be legibly and unmistakably written in the field- book, for if there exists any uncertainty whether 5 or 3, 6 or 0, 9 or 7, and so forth, be meant, the time of those to whose lot the computation eventually falls, will be more or less taken up in re- conciling chimeras.<sup>1</sup>*

#### Introduction

The next phase of the cycle of knowledge production was the management of data from the observations of the travellers. The raw numerical instrumental outputs were not normally ends in themselves. An essential part of the process was their manipulation to create meaningful results in terms of quantities, maps, or graphs, which could supplement and add authority to travellers' narratives. This activity constituted considerable resource. Don Ihde puts this succinctly; 'The laboratory not only prepares inscriptions- but it is the place, the site, where things-scientific objects- are prepared or made readable'.<sup>2</sup> In this case the centre of calculation, usually the map room, becomes the laboratory in Latoureaan terms. While they did not manage to attain their Platonic status as 'immutable mobiles', instruments allowed the production of more precise information than that possible using human or animal bodies. 'The instrument, while producing the display, is not fore-fronted'.<sup>3</sup>

The numerical nature of the information lent itself to the creation of maps in particular. Latour lists one of the advantages of maps to be their ability to be part of texts, and this is how they were usually deployed.<sup>4</sup> The first step was the production of the data in the form of a table; Rusnock has noted the importance of this mode of representation; 'the table itself was the most important technology for collecting and displaying quantitative information.'<sup>5</sup> As Porter has remarked; 'Quantification is well-suited for communication that goes beyond the boundaries of locality and community', but these quantifications needed translating.<sup>6</sup> For Poovey; 'there is a supposition that systematic knowledge should be gained from numbers. ... They articulate the ways we organise and making sense of the World.'<sup>7</sup>

---

<sup>1</sup> Everest (1860)

<sup>2</sup> Idhe (1998) p. 150

<sup>3</sup> Idhe (1998) p. 99

<sup>4</sup> Latour (2011), Keighren, Withers, and Bell (2015) p. 155-168

<sup>5</sup> Rusnock (2002) p. 6

<sup>6</sup> Porter as quoted in Shapin (2010) p. 30

<sup>7</sup> Poovey (1998) p. xv

# Boiling Point Observations on the White Nile

Station	Date	Temp. of air	Temp. of water	Boil. Pt.	Barometer	Height above sea	Remarks
Dz. Plate Pakawa	Feb. 15 <sup>th</sup> 1875	97°	87°	208.20	208.18	2209 ft.	good.
	"	"	"	208.00	208.28		
Faloro	March 14 <sup>th</sup> 1875	76°	14125	206.60	208.58	3077 ft.	good.
	"	"	"	206.50	208.78		
Kagat	April 22 <sup>nd</sup> 1875	89°	19103	209.20	209.40	1496 ft.	river level
	"	"	18001	209.25	209.45		17 ft. lower
Foot of 1 <sup>st</sup> Rapid.	April 25 <sup>th</sup> 1875	82°	19103	209.0	209.20	1538 ft.	river level
	"	"	18001	209.2	209.40		4 ft. lower
Bedden	April 25 <sup>th</sup> 1875	94°	19103	209.0	209.2	1605 ft.	river level
	"	"	18001	209.1	209.3		2 ft. lower
Bedden Rapid Top	April 25 <sup>th</sup> 1875	82°	19103	209.9	209.1	1645	
	"	"	18001	209.0	209.2		
So. So.	June 5 <sup>th</sup> 1875	76°	19103	209.1	209.3	1427 ft.	bad obs.
	"	"	18001	204.2	209.4		
1 <sup>st</sup> Camp between Bad. & Herri	So.	84°	19103	208.8	209.0	1648 ft.	river level
	"	"	18001	209.1	209.3		8 ft. lower
So. So.	June 6 <sup>th</sup> 1875	73°	19103	208.80	209.0	1603 ft.	river level
	"	"	18001	209.20	209.4		8 ft. lower
2 <sup>nd</sup> Camp	So. So.	80°	19103	208.90	209.10	1642	river level
	"	"	18001	209.00	209.20		8 ft. lower
So. So.	June 7 <sup>th</sup> 1875	75°	19103	209.1	209.3	1635	river level
	"	"	18001	208.8	209.0		8 ft. lower
Herri	do.	84°	19103	209.1	209.3	1591	river level
	"	"	18001	209.0	209.2		2 ft. lower
So.	June 11 <sup>th</sup> 1875	74°	19103	209.0	209.2	1547	river level
	"	"	18001	209.2	209.4		18 ft. lower
So.	June 17 <sup>th</sup> 1875	74°	19103	209.1	209.30	1576	river level
	"	"	18001	209.0	209.20		18 ft. lower

For barometrical observations turn over

All thermometers used were by Casella. W. A. Chippindall  
Lt. R. E.



BOILING POINT OBSERVATIONS - YUNNAN 1922. 2									
Date	Hour	Boiling Point Thermometers				Air Temp.	Locality	Result.	
		No. 5925	New Correc. <sup>n</sup>	No. 5681	New Correc. <sup>n</sup>			ft.	m.
May 29 <sup>th</sup>	7 am	-	-	203.9	+26	77°	Lukang village	4500	4345
June 25 <sup>th</sup>	9 pm	199°	-3	198.5	+30	65°	Mekong River Level	4300	4150
"	27 <sup>th</sup> 6 pm	201	-34	198.6	+3	67°	Wei-si	4700	7580
				200.5	+3		The Yamen say	8000	
							O-shia	6600	6237
July 5 <sup>th</sup>	noon	187.7	-1	187.4	+1	48°	Si-la	14300	13968
"	8 <sup>th</sup> 9 am	189.6	-1	189.4	+1	55°	Passat N. ft. of Mt. Francis Garnier	13100	12864
"	9 <sup>th</sup> 5 pm	200.5	-31	199.9	+3	72°	opp. Yangtze in house	6880	6621
							River	6800	6540
"	16 <sup>th</sup> 2 pm	183.1	-04	182.9	+05	47°	Temsu-la	14400	16810
"	19 <sup>th</sup> 6 pm	193	-13	192.9	+23	60°	Atunze	11400	10827
"	25 <sup>th</sup> 6 pm	195.8	-24	195.5	+3	66°	Shahi (Shalu)	9300	9206
							(9600) accept as		
"	31 <sup>st</sup> 10 am	191	-1	190.8	+18	65°	Tungo-la	13700	13380
							Tungo-Shan-la	12300	11980
							Hunga-shan-la (577)		
Aug. 18 <sup>th</sup>	6 am	203.4	-4	203	+27	? 68°	Hokiang	5100	4776
"	25 <sup>th</sup> 6 pm	202.7	-3	201.8	+3	68°	Yungchang	5600	5410
"	27 <sup>th</sup> 1 pm	207	-50	206.4	+20	94.5°	W. of Salween; lunch place	5300	
							Salween River	3100	2849
							or	2400	2050

Fig 7.1 a and b: Boiling point observations by William Chippindall on the White Nile in 1875, and by Gregory in Yunnan in 1922 <sup>8</sup>

Numbers produced by the travellers were intermediate between the observations and their eventual visual representation. This thesis argues that the fallibility noted by Withers, very apparent in the field, could be mitigated against to bring the resulting data within the range of acceptability. Outlying observations could be modified and the individuality of the traveller could be moderated for agreement by consensus of the Society. There were intrinsic tensions between calculators, map-makers, and travellers, with the Council sometimes acting as referee. Exciting experiences in the field were necessarily followed by the safe and routine activities of human computers and draughtsmen, often in offices or map rooms, which gave rise to far fewer inscriptions and were seldom in the public domain.

This chapter interrogates the archival evidence to investigate what was done to the raw results of observation, where, and by whom, and explores what were the issues, monitoring changes over time. There were two types of discourse taking place at the RGS over the century under investigation: The first was about what methods should be used, the second concerned by whom and where. The first type gave rise to discussions concerning

<sup>8</sup> Chippindall JMS/3/96, SSC-60 Gregory

best practice, the second to discussions about expediency, propriety and ownership. As these two aspects were intertwined they will be treated together.

Before data could be manipulated it had to be secured. The RGS could not compel their travellers to provide data; this lack of control over the travellers 'in the field' extended into the subsequent phase of the cycle. In 1864 the Council expressed displeasure with Speke: 'The Council regret that so very important a subject should be illustrated by so short a memoir only as that which Captain Speke has entitled 'the Upper Basin of the Nile''. They reminded him that his expedition had been supported throughout by the President and Council of the Society.<sup>9</sup> A similar situation arose with Pim who also borrowed instruments that year. The Council noted he had not yet provided data from his previous expedition.<sup>10</sup>

The process of mobilising data can be broken down into two principal parts; calculation and drawing. While the *practices* performed by the computers-those who performed the calculations required in order to produce meaningful results- were usually in the 'black box' of ANT, there was a consistent move towards increasing standardisation in order to improve intelligibility and universality, as well as credibility. The data, as with the instruments, were aspiring to be immutable mobiles. As regards *who* performed the calculations and *where*, it will be argued that the ownership of resource contained within the data was contested. There were constant tensions between the travellers and the computers and draughtsmen. It will also be argued that the integration of the human computers into the process could reduce the 'fallibility' apparent in the previous phase.

The practice of the draughtsmen was more debated than that of the computers; scale, projections, representation of height, and colour were particular subjects of discourse. There were attempts to introduce standardisation for intelligibility and universality. The ownership and control of the considerable resource embedded in the maps was also disputed. Over the century, the RGS had to relinquish control to international bodies as mapping became a global concern. It is argued that the 'fallible' observations of the heroic traveller became increasingly submerged and invisible in institutional bureaucracy.

### Calculation

The calculation practices were imported from sources outside the RGS and have been considered in chapter 4 as, it is argued, they were imbedded in the instruments. The detailed undertakings of the computers were not normally under discussion especially in the second half of the period. The calculations involved the sine and cosine rule for dead reckoning, finding areas where necessary, transforming barometric and hypsometric measurements into heights, and lunar and other astronomical distances into latitude and longitude. In the last case 'reductions' involved taking account of refraction and parallax.

---

<sup>9</sup> Special Committee June 1<sup>st</sup> 1864

<sup>10</sup> CM Nov 14<sup>th</sup> 1864

Index errors were included by the most sophisticated travellers. The human equivalent, the 'personal equation,' was incorporated implicitly by those who designated observing to certain individuals. The Society purchased few instrumental aids to calculation: five Gunter scales, five slide rules, five planimeters and one mechanical calculator, examples of some of which can be seen in figure 7.2. It relied, presumably, on computers being able to manipulate figures themselves using logarithmic tables, or having access to their own instruments.

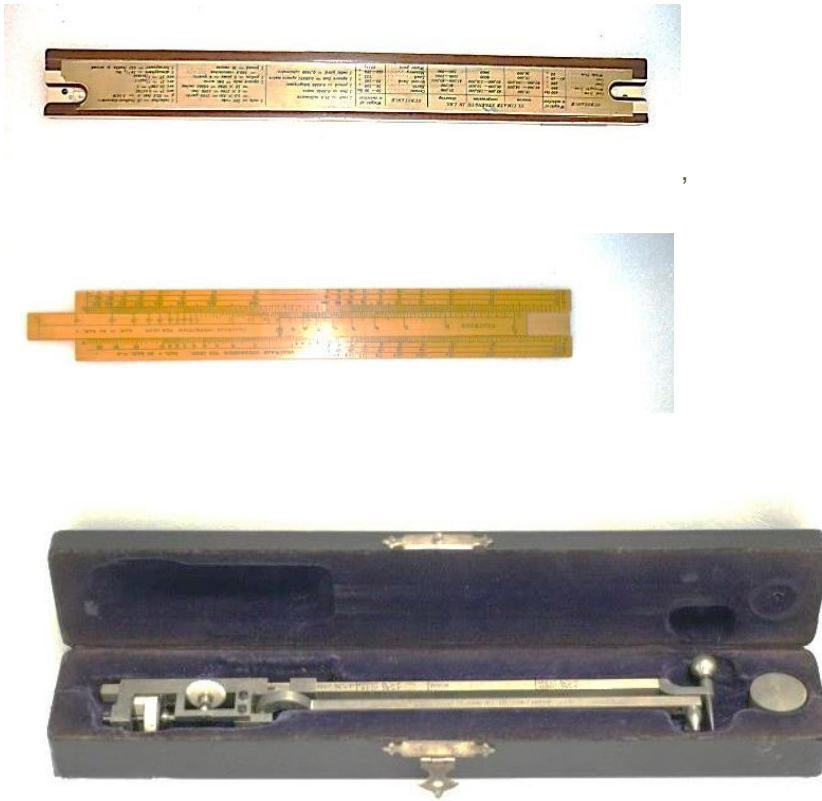


Fig 7.2: Calculating Instruments: celluloid slide rule, early 20<sup>th</sup> century, showing standard tables on reverse, 'chainage' rule for trigonometric calculations, and planimeter no 3 by Stanley for calculating areas.<sup>11</sup>

Not all calculation was performed in the Map Room, but here the space was constructed to conform to a 'centre of calculation' as defined by Latour, and explicated by Jöns. The end product was 'to create efficient inscriptions in the form of maps, diagrams, tables, texts and equations that represent comprehensible and well-communicable knowledge claims.'<sup>12</sup>

<sup>11</sup> Artefact A 8, Artefact A 4, Artefact A 15

<sup>12</sup> Jöns (2011) p.160

Standardisation was an aim both for measure and for procedure. Calculation was impeded by the large number of differing measures being used before the general introduction of the metric system. In 1841 the RGS Council stipulated that all temperatures should be given in Fahrenheit, Reamur and Celsius. This was seldom followed. All lengths were to be given in 'English', i.e imperial, in addition to anything else, which was sometimes ignored, (as noted in chapter 6.)<sup>13</sup>

A journal article by a Miss Colthurst in 1849 sought to remedy one aspect of this problem.<sup>14</sup> Not only was horizontal length different in different locations, but the height of barometer tubes was expressed differently; for example in 'French metres, pieds du Rhine, pieds du Berlin, palmas, Paris feet etc, rendering it necessary to enter into long calculations before comparative results can be obtained'. The table supplied a 'standard by which geographical students could compare the notations of vertical distances contained in foreign works'. The table of electrical resistances supplied by Schaffer is reminiscent of Colthurst's table.<sup>15</sup> The standard selected was the geographical mile taken at the equator: 'By this arrangement the student of every nation will find no difficulty in at once referring unfamiliar measures not only to one philosophical term, but to the standard to which he is himself best accustomed'. The geographical mile was not an obvious choice and there is nothing to indicate this strategy was successful. In 1876 a paper on the ratio of English miles to geographical miles was accepted from a Mr. Solomon Drach, indicating the latter were not familiar to most readers.<sup>16</sup>

The RGS resisted the adoption of metric measures, a system which would have facilitated calculation, until WW1, discussing the relative merits of that and the Imperial system in 1916.<sup>17</sup> They were being pressed by the Board of Scientific Societies to make the change, which they stipulated the following year.<sup>18</sup> Again this was slow to be effected. Another standardisation was introduced at this time; the RGS sent a representative to the hydrographers' conference on standard time at sea, and in 1918 the civil day was adopted for the nautical almanac, replacing the astronomical day.<sup>19</sup>

Interrogation of the archival evidence suggests that less than half of the RGS travellers were competent to compute their data in the first four decades of the century under review. In the 1850s, systematisation of calculation and mapping was advocated by Galton, who had similarly attempted to reform instrument acquisition. As with the latter case, specific discussions led to a general statement of intent, but implementation was slow to follow.

---

<sup>13</sup> CM Nov 22nd 1841

<sup>14</sup> Colthurst (1849)

<sup>15</sup> Schaffer (1997) p. 447

<sup>16</sup> CM Apr 10th 1876, JMS/19/22

<sup>17</sup> Research Committee 9<sup>th</sup> Nov 1916

<sup>18</sup> CM Nov 6<sup>th</sup> 1916, Research Committee 9<sup>th</sup> Nov 1916, 22<sup>nd</sup> Mar 1917, CM Nov 25<sup>th</sup> 1918

<sup>19</sup> CM 4<sup>th</sup> June 1917, Oct 22<sup>nd</sup> 1917, 8<sup>th</sup> Apr 1918, Research Committee 15<sup>th</sup> Apr 1918, Withers (2017) chapter 4

A particular case of interest was that of Livingstone who made many astronomical observations, particularly using lunar distances, between 1854 and 1856.<sup>20</sup> The RGS received the paper 'Explorations into the Interior of Africa' with these observations included on 7<sup>th</sup> March 1856, from Thomas McClear, Her Majesty's Astronomer at the Cape, together with a covering letter, which was read to the Society three days later.<sup>21</sup> Accompanying booklets show Livingstone's calculations in black, with corrections by McClear in red, as shown in figures 7.3a. The paper revealed lunars being taken about once a week. On the right-hand page McClear made remarks to the effect that Livingstone had got the date wrong, he (Livingstone) had got very large watch errors, but in other places everything was in accord. McClear used the 'theory of probabilities', in estimating the errors. In two places the watch must have been 'attired'; presumably stopped. The persistent problem appeared to be the watch and the astronomical measurements not correlating. McClear refers to several errors '(most likely occurring in copying)', which were deleted.<sup>22</sup>

---

<sup>20</sup> DL 2/10/1

<sup>21</sup> DL /2/10/2 p.121 Mar 10<sup>th</sup> 1856

<sup>22</sup> DL/10/1



## Results of Dr. Livingston's observations in Angola.

1854	Stations	South Latitude	East Longitude
May 19 } Oct 27 }	Golungo Alto.	VIII 9. 8. 30	14. 57 } 15. 9 }
Oct. 5. 7	"Aguas doces." in Cazengo: "10 miles west of Golungo Alto."	IX 9. 15. 2	14. 27 ?
Oct 11. 12	Confluence of <del>Lomba</del> <sup>Lomba</sup> & Lucalla <sub>Luinha</sub>	X 9. 26. 23	not obs <sup>d</sup>
	Massangano. Town & fort.	XI 9. 37. 46	not obs <sup>d</sup>
Dec <sup>r</sup> 6	Ambaca. Residence of Commandant	XII 9. 16. 35	14. 48. <sup>a</sup>
Dec <sup>r</sup> 11	Pungo Andango, on the river Coanza. <sup>(Vol xxv p 219 lat 9. 40. 35 - 9 40. 0 long. 15 33. 40)</sup>	XIII 9. 42. 14	15. 30
Dec <sup>r</sup> 22 1855	On the river Coanza, 2' west of Pungo Andango	XIV 9. 47. 2	not obs <sup>d</sup>
Jan <sup>y</sup> 2	Candumba. 15 miles East of Pungo Andango 300 yards North of the Coanza.	XV 9. 42. 46	15. 16. <sup>b</sup>
Jan <sup>y</sup> 3	Confluence of Lomba and Coanza, 8 or 10 miles Eastward of Candumba. Station, house of M <sup>r</sup> . Dices about 1/2 mile North of Confluence.	XVI 9. 41. 26	15. 18. <sup>c</sup>
Jan <sup>y</sup> 7	Sanza. On river Luize. 2' west of the sudden <sup>stream</sup>	XVII 9. 37. 46	16. 59.
Jan <sup>y</sup> 10	Banks of the Luize, near its source. 2' west of the sudden descent, which forms the valley of the Cassanga.	XVIII 9. 42. 37	17. 25.
Jan <sup>y</sup> 11	Tala Mungongo. 2 miles East of preceding station	XIX 9. 42. 37	not obs <sup>d</sup>

a There is an important error in this long. of Ambaca, if not less than 35 miles; the position here given is 3 or more miles to the W. of Golungo Alto; whereas it is about 32 miles to the E. of that place — its real long. is 15° 23' very nearly: Indeed Dr. Livingston himself states generally that Golungo Alto is about half way between Ambaca & Loanda. &c. See also Repts p. Vol xxv p. 219. (15° 23' 15")

b If the long. of Pungo Andango, viz. 15° 30' is correct (wh. there appears no reason to doubt) & Candumba is 15' to the E. of that place, the long. of the latter place will be 15° 46' & not 15° 16' 26'

c The junction of the Lomba with the Coanza is about 25' E. & not as shown 12' W. of Pungo Andango, & 5 or 10' E. of Candumba, the junction is therefore in long. 15° 56' & not as shown in 15° 18'



Fig 7.3 a and b: Livingstone's observations with McClear's comments in red, and Livingstone's original map of his route from Sesheke to Loanda, 1854.<sup>23</sup>

McClear had to be diplomatic in his choice of words, only pointing out one mistake;

Probability too has been freely, but not unfairly drawn upon where needed. It's almost impossible to escape errors in a fixed observatory, then can we expect more from a harassed explorer in the bush threading his way through unhealthy swamps and who has been nine times prostrated by jungle fever? It is astonishing that he has been able to accomplish so much for geography under the circumstances. Few,

<sup>23</sup> DL 2/10/2, 545317

very few explorers have so perseveringly and so geometrically fixed their tracks. It may be amiss here to remark that when longitudes on land are determined by lunar distances, the altitudes for clearing the distance for the effects of parallax and refraction should be omitted, and the labour handed over to repeated measures of distance between moon and stars or planets from both East and West of the Moon. The altitudes of time should also be East and West of the meridian.<sup>24</sup>

It is clear from this example that changes could be made in data if they were not considered credible.

In the case of Dr. Eduard Vogel the number of astronomical observations made was remarked on in 1855.<sup>25</sup> In a Council meeting in November 1857, it was stated that Vogel 's data was computed in the Map Room before it was read.<sup>26</sup> This was done by Captain George as it was recorded at the same meeting that he was paid £15 for the work<sup>27</sup> These issues led Galton to move that 'all astronomical observations be registered according to some uniform system so that a computer could work them without further explanation, and all copies be sent to England as soon as opportunities occur': This looks like a classic ANT initiative to develop a centre of calculation and impose a division of labour.<sup>28</sup> Galton's suggestions were taken up only slowly and spasmodically. Some changes did take place: Back presented five books of blank forms for registering observations.<sup>29</sup> At the end of 1858, George was paid £18 15s for computation, half a quarter's salary.<sup>30</sup>

Everest's paper of 1860 makes it clear that there was still no established procedure for delegating calculation.<sup>31</sup> He also submitted a form for registering lunars. He recognised that 'there doubtless are many travellers who would prefer computing their own observations.' For them he produced four pages of complex equations. A mathematical paper the following year by William Spottiswoode advocated weighing results using probabilities.<sup>32</sup> These highly technical contributions, as seen in figure 7.4a and b, made incongruous interventions in the *JRGS*, highlighting the difficulty of the procedures and revealing uncertainty as to who should perform them.

---

<sup>24</sup> DL/10/1

<sup>25</sup> CM Mar 26<sup>th</sup> 1855

<sup>26</sup> CM Nov 9<sup>th</sup> 1857

<sup>27</sup> CM Nov 9<sup>th</sup> 1857

<sup>28</sup> EC Feb 1<sup>st</sup> 1858

<sup>29</sup> CM Apr 12<sup>th</sup> 1858

<sup>30</sup> CM Nov 22<sup>nd</sup> 1858

<sup>31</sup> Everest (1860)

<sup>32</sup> Spottiswoode (1861)



OBSERVATIONS for LUNAR DISTANCE taken at El Majhul in Thibet between Noon and Midnight at 9 P.M. of June 20, 1858. Approximate Latitude 30° North, Longitude 90° East. Watch used Om. Os. slow of { M. S. time. } Rate { losing } Om. Os. per day. { Sidereal time. } { gaining }

Face of the Vertical Circle.	Names of Objects observed.	Times by Watch.	Readings of Azimuth Circle.			Readings of Vertical Circle.		REMARKS.
			A.	B.	C.	D.	E.	
Left	Regulus . . .	8 45 0	91 21 15	21 10	21 15	23 39 35	39 35	All three objects to the south of the zenith. Regulus and the moon to the west of the meridian. Antares to the east of the meridian. The West and Upper Limb of the moon were observed.
Left	γ's W. & U. Limb	8 50 0	26 16 40	16 35	16 40	42 46 40	46 40	
Left	Antares . . .	8 55 0	336 31 10	31 0	31 5	29 52 5	52 0	
Right	Antares . . .	9 5 0	158 56 15	56 10	56 10	30 41 15	41 10	
Right	γ's W. & U. Limb	9 10 0	211 58 20	58 25	58 15	40 40 15	40 15	
Right	Regulus . . .	9 15 0	274 58 35	58 35	58 35	17 11 30	11 25	
Right	Regulus . . .							
Right	γ's W. & U. Limb							
Right	Antares . . .							
Left	Antares . . .							
Left	γ's W. & U. Limb							
Left	Regulus . . .							

10, Westbourne Street, Hyde Park, W.  
November 7th, 1859.

SPOTTISWOODE on *Typical Mountain Ranges.* 153

column has been formed by means of the third in the following manner. From the number 500 written at the top of this column there has been deducted the number 178, placed opposite in the third column; and from the remainder, 322, there has been deducted the number 144, placed opposite in the third column; and so on to a remainder 48. A similar process has been applied from the bottom of the column.

TABLE I.

Differences in Directions by Variations from the Mean.	Weight of Observations.		Probability of the Variations according to Observation.	Rank of preceding Numbers in Scale of Precision.
	Absolute.	Relative.		
"				
292	158	178	.500	..
148	128	144	.322	14.5
64	54	61	.178	7.25
63	61	69	.117	4.75
27	91	103	.048	2
..	..	..	.055	2.20
2	12	13	.068	2.75
- 6	74	84	.152	6.20
- 70	23	26	.178	7.33
-130	33	37	.215	9.
-211	104	117	.332	14.75
-281	74	84	.416	21.75
-352	74	84	.500	..
..	886	1000	..	..

Fig 7.4 a and b: Everest's suggestions for tabling results, and Spottiswoode on probabilities.<sup>33</sup>

<sup>33</sup> Everest (1860), Spottiswoode (1861)

The first traveller recorded as having been paid to compute his own observations was Speke in May 1863, who was granted £10 for calculating his lunars.<sup>34</sup> This does not appear to have produced results, as in July the Finance Committee paid Edwin Dunkin £16 5s for calculations on the East African expedition, and in November Dunkin was paid specifically for Speke's reductions.<sup>35</sup> Dunkin was hampered by a neglect of the atmospheric conditions and urged travellers to include these readings in future; 'if they will faithfully do this they will greatly relieve the mind of the computer, and also (which is of more consequence), increase the value of their readings two-fold'.<sup>36</sup>

---

<sup>34</sup> CM May 18<sup>th</sup> 1863

<sup>35</sup> FC July 10<sup>th</sup> 1863, Nov 16<sup>th</sup> 1863

<sup>36</sup> Dunkin (1863 - 1864)

131

December 27<sup>th</sup> 1858 (P. Umbi)  
 Merid. doub. alt. \* Uenamar  
 Declin. of \* — 57° 57' 25" S  
 Obs. doub. alt. \* — 79° 6' 40"  
 — 20  
 2) 79 6 20  
 Obs. alt. \* — 39 33 10  
 Refraction — 1 9  
 True alt. \* — 38 32 1  
 90  
 Merid. zms. dist. — 50 27 59 N  
 Declin. of \* — 57 15 25 S  
 Latitude — 7 29 26 S

37 10 20

132

January 10<sup>th</sup> 1859 (Zunzmero)  
 Merid. doub. alt. \* Persei  
 Declin. of \* — 49° 21' 40" N  
 Obs. doub. alt. \* — 65° 25' 10"  
 — 20  
 2) 65 24 50  
 Obs. alt. \* — 32 12 25  
 Refraction — 1 26  
 True alt. \* — 33 10 59  
 90  
 Merid. zms. dist. — 56 49 1 S  
 Declin. of \* — 49 21 40 N  
 Latitude — 7 27 21 S  
 see also 24, 25, 26

133

January 29<sup>th</sup> 1859 (Mxlijos)  
 Merid. doub. alt. \* Canopus  
 Declin. of \* — 52° 37' 17" S  
 Obs. doub. alt. \* — 88° 48' 20"  
 — 20  
 2) 88 48 0  
 Obs. alt. \* — 44 24 0  
 Refraction — 58  
 True alt. \* — 44 28 2  
 90  
 Merid. zms. dist. — 46 36 58 N  
 Declin. of \* — 52 37 17 S  
 Latitude — 7 10 19 S

134

January 30<sup>th</sup> 1859 (Chya Kheng)  
 Merid. doub. alt. \* Capella  
 Declin. of \* — 45° 51' 15" N  
 Obs. doub. alt. \* — 74° 26' 0"  
 — 20  
 2) 74 25 40  
 Obs. alt. \* — 37 12 50  
 Refraction — 1 15  
 True alt. \* — 37 11 35  
 90  
 Merid. zms. dist. — 52 48 25 S  
 Declin. of \* — 45 51 15 N  
 Latitude — 6 57 10 S

135

January 31<sup>st</sup> 1859 (Kicowa)  
 Merid. doub. alt. \* Capella  
 Declin. of \* — 45° 51' 15" N  
 Obs. doub. alt. — 74° 36' 20"  
 — 20  
 2) 74 36 0  
 Obs. alt. \* — 37 18 0  
 Refraction — 1 15  
 True alt. \* — 37 16 45  
 90  
 Merid. zms. dist. — 52 48 15 S  
 Declin. of \* — 45 51 15 N  
 Latitude — 6 52 0 S

136

February 2<sup>nd</sup> 1859 (Ruici)  
 Merid. doub. alt. \* Capella  
 Declin. of \* — 45° 51' 15" N  
 Obs. doub. alt. — 74° 48' 40"  
 — 20  
 2) 74 48 20  
 Obs. alt. \* — 37 24 10  
 Refraction — 1 15  
 True alt. \* — 37 22 55  
 90  
 Merid. zms. dist. — 52 37 5 S  
 Declin. of \* — 45 51 15 N  
 Latitude — 6 45 50 S



Fig 7.5 a, b and c: Speke's notebooks showing calculation for position, manuscript map of Speke and Grant's route from Zanzibar to the Nile, and part of route of the first expedition by Speke to Lake Victoria, 1857-59.<sup>37</sup>

<sup>37</sup> Mr Tanzania S/S.12 Mr Tanzania S/S.12 (1), Mr Tanzania S.95 (1)

Bates, the Assistant Secretary, was allowed access to John Petherick's day books in order to compute his observations, and in 1866 Dunkin sent in another bill.<sup>38</sup> From this time until the mid-1880s calculating following observations became recognised as a distinct activity, and it became common for travellers either to charge for computing their own observations or to have them computed by a specialist.<sup>39</sup> This reflected the difficulty the Society had in obtaining computed data from their travellers. In the 1870s George the map curator, William Ellis from the Royal Observatory Greenwich, and Strachan from the Meteorological Office, were employed to compute various data from ten travellers, and later a further two.<sup>40</sup> Ellis was normally asked to work on positions, Strachan on heights. Longitude gave rise to the most demanding calculations and proposals for its simplification continued to be received.<sup>41</sup>

The computers were in a position to comment on the observations, but as professionals rather than gentlemen, they tended towards encouragement; criticisms were mild. R.B Shaw had borrowed instruments for an expedition to the Pamir Steppes in 1870. Ellis computed Shaw's later observations which involved much work. Ellis's general remarks were to the effect that there were days when observations could not be taken with the sextant, that an assumption was made regarding the lower limb of the Sun for latitude, and that the air temperature had not been recorded for the boiling point measurements. Ellis refers to Chauvenet and Bessel for his formulae for longitude. The mass of calculations that Ellis performed would have been impossible for anyone without mathematical training.<sup>42</sup>

Strachan reported on Johnston and Congreve's hypsometrical observations in Paraguay.<sup>43</sup> Strachan produced tables of meteorological records, correcting the observation for index error and temperature, and taking means taken at each station. He accounted for his results as follows: 'From the mean height of the barometer for the year 1874, and observations taken twice daily reduced to 32F, taking into account the level of the river, correcting for diurnal range, taking mean pressure at sea level from Buchan's Isobaric Chart, and ascribing 70F for mean annual temperature according to Dove's Isothermic Charts, the height of the river at Ascuncion is 321 feet, whereas the South American Pilot has it as 253ft.'<sup>44</sup>

Apart from the gap in rainfall records owing to the theft of the rain gauge previously mentioned, and the 'obliteration' of the weather records in a 'tremendous storm of wind,' the raw data was highly commended. As Strachan wrote, 'One year's register is of considerable value. I have worked up the observations to make the results available for geographers and

---

<sup>38</sup> CM June 13th 1864, Feb 26th 1866

<sup>39</sup> CM Mar 5th 1866, Nov 13th 1865, Nov 23rd 1868, FC Aug 2nd 1869

<sup>40</sup> FC May 2nd 1870, CM Apr 24th 1871, Nov 20th 1876, Dec 13th 1880, Feb 7th 1881, Dec 3rd 1883

<sup>41</sup> CM Nov 12th 1866

<sup>42</sup> LMS S 10

<sup>43</sup> JMS/6/113

<sup>44</sup> JMS/6/113 Letter to council 19<sup>th</sup> Apr 1876 p.5

meteorologists.’ The results of the mountain barometer and the hypsometer agreed well. It was very useful to have had readings taken both at the base station at Asuncion, and using a travelling instrument’.<sup>45</sup> Because Johnston and Congreve had made exactly simultaneous measurements the readings were especially valuable. Galton recommended that Strachan’s comments and careful calculations be published, presumably as a guide to good practice.

Ellis and Strachan were also involved in Samuel Baker’s calculations; the observations having been provided by Lady Baker and Julian Baker, Samuel’s son.<sup>46</sup> Strachan applied instrumental corrections determined at Kew for the particular hypsometers. He then applied Buchan’s *Isobaric Charts* to take into account atmospheric pressure, and air temperature from Dove’s *Isothermal Charts*. He concluded the ‘hypsometer observations were excellent.’ Using Regnault’s tables he applied corrections to the aneroid readings. Ellis performed the equivalent calculations for longitude, but also had to correct the *Nautical Almanac* distances for errors between those positions as determined from Greenwich. At one point Baker had used the eclipse of Jupiter’s satellites, involving a different calculation, and had also recorded the results using two chronometers. Again Ellis found the observations to be good. As the journey progressed, the rates were less certain but Ellis was fairly confident as the readings were ‘accordant.’

In the case of Cameron, however, the division of labour between observer and computer produced problems. In 1876 George, Ellis and Strachan were asked to assist with Cameron’s observations. He had taken a great many: Ellis wrote on May 27<sup>th</sup> 1876 that ‘Cameron has brought home with him a most extensive number of observations- in number greater possibly than any traveller has before, in an unknown county in a small space of time.’<sup>47</sup> He was ambiguous, however, as to whether Cameron had taken sufficient longitudes: ‘Latitude can be found from a few observations, but to obtain corresponding accuracy in longitude many observations are necessary. Whilst he has taken every opportunity on his route of making observation for latitude, he has accumulated his lunars at particular places only, with the object of determining well the longitude of a few fundamental points - this is good - they ought to give good results.’

Strachan’s report has not survived, but it is unlikely that he was so supportive. Cameron responded to the criticism with a report mimicking the title of their work; ‘Report on the work of Strachan and Ellis’, in which he exhibited frustration; ‘the mode in which some of the work has been done is open to much comment.’ Strachan evidently complained that there were no regular observations between the East Coast of Africa and Ujiji. Cameron responded; ‘The state of my health was so bad and the privations and hardships so great that ... it is a matter of wonder that any register journals were kept at all’. Strachan evidently

---

<sup>45</sup> JMS/6/113 Letter above p.1

<sup>46</sup> JMS/3/86

<sup>47</sup> VLC /5/2

criticised the state of the papers sent to him, as Cameron responded; 'if he had the slightest possible knowledge of what travelling in Africa is, he would know how difficult and I may say almost impossible a task it is to preserve documents from the effects of vermin and climate.'<sup>48</sup>

Cameron was able to attack Strachan's standing: 'If (my observations) were sent to some man of really scientific attainments some good might be done, but Mr. Strachan seems a simple official who has never had any experience in the field, and whose whole ideas seem to run in the narrow groove of considering reports as if they were made by men with perfect instruments.'<sup>49</sup> Cameron pointed out that Strachan had faulted the aneroids, ironically recommended by the Meteorological Office. The requirements for accurate observation were in conflict with the desire for adventure and physical challenges while exploring, noted by Richards.<sup>50</sup>

Regarding Ellis, Cameron had less to complain about, but criticised the *Nautical Almanac* which he 'had to use.' He had checked his lunars using spherics, by Jean's *Navigation* and by equation of second differences, which gave nearly the same results. He had also used dead reckoning which again agreed. Ellis's results did not agree so well, which Cameron claimed was due to him not taking into account the 'progression of the sights,' or the barometer and thermometer. He regretted not being able to reduce his observations himself, but the 'duties of my profession prevent it'. He concluded by advising the RGS to accept his positions and altitudes.<sup>51</sup> A letter to Bates dated February 1877 suggests Cameron had won some consideration as 'George was working the sights and heights out fresh' as 'Strachan seemed to do his best to spoil everything'. Strachan was paid £18 and Ellis £21 for this work, which, however, could be forfeited by the authority of a well-known traveller.<sup>52</sup>

Another disagreement relating to data manipulation occurred in 1884/5. Lieutenant S.S. Sugden of the Royal Navy, who had computed Thomson's data in 1881 and Charles Doughty's in 1883, also computed Henry O'Neill's in 1884.<sup>53</sup> Possibly because the longitude in question was that of Blantyre, the site of Livingstone's mission in Africa where a secondary meridian was to be set up, particular caution was applied. The Expedition Committee agreed to pay Coles the considerable sum of £80 for re-computing O'Neill's data later in the same year.<sup>54</sup> Galton expressed concern about O'Neill's observations early in 1885: 'The error of his instrument has not been constant, amounting to discrepancies of up to 40 miles, affected by circumstances such as jolts to travel. The behaviour of the sextant at various angles needs to be learnt.'<sup>55</sup> He proposed a resolution: 'When the lunars are computed, Mr Coles shall be

---

<sup>48</sup> VLC/5/3

<sup>49</sup> VLC/5/3

<sup>50</sup> Richards (2011a) p.55

<sup>51</sup> VLC/5/3 Feb 1877

<sup>52</sup> FC Dec 18<sup>th</sup> 1876

<sup>53</sup> FC October 6<sup>th</sup> 1884, Dec 3<sup>rd</sup> 1883, Mar 2<sup>nd</sup> 1885

<sup>54</sup> EC Dec 18<sup>th</sup> 1884

<sup>55</sup> CM Jan 5<sup>th</sup> 1885



instructed to construct a table of the mean data and the results of each set separately, and to submit a brief memoir for the consideration of the Council on the longitude that should be ascribed to Blantyre'. There would be no publication until the computations were done.<sup>56</sup>

O'Neill took a total of 1602 observations in 1883 and 1884, including many lunars east and west at The Manse, Blantyre.<sup>57</sup> Sugden signed a sheet which found the east lunars to be nearly a degree out from the west lunars. Nevertheless, Sugden expressed the view that, as the results of the lunars taken east and west had come out very close within each group, they were 'very, very, good observations'.<sup>58</sup> Coles applied himself to the task by creating over twenty notebooks of calculations based on Raper's Rigorous method, and compared O'Neill's data with that of previous results.<sup>59</sup> Eventually he came to the conclusion that 'Notwithstanding the large differences in the separate results, the mean observations east and west of the Moon fixed their positions with considerable accuracy.' 'The Longitude of Blantyre as deduced from Mr. O'Neill's Lunar Distances is as accurate as it could be by the class and number of observations used'.<sup>60</sup> In O'Neill's papers there is note by Coles with a calculation of longitude showing O'Neill's results to be 8 minutes 14 seconds different from Ernst Ravenstein's map. As O'Neill's observations, according to Coles, were 'all very good indeed', O'Neill's observations were accepted.<sup>61</sup> While his data survived, O'Neill was concerned about the production of his map, where some of the figures were misplaced.<sup>62</sup> Maintaining control throughout the process had proved impossible.<sup>63</sup>

---

<sup>56</sup> CM Jan 5<sup>th</sup> 1885

<sup>57</sup> HEO 23/1 old system

<sup>58</sup> Letter Sugden to Coles March 11<sup>th</sup> 1885 HEO/1/1

<sup>59</sup> HEO/1/1

<sup>60</sup> HEO/1/1 Statement signed by Coles

<sup>61</sup> HEO Letter Oct 2<sup>nd</sup> 1884 Coles to O'Neill

<sup>62</sup> HEO /1/2 Letter from O'Neill 13<sup>th</sup> Nov 1884

<sup>63</sup> CM Dec 14<sup>th</sup> 1885



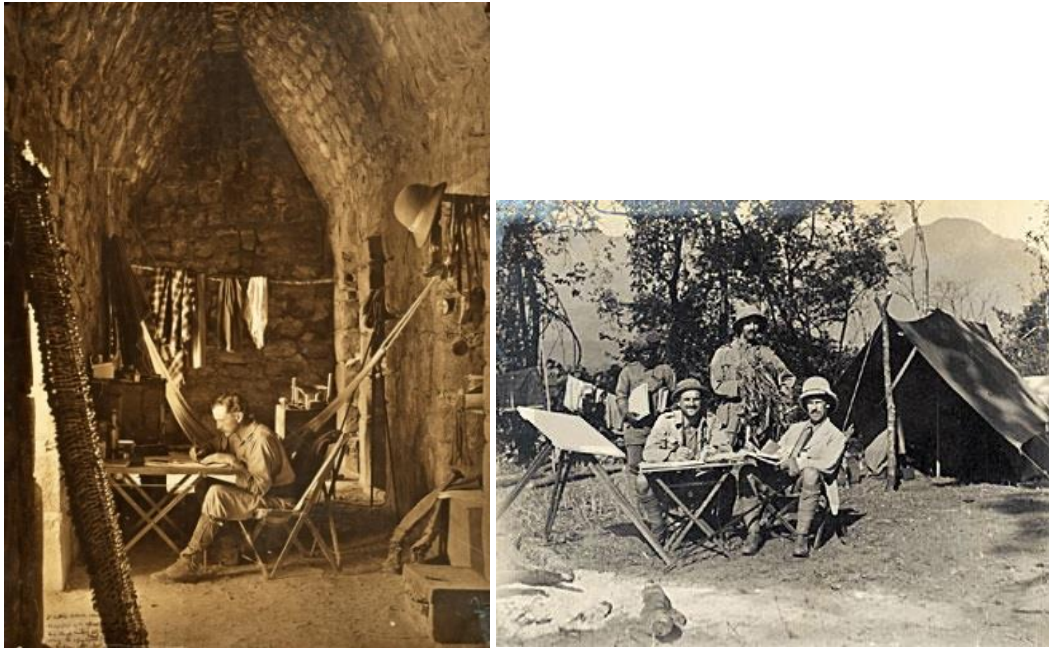


Fig 7.6 a and b: Calculating in the field: left: Maudslay in Yucatan 1889, and right: 'Computations at Nizamghat on the Mishmi Expedition in East India: 'Nevil and Nicolay assist with the logarithm book' 1912-1913.'<sup>64</sup>

It is difficult to assess what proportion of travellers computed their own observations, either in the field, as shown in figure 7.6, or on return. By the mid-1880s only about 10 per cent of travellers were recorded as having their observations computed. There were very few in the 1890s, and the practice was not mentioned by the twentieth century.<sup>65</sup> There are a number of plausible reasons for this. One possibility is that the programme of training at the RGS was enabling travellers to undertake computation. Another is that the information needed was more widely available, especially for those in the military. Another could be that the computers had become invisible at the Council and Committee level as issues relating to ownership of the material had been agreed upon or in the 'black box' of ANT. Support for this last hypothesis comes in a letter from Cheesman to Reeves sending him his observations in 1927.<sup>66</sup> A further factor could be the growing popularity of plane table surveys which focused on detail rather than fundamental position-finding and which required little in the way of mathematical ability.

In the twentieth century computation was mentioned only in connection with larger projects: The RGS contributed £50 towards calculation of tables 'of a new type with a view to

<sup>64</sup> Control numbers 023576 , 014963

<sup>65</sup> FC Apr 14<sup>th</sup> 1896, Apr 4<sup>th</sup> 1898

<sup>66</sup> SSC/18 REC 23 Letter to Reeves Dec 1926

graphical re-discussion of recent geodetic arcs' for a conference in Madrid in 1924.<sup>67</sup> The same year the Oxford Arctic expedition was allowed £20 for computation of the arc in Spitzbergen.<sup>68</sup> By 1930 computing the results of individual travellers had disappeared from view.

### Drawing and Map-Making

*If lists of longitudes, latitudes, altitudes, angles and itineraries are laid before a Map Maker he is able to elaborate the shapes of mountain ranges, the courses of rivers, the irregularities of coast, but to arrive at these desired results he must protract his materials, by placing each datum upon a chart in its proper geographical position. His next labour is critical and artistic; he has to weigh conflicting observations, to make the best of omissions and obvious irregularities, and finally, after deducing his results to delineate them in a map, in order to give permanence to his ideas and to make them intelligible to others.*<sup>69</sup>

Galton's words of 1863 encapsulate the construction and role of a map at the RGS, and echo Jöns' words above. His specific aspiration of *intelligibility* will be treated here; the aspiration of *permanence* is considered under 'Agency'.

Cartography has had more attention from historians than calculation. Since the 1980s maps have been recognised as being more than mere representations of parts of the globe.<sup>70</sup> For Edney 'Geography requires an overview that subsumes and supersedes the individual view, that overview is the communal image of space constructed through maps.'<sup>71</sup> Harley warned that maps are 'a cultural text not a mirror of nature,' and advocated deconstructing the map to challenge the idea of cumulative progress.<sup>72</sup> Viewing maps through the eyes of contemporary actors, who in their own terms were making progress, the cumulative aspect of which was clearly demonstrable, is not to exclude other views of maps as 'strategems, prizes or contests', 'powerful tools of persuasion,' and as 'arguments to align new allies.'<sup>73</sup> Harley wrote how 'Maps are never value-free images; except in the narrowest Euclidean sense they are not in themselves true or false. ... By accepting such premises it becomes easier to see how appropriate they are to manipulation by the powerful in Society'. It is clear from this study that even in the narrowest Euclidean sense maps were not in themselves true or false.

Poovey asks a series of questions regarding facts in which she advocates the postmodern approach of regarding them as socially constructed. At their point of production, however, temporarily and spatially, and for those who engaged with the geographical project

---

<sup>67</sup> CM June 2<sup>nd</sup> 1924

<sup>68</sup> CM May 5<sup>th</sup> 1924

<sup>69</sup> Galton (1863)

<sup>70</sup> Akerman (2009) Introduction p. 4

<sup>71</sup> Edney (1997) p.64

<sup>72</sup> Harley (2001) p.159

<sup>73</sup> Monmonier (1995) p.1-2, Latour (2011) p. 66

of the RGS, the latest maps had the status approaching that of facts. In the case of the Ordnance Survey maps of Britain they were referred to as 'the truth.'<sup>74</sup>

Drawing instruments featured regularly in the Society's acquisitions; the Society's first instrument was purchased for the Map Room.<sup>75</sup> The society recorded having acquired thirty four sets of drawing instruments, twenty protractors, eighteen plotting scales, seven proportional dividers or compasses, three beam compasses, five straight edges, seven parallel rules, five pantographs and sixty five plane tables. Drawing instruments were an integral part of the assemblage required for the construction of exploration, repeatedly enabling the production of maps for publication, without which there would have been no visually accessible record of the results of the instruments used in the field. Both the practice of drawing and its location and control were subjects of debate throughout the period. The 'critical and artistic' component of a map-makers' work in Galton's description could lead to tensions between map makers and travellers.



Fig 7.7: Drawing instruments. From top left clockwise: set used by Cameron in the mid nineteenth century, circular protractor by Cary 1892, passometer for map measuring by Cary 1894, and pantograph for enlarging and reducing drawings early to mid-nineteenth century.<sup>76</sup>

---

<sup>74</sup> Coles CB6/502 letter to Assistant Secretary Apr 30<sup>th</sup> 1880

<sup>75</sup> CM 15<sup>th</sup> Dec 1832

<sup>76</sup> Artefact [102.0] (1), Artefact B 4] (1), Artefact D 11 (6)] (1), <http://www.onlinegalleries.com/art-and-antiques/search/scientific-and-technical-instruments-brass-and-brassware-militaria-military-europe-william-iv> April 2017

While the use of the basic drawing instruments as seen in figure 7.7 were in the 'black box', issues of practice were debated in the nineteenth-century focusing on a small number of key issues.<sup>77</sup> These, which featured at the RGS and in contemporary texts, were scale, projection, representation of height, and to a lesser extent, colour. Standardisation was a constant thread. There were enduring tensions concerning control of the data and its manipulation.

As has been noted, the RGS instrument collection effectively came into being with the donation by Shedden in 1850: the twenty items he provided included a set of drawing instruments and two sets of Marquois scales (aids to plotting). One of the sets of Marquois scales went out to Africa with Cameron, but the other two remained in the Map Room. This division of location of the drawing instruments demonstrates the fluid nature of the allocation of these activities: In 1860 a beam compass was bought for the Map Room, and in the following year Petherick was provided with two sets of drawing instruments, a protractor, and a parallel rule for his expedition to Africa. In 1861 Cameron was lent a box of scales.<sup>78</sup> In 1863 Jules Gerard was provided with two circular protractors for Timbuctu, one horn and one brass, while in 1864 a drawing table was bought for the Map Room, and drawing instruments followed.<sup>79</sup> Like drawing instruments in general, the plane table was not confined to use in the field or the centre of calculation. In 1883 the Society purchased one for their Map Room, while in 1888 it was purchasing them for the loan collection.<sup>80</sup> The plane table was used for sketching and topographical work. Crone describes the basic procedure: 'Determination of mean sea level, preliminary plane table reconnaissance to select points for triangulation, erection of beacons, determination of latitude, longitude and azimuth to tie to Earth's surface, careful base measurement, triangulation, calculation, filling in by plane tablers of detail.'<sup>81</sup>

A result of Galton's intervention in 1859 was a stipulation that all maps were to be copied in the Map Room.<sup>82</sup> However, the RGS continued to pay for outsourced map drawing: although, on receipt of a bill from Stanford in 1864 the Finance Committee expressed a desire to reduce the cost of map production.<sup>83</sup>

In 1831 the RGS was sent a map of Armenia by William Monteith for consideration for publication in the fledgling *JRGS*.<sup>84</sup> They required an explanation of the orthography, and suggested that the map should be re-projected with the author's positions and triangles reduced to five inches per degree of latitude, which Messrs Walker, a firm of cartographic publishers, undertook to do for £30 to £35 a plate. The map was eventually published by

---

<sup>77</sup> Cartee (1859), Andre (1874), Elderton (1890)

<sup>78</sup> Sub-committee reporting on instruments for Capt Cameron Nov 12<sup>th</sup> 1861

<sup>79</sup> FC Nov 21<sup>st</sup> 1864, Mar 20<sup>th</sup> 1865, June 19<sup>th</sup> 1865

<sup>80</sup> IC Oct 26<sup>th</sup> 1883, Mar 1<sup>st</sup> 1888

<sup>81</sup> Crone (1953) p.152, Map Committee June 21<sup>st</sup> 1888

<sup>82</sup> CM May 9<sup>th</sup> 1859

<sup>83</sup> FC Nov 21<sup>st</sup> 1864

<sup>84</sup> CM 11<sup>th</sup> June 1831

John Arrowsmith in 1833.<sup>85</sup> The Society would require many such similar tasks: a map of Antarctica was to be reduced for the *JRGS* in March 1832, and having paid Walkers £215 that year for engraving, reducing and lithography, they decided to appoint a Draughtsman and Librarian to reduce costs.<sup>86</sup> Shortly afterwards the Society purchased a pantagraph.<sup>87</sup> The RGS was establishing its own drawing facilities: for financial reasons, to increase their control of the process, and as part of their emerging disciplinary identity.

An early commentator on map making was Major Thomas Mitchell who was surveying with a theodolite and chain in New South Wales in 1835, where there was a great deal of wood to clear and few landmarks. He offered his map with 'observations on the mode by which it had been reduced from the original field observations.'<sup>88</sup> Essentially he surveyed by triangulation, plotting points onto ruled paper. The original sketch was two miles to an inch, but was reduced to 8.5 miles to the inch using a camera lucida. Lines of latitude and longitude were added afterwards.<sup>89</sup>

In addition to discussions of practice, Mitchell was involved in two arguments with Arrowsmith over control of the product. On 9<sup>th</sup> June 1838 he wrote to Captain John Washington complaining that Arrowsmith had approached him 'with unmitigated firmness' regarding his map, informing him that the names had not yet been engraved and suggesting a new title; 'he tears the map from my own hands!' 'On my objecting to this he declared he would not alter the title.' (from that chosen by Arrowsmith): 'Now considering that I had put my map in his hands on condition he would publish it in six weeks, when he conceived he had me at his mercy'. Mitchell complained that Arrowsmith had reduced his scale and altered his longitudes, describing these actions as 'violating' his work, and also that it was not ready on the day it should have been coloured, complaining of 'shuffling delay' and the 'intolerable insolence' of Arrowsmith. Much later he wrote claiming Arrowsmith had made unagreed alterations to another map he had submitted.<sup>90</sup> Scale was a constant source of difficulty between travellers, who wanted their work in maximum detail, and map makers who were concerned with cost.

Arrowsmith was a central figure in the early days of map production at the RGS. He was a founding member of the Society, took over his family map-making business in 1839, and became their principal map producer following Messrs Walker. Arrowsmith showed himself as being extremely knowledgeable and able to exert his considerable influence; he did not spare the travellers his scorn on several occasions. The drawing of Godfrey Vigne's map appears to have caused particular difficulties. Arrowsmith wrote to Washington starting nearly every sentence with 'What is the distance and direction?' and asking for the scale.

---

<sup>85</sup> *JRGS* 3 p.1, Arrowsmith CB1/1 letter to RGS 21<sup>st</sup> June 1833

<sup>86</sup> CM 3<sup>rd</sup> March 1832, CM 10<sup>th</sup> Nov

<sup>87</sup> CM 15<sup>th</sup> Dec 1832

<sup>88</sup> CM 25<sup>th</sup> May 1835

<sup>89</sup> Hammond and Austin (1987)

<sup>90</sup> Mitchell CB4 Letter 19<sup>th</sup> Jan 1851 Mitchell to Capt Smyth

Writing again on 15<sup>th</sup> November 1839 he asked 'I think it stated in the Athenaeum that Mr. Vignes did not visit (Hebra), are we to understand from this that he neither visited the district or the capital of Hebra?' After about a dozen similar questions he asked whether a particular place was a hill fort or a fortified valley, demonstrating the difficulties of representing height at the time.<sup>91</sup>

Arrowsmith was aware of what had been published. On being presented with Count Karacsay's drawing of Albania in 1841 he remarked 'Two tolerably good maps of Turkey are in circulation,' giving the authors, place of origin and dates of publication.<sup>92</sup> He compared the latitudes and longitudes of the older maps with the new one. In the same year he was sent a drawing by 'De Martius' (probably Carl von Martius) which he considered to be different in many details from the map of America by the same author produced in 1825. Arrowsmith was 'much in favour of the drawing.' He then compared both these with another map published in 1831, finding the last 'the most faulty of the three.' It is not clear on what basis he came to these conclusions. Eventually he decided De Martius' drawing was not worth publishing but offered half the fee 'to keep the drawing by him.'<sup>93</sup>

On 20<sup>th</sup> Jan 1843 it was recorded that Arrowsmith was holding sixty-eight plates, fifteen of which had been passed on by John Walker, hydrographer to the East India Company. They were being 'taken care of' on behalf of the Society.<sup>94</sup> Arrowsmith had the authority to challenge travellers' figures: In 1848 a letter from him contained opinions on Captain George Grey's 'overestimated distances' and lack of latitudes, and remarked pointedly that Grey had lost his ships in Gantheaume Bay, off Australia.<sup>95</sup> It is clear considerable resource invested in the instruments, travellers, and expeditions had come to reside in the centre of calculation and in particular with, and within, Arrowsmith.

Arrowsmith had to contend with instrument errors as well as lack of information from several travellers. He wrote to Norton Shaw when he had Vogel's papers which included the following instructions: 'Observations made with a ten inch Dollond sextant. The error of collimation is to add to the value read off when negative, and to subtract when positive.' He continued acidly: 'You ask if there be any use in asking Dollond to see an instrument like the one used and notice if there be any peculiar construction about it. My reply would be no.'<sup>96</sup> Arrowsmith was sometimes unable to obtain the necessary data: Regarding the map from the Central Africa Expedition in 1860 he stated; 'a map should be constructed but cannot be without the positions which appear to be in the hands of McClear.'<sup>97</sup> As noted, McClear was

---

<sup>91</sup> Arrowsmith CB2/25 Letter 30<sup>th</sup> October 1839

<sup>92</sup> Arrowsmith CB3/22 report dated 8<sup>th</sup> Nov 1841

<sup>93</sup> Arrowsmith CB3/22 letter to Jackson 28<sup>th</sup> June 1841

<sup>94</sup> Edney (1997) p. 320-323, Kennedy (2014)

<sup>95</sup> Arrowsmith CB3/22 letter to RGS 14<sup>th</sup> Feb 1848

<sup>96</sup> Arrowsmith CB4/52 letter to Norton Shaw Nov 5<sup>th</sup> 1855

<sup>97</sup> DL/3/4/6 Mar 26<sup>th</sup> 1860

involved in the computation and production of authoritative results from Livingstone's observations, but unfortunately went blind before he could finish the task.<sup>98</sup>

Other discussions concerned practice. An intervention was made by a Professor E. Michealis from Switzerland discussing the various methods of representing heights; 'hachures', 'coubes horizontales' or 'effets des lumiere oblique', and referring to his paper in *Le Bulletin De la Societe de Geographie de Paris* the previous year.<sup>99</sup> Representing heights was part of ANT's science-in the making in the nineteenth century. In 1847 the RGS Council was approached by Drach with ideas for improving contour lines, the first mention of them in the minutes, although the document has not survived. Thomas Colby considered them ingenious but did not support Drach.<sup>100</sup> By 1862 they were seen as the future as Freshfield wrote 'the days of uncounted maps and black and white hachuring are numbered' in a letter to *The Times*.<sup>101</sup>

Contour lines were only one form of isomap which were becoming popular: Tidal, magnetic, and meteorological information was suitable for creating isomaps. Sabine asserted that by using his magnetic instruments and techniques, maps containing isodynamic, isogonic, and isoclinical lines could be produced.<sup>102</sup> Galton's 'Isochronic Passage Chart for Travellers' of 1881 was a new application of this presentation technique, vindicating London as the centre of calculation.<sup>103</sup> The creation of these topological plans was an example of the great advantage of maps according to Latour: 'They can merge with geometry, diagrams and numbers. The mobilisation of many resources through space and time is essential for domination on a grand scale.'<sup>104</sup>

---

<sup>98</sup> DL /2/10/2 p.121 Mar 10<sup>th</sup> 1856 CM Feb 28<sup>th</sup> 1881

<sup>99</sup> CM 2 Nov 23<sup>rd</sup> 1846

<sup>100</sup> CM Feb 22<sup>nd</sup> 1847, Drach CB4/519 Oct 15<sup>th</sup> 1858.

<sup>101</sup> CM Nov 13<sup>th</sup> 1893, Parsons (1880) p.113, p.126

<sup>102</sup> Herschel (1851) p.27

<sup>103</sup> Mr World S/106

<sup>104</sup> Latour ( 2011) p. 66, Withers (2011) p.44



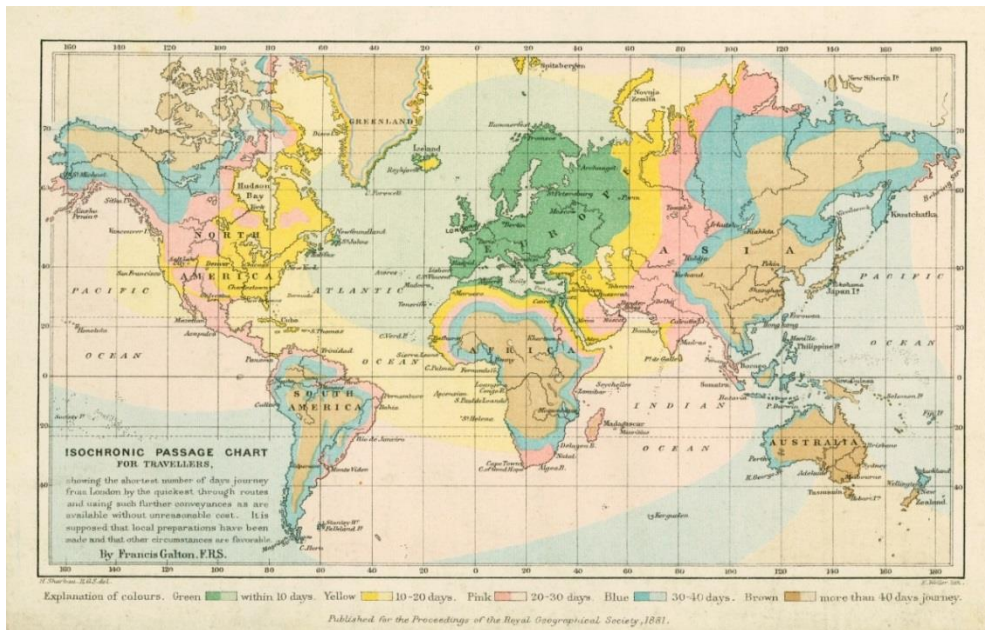


Fig 7.8: Isochronic passage chart for travellers by Galton, 1881.<sup>105</sup>

That maps could be subjects of friction in their preparation map as a contest is illustrated clearly in a dispute between Beke and Antoine D'Abbadie in 1850: it exemplifies the observation that authority could easily be questioned because exploration relied on trust. Beke accused D'Abbadie of never having been to Kaffa, South Abyssinia, in 1843. In a letter to the Council in August, Antoine D'Abbadie wrote that 'the most feasible way to impugn my veracity is to go over the same ground and follow step by step my observations of latitudes and azimuths. The observations and all my maps shall be placed before your eyes.'<sup>106</sup> Charles Johnston was also in dispute with Beke, the latter accusing Johnston of plagiarising his ideas on the course of a river. Beke was able to refer to a map that he had constructed in 1842 to support his case against Johnston.<sup>107</sup>

Outsourcing map drawing was expensive. In 1855 Ravenstein complained to the Society that the ten guineas he had received for a map did not even cover his outgoings, and that it had taken him thirteen weeks of 'actual labour.'<sup>108</sup> Occasionally the interests of the Society were in conflict with Ravenstein's business as a professional map-maker. In 1876 he let Rawlinson know that he would be publishing a map of Cameron's journey, but as the scale would be 'very small', i.e one degree per inch, it would not 'forestall that of the complete map by the Society'. Ownership of information was a difficult area of negotiation. Ravenstein promised not to make public the rough sketch he had made in the Society's Rooms, and

<sup>105</sup> Control number 503111

<sup>106</sup> D'Abbadie CB3/195 letter to the Council Aug 6<sup>th</sup> 1850

<sup>107</sup> Beke CB3/67 letter 7<sup>th</sup> Feb 1844

<sup>108</sup> Ravenstein CB4/1402 letter to RGS 21<sup>st</sup> April 1855



regretted that a tracing of Cameron's map was printed without permission.<sup>109</sup> He then asked for consent to publish two maps embodying Cameron's journey into maps of Africa for the *Geographical Magazine* and the *London Illustrated News* respectively.<sup>110</sup>

Acknowledging sources of data was a persistent issue. In 1877 Ravenstein worked with the RGS when he proposed a map of Central Africa together with a Memoir which would list all the sources and give astronomical observations and a discussion of observations for altitude.<sup>111</sup> Reporting on progress in 1880, Ravenstein intended to insert a biography immediately after the names of the travellers, and where a number of individuals comprised a team he would take all their reports.<sup>112</sup> This soon became a vast task which was not complete by the end of 1880. Arrowsmith compiled data from nine sources for his map of South America.<sup>113</sup>

The extent of the surface areas of these collaborative maps made projections an increasingly significant issue. Several ideas were suggested in the mid-nineteenth century to minimise the inevitable distortion.<sup>114</sup> The Mercator projection was the default model as it retained angles or 'rhumbs' across the entire area of the map. In Britain by 1800 the two-sphere 'stereographic' projection and the Mercator had been dominant to the extent that Johann Lambert's conformal conic projection of 1772 appears to have been unknown. Lambert is relevant because Herschel re-invented the conic projection in a paper to the *JRGS* on the 'new projection of a sphere' in 1859.<sup>115</sup> Herschel submitted maps and a table of data for the stereographic projection or 360 degrees, 240 degrees and 120 degrees, the last of which he declared 'seems to me not un-likely to supersede all other projections for a general chart'. He illustrated the last two examples. However the conical projection was not included in *Hints* until 1883 and was rarely used.<sup>116</sup>

Herschel's paper in the *JRGS* was followed by one from Henry James, the Director of the Topographical Department of the Ordnance Survey, advocating a projection in which he claimed distortion was 'diminished to a greater extent than in any other.'<sup>117</sup> James' projection was a special case of Alexander Clarke's 'zenithal' projection according to Hinks, who assessed it as being very good for Africa, which was the example used by James.<sup>118</sup>

---

<sup>109</sup> Foliard (2017) p. 152

<sup>110</sup> Ravenstein CB6/1863 letter to Rawlinson Jan 13<sup>th</sup> 1876

<sup>111</sup> Ravenstein CB6/1863 letter to Bates 25<sup>th</sup> June 1877

<sup>112</sup> Ravenstein CB6 /1863 9<sup>th</sup> Feb 1880

<sup>113</sup> Arrowsmith LMS.A.27

<sup>114</sup> Fenna (2006) p. 472

<sup>115</sup> Herschel (1860), pp. 100-106, CM Mar 28<sup>th</sup> 1859, April 11<sup>th</sup> 1859, Monmonier (2004), Snyder (1993)

<sup>116</sup> *Hints* (1865) p.30, (1871) p.55, (1878) p.65, (1883) p.105, (1889) p. 146, (1893) p.148

<sup>117</sup> James (1860) p. 106

<sup>118</sup> Hinks ( 1921) (2<sup>nd</sup> edition) pp. 48-50



Fig 7.9: 'Political and Physical Chart of the World on Gall's projection,' by Bartholomew, 1869.<sup>119</sup>

The Rev James Gall submitted a paper on his projection in 1869.<sup>120</sup> He advocated using the same latitude lines or parallels as on the stereographic projection, rectifying latitude to longitude at 45 degrees north and south only.<sup>121</sup> This was a cylindrical projection but had advantages over the Mercator. He had first put this idea forward in 1855 at the BA meeting in Glasgow, but since then had improved it by adding 'Polar Supplements.'<sup>122</sup> General Scott Waugh refereed the paper recommending it for publication. While Gall sacrificed the advantage of Mercator for rhumb lines, Scott Waugh judged that he had managed to represent two thirds of the globe reasonably accurately.<sup>123</sup> *Edkin's Elliptic Chart of the World* was acquired for the Map Room in 1871, but when the RGS was commissioning maps the Mercator's projection was still preferred: it was chosen for the new diagram of Asia in 1867, and for a map of Central Africa commissioned in 1878 from Keith Johnson.<sup>124</sup>

During the final three decades of the nineteenth century the tension between in-house staff and outsourcing can be seen with respect to map making. In 1871 Galton

---

<sup>119</sup> Mr World 265 (1)

<sup>120</sup> JMS/19/20, Gall (1870 - 1871) p. 159

<sup>121</sup> Snyder (1993) p 109

<sup>122</sup> JMS/19/20 p. 191, CM Jan 24<sup>th</sup> 1870

<sup>123</sup> Monmonier (2004) p. 12

<sup>124</sup> Special Library and Map Committee 8th Feb 1867 Accessions to the Map-Room, from May 22nd, 1871, to May 27th, 1872 *JRGS* Vol. 42 (1872), pp. cxxii-cxxxiii, SPC 9<sup>th</sup> Jan 1878

initiated another of his many reorganisations.<sup>125</sup> He argued that more needed to be done for the assistant secretary, so a new assistant curator of the Map Room was required. Following advertisement Keith Johnston was appointed in 1872.<sup>126</sup> Johnston had been taught mathematics by Edward Sang, who invented a planimeter.<sup>127</sup> In 1872, shortly after this appointment, Galton suggested a report on styles of cartographic representation.<sup>128</sup> Following Johnston's departure to Paraguay in 1874 the post was filled by William Turner.<sup>129</sup> Turner asked for an increase in pay in 1876, claiming to have frequently worked very late with a cost to the Society of less than half that of an ordinary map maker.<sup>130</sup> Turner and Ravenstein had their disagreements, but Turner considered himself fit for promotion to Map Curator when the post was advertised on George's retirement in 1877.<sup>131</sup> Turner was not successful as the post went to John Coles. Coles' files contain a description of the duties of the Map Curator, a senior post, which included being in charge of the instruments as well as the maps. A decision not to re-appoint an assistant, but to let out the work of compiling maps was taken in 1888.<sup>132</sup> This move was short-lived as in 1895 map drawing was put back under the assistant secretary and Bernard Darbishire was to compile William MacGregor's map.<sup>133</sup>

In 1879 the Society received a paper from Arthur Cayley, Sadleirian Professor of Mathematics at Cambridge. Galton wrote to Cayley asking for 'a short paragraph suitable for the Proceedings explaining the very curious problem of the sufficing of four colours to distinguish adjacent territories in maps, which has lately excited great interest among the higher mathematicians'.<sup>134</sup> Galton received a reply that was 'more technical than he had hoped,' but 'I am sure it would interest a small section of our Society'. It was 'also something to obtain a paper from the most eminent mathematician in England, and probably in the World, on a geographical topic.' In 'Note on the Colouring of Maps,' Cayley asserted that the late Augustus De Morgan had referred to the theorem as being 'known to map makers'. However, there was a difficulty in giving a 'strict and complete proof of it'. 'This I have never succeeded in finding.'<sup>135</sup>

De Morgan's assertion that map makers knew of this is difficult to substantiate. Many maps were drawn with four colours in the period before explication of the theory, but five colours were used on more complex maps indicating that the number of colours was not such a significant factor in the cost of production. This was probably due to six colours being immediately available from the purchase of three: the common three recommended were

---

<sup>125</sup> Special Committee Dec 15<sup>th</sup> 1871

<sup>126</sup> CM Mar 11<sup>th</sup> 1872, Galton CB6/864 letter to Markham, March 3<sup>rd</sup> 1872

<sup>127</sup> McCarthy (2004) p. 59

<sup>128</sup> CM Mar 25<sup>th</sup> 1872

<sup>129</sup> CM Mar 11<sup>th</sup> 1872, Holland (1980) p. 211

<sup>130</sup> Turner CB6/2225 18<sup>th</sup> June 1876

<sup>131</sup> Turner CB6/2225 letter to the Secretary Sept 16<sup>th</sup> 1876, CM May 14<sup>th</sup> 1877, June 11<sup>th</sup> 1877

<sup>132</sup> Map Committee June 21<sup>st</sup> 1888

<sup>133</sup> Instruments and SPC Nov 13<sup>th</sup> 1895

<sup>134</sup> JMS/19/24 Galton letter to Bates Jan 24<sup>th</sup> 1879

<sup>135</sup> JMS/19/24 Jan 27<sup>th</sup> 1879

Crimson lake, Prussian blue, and Gamboge, (a yellow). In light washes they produced pink, yellow, green (from blue and yellow), and brown (pink and yellow). A blue wash was used for water.<sup>136</sup> It was not difficult to produce purple, normally the fifth colour on land. While colours were often purchased at Finance Committee meetings, it was never recorded how many.

In 1877 Ravenstein produced a map to accompany his paper 'Recent Changes in the Map of East Africa,' referred to by Kirk.<sup>137</sup> The paper was deemed 'quite uncalled for' because British crimson lake had been applied to German territories. The reception of the map demonstrates the political significance of colouring: 'This station and the German colour cannot possibly be permitted to stand.' However, this understanding of what was proper remained implicit until 1913 when standardisation of map colours was discussed at the Society.<sup>138</sup>

Another contest involving maps followed the dispute over O'Neill's calculations discussed above. In 1884 O'Neill was involved in a dispute with Rev W.P. Johnson regarding the latter's map of the Blantyre district.<sup>139</sup> Having seen Johnson's map in the Proceedings of September that year, O'Neill wrote a detailed letter questioning Johnson's data; 'if Lake Shirwa be as Mr. Johnston has represented it, I must have lived for ten days in its waters. The series of latitude observations and cross bearings by prismatic compass, which I obtained at four different stations, must be entirely apocryphal'. O'Neill felt he had been attacked 'indirectly'. Both maps were standing as 'knowledge' but were in conflict. As frequently happened, O'Neill accused Johnson of not actually going to the places he described. Grant, who was the referee, suggested that the letter was not published but sent to Johnson to answer, and the two points of view would be compared by Council. Grant acknowledged that Johnson had not claimed 'scientific accuracy.'

The particular instruments used in the field affected the style of map, and hence the type of knowledge produced. H.H. Johnston's reliance on the compass and distance measurement was remarked on in chapter 6. His maps therefore consist of linear route marches. The plane table, however, gave rise to more descriptive sketches of areas; the one below by Mersh Strong is typical.

---

<sup>136</sup> *The Pupil's Copy Book* (1880), Warne (1868), (1870), Hughes (1861)

<sup>137</sup> JMS 2/252

<sup>138</sup> CM Apr 28th Apr 1879, Research Committee Dec 18th 1913

<sup>139</sup> JMS/2/233, CM Dec 8th 1884

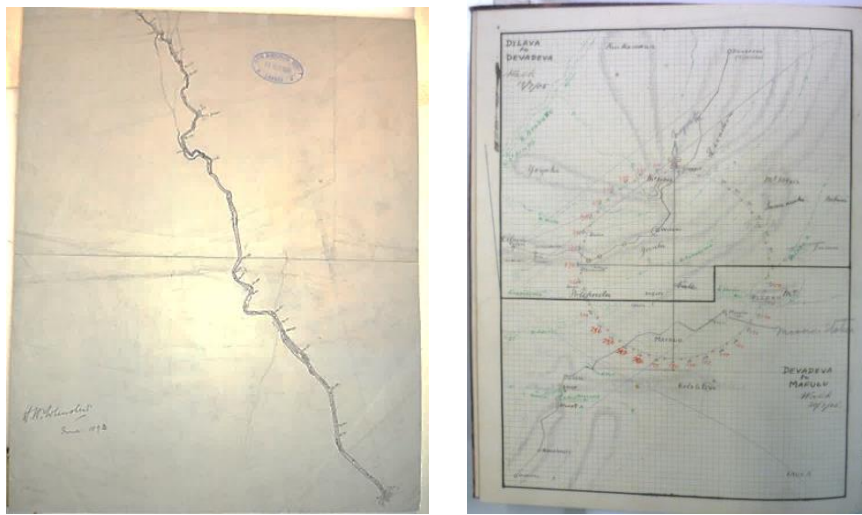


Fig 7.10 a and b: Sketch maps by H.H. Johnston and Mersh Strong demonstrating the differing results from using different instruments.<sup>140</sup>

In 1892 a Special sub- Committee of the Library and Map Committee decided on rules for map making. Maps for the *JRGS* should be accompanied by notes and observations, and should include routes of the travellers. Standard maps for general consumption should be produced by the Society, not just for the *JRGS*. All maps should be in multiples or sub-multiples of one million. Latitudes and longitudes should be fixed astronomically determined and be tabulated on the face of the map, anything doubtful shown by dotted lines, with a uniform style but colour printing necessarily varying with circumstance.<sup>141</sup> In 1897 a draughtsman was appointed to draw standard maps of interesting regions ‘as decided in December 1892’, which suggests no action was taken.<sup>142</sup>

The Society was increasingly subject to standardisation from external agents. In 1891 the *GJ* contained a note from Holdich recommending the adoption of the Greenwich meridian for all English maps. He reported ‘awkward discrepancies’ because the position of the Madras Observatory was incorrect, thus compromising maps of India. The India Office forwarded a similar report by Holdich the following year.<sup>143</sup> In 1897 the fifth international congress of geography resolved that a map of the World should be made 1:1,000,000, with the meridian at Greenwich, and the metre be accepted. When Colonel St George Gore offered a map of India and adjacent countries at 1:1,000,000 he was congratulated for using metric and for not using 16 miles to the inch, which suggests a nationalistic reversal to British measure in the early years of WW1.<sup>144</sup> The 1897 congress also asked the societies to

<sup>140</sup> H.H. Johnston SSC/86, WMS

<sup>141</sup> Special sub- Committee of the Library and Map Committee 13<sup>th</sup> Dec 1892

<sup>142</sup> Library and Map Committee Feb 19<sup>th</sup> 1897

<sup>143</sup> CM Nov 14<sup>th</sup> 1892, Holdich (1891b), Withers (2017) p. 251

<sup>144</sup> EC May 8<sup>th</sup> 1900

consider the use of decimal time and angles. The RGS considered this impracticable.<sup>145</sup>

At the start of the twentieth century the subject of projections enjoyed renewed interest owing to the proposed third series of the Ordnance Survey.<sup>146</sup> It was decided to set up a committee in order to standardise projections with the result that the third series was to be emulated.<sup>147</sup> In response to a pamphlet by Major Charles Close setting out his intentions, suggestions were received by a number of authors including Reeves.<sup>148</sup>

Stein's correspondence with Keltie allows further insight into the discussions over maps in the early 1900s. Stein related that he had called in at the map room to see how his map was coming along, only to be disappointed the scale was 1: 1,500,000, which he regarded as far too small: 'This map would not suffice for the purpose of my Detailed Report for the Government of India.' He suggested the expenses were borne jointly with the India Office to produce a map of 1: 500,000.<sup>149</sup> If this proved impossible he would like a compromise of 1:1,000,000. Keltie considered 1:1,500,000 to be adequate so Stein could do little.<sup>150</sup>

In his paper of 1915 Alan Ogilvie Grant recognised that that official survey departments needed to produce maps which would satisfy the greatest number of interests.<sup>151</sup> The result of this, he argued, was that features of special interest to certain groups were obscured. He lamented the hachuring had become 'subsidiary and frequently indistinct', compared with the 'clear and beautiful hachures of the old engraved map.' The Ordnance Survey had introduced a colour scale based on the International Map, which he believed did not give a 'clear conspectus' of the relief. On the six inch maps he believed there should be more contouring. Ogilvie represented one of the specialist interest groups which were becoming a feature of twentieth-century geography, with corresponding fragmentation of desiderata.<sup>152</sup> These specialist interests were not always well-served by standardisation. An increased tension between the requirements of the different users of the maps is evident.<sup>153</sup>

The Great War gave impetus to aerial surveying, which required different types of map.<sup>154</sup> Ball pointed out the requirements in maps for aerial use, for example the hills did not show up from above so needed to be in different colours. 'Mercator loses some of its attraction.'<sup>155</sup> He did not believe there could ever be serious aerial surveying as pilots always had to look for a place to land. However, according to Crone it was not until after the period in

---

<sup>145</sup> EC May 7<sup>th</sup> 1897

<sup>146</sup> For example SPC Nov 13<sup>th</sup> 1895

<sup>147</sup> CM Jan 6<sup>th</sup> 1903, Map Committee Feb 4<sup>th</sup> 1903

<sup>148</sup> Everett (1904)

<sup>149</sup> Stein CB7/81 letter to Keltie 24<sup>th</sup> July 1902

<sup>150</sup> Stein CB7/81 Letter from Keltie 25<sup>th</sup> July 1902

<sup>151</sup> JMS/20/85

<sup>152</sup> Godlewska and Martin (2011) p. 363

<sup>153</sup> CM Nov 11<sup>th</sup> 1902, Reeves (1904) p. 670-672

<sup>154</sup> Crone (1953)

<sup>155</sup> CB9 Ball/11 letter to Hinks July 21<sup>st</sup> 1921

question that 'the aerial camera achieved final triumph over the plane table as the cartographer's primary tool.'<sup>156</sup>

Gregory in a letter to Reeves in 1922 gave an idea of the topics of concern for map makers at this time; 'The areas off our route had to be hunted up off many authors'.<sup>157</sup> He gave a list of conventional signs that he had used, indicating they were not as yet 'closed'. He treated each 'form' line as a contour line, but frequently had to 'end them off', a forbidden practice with an isogonal line. 'I did not think it necessary to take the very great pains required to avoid such occurrences, although I tried my best to avoid it'. 'I expect the draughtsman will replace my continuous with broken lines.' The projection was a secant conic. 'I fear the linen has shrunk a bit since I started work'. He advised against putting in latitudes because 'at many points other people's observations ought to be taken into consideration, and with many of them there is no means of finding out at what places the latitudes were taken'. He volunteered sending tracings of altitudes to be pricked through, and the instrumental corrections also needed attention. He did not want it reduced in scale but summed up the situation with; 'one can't have everything one wishes'.

As the RGS was drawn into international collaboration it inevitably lost control of aspect of map production. Rodd submitted a note on the 'Croquis de Sahara' Agades sheet together with the 'Journal of his Route across the Sahara in 1927'. The sheet was 'presumably destined to serve as a preliminary for the International Million' as it was on the same scale, projection, and sheet arrangement.<sup>158</sup> 'The Million map' was proposed at Berne in 1891 by Albrecht Penck with a scale 1 to million, and was intended to cover the whole World, but was not complete fifty years later.<sup>159</sup> It was a modified polyconic. There were difficulties with representing countries like England and the Himalayas and England with same contours. Eventually Africa was completed on a scale of 1:2,000,000, and Asia 1:4,000,000.<sup>160</sup> As found in chapter 6, the increasing physical remit of the geographic enterprise only brought new problems.

## Conclusion

Assessment of evidence relating to the manipulation of instrumental data has revealed several points. Calculation and map production were necessary activities within the cycle of knowledge production, with resources devoted to them explicitly. Calculation practices were largely agreed, but ownership and control of the results was constantly contested. The tendency was for the observations of the gentlemen travellers to be moderated by professional scribes working in offices in order to produce more credible knowledge, and to diminish fallibility, thus diminishing the immutability of the data as

---

<sup>156</sup> Crone (1953) p.153

<sup>157</sup> Leake (2011), SSC 60 letter 23<sup>rd</sup> Nov 1922

<sup>158</sup> FJR/2

<sup>159</sup> Pearson and Heffernan (2009)

<sup>160</sup> Crone (1953) p. 163

immutable mobiles. A consensus regarding the computed results at the centre of calculation was a necessary step in knowledge production, but the process of reaching that consensus has been shown not to have been smooth in many cases.

The Society had to oversee many instances of debate concerning practice and ownership with regard to map drawing. There were tensions between travellers and map makers particularly over scale, the representation of height was a subject of debate and innovation, and as the regions represented grew larger, projection became an increasing focus for discussion. Different instruments in the field produced different forms of information which augured against standardisation. During the period norms of presentation were progressively imposed from outside the Society, which did not always suit specialist interests; the RGS itself had to defer to a larger centre as international pressure increasingly dictated how things should be done.

As a consequence of the need for calculation and map drawing to make observations meaningful, those who had been out to the periphery were forced to defend their results against those based at the centre. The necessity of reaching consensus with groups such as calculators, draughtsmen, and the RGS Council, ensured the 'fallibility' of the individual, with his or her 'ill-mannered mediators,' could be subsumed into the increasing quantity of 'knowledge'. The nature of this knowledge depended on the selection of instruments deployed in the field, and the constraints exerted by tensions in the processes undertaken in its production.



## Chapter 8:

### The Agency of Instruments

*Mr. Steains is proposed for the Back Grant as he 'carefully plotted map of Rio Doce based on upwards of 4000 magnetical bearings and careful dead reckonings made during an adventurous exploration undertaken at his own risk and cost'.<sup>1</sup>*

#### Introduction

From the wide-ranging investigation of the Society's practices, the final empirical chapter identifies the outcomes of instrument use in exploration, and what impact the use of instruments had, intentional or otherwise. Following ANT, it is accepted that the non-human tools engaged in the practice of knowledge-making had an agency which extended beyond the tangible products.<sup>2</sup> Several of the expeditions discussed in chapter 6 will be revisited. Many of the arguments of the thesis manifest themselves at this stage of the cycle.

Four aspects of the agency of instruments have been selected for discussion. The first considers the agency of instruments in knowledge-construction, in which the journal papers published by borrowers, and their associated referee reports, form the principal sources. The second investigates the role of instruments in the creation of the explorer, focussing on the awarding of medals and other marks of individual distinction. The third examines the use of instruments in the appropriation of political power on behalf of their owners in the service of the British Empire. The fourth interrogates the unstated and sometimes unintentional role of instruments in the forging and maintaining of social relationships. It is argued they reinforced hierarchies and increased 'othering.'

#### Knowledge Creation

Knowledge creation was the principal ambition of the Society's engagement with instruments. Hansen argues that the RGS was the repository of Britain's imperial archive of geographical knowledge.<sup>3</sup> This study has concurred with Dritsas that knowledge collection from expeditions was the result of an 'iterative process'.<sup>4</sup> Knowledge creation by means of instrumental data led to the construction of numerical 'facts,' the authority of which has been discussed by authors cited in chapter 2.<sup>5</sup> The publication of papers in the *JRGS*, the *PRGS*, the *GJ*, and other related periodicals were contributions to knowledge creation. The information they contained may have been disputed, nevertheless the material had passed peer review, so entered the arena where facts were disseminated. The decrease in the twentieth century of numbers publishing as a *result* of borrowing instruments, demonstrated in chapter 3, is

---

<sup>1</sup> CM Apr 13<sup>th</sup> 1891

<sup>2</sup> Latour (1987) p.190

<sup>3</sup> Hansen (1996) p. 49

<sup>4</sup> Dritsas (1999) p.263

<sup>5</sup> Poovey (1998) p. xi, Edney (1987) p.17

significant. Alongside this decrease is a corresponding increase in papers from travellers who published on topics other than those directly concerning the expeditions for which instruments were provided, usually preceding the loan. This indicates the advantage of a publication record for bestowing this particular mark of approval, and the subsequent diminished interest in the actual mobilisation of the instruments.

The published papers forged and maintained the Society's reputation: They set forth the durable inscriptions of the developing discipline, and defined 'orthodox' thinking. The unpublished referees' reports are more revealing of underlying conflict and suppression of dissent within the construction of narratives.<sup>6</sup> Agreed criteria for acceptance were slow in coming and were subject to considerable interpretation.<sup>7</sup> Basic questions were sent to referees from the 1850s until the end of the nineteenth century regarding originality, acceptability for publication, length, or adaptability for reading, but otherwise there was no guidance. The behaviour of travellers in the field, as described in chapter 6, can be compared with the results of their expeditions. While in some cases the agency of instruments in knowledge production was in accordance with the ANT model, other less obvious results also arose. Some examples from chapter 6 are followed through and discussed chronologically.

One agency of instruments evident from the data was to improve the chances of the expeditions to which they were lent having a resulting publication. This was not necessarily connected with instrumental use. Alexander's difficulties with mobilising instruments have been noted. Following his loan in 1834, his paper of 1836 was covered in remarks by the referee who asked 'where are the measurements?' and claimed his latitudes and longitudes were ridiculous, so was not published.<sup>8</sup> However, having bestowed on him their confidence and considerable resource, the Society was not in a position to make these views public. Alexander did not submit anything worthy of publication until 1837, and his report, almost devoid of instrumental results, then appeared as a travelogue.<sup>9</sup> At the 1838 Annual General Meeting it was reported that as a result of Alexander's work 'features of an extensive part of hitherto unexplored country have been traced on our maps.'<sup>10</sup> This was not an entirely successful façade given the perceptive piece in *The Athenaeum* quoted in chapter 6.<sup>11</sup> However, while the RGS would have preferred the instruments to have been utilised appropriately, the resources bestowed on Alexander ensured a product, albeit one merely descriptive.

---

<sup>6</sup> Edney(1987) p. 80

<sup>7</sup> Benjamin Newman's PhD thesis in progress

<sup>8</sup> Alexander (1836), JMS/2/11

<sup>9</sup> Alexander (1837)

<sup>10</sup>Alexander(s) (1838), Report from the Council *JRGS* 8 (1838) p.v

<sup>11</sup>*The Athenaeum* Sept 29<sup>th</sup> 1838 no 570 p.714



Fig 8.1: Schomburgk's map of British Guayana, 1836.<sup>12</sup>

In other cases instruments contributed directly as intended to knowledge creation. Schomburgk, the second traveller to have been granted instruments in 1834, was able to make them participate strongly in his contribution to knowledge, and in spite of some issues of control, the RGS benefitted from his instrumental results.<sup>13</sup> The *JRGS* for 1836 contained an abridged

<sup>12</sup> Schomburgk (1836)

<sup>13</sup> CM June 13<sup>th</sup> 1836 and Feb 27<sup>th</sup> 1837

version of his first three reports from British Guyana including astronomical and meteorological observations and a map.<sup>14</sup> The format became prevalent for the more scientific papers incorporating measurement. The narrative style was similar to that of Alexander, except that the text was peppered with references to taking measurements; 'by a meridian altitude of the Sun'; 'By an excellent meridian altitude'; 'According to my chronometer.'<sup>15</sup> The paper ended with a summary of the daily meteorological register, a comparison of water and air temperatures, and a detailed map of scale eight and a half miles to the inch. This information would not have been possible without the mobilisation of instruments.

The third traveller to borrow instruments was Ainsworth, who was a pioneer in the use of the magnetometer.<sup>16</sup> Sabine revealed slight misgivings over the quality of the data: 'I have carefully examined his observations. Nothing could be done to make his observations more perfect in future than they are now- so they should be published, which would be good for Ainsworth, the RGS, and Science, provided it is not accompanied by a sacrifice in accuracy. Please approve publication.'<sup>17</sup> The paper was duly published. The agency of a new instrument included increasing emphasis on a particular natural phenomenon. The magnetometer was promoted by its supporters even though they knew the data produced was tenuous, as it also opened up new interesting lines of enquiry.

Galton produced a publication following considerable mobilisation of instruments.<sup>18</sup> While his narrative demonstrated an aptitude for measurement, most of the instrumental material appeared in a long footnote.<sup>19</sup> There was a table of data at the end of the paper giving latitudes and longitudes, and a carefully delineated map. The strategy of separating instrumental measurements from the principal narrative by means of maps, tables, and footnotes was becoming established, but the exact format was not yet agreed. The practice of separation allowed papers without measurements, or where the measurements had been deemed inadequate, to be published without discrepancies in narrative style.

---

<sup>14</sup> Schomburgk (1836)

<sup>15</sup> Schomburgk (1836) p.227, p.230, p.234 p. 239,and p.254

<sup>16</sup> JMS 20/2

<sup>17</sup> Sabine CB2/471 Oct 20<sup>th</sup> 1838 Sabine to Washington

<sup>18</sup> Galton (1852)

<sup>19</sup> Galton (1852) p. 155

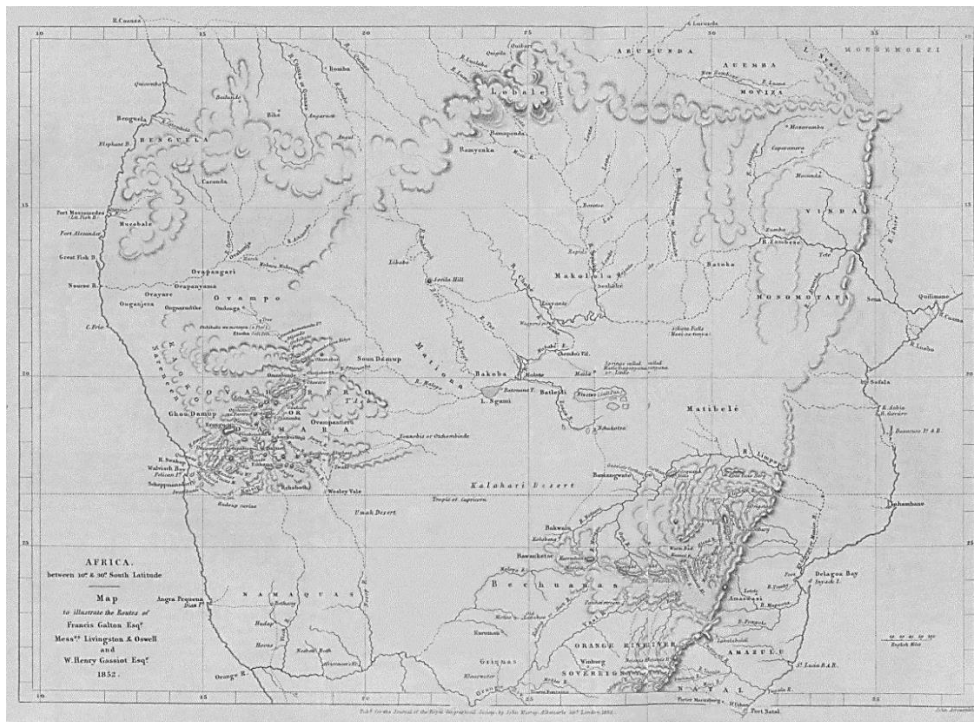


Fig 8.2: Galton's map of Africa between 10 and 30 degrees South latitude, 1852.<sup>20</sup>

Sutherland's successful mobilisation of instruments on his ocean voyage in 1853 has been described. Murchison, his referee, thought his paper 'methodological and a positive addition to physical science.' Murchison commented that 'The barometer observations, although made generally with the aneroid, an instrument rightly excluded from scientific pursuits, may not be altogether valueless, as the error was carefully ascertained by the Secretary of the British Meteorological Society, and while the instrument is totally useless at elevations, it is due to its inventor to state that at such variations as are common at sea level in atmospheric pressure, its undulations usually perform with those of the mercurial barometer.'<sup>21</sup> Results using an aneroid had little authority, but if the readings agreed with the mercurial barometer they could be held to have value, especially if the British Meteorological Society had been incorporated. Therefore one instrument could add to knowledge through the agency of another. Sutherland's readings also gained value by being taken over a large area: 'The thermometric observations may not be unimportant as they apply to considerable portions of the currents in the north and south Atlantic'. Sutherland's diligence and the resource invested reaped direct rewards.

In the case of Livingstone the RGS had a similar problem to that of Alexander, but one exacerbated by Livingstone's extraordinary following.<sup>22</sup> Because of the anomalies of his observations, for example in his dates, it was not possible for Livingstone's observations to be

<sup>20</sup> Galton (1852)

<sup>21</sup> JMS/20/6

<sup>22</sup> DL 2/10/1

promoted as knowledge, but instead an accolade in general terms had to be constructed.<sup>23</sup>

McClellan's covering letter excusing Livingstone has been noted. Arrowsmith, who was chosen as the referee, advised that the paper needed the addition of footnotes including the longitudes, which he had added. 'McClellan's calculations were not to appear, only his covering letter'. Thus Livingstone's work was not exposed to scrutiny.<sup>24</sup> Livingstone's instruments thus had virtually no agency in knowledge creation, but were held up as objects representing vague senses of perseverance and precision: 'Very few explorers have so perseveringly and so geometrically fixed their tracks'.<sup>25</sup>

Burton and Speke each contributed to their published papers. Burton listed the instruments they carried: a sextant, artificial horizon, two compasses, an ordinary thermometer and a boiling point thermometer.<sup>26</sup> He only mentions the ordinary thermometer and a pedometer as having been used: 'The pedometer showed six miles.'<sup>27</sup> 'We could not set up marks, and at times the thickness of the jungle rendered sights somewhat uncertain.'<sup>28</sup> 'On the coast we might easily have rectified the extraordinary errors of the charts; but not having been supplied with copies we concluded that a regular survey had left us nothing to do'. Burton gave the impression that the lack of measurement was unfortunate but of no real consequence.

The third and fourth reports were penned by Speke as Burton had become ill. Contrary to Burton's complacency, Speke apologised for the lack of measurements, including all the frustrations described in his letters. He did manage to send a list of meridian altitudes used to construct the map. He admitted doubting his boiling point thermometer, but reported having another with which he checked it by, in a manner similar to Sutherland's transfer of authority. Speke described his methods: 'My principle in protracting the map has been in carefully observing the distance by time, making due allowance for curvature, and by taking the latitude from a star every 10 to 20 miles'. Paradoxically, his regrets over malfunctioning instruments served to support their importance, as his unquestioning belief in Edney's 'epistemological ideal'- that 'correct and certain archives of knowledge could be constructed by following rational processes'- is compelling.<sup>29</sup>

---

<sup>23</sup> DL/2/10/2-3 7<sup>th</sup> March 1856

<sup>24</sup> DL/2/10/4 CM Feb 9<sup>th</sup> 1857, Mar 23<sup>rd</sup> 1857

<sup>25</sup> DL /2/10/2, CM Mar 10<sup>th</sup> 1856

<sup>26</sup> Burton and Speke (1858) p.206

<sup>27</sup> Burton and Speke (1858) p.207

<sup>28</sup> Burton and Speke (1858) p.219

<sup>29</sup> Edney (1987) p. 17

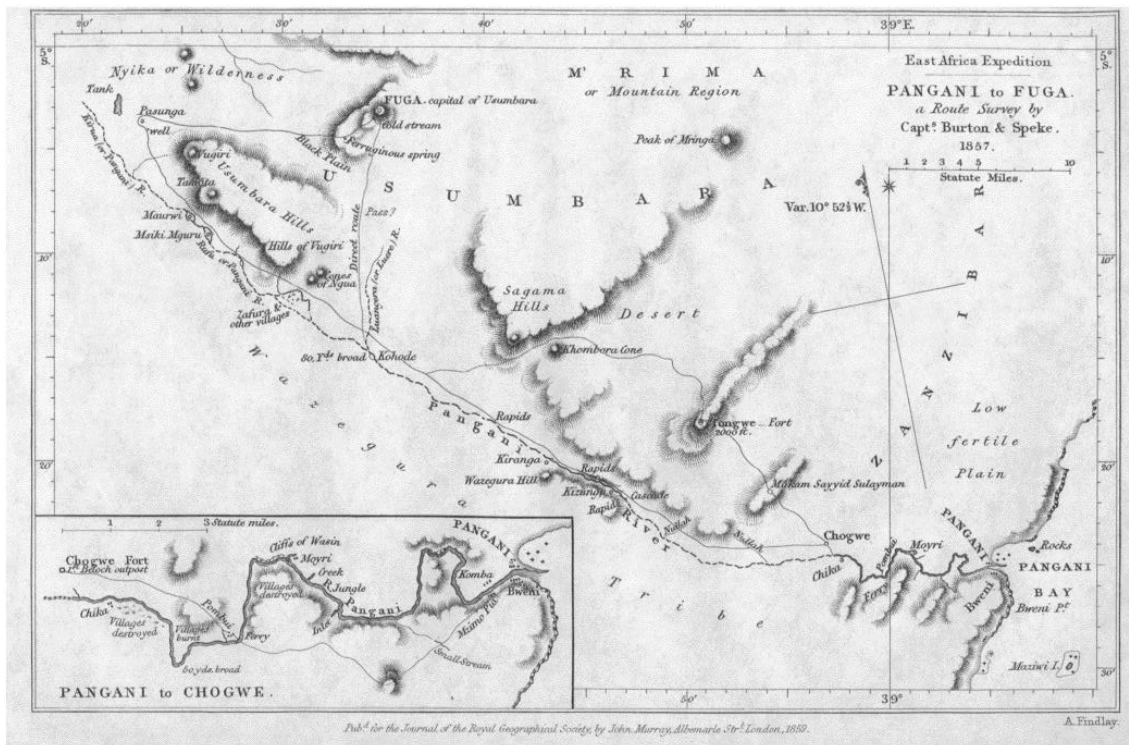


Fig 8.3: Map of Burton and Speke's expedition from Pangani to Fuga, 1857.<sup>30</sup>

Both Duncan and Rae were travellers for whom instruments had more agency in knowledge creation than was justified judging by accounts in the field. Duncan's map was published in the *JRGS*.<sup>31</sup> While Rae's manuscripts revealed that he took astronomical observations infrequently or not at all, and had difficulties with the compass, on April 13<sup>th</sup> 1863 the President of the RGS stated at an evening meeting that Rae 'had fixed by astronomical observations the latitude and longitude of places which were before very imperfectly laid down on the maps.'<sup>32</sup> Despite the paucity and unreliability of data, Rae's methods were praised and his measurements became agreed knowledge concerning the northern shores of America, Iceland and Greenland.

<sup>30</sup> Burton and Speke (1858) p. 226

<sup>31</sup> Duncan (1846)

<sup>32</sup> Rae (1852), MS 387c, Rae (1860 - 1861) p. 80, Rae (1862 - 1863) p. 103

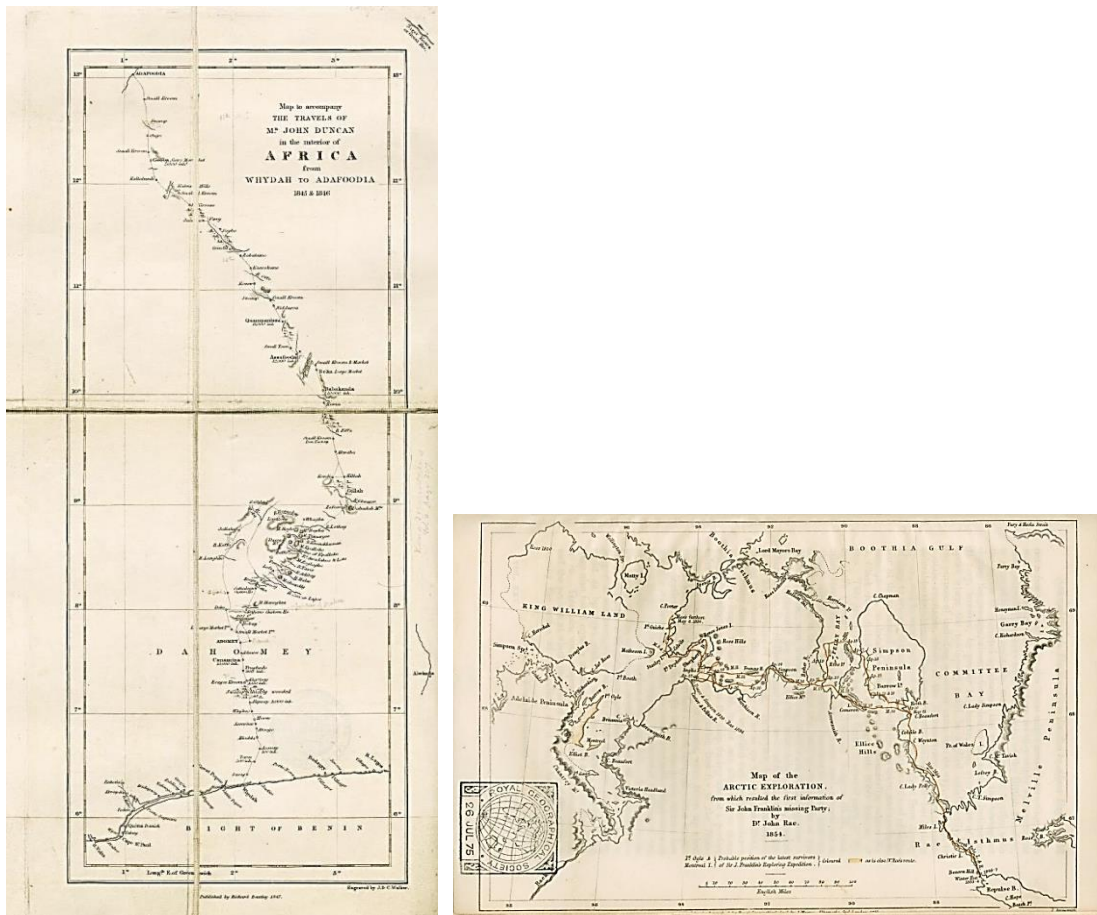


Fig 8.4 a and b: 'Map to accompany the travels of Mr John Duncan in the interior of Africa from Whydah to Adafoodia, 1845 and 1846', and part of Rae's Map of the Arctic Exploration of 1854.<sup>33</sup>

As the areas of the globe for which there was information expanded, and ways in which measurements could be made increased, it was more likely that comparisons of results would be made. Keith Johnston's paper following his expedition with RGS instruments was published in 1875-6 together with a report on it by Strachan, who compared the 'simultaneous indications of Captain George's portable barometer with the hypsometers, and the results appear to prove that the instruments were practically correct.'<sup>34</sup> The portable barometers had been used by another expedition whose results had been made available. The discrepancies between two or more determinations of heights for the same place were 'merely of such a kind as must be expected from the complicated nature of this method of measuring elevations.'<sup>35</sup> The congruence of the various results was viewed positively, with one type of instrument supporting another: when there was not agreement, as in the case of rainfall, the authority of the design

<sup>33</sup> Duncan (1847), Rae (1855)

<sup>34</sup> Johnston (1875 - 1876) p. 504

<sup>35</sup> JMS/6/113 p. 43 CM June 12<sup>th</sup> 1876



promoted by the RGS in *Hints* was marshalled, and the good practice of Congreve cited. When Johnston and Congreve's results indicated an adjustment to the height of Ascuncion, their value was promoted with authority. The nine pages of data submitted by Johnston and Congreve, and supported by Strachan, had instilled a confidence for them to create knowledge.<sup>36</sup>

The papers by Nares following the Arctic expedition of 1875 were principally concerned with prognostications as to the possibility of reaching the North Pole in future. The principal numerical scientific result was the calculation of the rate of drift of ice between Spitzbergen and Greenland, estimated by the rate of a previous expedition.<sup>37</sup> Charles Daly's defence acknowledged the general disappointment: 'It was felt that an expedition from which so much had been anticipated had failed to accomplish its object', but then argued against this interpretation.<sup>38</sup> While Markham conceded that getting furthest north had been discarded as a useful object by the Council, Erasmus Ommaney suggested that as the expedition had reached the Great Polar Ice Sea above 80 degrees North, the country had been fully rewarded for the expense.<sup>39</sup> Nares' medal was awarded simply for the latitude, not any geographical findings.<sup>40</sup> There is no indication that instruments had had appropriate agency. As with Alexander, the RGS praised the expedition as it had considerable resource invested in it, not because of the results produced.<sup>41</sup>

In situations where less resource had been bestowed the RGS could be more critical. Forbes' paper on the coral reef, which did not demonstrate any engagement with his instruments, was deemed by the referee Admiral R.S. Mayne to be not geographical in large part and was reduced to a short notice.<sup>42</sup> The agency of Forbes' instruments in knowledge creation was inconsequential, but this was not disguised as in Nares' case.

Work devoid of observations continued to be published as descriptive narrative as the nineteenth century progressed. Colquhoun's paper demonstrated no engagement with his instruments. Yule, his referee, was unimpressed, deeming it to unsuitable for reading or printing, however, Colquhoun went on to have a travelogue without instrumental data accepted in 1882.<sup>43</sup> In terms of knowledge creation his instruments had no discernible agency.

Conway was a prolific author although his papers, like those of Colquhoun, contained little instrumental material. His journal manuscripts were approved in spite of this. Conway's first contribution to the RGS's publications was a letter in which he mentioned carrying instruments, 'observing his instruments', and taking 'angles' at a summit.<sup>44</sup> The letter

---

<sup>36</sup> Johnston (1875 - 1876), Johnston, Congreve and Strachan (1875-1876)

<sup>37</sup> Nares (1876 - 1877a), Nares (1876 - 1877b) p.98

<sup>38</sup> Daly (1877)

<sup>39</sup> Markham (1876 - 1877) p.542, Nares (1876-1877b) p.283

<sup>40</sup> <http://www.rgs.org/NR/rdonlyres/C5962519-882A-4C67-803D-0037308C756D/0/GoldMedallists18322011.pdf> June 2017

<sup>41</sup> Barczewski (2007) p.26

<sup>42</sup> JMS/8/64

<sup>43</sup> Colquhoun (1882), Conway (1892) p. 765

<sup>44</sup> Conway (1892) p. 765



Papers could be recommended for reading only but there were no set criteria for what distinguished these from those to be published. There was a general assumption that the papers to be read were lighter, less 'scientific', and would not include tables of data, although maps were often provided.<sup>48</sup> Following Battye's unconvincing use of instruments his paper was accepted for reading but not publication.<sup>49</sup> In Mrs Bishop's case Markham recommended the paper for reading but wanted another opinion on publication.<sup>50</sup> This could appear discriminatory as papers without numerical appendages were frequently accepted. Mrs Bishop's paper was eventually accepted for publication without an accompanying table but with a map. A note at the end read: 'The map has been reduced from a drawing supplied by Mrs Bishop and supplemented from her itinerary, but has no pretence of being a correct survey.'<sup>51</sup> It appears that Mrs Bishop's instruments were allowed little agency in knowledge production.

It was noted in chapter 6 that Milne had a problem not previously encountered by the RGS explorers under investigation. He had inscriptions on a seismograph but did not know what was being measured. The referee, William Blanford, picked up on this and objected; 'I wish to protest at what I regard as a doctrine at explanation of instrumental observations.'<sup>52</sup> As for the magnetometer fifty years earlier, the seismograph had great potential to open up new fields of investigation, but had yet to convince those without a stake in their promotion. In spite of Blanford's concerns, Milne's paper was published and he went on to produce several more on seismography.<sup>53</sup>

In a paper published in 1892 as a result of borrowing instruments, Freshfield set out his strategy: 'I shall not encumber these pages with a laboriously detailed statement of the topographical facts accumulated in the map. To decompose a map is a short way of making an article appear solid, much favoured by some writers, who apparently flatter themselves that what is clumsy and unreadable must be scientific.'<sup>54</sup> Freshfield provided a map but without accompanying data, and his measurements of height in the text gave three, four or five significant figures indiscriminately. The increasingly popular practice of producing a map without accompanying data was probably the result of using the plane table. As Freshfield was contributing topographical rather than primary information, it was principally his plane table that had agency.<sup>55</sup>

Savage Landor was the subject of unusually unrelenting criticism at Council and in the Committee minutes, criticism which focussed on his instrumental practice. The underlying reason appears to be a transgression of publication protocol, as he had promised his story to

---

<sup>48</sup> Coles CB6/502 March 23<sup>rd</sup> 1877

<sup>49</sup> JMS/15/99

<sup>50</sup> JMS/10/102

<sup>51</sup> Bishop (1897)

<sup>52</sup> JMS/20/66 Letter Nov 24<sup>th</sup> 1895 to Keltie from Blanford the referee

<sup>53</sup> Milne (1896)

<sup>54</sup> Freshfield (1892) pp. 100-116

<sup>55</sup> JMS/11/142

the *Daily Mail*.<sup>56</sup> His paper was turned down by Holdich, his referee; 'it would be impossible to produce a satisfactory map, he worked under such difficulties as to preclude the possibility of accurate observation'. This was the opposite of the response to Livingstone in similar circumstances. The lurid recounting of the misadventures of Savage Landor and his servants may also have been seen as stretching credence and in poor taste; Freshfield believed it 'affected the credit of English travellers and scientific societies.'<sup>57</sup> The criticism intensified: On November 16<sup>th</sup> Markham wrote 'Your latitudes are deficient, and cannot be computed. You make no observations for longitude. Your traverse survey differs by forty seven miles from that of Rai Singh, his agrees better with other independent observations. None of your altitudes have been computed, and the results are therefore of no value.'<sup>58</sup> While forty seven miles is a large discrepancy, the other accusations could have been made of many travellers. Savage Landor had angered the Society by not respecting publication etiquette; hence the agency of Savage Landor's instruments was squandered.

By the twentieth century there was more likelihood of earlier results being available to compare with returning data. There were more ways of measuring: height could be taken with a mercury barometer, aneroid, hypsometer or theodolite. Longitude could be taken by various astronomical means, chronometer, and in places telegraph, although astronomical methods appear to have not been replaced.<sup>59</sup> Mackinder's referee, Gregory, queried his height of Mount Kenya: 'MacKinder with the Watkin's aneroid supports Smith's 17,200 feet, but from a triangulation with the Abney level from bases in the Alpine zone determined by boiling point thermometers, I accept Von Hohnel's result of 19,000 plus'. Gregory had to weigh up the value of results taken by different means by assigning value to various instruments and methods. Gregory questioned why Mount Kenya had so much snow on it if it was only 17,200 feet, when mountains further north did not. This detail could not be resolved 'until a mountain barometer has visited Kenya.'<sup>60</sup>

Lewis was a missionary who had little or no interest in instrumental observation. His referee, Ravenstein, had to ask for the meteorological observations to be added to his paper.<sup>61</sup> Lewis did publish a map in 1902 following his instrument loan, which was based on his itinerary surveys checked by latitude observations.<sup>62</sup> The longitude, however, had been taken from a previous observation by Grenfell. Ravenstein was frank concerning the discrepancy of Lewis's results with others, inserting alternative values for comparison.<sup>63</sup> Nevertheless, Lewis got a favourable reception as one who wanted to better the lot of the Congolese. His instrumental results had in effect been rejected and had not replaced or modified previous data.

---

<sup>56</sup> Allen (2003)

<sup>57</sup> Hopkirk (1982) p. 135

<sup>58</sup> CM June 20<sup>th</sup> 1898, Report by Markham bound with CM Dec 12<sup>th</sup> 1898

<sup>59</sup> Mackinder JMS/2/328 p. 6

<sup>60</sup> JMS/2/238 Gregory's referee report p.3

<sup>61</sup> JMS/2/341

<sup>62</sup> Lewis (1902a)

<sup>63</sup> Lewis (1902b) p. 558

On the Antarctic expedition under Robert Scott, the failure to obtain charts or data from the ship became a significant problem, meaning that descriptions of the scientific work were necessarily vague: 'marine biology, magnetism, oceanography, meteorology, seismology etc.'<sup>64</sup> The distance south reached by Scott was emphasised.<sup>65</sup> The physical deprivations of the expedition made the scientific outcome a lesser focus for attention, but the basis for much of the instrumental data was flawed, so the considerable resource was largely squandered. The underlying frustration of men such as Ettrick Creak was hard to suppress.<sup>66</sup>

Cornish's paper on the Jamaican Earthquake afforded leverage to the instruments he had borrowed in 1907.<sup>67</sup> Cornish had to find a phenomenon to which he could assign numbers, so decided on the percentage of pillars destroyed by the tremors in each street to construct a map showing the relative strength of the 'overturning force', which he 'connected with the short and steep surface waves'.<sup>68</sup> In the ensuing discussion Strachan opined that he considered the 'theory has sometimes been forced beyond its legitimate limits'.<sup>69</sup> Vaughan Cornish had results but they defied interpretation, rather as the earlier ones of Milne had done.

It appears that the agency of instruments borrowed in the early twentieth century was to bestow authority and esteem to some travellers, not to act directly in the production of new knowledge. Stein, who borrowed instruments in 1906 and 1912, had a resulting paper published in 1907 which does not include instrumental data.<sup>70</sup> In 1908 a second paper related how Stein had taken measurements, however, no data was provided and the promised map did not appear.<sup>71</sup>

It is likely to be the case that the growing popularity of the plane table in the 1890s allowed sketch maps to be provided as accompaniments to papers relatively easily, which in many cases was considered sufficient. Carruthers produced a map with his paper but no data and little in the way of measurements, although he mentions taking altitudes by hypsometer and clinometer.<sup>72</sup> Strong also produced a map without data.<sup>73</sup> Rawling, who wrote up Wollaston's expedition, only produced a map, but in this case there were some latitudes and magnetic variation included on it.<sup>74</sup> Bullock Workman produced a paper following this pattern in which it was made clear that her material for a definitive map was not yet ready, so she submitted a sketch map with no data.<sup>75</sup> It is therefore argued, as in chapter 7, that the type of instrument had an influence on the form of knowledge produced.

---

<sup>64</sup> Letter from the Admiralty 14<sup>th</sup> May 1903, BAE (1903a) p. 441, BAE (1903b) p. 658, BAE (1903c)

<sup>65</sup> AA/10/2 Letter to Farr 21<sup>st</sup> Mar 1902

<sup>66</sup> BAE (1905)

<sup>67</sup> Cornish (1908)

<sup>68</sup> Cornish (1908) p.253

<sup>69</sup> Cornish (1908) p. 271

<sup>70</sup> Stein (1907)

<sup>71</sup> Stein (1908b), Stein (1909)

<sup>72</sup> Carruthers (1910), (1911)

<sup>73</sup> Strong (1908)

<sup>74</sup> Rawling (1911)

<sup>75</sup> Bullock Workman (1912)



from a good astronomical position.’ and ‘surveying our route with compass and clock.’<sup>81</sup> Rodd dragooned the specific instruments into arguing his case: ‘Our modern surveying instruments, for the most part lent by the RGS, proved that even a small private expedition can obtain not only latitude but also longitude correct within a couple of hundred yards with no difficulty.’<sup>82</sup> Rodd could therefore create knowledge with confidence: ‘The result of our astronomical work has been to move the whole of Air some two to five miles further East on the map than it had been fixed by previous French observations’.<sup>83</sup> Rodd also produced a separate paper containing his scientific data. He produced three pages of astronomical positions and heights by boiling point together with anthropological measurements on the Tuareg. Rodd incorporated a methodology, citing his authorities and explaining why the 1927 figures were to be preferred; namely the three inch micrometer theodolite was available in 1927 but not in 1922. This is one of the clearest demonstrations of the intended manner in which instruments had agency in knowledge creation.<sup>84</sup>

The study demonstrates that there was little correlation with success and time period; in Steers’ paper in 1927 the only reference to any use of instruments was a plane table sketch by a C. Marchant.<sup>85</sup> Cheesman did not make the best of his instruments; again he included a map but no data.<sup>86</sup> In the ensuing discussion in 1928 Cheesman was commended for pluck and skill, often a euphemism for lack of instrumental success.<sup>87</sup>

In some cases the instruments produced knowledge in the manner expected by ANT and classic theoretical models involving concepts of objective information retrieval by measurement, data collection, and promulgation of results. That is; the instruments worked, they were handled convincingly well, and the travellers were able to return with results which were seen to be an improvement on what had gone before. In other cases where data was dubious or lacking, the agency of the instruments could nevertheless increase the chances of publication, especially if the resources invested were considerable; the papers became travelogues or tales of heroism and adventure. Sometimes instrumental results had more authority than was warranted given flawed practices. The instruments appear to have had more agency in the hands of established males than for others, given both the women were not considered capable of producing more than sketch maps, so they served to enhance existing hierarchies.

Later in the century results were more likely to be compared one to another, with value being assigned to various techniques; this was more difficult with new instruments such as magnetometers or seismographs. The expeditions and their resulting papers became more

---

<sup>81</sup> Rodd (1929a) p.6, p.11

<sup>82</sup> Rodd (1929a) p. 12

<sup>83</sup> Rodd (1929a) p. 13

<sup>84</sup> Rodd (1929b)

<sup>85</sup> Steers (1929)

<sup>86</sup> Cheesman (1928)

<sup>87</sup> Cheesman (1928) p.376

specific, and many types of output- for example those relating to natural history or mountaineering- were accompanied by little or no data derived from mathematical instruments. A trend in the late nineteenth and early twentieth century was towards less data, probably resulting from the use of the plane table. In a minority of cases papers were recommended for reading rather than publication. There were no cases of work being rejected solely due to failure to mobilise instruments.

### **The Creation of Reputations**

The agency of instruments in the creation of their users' reputations is investigated through the awarding of medals. Instruments could confer individual authority by other means; for example the portrait of Speke by James Watney Wilson in 1863, and that of Humboldt and Aime Bonpland in 1856 by Eduard Ender, feature instruments placed to suggest successful mobilisation and therefore confer distinction. However, recognition through awards is a reliable and consistent indication of how the RGS saw the ideal of the instrumental culture they were promoting.

As for the published papers, there were no written criteria for awards, but four attributes were cited repeatedly. These were; that the recipient be a gentleman of means, should have visited a region where no European had previously been, was to have been 'scientific' in taking measurements; and to have made great effort, the last normally to have involved considerable suffering. The criteria were flexible and often led to contradictions.<sup>88</sup> From 1853 all members of Council voted for the medallists.<sup>89</sup> The awarding of the Royal Premium began soon after the Society's founding: The first mention of the word 'scientific' in the awarding of medals came in 1839 when Humboldt was presented with the Royal premium for being 'the most scientific traveller in Europe.'<sup>90</sup> The following year the Patron's medal, the highest honour of the Society at that time, was awarded to Schomburgk, one of the first to have been supplied with instruments.<sup>91</sup>

In 1841 the Medals Committee agreed that the medals should be for 'geography proper not mixed geography' and that they should not be given to anyone who pursues geography 'as a trade.'<sup>92</sup> Raper was awarded a medal in 1841 for his 'excellent work on practical navigation, and longitude in the Nautical Magazine', and in 1844 Adolphe Erman for work in Siberia with 'numerous astronomical, hypsometrical and magnetical observations'.<sup>93</sup> In similar vein, when Galton was proposed for a medal in 1853 it was recognised that he had taken

---

<sup>88</sup> Richards (2011a) p.55, Keighren, Withers and Bell (2015) p.98

<sup>89</sup> CM Mar 14th 1853

<sup>90</sup> CM Apr 22<sup>nd</sup> 1839

<sup>91</sup> CM Feb 12<sup>th</sup> 1838, Apr 27<sup>th</sup> 1840

<sup>92</sup> Medals committee March 29<sup>th</sup> 1841

<sup>93</sup> CM April 20<sup>th</sup> 1841, April 29<sup>th</sup> 1844



astronomical observations in places not hitherto known, and that he had done it with his own resources.<sup>94</sup> Mansfield Parkyns was applauded in 1855 for his 'scientific exploration.'<sup>95</sup>

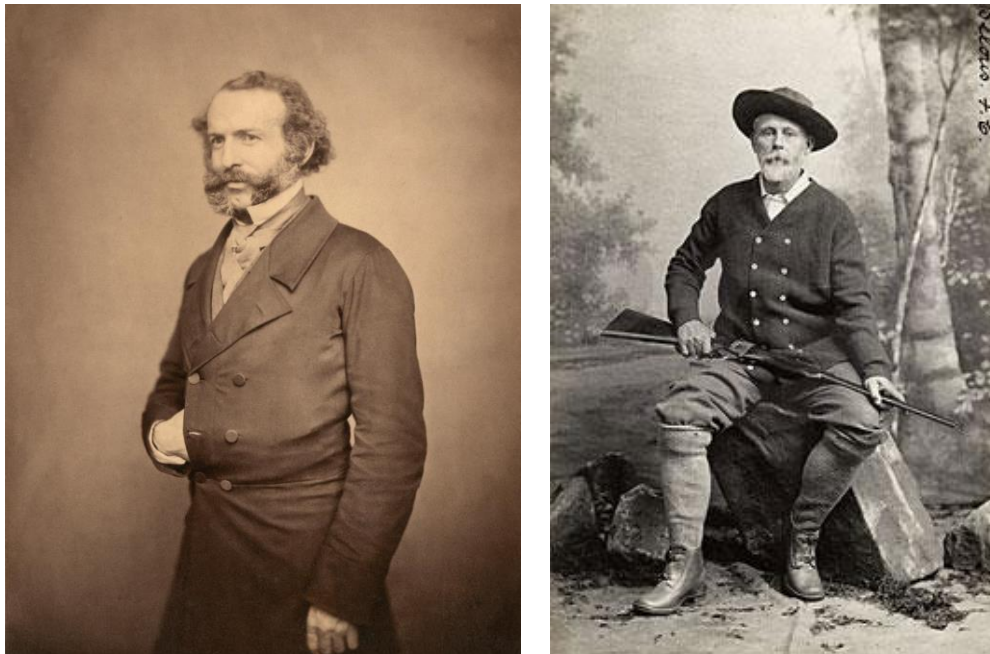


Fig 8.7 a and b: Left: 'Dr. John Rae - recipient of an 'RGS Gold Medal 1852'. Right: The caption for the photograph of Selous states he was awarded the Founders Medal in 1893.<sup>96</sup>

However, travellers who had not been 'scientific' were also rewarded. Rae's practices in the Arctic were noted as being flawed, but his data was thought sufficiently valuable not only to enable him to borrow instruments at a later date, but to be awarded the Founder's medal in May 1852 'for his very important contributions to the Geography of the Arctic'.<sup>97</sup> In 1855 Livingstone was put forward for a gold medal because 'his chronometer watch had been of such use to him in making his astronomical observations', and was successful.<sup>98</sup> As Withers has noted, Livingstone's reputation has been created by a 'commemorative trajectory' similar to that created for Newton, which was constructed to suppress any blemishes.<sup>99</sup> Draitsas recounts an episode in 1864 when Murchison had to navigate between criticism of contradictory maps and methods.<sup>100</sup> Even when the instrumental data secured by its medal recipients did not bear close scrutiny, the RGS maintained a public position of respecting the good use of instruments in acquiring reliable numbers as a statement of worth.

---

<sup>94</sup> CM Mar 21<sup>st</sup> 1853

<sup>95</sup> CM Mar 26<sup>th</sup> 1855

<sup>96</sup> Control numbers 026749, 052057

<sup>97</sup> Bunyan, Calder, Idiens and Wilson ( 1993)

<sup>98</sup> CM Mar 26<sup>th</sup> 1855, April 23<sup>rd</sup> 1855

<sup>99</sup> Withers (2004) p.319

<sup>100</sup> Draitsas (2010) p. 68-70

On April 14<sup>th</sup> 1856 the Council spent some time discussing medal contenders, their discourse revealed clearly the incommensurable nature of the criteria.<sup>101</sup> Dr Elisha Kane was put forward for suffering; he had spent the winter at seventy eight degrees latitude, with no sun for 120 days in 'terrible cold'. Burton, who has been noted for his casual attitude towards measurements, was proposed for learning languages and getting to Mecca in disguise: 'He has great self-possession and physical powers and shows all the attributes of a thorough traveller.' On the other hand Andrew Scott Waugh was suggested for the Trigonometrical Survey of India: 'The country is now accurately delineated on the basis of astronomical observations.' Collinson was recommended for his astronomical observations, meteorological, tidal, and other scientific observations in the Behring Straights. Criteria were also overlooked: Waugh could be seen as practising geography as a 'trade.' He was a commissioned officer; as was Montgomerie who was proposed in 1862 for his trigonometric survey of Kashmir and Thibet.<sup>102</sup> Despite other inconsistencies, throughout the 1860s the ability to find astronomical positions and the ability to navigate were consistently held up as desirable.<sup>103</sup>

Nain Singh Rawat satisfied multiple criteria. He was exposed to constant danger, in areas which had not and could not be surveyed by Europeans, and used his instruments to maximise their agency. Colonel Yule, addressing the RGS said 'It is not a topographical automaton, or merely one of a great multitude of native employees with an average qualification. His observations have added a larger amount of important knowledge to the map of Asia than those of any other living man!' 'Singh is equally good on his own account as when under the direction of others'; a comment that would not have been made of a European gentleman.<sup>104</sup> It is clear that Rawat had to overcome prejudice not applicable to Europeans. In 1868 Nain Singh was presented with an inscribed gold chronometer watch, and in 1876 his achievements were announced in the *GJ*. In 1877 he was awarded with the Victoria Patron's Gold Medal.<sup>105</sup>

While much has been written about the length measurement by paces and beads, Nain Singh also made extensive use of classic mathematical instruments: 'The compass for taking bearing was hidden in the lid of the prayer wheel. Mercury used for setting and artificial horizon, was kept in cowri shells and for use poured into the begging bowl carried by the Pundit. The thermometer found place in the topmost part of the monk's stave. False bottoms were made in the chests to hold a sextant. Pockets were also added to the clothes used during these secret missions.'<sup>106</sup> Length by estimates of paces of men or animas was common, so Singh was

---

<sup>101</sup> CM 14<sup>th</sup> April 1856

<sup>102</sup> CM April 28<sup>th</sup> 1862

<sup>103</sup> CM Apr 23<sup>rd</sup> 1866, Apr 8<sup>th</sup> 1867

<sup>104</sup> CM Mar 22<sup>nd</sup> 1909, Jones (2010) pp.58-80, Raj (2000)

<sup>105</sup> Waller (1990), Hopkirk (1982), Raj (2002) pp 164-168

<sup>106</sup> Bhatt and Pathak (2006)

being rewarded for practices conforming to those of European travellers of the time, even though historians have focussed on the extemporising aspects.<sup>107</sup>

McEwan was the first recipient of the aforementioned Peek Grant 'because of his qualifying himself under the Society's instructor as a geographer and astronomical observer.'<sup>108</sup> McEwan had incorporated work produced by Stewart, who despite the latter's humility, was contributing to the cycles of knowledge.<sup>109</sup> Nansen was proposed for the Patron's Medal because he had made a 'perilous and daring achievement in which failure must involve the destruction of himself and his companions, having taken a series of astronomical and meteorological observations under conditions of extreme difficulty and privation.'<sup>110</sup> This again highlights the different treatment of Savage Landor who was deemed to have been working 'under such difficulties as to preclude the possibility of accurate observation'<sup>111</sup> Lack of astronomical observations could be excused. In 1893 Selous was awarded the Founder's medal; 'While astronomical observations have (often) proved a delusion, his triangulations have resulted in trustworthy meridian differences.'<sup>112</sup> Gregory won the Peek prize for a series of useful scientific observations in 1894. In 1896 MacGregor was awarded a medal for 'assiduous astronomical positions of New Guinea.'<sup>113</sup> At the same meeting St. George Littledale was also rewarded, for 'careful mapping by means of instruments' from Caspian to Peking. 'He fixed his position daily, and on the spot plotted in ink the results on a map, on the scale of five miles to an inch.'<sup>114</sup> It appears not to have mattered that Littledale had not been able to compute his data, asking for 'someone to work out his aneroid and boiling point observations' which had cost the Society £8.<sup>115</sup>

In 1899 a stipulation was made that medallists must have undertaken astronomical observations and position fixing.<sup>116</sup> In this time of heightened conflict between those supporting the idea of the romantic explorer and those supporting rigorous surveying, the latter appears to have got the upper hand. The preference for gentlemen of means could frustrate the scientific aims. The difficulty involved in managing these tensions can be seen in the 1900 and 1901 awards.<sup>117</sup> In 1900 Henry Deasy was said to be 'incessantly engaged in surveying in districts where an experienced professional surveyor would find exceptional difficulty'. Deasy could not be an experienced professional surveyor to get an award, but had to overcome this disadvantage to be as good as one. In 1901 medals were awarded to those who had operated

---

<sup>107</sup> Raj (2002) pp 165-166

<sup>108</sup> CM Nov 12<sup>th</sup> 1883, May 12<sup>th</sup> 1884

<sup>109</sup> SSC McEwan

<sup>110</sup> CM Apr 13<sup>th</sup> 1891

<sup>111</sup> Savage Landor CB7/55 Referee's report by Holdich 6<sup>th</sup> Aug 1898

<sup>112</sup> CM Apr 24<sup>th</sup> 1893

<sup>113</sup> CM Apr 27<sup>th</sup> 1896

<sup>114</sup> CM Apr 27<sup>th</sup> 1896

<sup>115</sup> EC Jan 31<sup>st</sup> 1896, FC Apr 14<sup>th</sup> 1896

<sup>116</sup> CM May 8<sup>th</sup> 1899

<sup>117</sup> CM 26 Apr 30<sup>th</sup> 1900

at their own expense.<sup>118</sup> Thus the Duke of Abruzzi got one, and while his may have been deserved, this criteria applied stringently would rule out many of the travellers that the RGS supported with instruments. Later both Boyd Alexander and W. Longstaff were awarded medals principally for funding themselves.<sup>119</sup> The ideal of the lone explorer was perpetuated by awards such as that to Talbot for 'triangulations single-handed'.<sup>120</sup>

The meaning of scientific geography was changing by the early twentieth century. In 1903 a Special Research Committee was set up to award £200 for 'geographical research as distinguished from pioneering'.<sup>121</sup> The image of the lone explorer was becoming marginalised as constituting only one of several modes of operation of the RGS. The classic mathematical surveying instruments, already joined by photographic and telegraphic equipment, now formed part of an even larger armoury which included laboratory chemicals and testing, statistical manipulation, archaeology, archival studies, oral histories and aerial methods.<sup>122</sup> Traditional survey methods were not replaced, however, merely supplemented. The mathematical measuring instruments could still have agency in the creation of reputation, and continued to do so in spite of the RGS promoting new fields.<sup>123</sup> In 1905 both Conway and M. Maud were proposed for medals because of their 'careful survey work'.<sup>124</sup> In 1907 Roald Amundsen was praised for using 'the best instruments' in his mastery of terrestrial magnetism.<sup>125</sup> In this way the instruments were directly used as badges of achievement, and had agency before they were mobilised.

The emphasis on self-funding perpetuated the gentlemen's club aspect of the society. F. Cope Whitehouse was awarded a medal in 1909 for 'energy, perseverance and resource under considerable difficulties'.<sup>126</sup> That year Ommaney was awarded a medal for 'tact, patience and endurance' in determining telegraphically the longitude of fifteen towns in Nigeria.<sup>127</sup> The description of desirable characteristics in an explorer could overrule any effective mobilisation of instruments by those who did not fit the trope of the European imperial man. Having personal characteristics as effective criteria allowed the RGS free rein to allocate its approval. Nevertheless, having and using instruments could still be cited as an attribute.

Occasionally a specific skill with a particular instrument was mentioned, so that the agency of that instrument defined the explorer: additionally the agency of the Society promoted that instrument. Godwin- Austin was awarded a medal in 1910: 'His plane-tabling was a marvel

---

<sup>118</sup> CM Apr 29th 1901

<sup>119</sup> CM Mar 9th 1908

<sup>120</sup> CM Mar 22nd 1909

<sup>121</sup> Special Research Committee Apr 30th 1903

<sup>122</sup> CM Mar 9th 1908

<sup>123</sup> CM Feb 13th 1905

<sup>124</sup> CM Mar 13th 1905

<sup>125</sup> CM Mar 25th 1907

<sup>126</sup> CM Mar 22nd 1909

<sup>127</sup> CM Mar 22nd 1909

in western Bhutan.<sup>128</sup> What instruments added was not always explicitly stated: Charcot was awarded a medal in 1911 because he had achieved 'much more precision' than that previously available.<sup>129</sup>

The treatment of those not conforming to the white male upper class genre was more complex. It was impossible to supervise the pundits, so Europeans had to trust them. Sahib Rab Singh had performed the majority of the surveying for Stein. When Stein was considered for a medal in 1909 it was acknowledged that he had with him a 'trained native surveyor.'<sup>130</sup> Later in the discussion it was recalled that Rab Singh had 'carried Stein's plane table', and only then that 'he mapped the last portion of terra incognita'. In 1910 Lal Singh was awarded the Back Grant and in 1917 Rab Singh was awarded the Murchison grant.<sup>131</sup> Both Rab and Lal Singh's instruments had agency in knowledge creation, but less than they might have done in promoting them than if they had been European. Women medallists, like non-Europeans, were very few. Lady Jane Franklin and Mary Somerville were awarded medals for activities not involving the use of instruments, as was Gertrude Bell later.<sup>132</sup> Mrs Bishop and Bullock Workman were not awarded medals, so their instruments had little or no effect in establishing their reputations by this criterion.

From WW1 onwards less was written as to the reasons for the award of medals, so less can be said about what provoked this conferral of distinction. It is argued that instruments frequently had agency in the promotion of the individuals who used them, unless it was impossible to retrieve any value from their use. On many occasions instruments had more agency in promoting reputations than was warranted by their use in the field according to the classic scientific method, or ANT. Gentlemen of means were able to extract more leverage from their instruments than others, with women and non-Europeans lagging behind. The increasing difficulty in finding new regions to discover dictated a move away from the criteria of new territory as the century under investigation went on. The desirability of effort and hardship was frequently in contradiction to the equal emphasis on 'scientific' measurement, with the Society maintaining consistently its fraught position between professionalism and the cult of the 'grand amateur.'

### **The Creation of Imperial Power**

The substantial scholarly literature on geography and empire, some of which concerns the RGS directly, was discussed in chapter 2. The role of instruments in the Society is considered within this context.

'By Royal patronage the Society will be enabled to afford such an effectual encouragement to geographical Science and Discovery, as may contribute to the particular

---

<sup>128</sup> CM Mar 14<sup>th</sup> 1910

<sup>129</sup> CM Mar 13<sup>th</sup> 1911

<sup>130</sup> CM Mar 22<sup>nd</sup> 1909

<sup>131</sup> CM Mar 5<sup>th</sup> 1917

<sup>132</sup> CM Mar 10<sup>th</sup> 1913, *GJ* 51(5), (1918) pp. 335-338, Bell (1910), (1914)

interest of his Majesty's Dominions, and to the general advantage of the Civilised World'.<sup>133</sup> The Society was linked to the British Empire and its instruments had agency in developing that empire in the creation of boundaries and in the assessment of climates and terrains in the potential for exploitation. Instruments could act as bartering tools between the government and the RGS in a system of exchange, with the resulting data having agency for both parties. While some in the RGS worked to distance the Society from government science, on many occasions its instruments became involved in activities closely aligned with the carving out of land for colonisation, or subjugation of some form on behalf of the various Imperial projects. 'Exploration' as a term conferred certain altruistic and scientific goals, but very often the ends in view were multiple.

It would be a gross over-simplification to align the work of the RGS entirely with that of the British Empire. The RGS often worked in co-operation with international scientific projects such as those instigated by Humboldt and Gauss, and with other colonial powers such as in the initiative by Prince Leopold of Belgium over the apportioning of central Africa. It exchanged scientific information with counterparts in France, Prussia, Russia, Spain, Portugal, Italy, and later, the USA and Germany.<sup>134</sup> Nevertheless, in order to survive and succeed the Society was compelled to expound nationalistic sentiments as it was crucial to obtaining funding, permissions to enter certain areas, and safe passages. For example in 1886 the RGS supported the relief expedition for Emin Pasha because it would keep open unexplored parts of Africa.<sup>135</sup> In return the Government exploited the expertise within the Society within a symbiotic but unequal relationship. Of the scientific societies that came into being in London at around the same time, the RGS was particularly crucial to the idea and realisation of Britain's imperial vision.

The RGS was keen to promote its relationship with the state from the outset.<sup>136</sup> This was a time when the struggle for disinterested Humboltian science was at its height. James Rennell had pointed out in 1832 that only the state could afford to fund Humboltian science: 'This can be the work of government only; for individual enquiry can produce little more than unconnected facts.'<sup>137</sup> While the RGS constituted a large collection of wealthy individuals, the engagement of the state was vital for any project of significance.

The Colonial Office had some influence over the Society in the early years; it drew the Society's attention to areas of interest, and could demand the printing of maps.<sup>138</sup> At the start of 1834 the RGS case for exploring in British Guyana included the classic phrase 'it is almost an entire blank on our maps,' but also involved preventing the French getting there.<sup>139</sup>

---

<sup>133</sup> CM 4<sup>th</sup> Nov 1830

<sup>134</sup> CM Mar 2<sup>nd</sup> 1877

<sup>135</sup> EC Dec 21<sup>st</sup> 1886

<sup>136</sup> CM 4<sup>th</sup> Nov 1830

<sup>137</sup> Cock (2005) p. 98

<sup>138</sup> CM 1<sup>st</sup> Dec 1832, 2<sup>th</sup> Jan 1833

<sup>139</sup> CM 25<sup>th</sup> Jan 1834

Later that year the Council was said to be 'pledged' to the government over the Guyana expedition, which was funded by both institutions. By 1838 Schomburgk was able to produce a report on the boundary between British Guiana and Brazil, and in 1840 he was appointed to survey it on behalf of the Colonial Office.<sup>140</sup>

After his governmental appointment, the RGS continued to supply Schomburgk with instruments. Wanting to retain some control over his activities, it urged that he should connect his survey with that of French to the East.<sup>141</sup> Permission was necessary for Schomburgk to explore the source of the Orinoco, and in 1843 the RGS had to ask the CO for permission to publish Schomburgk's papers.<sup>142</sup> The relatively new Society was trying to assert itself in an environment where the Government had superior resources and control. One of the ways the RGS could have influence was through the provision of instruments, and so these instruments were employed to have agency in the construction of imperial knowledge on behalf of government, but also promote the disinterested knowledge for which purpose the RGS had been established.

In the case of the North West Passage Government support was difficult to obtain: 'In the years of depression following the war 'economy' was a persistent cry. By 1828 a utilitarian approach to economy and efficiency was accepted'.<sup>143</sup> Conventional wisdom saw the North West Passage as useless by 1835; 'utterly unworthy of that sacrifice or risk of life and resources by which it may have been acquired', according to the *Edinburgh Review*.<sup>144</sup> For Henry Taylor, a senior Clerk at the CO in 1836: 'It is one business to do what must be done, another to devise what ought to be done. It is in the spirit of the British government to transact only the former business and the reform which it requires is to enlarge that spirit so as to include the latter.'<sup>145</sup> The RGS formed part of the reforming movement relying on approaches by individuals. The Arctic Committee was adjourned until the President of the RGS could sound out his Majesty's ministers on the exploration of the North Eastern Coast of America in 1836.<sup>146</sup>

The Society's strategy was to present the North West Passage as the completion of an existing project: 'We should not think of this as a new expedition. The progress already made in Northern Discoveries has raised the reputation and renown of this Country in the eyes of all Europe. The completion of this must be seen as a great National Object in which no Foreign Power should be suffered to interfere.'<sup>147</sup> At the end of 1836 the Society asked for £100 for instruments and outfit: 'The expense would merge with money voted on the Navy estimate for the Surveying and Scientific Department'. The threat of France and America getting to Dampier

---

<sup>140</sup> CM Nov 26<sup>th</sup> 1838, June 8<sup>th</sup> 1840, Riviere (2006) 2 p. xi and xii

<sup>141</sup> CM June 8<sup>th</sup> 1840, Nov 9<sup>th</sup> 1840

<sup>142</sup> CM 25<sup>th</sup> Jan 1841, Mar 27<sup>th</sup> 1843

<sup>143</sup> Young (1961) p.7

<sup>144</sup> Berton (1988) p.125

<sup>145</sup> Taylor (1836) p.103

<sup>146</sup> CM 20<sup>th</sup> Feb 1836, 14<sup>th</sup> March 1836

<sup>147</sup> CM Apr 25<sup>th</sup> 1836

Land first was brought to bear.<sup>148</sup> According to Markham the government was asked for resource but the Society should provide expertise in the form of instruments: 'the authorities were pleased to attend favourably', and even if the object was frustrated; 'the hair-breadth escapes, the gallantry of the men. It is a distinct gain to the Country's literature. It is a treasure more than many leagues of new coastline!'<sup>149</sup> By 1838, however, the CO was of the opinion that 'We cannot recommend exposing officers and men to great danger and difficulty in further pursuit of an object from which no equivalent advantage is appears likely to arise'.<sup>150</sup>

Possibly concerned that Victoria was not as supportive as her uncle, a special meeting was convened in 1840: 'In the past two years geographical discovery in the Arctic and Antarctic has made rapid progress and the name of Victoria is now extended to various parts of the globe.' She was urged to 'continue to extend your fostering patronage to the peaceful pursuits so materially conducive to the real glory of a nation, that your majesty's reign may be rendered illustrious by the extension of science'.<sup>151</sup>

While the Admiralty bestowed small favours such as providing passages out- in 1844 John Barrow volunteered a passage for Duncan- the RGS had little real influence.<sup>152</sup> In 1854 the Council expressed regret that the survey of the Gulf of Carpentaria had not been included in the Navy estimates for that year, and Galton urged the RGS to write to the Australian government asking them to equip expeditions into their interior.<sup>153</sup> In 1858 the RGS was asked for maps by the statistical depot of the War Department, but the Council complained that on the previous occasion they were returned soiled. The RGS, however, was not in a position to refuse.<sup>154</sup> The following year Washington of the Admiralty requested the largest map in the Society's possession for the 'public service'.<sup>155</sup> In 1870 Erskine from the Colonial Office asked for the immediate loan of instruments but was told his application was too late.<sup>156</sup> A fortnight later the Expedition Committee selected instruments for Erskine.<sup>157</sup>

The African Association 'For the Promotion of the Discovery of the Interior Parts of Africa', which had been founded by Banks in 1788, was incorporated into the RGS in 1831.<sup>158</sup> The dominance of Africa as a destination has been demonstrated in chapter 3. The expedition of Burton and Speke required funding beyond that which the RGS could provide. Appealing to the government for support, the Council emphasised the economic and cultural benefits: They expressed 'no hesitation in believing that great advantage to geographical science and incidentally to commerce and civilisation must be expected.' Speke was to look for source of

---

<sup>148</sup> CM Dec 12<sup>th</sup> 1836

<sup>149</sup> Markham (1881) p. 60

<sup>150</sup> CM Mar 12<sup>th</sup> 1838

<sup>151</sup> CM Feb 27<sup>th</sup> 1840

<sup>152</sup> CM 2<sup>th</sup> Feb 1844

<sup>153</sup> CM Jan 9<sup>th</sup> 1854, July 19<sup>th</sup> 1854

<sup>154</sup> CM June 14<sup>th</sup> 1858

<sup>155</sup> CM May 9<sup>th</sup> 1859

<sup>156</sup> CM Nov 15<sup>th</sup> 1870

<sup>157</sup> EC Nov 29<sup>th</sup> 1870

<sup>158</sup> *JRGS* 1 (1831) pp. 257-258



White Nile, and Burton to explore around the Horn.<sup>159</sup> The RGS was successful: the government would bear the cost of conveying the native escorts back to their homes, and £2500 was awarded on top of Speke's salary because he was 'not only a skilful astronomical observer but a naturalist and he will be put to expense by collecting and transporting specimens'. As Burton's route was a 'recognised caravan route' they expected the land would be fertile and good for coffee, ivory, and 'other things'. Curtin has noted that there was a great deal of Arabic knowledge exploited in this area.<sup>160</sup>

These African expeditions feared hostility, and as was often the case, instruments and weapons were provided together; Speke and Grant were provided with 50 cavalry carbines and scientific instruments in an uncomfortable juxtaposition of altruistic science and violence.<sup>161</sup> Seeing to be attached to imperial powers was advantageous as Speke knew. He requested passage on a ship of war because 'it would invest his mission with a character of importance that might greatly assist his views if he were conveyed from Aden to Zanzibar under the imposing flag of one of her Majesty's ships of war'.<sup>162</sup> He got his wish and the Admiralty provided free passage to Speke and Grant to the Cape.<sup>163</sup> In a move indicating an awakening of government interest in 1864 a special meeting was held to discuss founding an expedition to east equatorial Africa to survey the Lake Victoria area. The RGS was to work with the British government and the Pasha of Egypt to open up a 'highway of commerce and civilisation to that part of the African interior recently been made known by the labour of British geographers'.<sup>164</sup> A search party for Livingstone in 1872 led by Grandy was jointly funded by the Admiralty, CO and RGS.<sup>165</sup>

After the 1876 congress in Brussels it was decided by the African Exploration committee that 'the time has arrived when it becomes a duty of the RGS to organise a scheme for the systematic exploration of Africa.'<sup>166</sup> Thus the emphasis on African exploration was made explicit. There was an uneasy combination of national and international ambitions in the resolutions made. An international fund was to be set up which must 'combine the energies and sympathies of all civilized nations', but Galton would prepare a map of Central Africa 'claimed by British explorers'.<sup>167</sup> In 1878 Henry Stanley approached the RGS for £2000 for an expedition involving West Africa because of the potential for long-term, large-scale development there.<sup>168</sup> It was decided to mount a preliminary expedition to the country between the Lakes Tanganika and

---

<sup>159</sup> EC June 21<sup>st</sup> 1859

<sup>160</sup> Curtin (1964) p.10-11

<sup>161</sup> EC Jan 30<sup>th</sup> 1860

<sup>162</sup> EC June 21<sup>st</sup> 1859

<sup>163</sup> CM April 23<sup>rd</sup> 1860

<sup>164</sup> Special meeting Mar 24<sup>th</sup> 1864

<sup>165</sup> EC Dec 9<sup>th</sup> 1872

<sup>166</sup> African Committee Jan 19<sup>th</sup> 1877

<sup>167</sup> African Exploration Committee Jan 19<sup>th</sup>, Mar 2<sup>nd</sup> 1877

<sup>168</sup> African Exploration Committee Feb 22<sup>nd</sup> 1878

Nyasa to test out the dangers.<sup>169</sup> The maps held by the Society demonstrate the emphasis on territorial control in concurrence with Prior's work.<sup>170</sup>

The Society had to negotiate a position on commerce which upheld, developed and promoted their understanding of Geography. In some instances commercial schemes were supported, for example the RGS supplemented the instruments provided to Lewell by the Red Sea Telegraph Company in 1859, thus the Society's instruments had agency in the support of private entrepreneurship.<sup>171</sup> A few years later the Council discussed another telegraph project; the South Atlantic. It was agreed the RGS would try to persuade the government to support the survey of its route, without which the telegraph was likely to fail.<sup>172</sup> In 1870 Erskine had a paper accepted on the route of the African telegraph.<sup>173</sup> However, when asked for their approbation for an agricultural colony set up in Uruguay by Adolf and Emil Heagnauer, the Council decided it was not connected with Geography.<sup>174</sup> Butlin also remarks on the inconsistent attitude towards commercial enterprises, which has been borne out by a study of the archives.<sup>175</sup> Driver's similar observations were noted in chapter 2.

The fourth edition of *Hints* (1878) included a companion volume instructing travellers on how to report on economic products and commercial capabilities.<sup>176</sup> In 1882 the instructions to Joseph Thomson included 'gathering data for as complete a map as possible in a preliminary survey, and to take all practicable observations on meteorology, geology, natural history and ethnology, and to investigate if there was a possible route for Europeans. For this he was furnished with instruments as well as being awarded £2600.<sup>177</sup> Similarly, in 1885 Joseph Last was to go to the Namuli Hills in East Africa and was instructed to 'make a complete survey, determine the longitude astronomically of chief points, to record climate, economic products and character and language of the natives. Come back via Likugu valley which is supposed to be very fertile. Take meteorological data and observations. A set of instruments for scientific observation and survey will be lent to you, to be returned.'<sup>178</sup> In such ways instruments were intrinsic to imperial aspirations in Africa.

Even if the RGS wanted to be seen to promote 'pure science', as Butlin has commented, they could not always control the imperialistic aspirations of their travellers. In 1882 Selous defended naming mountains after distinguished Englishmen: 'We claim the country too (as well as the Portuguese) under the Queen's charter and we mean to have it, and as an Englishman travelling in an unexplored country I have the right to call any distinguished

---

<sup>169</sup> African Committee Apr 10<sup>th</sup> 1878

<sup>170</sup> Prior (2012)

<sup>171</sup> CM Feb 28<sup>th</sup> 1859

<sup>172</sup> EC Dec 1<sup>st</sup> 1862

<sup>173</sup> CM Mar 25<sup>th</sup> 1878, Apr 8<sup>th</sup> 1878

<sup>174</sup> CM Nov 25<sup>th</sup> 1861

<sup>175</sup> Butlin (2009) p.290-291

<sup>176</sup> CM May 13<sup>th</sup> 1878

<sup>177</sup> EC 16<sup>th</sup> Nov 1882

<sup>178</sup> EC June 18<sup>th</sup> 1885

mountain after a distinguished Englishman. Such names on the map will show that Englishmen have been there'.<sup>179</sup>

By the 1890s the alignment of the RGS with the government appears to have been closer than previously, and a hardening of attitude is apparent, as has been noted in chapter 2.<sup>180</sup> Patrick Brantlinger cites the Berlin Conference of 1884-5 and describes the 'New imperialism' of 1880s which was characterised by intense rivalry between European powers.<sup>181</sup> In 1890 David Rankin asked for the loan of instruments but was declined as they were 'not exploring east and west of Lake Nyassa at the moment, except with Government approval and support'.<sup>182</sup> In 1891 John Werner's application for instruments was refused because 'the RGS was in contact with the Joint Boundary Commission which is surveying in the same region and is fully equipped with instruments'.<sup>183</sup> A Mr. Du Pres was told he must go to British East Africa or India if he wanted instruments in 1899.<sup>184</sup> That year a Mr Marden was turned down because Africa was being 'officially' explored.<sup>185</sup> While Freshfield, writing from the Athenaeum at the end of the century, could describe the RGS as being at the centre of the British Empire, it was never straightforward.<sup>186</sup>

Holdich's first paper of 1891 reflected the growing sense of anxiety noted by Kennedy and others.<sup>187</sup> 'Fifty years ago we were a happy people counting up our possessions in a series of neat ring fences. We have now discovered that one short but weak corner of a fence may be a heritage of political vexation for years to come. These boundaries should enclose immense sources of national wealth and strength.' 'Our first serious survey projects should start with our boundaries.' 'The government which possesses the best topographical knowledge will be able to play the stronger hand in the international game.'<sup>188</sup> Holdich was not only making broad statements, but connected the use of specific instruments to the British imperial project. He worried that the 'extreme difficulties of fixing absolute longitudes' could lead to a disjointed geography. 'All our boundary lines want more or less of surveying, this is not merely a matter of private interest but that it is an Imperial measure, demanded in the first instance by the necessity of obtaining a definite outline to our Colonial possessions.'<sup>189</sup>

In a second paper on boundaries Holdich emphasised that he was advocating proper surveying: 'I should emphasised the word 'surveyed'. I do not mean that individuals had merely passed along a line of country contenting themselves with leaving a red trail over a blank white space as the map record of their travels, but that sound square mapping, sound square

---

<sup>179</sup> JMS/2/274

<sup>180</sup> Curtin (1964) p. xii Richards (1993), Bridges (2000), Kennedy (2002) p. 4

<sup>181</sup> Brantlinger (1988) p. ix

<sup>182</sup> CM Apr 14<sup>th</sup> 1890

<sup>183</sup> EC June 10<sup>th</sup> 1891

<sup>184</sup> EC Feb 6<sup>th</sup> 1899

<sup>185</sup> EC Committee Oct 23<sup>rd</sup> 1899

<sup>186</sup> SPC and Education Nov 1<sup>st</sup> 1893

<sup>187</sup> Holdich (1891a)

<sup>188</sup> Ibid p. 597

<sup>189</sup> Ibid p. 600

mapping, based on triangulation, with completed maps in our hands we entered on boundary negotiations.<sup>190</sup> In a report of the Pamir boundary commission in the *GJ* the instruments were mentioned specifically: 'From Osh to the boundary line the longitudes were brought down by chronometric deduction, a very fine battery of chronometers being carried in circuits.'<sup>191</sup> Boundary commission work involved precision and speed. Articles in the *GJ* advocated methods that would deliver this in the service of Imperial power: Bertrand advised among other procedures the use of polygons, pre-printed forms to fill in, the use of small transportable instruments, and checking by telegraph.<sup>192</sup>

The RGS had limited success in persuading the government of the need to explore Antarctica, which Max Jones points out was a preoccupation 'unintelligible in an imperialist framework.'<sup>193</sup> In a change of role, the Admiralty volunteered instruments but was reluctant to provide funding.<sup>194</sup> A further appeal to the PM and First Lord of the Treasury included a letter signed by the foremost scientists of the day.<sup>195</sup> By 1901 the instructions were drawn up, with magnetic and geographic aims.<sup>196</sup> Markham invoked nationalism in his letter to fellows of scientific societies to gain support for Antarctic expedition: 'The credit of the country is at stake'.<sup>197</sup> Eventually the ship *Morning* was taken over by the Admiralty, who kept it afterwards, notwithstanding that it was the first ship to have been designed especially for science. The chronometers and other instruments were also returned to the Admiralty.<sup>198</sup>

Having supported commercial telegraph ventures in the 1850s to the 1870s, by the twentieth century the Society took a different view. When Conway asked for a loan of instruments the Committee required assurance that they would not be connected with commercial activities.<sup>199</sup> In 1902 the Foreign Office sent a letter containing a list of trained surveyors available for work in Africa to the RGS, but when a Mr. Cator asked for a sextant, plane table and artificial horizon for Nigeria in 1904 the response was that the Government should furnish instruments for their own surveying work.<sup>200</sup> When John Parkinson asked for instruments the same year it was noted that he was serving under the CO and the instruments would have to be purchased.<sup>201</sup> Similarly, when Percy Talbot asked for instruments he was asked whether he had applied to the CO.<sup>202</sup> When Talbot replied in the affirmative but had been refused he was granted the instruments from the RGS.<sup>203</sup>

---

<sup>190</sup> Holdich (1897) p. 417

<sup>191</sup> Holdich (1899) p. 51

<sup>192</sup> Bertrand (1900) p. 329, *Longitude* (1906)

<sup>193</sup> Jones M. (2005) p.336

<sup>194</sup> Special Committee Apr 12<sup>th</sup> 1897

<sup>195</sup> CM June 6<sup>th</sup> 1899

<sup>196</sup> CM Mar 11<sup>th</sup> 1901

<sup>197</sup> Special committee Oct 1901

<sup>198</sup> Special Antarctic meeting July 2<sup>nd</sup> 1903, Nov 7<sup>th</sup> 1904

<sup>199</sup> EC May 30<sup>th</sup> 1901

<sup>200</sup> CM Jan 13<sup>th</sup> 1902 EC 18<sup>th</sup> May 1904

<sup>201</sup> EC October 18<sup>th</sup> 1904

<sup>202</sup> FC Dec 18<sup>th</sup> 1905

<sup>203</sup> EC Feb 2<sup>nd</sup> 1906, CM Jan 15<sup>th</sup> 1906

Another state function that the RGS supplied at this time was to give evidence with respect to finding longitude by lunar distance. Reeves and a Major Hills of the War Office were proposed.<sup>204</sup> This is likely to relate to the court case heard on January 16<sup>th</sup> 1903 between Great Britain and the United States regarding the collision of two steamers.<sup>205</sup>

In the early twentieth century the RGS had an increased involvement in boundary projects: in 1907 the Society decided to support the Boundary Survey between Uganda and Congo, for example.<sup>206</sup> These imperial projects sometimes combined with more scientifically altruistic endeavours: In 1906 David Gill requested support for his work on the geodetic arc being constructed along a line 30 degrees east of Greenwich. The RGS gave £100 for four years and hoped that the work would be useful in establishing the interests of geographical mapping.<sup>207</sup> Gill was urged to use the services of the Boundary Commission survey. Only two geodetic theodolites would be necessary and could be purchased from the Transvaal government.<sup>208</sup> In 1911 the RGS was asked to arbitrate on the Bolivian boundary, and was asked for the loan of an occultation telescope for the delineation of the Anglo-Liberian frontier.<sup>209</sup> The RGS was involved in the detailed decisions with regard to the Peru-Bolivian boundary after the start of WW1.<sup>210</sup>

---

<sup>204</sup> CM Jan 6<sup>th</sup> 1903

<sup>205</sup> [Legal.un.org/riaa/cases/vol VI/64-8-China.pdf](http://Legal.un.org/riaa/cases/vol_VI/64-8-China.pdf) Jan 2017

<sup>206</sup> CM Jan 9<sup>th</sup> 1907

<sup>207</sup> CM May 7<sup>th</sup> 1906, Special Geodetic Committee Mar 1<sup>st</sup> 1907

<sup>208</sup> Special Geodetic Committee Mar 1<sup>st</sup> 1907

<sup>209</sup> Special committee on Bolivian boundary arbitration Nov 20<sup>th</sup> 1911, Dec 4<sup>th</sup> 1911

<sup>210</sup> CM Mar 10<sup>th</sup> 1913, May 6<sup>th</sup> 1915

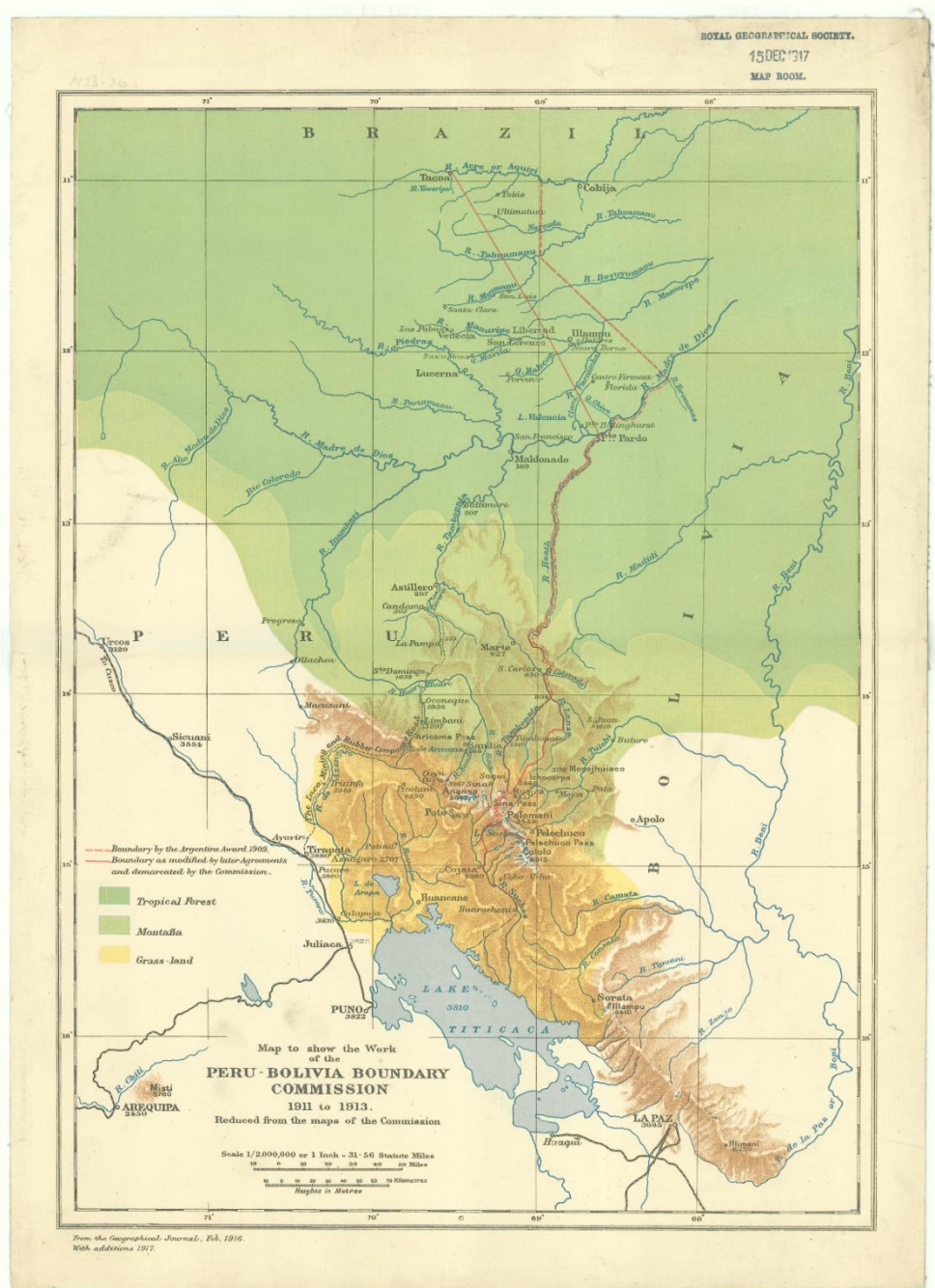


Fig 8.8: Map to show the work of the Peru-Bolivia Boundary Commission 1911 to 1913.<sup>211</sup>

The advent of WW1 had an immediate effect on the relationship between the RGS and the government as the RGS's agenda became subservient to the war effort. Maps were

<sup>211</sup> RGS Mr Peru S/S/2

provided by the Society and resources were placed at the disposal of the general staff.<sup>212</sup> Instruments were loaned for training artillery officers, maps were prepared for Earl Kitchener and for the defence of London; rooms were made available for the Admiralty.<sup>213</sup> The Army paid for the salaries of those at the RGS for their work on the war effort.<sup>214</sup> As circumstances demanded, the RGS became an arm of the nation's military complex. Even after 1919 the country remained on a war footing. The scientific societies were represented on committees on war science, air mapping and similar themes.<sup>215</sup> During a discussion on aerial photography in 1921 it was suggested the RGS borrowed war office apparatus for stereo-photography.<sup>216</sup> WW1 had set back the internationalist altruism of science.<sup>217</sup> A paper on sound ranging underwater was rejected because it would have given away secrets, and the Library and Map Committee decided not to resume the exchange of publications with 'enemy' countries.<sup>218</sup> The War Office continued to borrow instruments from the RGS, which the Society was willing to loan providing the results were disseminated.<sup>219</sup> Work continued to be done by the Society directly for the national interest: Lyons's cadastral survey of Egypt was deemed 'useful for the administration'.<sup>220</sup> However there were tensions over the promulgation of results.<sup>221</sup> The FO was not willing for knowledge from boundary commissions to be made available which caused friction between it and the RGS.

A way in which instruments had agency on the international stage was as 'bargaining chips' in allowing exploration on behalf of their owners in places otherwise inaccessible for political reasons. In the 1920s an important new technique was survey by stereo-photography described in chapter 4. During discussions regarding the proposed Everest expedition, the RGS wanted to involve this new technique, but were told no photographic survey equipment should be sent as The Survey of India was responsible.<sup>222</sup> However, in 1921 the Council decided to write to the Surveyor General asking if they could use a photo-theodolite and have the results worked up in Paris on the Orel apparatus owned by Society Francois Stereoscopie.<sup>223</sup> The resources were considerable and Europe-wide collaboration was necessary. The survey of India expressed an interest, and the RGS was equally assiduous to use it to advantage, seeing an opportunity to secure favours.<sup>224</sup>

---

<sup>212</sup> CM 9<sup>th</sup> Nov 1914

<sup>213</sup> CM Jan 25<sup>th</sup> 1915, Nov 15<sup>th</sup> 1915, Feb 7<sup>th</sup> 1916, Feb 19<sup>th</sup> 1917

<sup>214</sup> CM Feb 21<sup>st</sup> 1916

<sup>215</sup> CM 12<sup>th</sup> Apr 1920 p. 79, Research Committee 10<sup>th</sup> May 1920, 15<sup>th</sup> Nov 1920

<sup>216</sup> Research Committee Jan 17<sup>th</sup> 1921

<sup>217</sup> CM 21<sup>st</sup> Dec 1925

<sup>218</sup> Research Committee Jan 20<sup>th</sup> 1919, Library and Map committee June 25<sup>th</sup> 1919

<sup>219</sup> CM Nov 22<sup>nd</sup> 1926

<sup>220</sup> CM Mar 13<sup>th</sup> 1911

<sup>221</sup> CM Jan 12<sup>th</sup> 1925

<sup>222</sup> Research committee Mar 14<sup>th</sup> 1921

<sup>223</sup> Research Committee Mar 14<sup>th</sup> 1921

<sup>224</sup> EC 9<sup>th</sup> Nov 1925

From 1926 the photo-theodolite was lent out continually. It went to Shaksgam and the Singalia Ridge before the Surveyor General of India asked for it for use in Iraq.<sup>225</sup> The RGS was prepared to lend it if their members could be allowed to explore in the Himalayas in future. It transpired that the War Office would be borrowing the photo-theodolite, which the RGS agreed to if the results would be disseminated. The RGS were using the instrument as a 'bargaining tool' in order to balance research towards disinterested science rather than direct imperialism, and to gain permission to explore places otherwise inaccessible. The photo-theodolite continued to be in demand up to the end of the period under scrutiny.<sup>226</sup>

In these ways the instruments lent by the RGS can be seen to have had agency frequently in establishing boundaries and assessing territories for imperial projects. The RGS supplied expertise and instruments to various government departments in an unequal relationship. The agency of these instruments was used to negotiate a space for disinterested science and public dissemination, but their contribution to knowledge creation was compromised in the process.

### **The Construction of Social Relations**

It was remarked in chapter 6 that successful instrument engagement relied on a successful expedition overall, but not vice versa. The archives reveal a great deal about the reliance on indigenous people for a successful expedition, which, it is argued, was therefore crucial for successful instrumental engagement. Driver has argued indigenous people were 'partly visible' which this thesis supports.<sup>227</sup> The instruments, being part of the assemblage, required local support in terms of their transport and care: therefore one of their agencies was to dictate these roles for local people. This section investigates this before discussing the relationship between the use of instruments and social hierarchies.

Indigenous people contributed to the physical success of expeditions in providing food and transport, and to their intellectual success in the provision of geographical information. Bravo has described this transaction of the 'geographical gift' as an act of surrender.<sup>228</sup> Driver and Jones write: 'sometimes hidden sometimes visible, the role of locals and other intermediaries deserves to be much better known.'<sup>229</sup> Jöns writes: 'By imposing ethnic labels on their informants and by replacing the native sketches with surveys based on precise astronomical instruments, the Europeans contributed to the marginalisation of these people and their knowledge as 'other' subordinate and less enlightened.'<sup>230</sup> The culture clashes between

---

<sup>225</sup> CM 12<sup>th</sup> Apr 1926, Expedition Committee Oct 25<sup>th</sup>

<sup>226</sup> CM Nov 22<sup>nd</sup> 1926, Mar 25<sup>th</sup> 1928, 18<sup>th</sup> Feb 1929

<sup>227</sup> Driver (2015) p. 17

<sup>229</sup> Bravo (1999) p.218

<sup>229</sup> Driver and Jones (2009) p.5

<sup>230</sup> Jöns (2011) p.160



the travellers and the various indigenous peoples they encountered manifested themselves as perceived irrationalities, in the manner that ANT predicts.<sup>231</sup>

In recent years historians have endeavoured to uncover the 'hidden histories' of those whose voices have been excluded by the imperial archives, and whose land was traversed and conquered by the various imperialist projects.<sup>232</sup> Driver has noted that there are several distinct types of intermediaries, which can be discerned throughout chapter 6. He also argues convincingly that they are partially visible.<sup>233</sup> Historians have access to the travellers' attitudes because they are represented in the archives, but unfortunately those of the indigenous people are rarely available. Bravo and Sörlin argue that the imbalance is a result of the 'almost exclusive historiographical focus on practices of description, measurement and classification, (leading to) effacement of indigenous agency.'<sup>234</sup> However, archival theory also predicts this situation. It is very much more difficult for any historical discipline, not just the history of science, to represent other voices than those of the compilers of archives. While viewing the encounters through the eyes of the locals is impossible in this thesis, it is imperative that their role be acknowledged and discussed appropriately for the essential contribution they made, even if their views can rarely be represented.

While the larger context was appropriation and marginalisation involving the geometrisation of space, close study of the archives reveal widely different attitudes between individuals.<sup>235</sup> Of the travellers studied in chapter 6, Selous was particularly appreciative of the help he had received from indigenous people, and Duncan remarked on their kindness.<sup>236</sup> Stewart was sensitive of the impact that the white man, and their institution the RGS, had on those who had not encountered them before: 'It is impossible to disconnect the influence of so powerful a society as the RGS from many results which follow on the first exploration and the first impressions produced on the people of any region by the entrance of white men.' Livingstone's good relationships have been well documented.<sup>237</sup> At the other extreme some travellers showed no appreciation, caused suffering and hardship, and were offensive in twenty-first century terms and even in the eyes of some contemporaries.<sup>238</sup>

In the early years of the Society when fewer expeditions were supported, the instructions given to travellers were documents of substance, and the importance of indigenous people could not be obscured as it could in the resulting publications. Alexander's instructions contained the following: 'On your arrival select a guide and an interpreter from among the chiefs if possible. Then procure bullocks. However safety must come first so it may be expedient to

---

<sup>231</sup> Latour (1987) p. 190

<sup>232</sup> Driver and Jones (2009), Driver (2015), Bravo(1999)

<sup>233</sup> Driver (2015) pp.16-17

<sup>234</sup> Sörlin (2002) introduction p. 4

<sup>235</sup> Baron (2013)

<sup>236</sup> JMS/1/18

<sup>237</sup> Driver (2011) p. 5

<sup>238</sup> JMS/10/102

take most frequented routes and line of densest population.<sup>239</sup> It was clear that guide and interpreter were essential prerequisites and that populations were seen as procurable human assets. It was also stressed that Alexander should take advantage of the hospitality which the indigenous people accepted as a moral obligation.

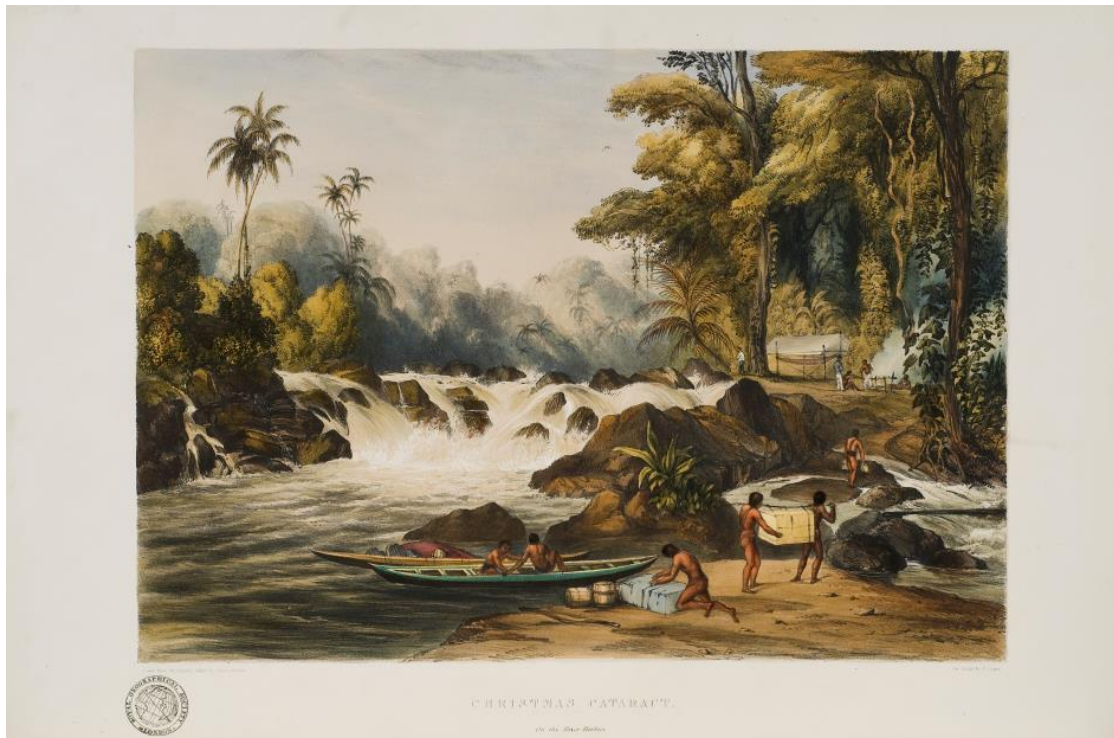


Fig 8.9: Schomburgk's luggage carried by indigenous people.<sup>240</sup>

Reliance on local assistance and knowledge was constantly evident but rarely stated explicitly, sometimes being revealed by images rather than in the text as figure 8.9 demonstrates. In 1838 Symonds in New Zealand commented on the lack of opposition from indigenous people. 'Having prepared myself for such a contingency by taking with me a sufficient number of friendly natives who would at once carry stores, instruments etc and act as guards,' and referred to 'A native New Zealander who I brought with me.'<sup>241</sup> When D'Abbadie was injured it was a slave who provided the information he lacked.<sup>242</sup> When Lady Franklin was funding one of the Franklin search parties she asked for an Esquimaux interpreter.<sup>243</sup> Galton reported that he had good interpreters and a black servant.<sup>244</sup> News of the death of Leichardt's party was relayed from 'natives' in Western Australia, who had been asked as being thought

<sup>239</sup> CM October 18<sup>th</sup> 1834

<sup>240</sup> 'Christmas Cataract On the River Berbier' in Schomburgk (1841)

<sup>241</sup> Symonds CB2/517 23<sup>rd</sup> June 1838

<sup>242</sup> CM Dec 14<sup>th</sup> 1840

<sup>243</sup> CM May 11<sup>th</sup> 1857

<sup>244</sup> JMS/2/28

likely to know.<sup>245</sup> In an unusual mark of gratitude Wollaston admitted that 'Without sufficient and good coolies it would be impossible to move across the country. The country supplies no food whatsoever. The natives assist a bit or we should have done nothing'. Cameron's papers contain accounts paid to 53 indigenous people.<sup>246</sup>



Fig :8.10: "Moobarik Bombay" who accompanied Captain Speke in Central Africa, taken by J.A. Grant 1860<sup>247</sup>

Notwithstanding their total reliance on the support of indigenous people, the travellers were frequently dismissive of them; Colquhoun could not understand the view of the 'servants and coolies', complaining that they saw his journey as 'objectless and dangerous'. While both St John Philby and A.L. Holt depended on Bedouin for their camels and to drive their cars, they described them as 'of no account'. Holt would have liked to see them fed properly in an irrigated Mesopotamia 'so they can do hard work'. Lewis had similar ambitions for 'natives' who 'should be trained and equipped to take their proper position in the triumphant march of progress and civilisation.' Regarding culture, the irrationalities for twenty-first century historians are very marked: Duncan constantly tried to tell the local people their fetishes were absurd. Lewis wrote of the natives giving themselves 'empty and self-assumed' titles, and that 'the crucifix is to be found among the many fetishes of native chiefs. They are looked upon as charms'.<sup>248</sup> By the

<sup>245</sup> CM June 10<sup>th</sup> 1850, p. 667 Nov 15<sup>th</sup> 1875

<sup>246</sup> VLC 1/3

<sup>247</sup> RGS 018802

<sup>248</sup> JMS/2/341

20<sup>th</sup> century decades of destructive association with Europeans made difficulties for travellers. Carruthers in Congo in 1906 complained; 'When the natives see us they run away so we can't get food.'<sup>249</sup>

Information provided by indigenous people was frequently considered suspicious. Franklin reported information having been gathered from the Indians and having been 'suspected by every traveller since'.<sup>250</sup> A deposition, sent via the Hanseatic Consul at Zanzibar, dated 22<sup>nd</sup> Nov 1865 from 'Mabrule' who had been a slave, regarding the death of Baron Van de Decken, was dismissed by Galton as 'not having done anything beyond the confirmation of the account of Playfair' and 'contained only 3 or 4 lines of geographical interest.' It was relegated literally to a footnote. Collinson, Whymper's referee, thought his paper worthy as it contained material 'hitherto laid down from native information only'.<sup>251</sup> The Gregorys' ambivalent attitude towards indigenous knowledge was typical. Discussing a map they wrote; 'As this map was merely from information supplied by natives, and has since proved to be wrong it has been considered advisable to reject it. Nevertheless, one or two places shown have been given approximately on the map, as there appear to be other reasons for supposing that they do exist somewhere near the positions in which they are shown.' The 'other reasons' had superior authority.

Regardless of its usual dismissal of local knowledge, the RGS saw no obstacle to using it when necessary. In a letter from South Africa Alexander wrote that according to native information he had only 30 days journey to get to Walvisch Bay.<sup>252</sup> In extracts from a letter from The Rev J. Rebmann to the Rev H. Venn dated April 13<sup>th</sup> 1854, from Rabbai, Rebman wrote 'My informant is a slave from Mombas, who came into our service before I knew anything about his origins, which I accidentally discovered when I heard him speak.' Rebman then related a quantity of geographical information from this person including the width of lakes and the presence of ice in winter.<sup>253</sup> Arab and Swahili caravans were also used for information as well as supplies: an Arab caravan brought supplies for Burton, and later Thomson was asked to find if there was a route for Europeans: 'The Swahili caravans may have an idea.'<sup>254</sup>

Harding King took a typically ambivalent attitude towards that which had been imparted to him.<sup>255</sup> His principal informant was an Arab guide who he described as 'some sort of tax collector' and who remained anonymous. Sometimes the positions were described as 'much in error when compared with those fixed by actual survey'. Reports of dried up river beds were said to be 'without foundation': 'Information of this kind must be regarded with suspicion.' Nevertheless, several pages of description were thought fit to publish in the *GJ*.

---

<sup>249</sup> JMS 9/248

<sup>250</sup> CM Mar 28<sup>th</sup> 1836

<sup>251</sup> JMS/4/73

<sup>252</sup> CM June 26<sup>th</sup> 1837

<sup>253</sup> JMS/2/37

<sup>254</sup> CM June 21<sup>st</sup> 1859, Dec 8<sup>th</sup> 1882

<sup>255</sup> Harding King (1913)

Evidence concerning the relationship of indigenous people with instruments is less obvious, but present. For example, the crossing of Africa was a 'geographical exploration' when performed by a European: Galton wrote: 'Livingstone's evident merits are not brought out into proper relief when the culminating point of what he has done is stated simply to be the crossing of Africa. The geographical exploration of his line of route is a far superior merit. The one can be done, and is done, by uneducated negroes, the other cannot'.<sup>256</sup> It is clear that the use of instruments in the geometrical construction of place was an act intrinsic to Europeans. Freshfield, relating the story of the Pundits, remarked that 'a native had led an expedition over a pass a most remarkable feat for a native'. However 'It would be a mistake to regard them as scientific cartographers'.<sup>257</sup> If an indigenous person demonstrated they were as capable as a European, they were seen as unusual: Peek described an Icelander as 'a most intelligent man who also seemed to understand the points of the compass, a rare thing among Icelanders'.<sup>258</sup>

When non-Europeans observed with instruments their contribution was frequently airbrushed from the narrative, or they were not named. Boyd Alexander's paper as a result of his expedition to Nigeria was well received by H.H. Johnston the referee. According to Bederman, however, a childhood friend from Cape Verde Islands, Jose Lopes, was 'absolutely vital to whatever success the expedition experienced' but was not credited.<sup>259</sup> Fanny Bullock Workman took a 'native plane tabler' for her Survey of the Siachen Glacier who remained anonymous.<sup>260</sup> In 1907 the RGS refused a request from the Governor of Newfoundland to provide medals for the indigenous people who accompanied Peary.<sup>261</sup> Perhaps the most noteworthy is Stein's ownership of the map surveyed by Rab and Lal Singh which was completed in the 1930s. The sketch map in the archives reveals that the surveyors were Lal and Ram Singh. The caption of the published map only credits Stein: 'The Turfan Basin from surveys made during the explorations of Sir Aurel Stein in the years 1907 and 1914-15'

---

<sup>256</sup> Galton CB4/680 letter to Norton Shaw 12<sup>th</sup> May 1860

<sup>257</sup> JMS/11/142

<sup>258</sup> JMS/15/87

<sup>259</sup> Bederman (2000) p.69

<sup>260</sup> Workman (1912) p. 897-903

<sup>261</sup> CM June 17<sup>th</sup> 1907



MAP OF PORTIONS OF CHINESE TURKISTAN AND KANSU

1662

TO ILLUSTRATE THE EXPLORATIONS OF  
DR. M. A. STEIN, C. I. E., AND HIS ASSISTANTS,

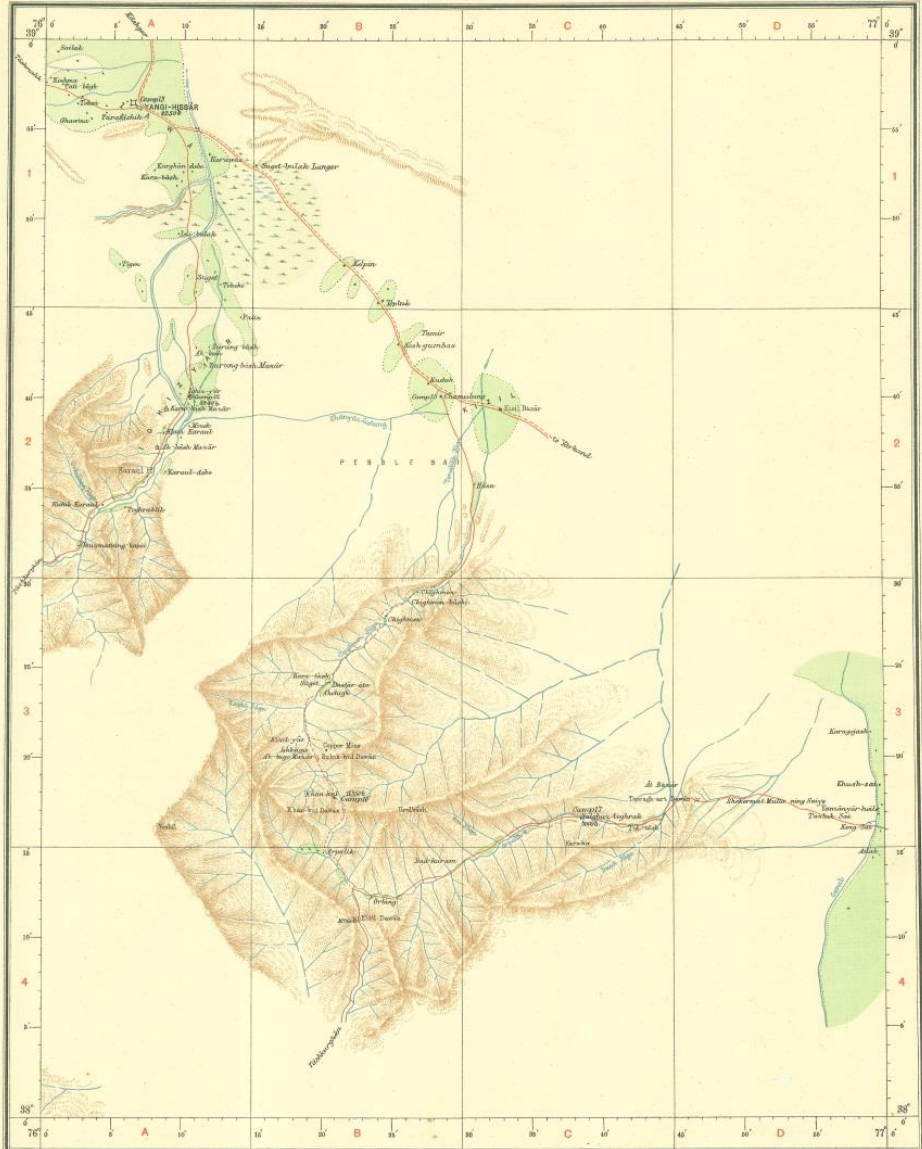
SURVEYORS R. B. LAL SINGH AND R. S. RAM SINGH, SURVEY OF INDIA.



YANGI-HISSAR

1906-08

SHEET No. 7



Published under the direction of Colonel R. C. Dorman, R.E., F.R.S., 1919, Surveyor General of India.

Scale 1 inch = 10 miles

Vertical scale: 0 to 10000 feet

Horizontal scale: 0 to 10 miles

Legend:

- Latitude shown approximately
- Latitude and longitude shown approximately
- Triangulation station with height
- Topographical point with height
- Barometrical height
- Chromolite height
- Barometrical height
- River bed
- Channel
- Bank
- Cliff
- Water course
- Sandy tract with scrub or jungle
- Area of scrub or water grass
- Area of cultivation
- Settling marks
- Depression
- Spring
- Well
- Stake

EXPLANATION OF SOME PERSIAN AND CHINESE TERMS:

Abad	Spring	Ak, Ak	Lake	Pa-jai 42 (Ch. 1)	Water stage
Abad	Settlement	Amir	Chief	Shir	Chief of water project
Abad (Ch. 1)	Water stage	Amir	Chief	Shir (Ch. 1)	Chief
Abad	Pass	Amir	Chief	Shir (Ch. 1)	Chief
Abad	Pass	Amir	Chief	Shir (Ch. 1)	Chief
Abad	Pass	Amir	Chief	Shir (Ch. 1)	Chief
Abad	Pass	Amir	Chief	Shir (Ch. 1)	Chief
Abad	Pass	Amir	Chief	Shir (Ch. 1)	Chief
Abad	Pass	Amir	Chief	Shir (Ch. 1)	Chief
Abad	Pass	Amir	Chief	Shir (Ch. 1)	Chief

Vertical scale: 0 to 10000 feet

Horizontal scale: 0 to 10 miles

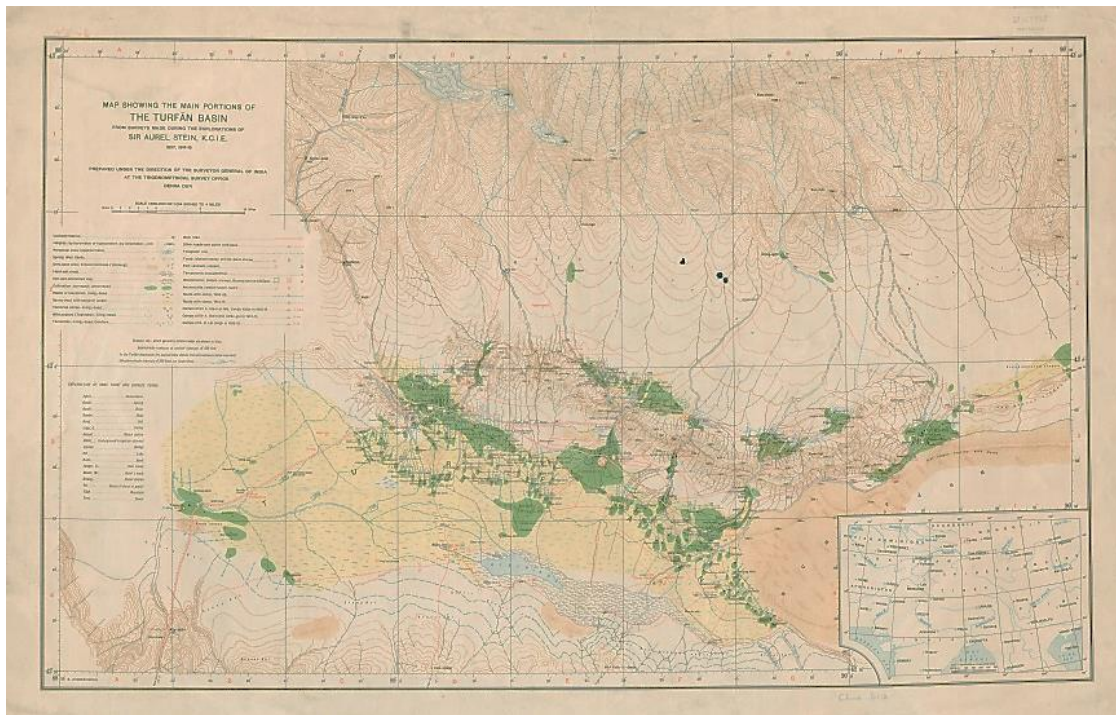


Fig 8.11 a and b: Comparison of attribution between maps. The first, published in 1913, credited surveyors Lal and Ram Singh as Stein's assistants. The second, published later but relying on the same work, did not.<sup>262</sup>

Some travellers saw indigenous people as a similar resource to pack animals. However, they were supposed to take responsibility for the instruments as if they had an interest in any outcome. Stewart found that the indigenous people on his route refused to carry his belongings saying they were warriors not porters.<sup>263</sup> However, usually it could be expected that 'coolies' would carry everything and frequently they were provided by local chiefs.<sup>264</sup> Kingdon Ward asked for mules and coolies in 1923. The Secretary responded saying that he could 'easily get two Tibetans for you, but as for the mules.'<sup>265</sup> McEwan's chronometer had been carried by one of the porters, O'Neill's sextant was carried by 'a man', and numerous other examples can be found.<sup>266</sup> Responsibility for the expensive instruments was also required:

<sup>262</sup> RGS 55ICAT 94 maps, Mr Survey of India 1662 (sheet 7), 1913 and Mr China S.113 'Map showing the main portions of the Turfan Basin from surveys made during the explorations of Sir Aurel Stein 1907, 1914-15.' dated 1933 RGS 536470

<sup>263</sup> JMS /2/196

<sup>264</sup> Dirks (1992) p.7

<sup>265</sup> Kingdon Ward CB9/151 letter dated Dec 14<sup>th</sup> 1923

<sup>266</sup> SSC McEwan 'Observation Calculation Books 'Number 5 p.49, HEO /4 p. 1

Strong had a bag containing an observing instrument left behind 'owing to lack of concern.'<sup>267</sup>  
Singh appears to have carried the plane table for Stein as well as performing the mapping.<sup>268</sup>



Fig 8.12: Tibetan porter acquired to carry Kingdon-Ward's supplies.<sup>269</sup>

As well as imposing responsibility simultaneously with the role of a pack animal, the instruments needed to be protected, so dictated boundaries which heightened 'othering'. In Mackinder's expedition we see the physical and intellectual marginalisation of indigenous people. In part due to Mackinder's own intransigent attitude he found it necessary to protect himself: 'We had to put a fence around us as the natives were distrustful. White men kept guard. We had to keep the Kikuyu at bay by displaying firearms. Guides ran away. I tried to get shots of sun and stars.'<sup>270</sup>

While there are no images of Mackinder's fence, other illustrations serve to demonstrate this feature of some larger expeditions. The secluding of the instruments from the surrounding areas was in keeping with Gieryn's description of 'truth spots' whereby laboratories

---

<sup>267</sup> Lawrence (2006)

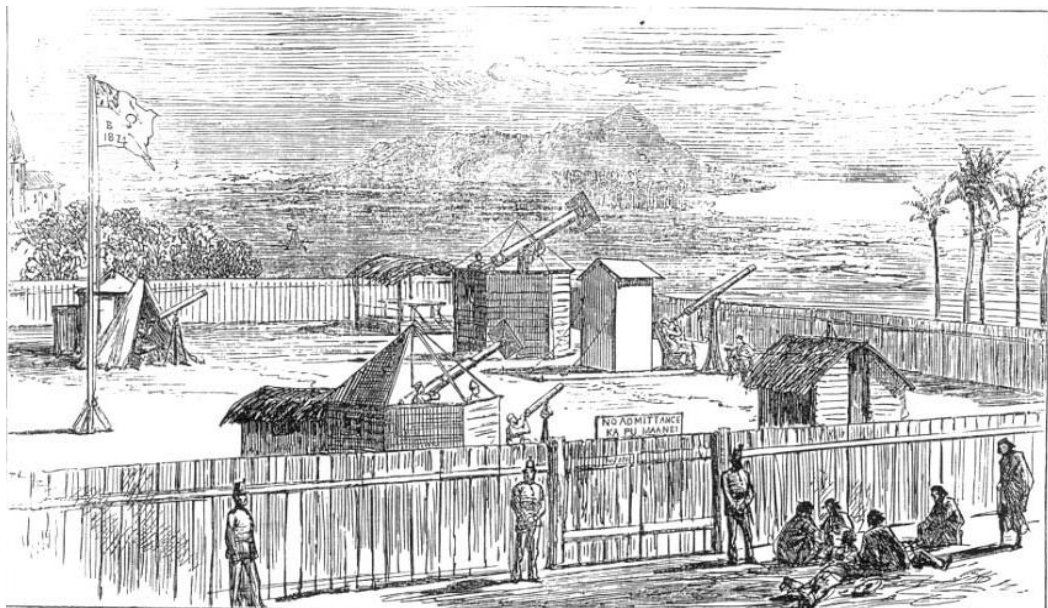
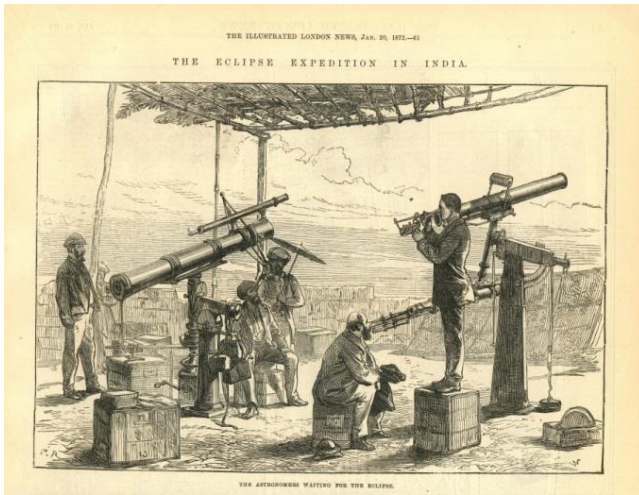
<sup>268</sup> CM Mar 22<sup>nd</sup> 1909

<sup>269</sup> KW/102/6

<sup>270</sup> JMS/2/328 Hansen (1996)



were created in the field.<sup>271</sup> Paradoxically, the ‘truth spot’ needed to be protected from its surroundings. The instruments were expensive, were only able to function within controlled environments of appropriate behaviour, and therefore their agency dictated the removal of indigenous people from their habitat.



---

<sup>271</sup> Withers (2011) p.45

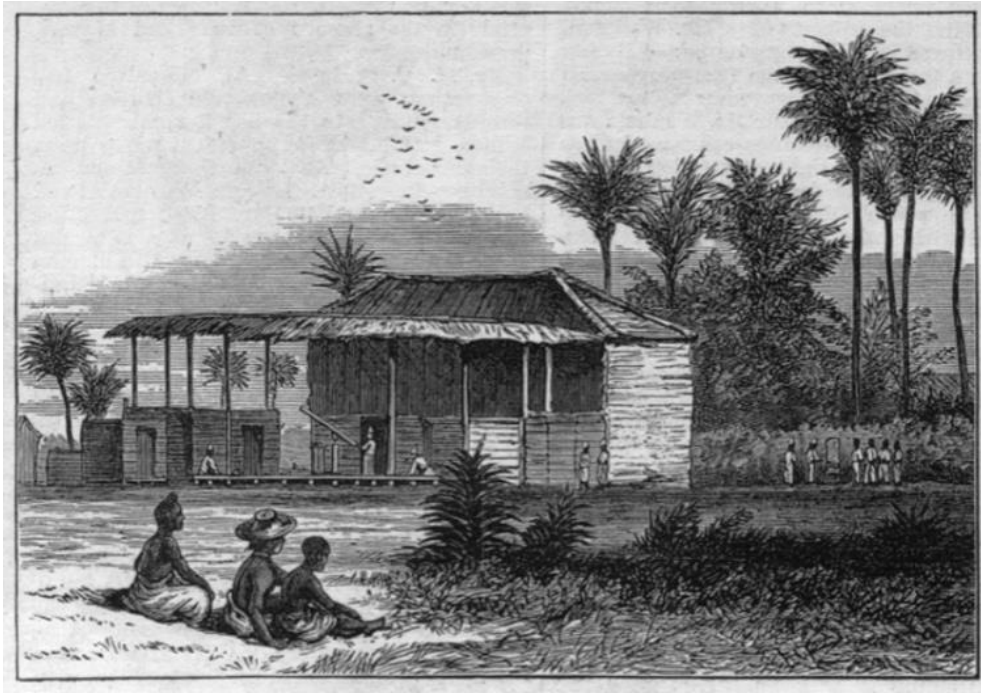


Fig 8.13 a, b, c and d: Two images of Norman Lockyer's 1871 Eclipse expedition to India where instruments were installed in a fort, and observing the Transit of Venus in Honolulu in 1874.<sup>272</sup>

As Driver remarks, occasionally indigenous people were acknowledged. The first suggestion to train Africans to explore Africa came in 1880.<sup>273</sup> The same year swords were presented to the 'native' helpers of Thomson in Africa.<sup>274</sup> Occasionally indigenous individuals would be recognised; Kirk said he had paid Jumba Kimamenta 1000 rupees as 'he rendered essential services.'<sup>275</sup> Projects incorporating training indigenous people were undertaken: in 1901 The RGS supported the arc of the 30<sup>th</sup> meridian project in this way.<sup>276</sup> The following year Molesworth Sykes was proposed for an award for 'giving strongest support to our native explorers'.<sup>277</sup>

Economic necessity dictated a more tolerant and expansive attitude in the longer term. After WW1 Holdich advocated a homogeneous map of Africa 'not the patchwork we are getting.' He wanted it based on Indian methods with a rapid system of triangulation. 'Then extend a graphic system of mapping from these lines by means chiefly of native labour.'<sup>278</sup> 'We

<sup>272</sup> ILN 10<sup>th</sup> Jan 1872, 27<sup>th</sup> Jan 1872 <https://www.ifa.hawaii.edu/users/steiger/post-cook.htm> ILN 'Principal Observatory Chulai Point, Siam' and 'Waiting for contact at Honolulu'. 1784. ILN Nov 21<sup>st</sup> 1874. Chauvin (1993), Pang and Soojung (2002)

<sup>273</sup> CM Apr 26<sup>th</sup> 1880

<sup>274</sup> African Committee Nov 15<sup>th</sup> 1880

<sup>275</sup> CM Dec 8<sup>th</sup> 1884

<sup>276</sup> EC Jan 18<sup>th</sup> 1901

<sup>277</sup> CM Mar 10<sup>th</sup> 1902

<sup>278</sup> JMS 19/29

need to resort to native agency for the topography of the vast area of Africa. Effective topography requires special training. European agency, except for supervision, is out of the question due to expense. Indian agency is equally impossible for more than comparably restricted areas. Africa must be mapped by Africans as India had been by Indians'. Of course there would be a role for Europeans as 'There is no method which does not require scientific direction.'<sup>279</sup> 'There are two distinct classes of topographer needed in Africa; European and native'.<sup>280</sup> Europeans were the only people considered capable of directing.

It is sometimes possible to be more specific about the agency of instruments in the division of labour between Europeans and others. The document deposited in the RGS archives by Antonio Jozi, a native of Angola, gives a rare insight into the viewpoint of an indigenous person.<sup>281</sup> It contains the narrative; 'Proceedings of small party sent by Captain Owen under command of Lt C.W. Browne to explore the course of the river Zambesi 1827'. The party consisted of three Europeans, one black man and Jozi himself. 'Mr. Browne observed latitude at noon, and took many astronomical observations, another European 'botanised' and a third 'took birds'. The Europeans were conveyed by palanquins, with local people carrying their baggage. The Europeans died one by one, but there was no attempt to share their respective tasks with each other or their indigenous colleagues. From the diaries it appears the instrumental observations on small expeditions were undertaken exclusively by white men.

---

<sup>279</sup> JMS 15/120 letter to Keltie from Holdich 7<sup>th</sup> Oct 1918

<sup>280</sup> JMS/2/332

<sup>281</sup> LMS J 13



Fig 8.14 a and b: 'Team member with surveying equipment' by C.G. Rawling in Tibet in 1905, Major Wheeler photographed by Wollaston in 1921. <sup>282</sup>

Often nothing is written about the various roles, but many images in the archives show Europeans using instruments while indigenous people hold animals or stand in attendance as in figure 8.14a and b. Haraway reminds her readers that there is no unmediated photograph.<sup>283</sup> Ryan describes photographs as 'bringing visual residues of its landscapes back home as trophies'.<sup>284</sup> More immediately relevant, Kathleen Stewart Howe writes of the Egyptian survey in 1868 'Indigenous guides and servants are seated in the sand, their passive presence in vivid contradistinction to the emphatic and active postures of the English members of the survey'.<sup>285</sup> On large scale projects such as triangulations there is evidence that the set up of a triangulation, with an expensive theodolite and horses at the centre of the proceedings and the out parties with simpler lamps, heliographs, flags and oxen reflected and complemented the social status of the participants. 'Surveyor' was a term reserved for those who used the theodolite, however essential the work of the heliographic parties was to the whole enterprise. The arrangements of the smaller explorative projects typical of the RGS are more difficult to assess, but the evidence suggests that instrument use was normally the preserve of Europeans.

<sup>282</sup> Control numbers, 073375, MEE21/0279

<sup>283</sup> Haraway quoted by Schwartz and Ryan (2003) Introduction p.5

<sup>284</sup> Ryan (1997) p. 97, Ryan (2010)

<sup>285</sup> Stewart Howe (2003) p. 237

## **Conclusion**

This chapter has examined the agency of instruments. The principal findings have been that in accordance with ANT the instruments have been shown to have agency, the most direct form being in the creation of new knowledge. This did not always follow the path of reliable observations being transcribed into published papers for dissemination. On the contrary, often the mere presence of the resource imbedded in the instruments was sufficient to improve the chances of successful knowledge-creation rather than their successful mobilisation.

The instruments conferred authority on their users, but those higher up the social order; white males, benefitted disproportionately from their instruments. Non-Europeans had to do more to be recognised, and women were not considered able to produce authoritative maps. Later in the period instruments were borrowed by those who had already gained distinction, so were less likely to be used to enhance reputations through successful engagement.

The RGS maintained an unequal relationship with the British government throughout the period in question. While the RGS used its instruments and the expertise fostered in order to argue for disinterested science, in times of need they became subsumed into the British state's interest in imperial governance.

The instruments were used as a mark of distinction separating what was done by European men from what could be done by others. By being valuable, fragile, and difficult to use they dictated that they were guarded, cared for with diligence, and handled by experienced users respectively. While it is seldom made explicit, the instruments appear to have been used predominantly by European men in small parties. In larger projects non-Europeans could be supervised and assigned the simpler tasks with the cheaper instruments.

## Chapter 9:

### Conclusion: Instruments and Exploration in the Work of the RGS.

#### Overview

This thesis set out to investigate the role of instruments in exploration by taking a systematic approach to a wide range of material in the RGS archives. Fresh light has been shed on instrumental practice and its products by framing the process of knowledge creation as a cycle, resulting in a number of key findings which challenge accepted views. The conclusion traces the chapters of the thesis to summarise arguments at each stage.

The theoretical framework adopted was that of ANT as proposed by Latour and others, as representing the best fit to the cyclical process of information gathering, with the RGS Map Room as the privileged site of data collection, manipulation, and presentation; the 'centre of calculation.'<sup>1</sup> Instruments and their users were viewed as embodying resource as explicated by Morus, which was enhanced by the RGS, before being dispatched to be mobilised in the field or periphery in order to provide data, which subsequently returned to the centre where it was processed to become new knowledge.<sup>2</sup> The process was repeated with the majority of the instruments going out several times. Information from specific areas was increasingly compared over the period in an iterative process. While the structure of the thesis is based on this cycle, the ideal features of mobility and immutability as explicated by ANT, were seen to be difficult to maintain, as ANT predicts. Furthermore, the authority of the instruments was found to be not directly connected to the quality of the data returning.

The travellers and the Council of the RGS adhered to the belief in the altruistic and disinterested nature of science. More specifically, it has been shown that the Society was influenced by the writings of Humboldt and Herschel in the early decades, to which the convenient label of 'Humboldtian science' was attached by Susan Cannon.<sup>3</sup> These models require numerical data to be produced in order to strengthen authority and to reveal patterns in global natural phenomena. The commitment to number in this period has been discussed by many writers.<sup>4</sup> The thesis observed a lessening of the grip of number in the twentieth century.

It is argued the RGS Map Room at its various London sites can be considered the centre of calculation; in the vast majority of cases it was where inscriptions derived from instrument use were processed, modified, rejected, or made to conform to expectations. In

---

<sup>1</sup> Latour (1987) p.232, Jóns (2011)

<sup>2</sup> Morus (2006)

<sup>3</sup> Cannon (1978)

<sup>4</sup> Porter (1995), Cline Cohen (1982), Poovey (1998)



accordance with Driver the RGS, and more particularly the Map Room, had multiple roles.<sup>5</sup> However, the thesis suggests complexities even in the complex model of ANT; the conceptual black box was opened frequently, particularly in the first half of the period, in that purchased instruments were not merely used as observational tools but were under scrutiny themselves. While the concept of instruments and data as immutable mobiles is extremely illuminating, the resources required to maintain this ideal was considerable. Multiple networks were not necessarily found to be strong.

The thesis has reconciled in general terms the two apparently contradictory statements offered by Withers: the first being that the RGS had an instrumental culture, the second remarking that instruments were fallible in the field.<sup>6</sup> This apparent contradiction has been resolved by establishing that the Society worked to minimise the fallibility by amending the travellers' data in various ways to provide agreed knowledge. Instruments conferred authority, but usually not in the manner predicted by the various models of science. On the contrary, the considerable resource inherent in the instruments and their users could corrupt knowledge creation. By privileging the publication of material based on instrumental resource *invested*, rather than its effective *mobilisation*, the RGS at times frustrated the efficient production of knowledge in favour of maintaining an appearance of success. The instrumental investment itself was a more reliable asset than the data resulting from its mobilisation.

Other important findings include the conferment of epistemic authority.<sup>7</sup> The instruments bestowed authority on their users, but this was more pronounced in the case of European white men than it was for women or non-Europeans. It is also argued that as the RGS was subsumed into the state mechanism during the crisis of WW1, ultimately the instruments belonged to the British state. They worked tirelessly for its benefit, so that in times of imperial crisis their other roles disappeared.

The thesis has observed the instruments play an important role in positioning the RGS between a scientific establishment and a promoter of populist individual heroism. Aspects of the loan of instruments, the training of their users, and the manipulation of results have demonstrated the interplay between an emerging professional meritocracy linked to the former ambition, and a privileged elite linked to the latter. The instruments worked- or did not work- for their users. They worked for their owners, the RGS in this case, but not always in the direct production of new knowledge, nor was the authority they conferred always related to reliable data. The implications for this finding suggest that historians need to look at, but also beyond, the mechanism of data production in order to understand more fully the role of instruments.

---

<sup>5</sup> Driver (2010)

<sup>6</sup> Withers (2013), Rae, Souch and Withers (2015) p. 158

<sup>7</sup> Shapin (1994)

### **Empirical Data Presented**

The thesis supports the claims made for an instrumental culture at the RGS advocated by Rae, Souch and Withers.<sup>8</sup> It has established that around 1500 instruments were procured, the vast majority of them for loan. The thesis has demonstrated that the Society was slow to acquire a collection: for the first twenty years it relied considerably on borrowing for each expedition. Purchasing increased from the 1870s, peaking in the 1890s. Spending on repairs has been represented numerically and again shows a slow start in the 1860s rising to the 1880s, and with the exception of WW1, continuing throughout the period. Other forms of the enhancement of value on behalf of the RGS have been found by analysing the various texts. The Society lent instruments to 436 expeditions over the period, with the number increasing sharply in the 1870s. Africa was found to be the most popular destination, especially in the later nineteenth century. The make-up of the borrowers changed only slightly, with men of private means dominating. Military men constituted an increasing proportion in the twentieth century. It has been demonstrated that over half the borrowers published, although the rate was higher in the nineteenth century and lower in the early twentieth century. Data for each individual instrument was collected and tabulated to reveal that with the exception of a few instruments designed for use at the Poles, there was no specificity for the various climates or terrains, many instruments being sent to various climatic destinations.

### **Embedding Resource in the Instruments**

The thesis considered instruments as having embodied resource. The statements of intent on behalf of the RGS confirm a commitment to their use, supported by others' previous work.<sup>9</sup> However, the thesis revealed that throughout the period under consideration there was disagreement as to which instruments were considered 'proper.' The principal tension was found to be that between the lone 'heroic' explorer and the professional, 'scientific' surveyor.<sup>10</sup> At times these conflicts became heated; in 1899, Markham defended the use of the sextant against Holdich's promotion of the theodolite. These instruments differed physically, but it is argued also dictated various methods of use, so carried with them differing interpretations of exploration, and therefore promoted differing roles for the RGS. Other tensions were found to come into play over the question of instrumental propriety; the Humboldtian paradigm was expensive and therefore difficult to maintain, and new more portable instruments, such as the aneroid and hypsometer in the 1850s, were initially viewed

---

<sup>8</sup> Rae, Souch and Withers (2015) p.158

<sup>9</sup> Rae, Souch and Withers (2015) p.158

<sup>10</sup> Richards (2011a)



with suspicion as they were not considered as precise as the more established mountain barometer.

A study of the *actual* acquisition patterns revealed a failure to implement the Society's original intentions of 1831, as remarked by Rae, Souch and Withers<sup>11</sup>. Before 1850 the Society failed to acknowledge the concept of an instrument collection. Two donations, one from Mansfield Parkyn and a larger one from Robert Sheddon, were crucial in realising this concept. The first listing appeared in 1851 and these assigned numbers remained attached to these instruments for a decade. Other studies of the RGS have overlooked these donations and the early listings, an important turning point which marked the beginning of the recognition on behalf of the Society of its possession of a valuable resource. From this time onwards some care was taken to record what the Society possessed, and where the instruments were sent. This recording was most evident from 1879 when 'The Catalogue of Instruments' began.

It is argued the resource was enhanced by association with the RGS. This association was not merely nominal; the thesis has demonstrated that the RGS added value to its collection in various ways. Following listing, calibration was the next aspect of value enhancement undertaken. Calibration is an essential requirement for the universality of science. Although it is an ideal never achieved, attempts to regulate the performance of instruments after 1860 in accordance with standards at Kew, added value to the RGS instruments. Kew certificates with stated index errors added a degree of confidence by association with the state's institutions of science as discussed by MacLeod.<sup>12</sup> Greenwich and Kew observatories undertook a vital service to the British Empire in general, and to the RGS's project of exploration in particular.

The thesis has traced other aspects of instrumental management: repairs, weeding, inscription, storage, and insurance. On several occasions there were initiatives taken to delegate the responsibility for instruments in order to improve their care. Contrary to Rae, Souch and Withers it is argued all these failed to produce changes until the improvements of 1879. While never sufficient, it is here argued the actions of the RGS ensured a minimum standard of performance, a standard which was lamentably low in the early part of the period, but which improved. The instruments could instil confidence and enjoyed a status above that of instruments outside the Society's remit.

The thesis has traced the debates with instrument makers and inventors regarding instrumental design and improvement, noting the discussions included instruments purchased by the Society. In agreement with Golinski, bought instruments were found not to be simply tools but subjects of investigation in their own right.<sup>13</sup> These discourses decreased after 1870 when, it has been shown, other technologies became the focus of debate and

---

<sup>11</sup> Rae, Souch and Withers (2015) p. 143

<sup>12</sup> MacLeod (2003) introduction

<sup>13</sup> Golinski (1998) p.134

mathematical instruments were placed firmly in the 'black box' of ANT, as they were agreed upon. This engagement on behalf of the RGS with instrument design conferred authority on its collection by maintaining a 'firewall' against faulty, unworkable or outlandish suggestions.

The thesis has demonstrated that the Society fell short of realising its intentions regarding the procurement of instruments designed for specific locations. Although instrument makers were invited to submit designs for various different climates in 1859, the records of purchase, and of their allocation to expeditions, do not exhibit specificity. Rather, the same items were sent to locations with very different terrains and climates. Not until the polar expeditions of 1875 onwards was there any evidence of procurement of specialised instruments for specific expeditions.

The discussions regarding the supporting mathematical theories have been regarded as complementary to the discussions regarding the physical design of instruments. This engagement on behalf of the Society ensured that the instruments were used in conjunction with the latest information on astronomical positions, relationships between various types of measurements, and changing natural phenomena such as magnetic variation. Resource already inherent in these mathematical relationships was marshalled by the Society and its users, and exploited for the benefit of its instrumental activities. This, the thesis argues, enhanced the value of the instruments.

In summary the thesis argues that the RGS instilled an instrumental culture, but never one to match its ambitions. The Society increasingly both purchased instruments and enhanced the considerable resource embedded within them through management and discourses on their design, and on their supporting mathematics. By defining what instruments were 'proper,' the Society helped to construct the concept of exploration, with implications for itself and for geography more widely. Even when more recent technology was introduced, the mathematical measuring instruments continued to be used, but simply as tools.

### **Resource Invested in Users**

The thesis has considered the users of the instruments to be a complementary resource inputted into the cycle of knowledge creation by the RGS. The composition of the borrowers was found to remain similar over the century. Men of private means were predominant, followed by military men, doctors, churchmen, and a small percentage of others, including women. Resource was added to the potential travellers by means of instructional texts and practical training. While there was an intention to provide advice for users of instruments in the 1830s this was not acted upon. The thesis has shown hidden resource provided by navigators on vessels en route, and mathematical instructors who usually remain anonymous.

The first text associated with the RGS was that of Jackson in 1841 which has been discussed by Jones, Driver and Withers. Withers notes the efforts made by Jackson to

regulate travelling and describes *What To Observe* as an attempt to 'methodise' geographical travel.<sup>14</sup> From a comparison with similar texts the thesis argues that it was not in competition with mathematical texts of the time, but that it filled a niche for travellers. The thesis argues that the first edition of *Hints* challenges the assertion, crucial to ANT, that a network involving multiple sources adds strength to a product. On the contrary, in this case the multiplicity of authors undermined the authority of the work. In agreement with Driver, *Hints* may be viewed as a tentative offering. Having considered all the editions over the century under scrutiny, and compared them with a range of similar contemporary texts, the thesis argues that while the second, third and fourth editions moved towards an integrated approach with a common introduction for all the constituent parts, these editions collectively failed to establish a place in the literature. In agreement with Jones, the fifth edition (1883) constituted a departure in that it was an informative and comprehensive text which provided a unique resource.

From the late nineteenth century the tensions between an Enlightenment reliance on number and the more reflective, romantic aspirations of geography, in particular from Freshfield and Mackinder, was apparent in *Hints*. The tenth edition of 1921 exhibited war-weariness in advocating the enjoyment of nature. The thesis argues that *Hints* reflected the findings that the numerical emphasis, which has been linked to the Enlightenment, was losing its ascendancy in the light of new and more varied approaches to geography.<sup>15</sup>

Hands-on instruction in instrument use was being provided on a regular basis by Captain George from 1868, before the role of instructor became formalised with Coles' appointment in 1880. George acted as a gate-keeper for instrument loans. Hands-on training was extremely expensive for the Society, as it was not feasible to teach groups. In agreement with Collier and Inkpen, training became a source of conflict where the tension between the heroic and professional models of exploration came to a head in 1899. Contrary to Collier and Inkpen, the thesis argues the nature of the training did not change when Reeves took over in 1902. Rather a change in instruments deployed resulted.

Importantly, the thesis noted the constant undermining of initiatives to regulate the borrowing of instruments to those who had been trained. This, it has argued, demonstrated a tension between meritocracy and privilege. High-status individuals could circumvent the process. The resource invested was not entirely wasted as the thesis has found that some travellers demonstrate considerable capability to undertake observations and compute the results having received training, especially from Coles in the last quarter of the nineteenth century. Even if the resource input was not matched on an equal basis by output, both because some trained without borrowing and others borrowed without training, the resource embedded in these users remained significant.

---

<sup>14</sup> Withers (2013) p. 172

<sup>15</sup> Daston (2000) p.39, Porter (1995), Collier and Inkpen (2002)

## **Mobilisation in the Field**

The next stage in the cycle-practice the field -has been considered as a mobilisation of the combined resource of instrument and user. A narrative form was utilised to convey the situations of the travellers most effectively.<sup>16</sup> An emphasis on Africa has been noted, however, the fifty expeditions were chosen to give a range of destinations, time periods, and type, so are less focussed on Africa than a representative sample would be. The thesis has identified a number of factors salient in the successful observation and production of instrumental data, and has argued that these factors did not change markedly either over time or with respect to place. The factors determining successful mobilisation of instruments did not necessarily correlate with those which determined whether or not the expedition was an overall success. Successful instrument use depended on a successful expedition, but the reverse was not the case. David Livingstone was the most extreme example of the latter.

Private letters and unpublished material were more revealing of difficulties than published accounts. The thesis demonstrates that competence of the traveller, communication of desiderata, physical issues, human encounters, the political situation, logistical concerns, and systemic aspects all played a part in determining whether the resources embedded in the instruments and in their users were successfully mobilised. Usually one or two aspects were responsible for the outcome; for example the RGS did not communicate to Alexander what was required of him, neither did it ensure that he was capable of using instruments. In other cases, such as that of Rae, fundamental systemic flaws were revealed in the measurements as well as in the more obvious effects of extreme cold.

Instrumental culture values numerical measurement in accordance with Humboldtian science. Several examples of the propensity for measurement have been noted: Galton measured the strength of thorns, Speke was 'tormented' by not being able to fix his longitude, Cornish counted the number of pillars destroyed in an attempt to find a variable to which to attach a number. As the century under consideration proceeded, and the diversity of the expeditions increased, the value put on numerical measurement diminished. A higher proportion of expeditions was concerned with specific descriptive aspects of knowledge: for example natural history, anthropology, and mountaineering. In the twentieth century a significant number of travellers including Ramsay, Freshfield and Steers, opined that instrumental observing interfered with 'seeing' and 'thinking.' Haddon had surveying 'thrust upon him' unwillingly. However, the dominant culture within the RGS retained an attachment to the importance of number.

A significant factor distinguishing field science from laboratory science is the lack of ability to simulate equivalent surroundings in the first. This undermines the capacity of the instruments to operate consistently. While ANT suggests that instruments should be

---

<sup>16</sup> Golinski (1998)

immutable mobiles this thesis argues this was rarely the case in reality. Instruments can never be identical, and even the same instrument cannot be expected to behave as an immutable mobile after a long journey or if damaged. Similarly, the locations cannot be made equivalent, even the same geometric point on the globe can change fundamentally over time, as rivers and lakes dry up, sand shifts, or ice melts, so challenging the best instrumental observers to return with comparable data.

The thesis has revealed many instances of instruments not arriving, not being suitable for the climate, or not having the necessary support to function in place. This may have been expected to improve over time, but it is argued it did not. There are two principal reasons: the RGS' plans to send expeditions to increasingly remote places in its quest for the 'heroic' vision of exploration were supported by a strong faction in the Society even in the twentieth century. Blank spaces were pursued at the Poles and at great heights: logistical gains through telegraphy and railways were rendered irrelevant. The other reason was that new instruments and technologies required new forms of backup: petrol, batteries, and repair facilities for pieces of equipment such as the phototheodolite were not available.

The thesis has demonstrated that instrumental observation, not simply the success of an expedition, relied considerably on indigenous people. They were expected to carry the instruments and often to care for them. It is difficult to extract the extent to which they were the principal users. Stein for example was slow to acknowledge the extent to which Ram and Lal Singh had contributed to the survey in Turkestan. Images show the Europeans using the instruments while indigenous people remain marginalised and inactive. The deterioration of relationships with indigenous people and the hardening attitude of travellers after about 1885 have been remarked on by many writers, and corroborated by many accounts of expeditions.<sup>17</sup> This factor worked to make life increasingly difficult, with new technology not always off-setting these difficulties, as remarked by Carruthers.

Systemic issues were the least obvious of the pitfalls of the field: underlying theory could be absent, or a crucial aspect of the structure of information omitted. New types of instrument were especially prone to these shortcomings. The thesis argues that in the case of seismology, as validated by Milne and Cornish, it was not at all clear what the seismographs were measuring as there was no theory behind their use. This instrumentalism tended to be overlooked: only Strachan from outside the RGS objected. In general, advocates of new instruments were motivated to disregard these difficulties- as with Sabine and the magnetometer- because the new instruments opened up new fields of research.

Yet systemic failings were common. Failing to take the base reading before measuring differences in height, failing to find position before measuring height, taking many latitudes and very few or no longitudes, and being unaware of, or unable to ascertain, magnetic variation, were all common problems. Lack of rigour was apparent in the testing of

---

<sup>17</sup> Kennedy (2002), Curtin (2002).

instruments simultaneously with using them as tools to measure natural phenomena. Probably the most significant incongruity was in the measurement of length which, until the twentieth century, was almost always achieved by pacing of humans or animals. The resource invested in both instruments and users was thus compromised by the mismatch of tolerances.<sup>18</sup> Another example of the mismatch of tolerances was apparent in the difference of numbers of significant figures in some travellers' data. There was a moral imperative to measure with precision as has been remarked by Withers, but a physical inability to do so, the tension resulting in scientifically inappropriate measurements.

Measuring without instruments has been a fraught topic for historians. The practice was referred to in *Hints* as 'extemporising.' The prevailing view within the RGS was that measurement without instruments was substandard, only to be resorted to when all else failed. This was the dominant attitude consistent throughout the century under investigation. In the early decades the travellers who tended towards the heroic image of the explorer, especially prevalent in African expeditions, promoted 'roughing it', but this was always considered marginal to the principal focus of the RGS. Bourguet, Licoppe and Sibum note the preference for instruments when under pressure, which the thesis argues was the underlying approach at *all* times.<sup>19</sup> The absence of instruments in length measurement was never explicated, although a minority of travellers explained how they had calculated distance from speed and time. Raj writes about the pundit surveyors as if the manner of their techniques was somehow more natural than that of Europeans. The thesis contends that the pundit surveyors used the same instruments and techniques as those of the gentlemen travellers, some of whom also resorted to disguise.

Much has been written about instruments as extensions of humans versus instruments as replacing humans.<sup>20</sup> The thesis has argued that for the common measuring instruments used by RGS travellers, instruments were seen as replacing humans, not as extensions. There was no method by which humans could detect variation without a compass, or height without recourse to some type of barometer or hypsometer, or longitude without either a chronometer or some angle- measuring instrument. A telescope or sun signal extended the human attribute of vision, but they were not central to the 'armoury' of the RGS traveller. When recording instruments became involved, such as the barograph, the absence of any human intervention was celebrated as the replacement had become complete.

### **Management of Data**

The next point on the cycle was the management of data from observations in the field to produce meaningful information and maps. This part of the process involved

---

<sup>18</sup> Withers (2011) p.45-46 Schaffer (1995)

<sup>19</sup> Bourguet, Licoppe and Sibum (2002) p. 7 Introduction

<sup>20</sup> Outram (1999)

calculating and drawing instruments. On some occasions following the expeditions studied, data was not forthcoming. Ultimately the RGS had no control over the travellers, hence at this point the resources discussed in the earlier phases were squandered.

Although some travellers became able to compute their own data after training, computing remained beyond the capabilities of about half the travellers. It was considered separate from observing from the 1850s. It could be done in the field or at the centre of calculation, and was frequently outsourced. The data, like the instruments, did not constitute ideal immutable mobiles, but in accordance with ANT, were the subject of modification, manipulation and tensions between individuals and groups. Some returning data-for example those from Livingstone- were obviously outside the range of probabilities, and had to be extensively worked on by professionals. On one occasion-that of Harris-it was revealed that pressure was exerted on a traveller to change observational results after return. Thus ownership of the figures became an issue.

For the most part the travellers were gentlemen of means and the calculators were middle-class professionals, so the travellers resented the intrusion, and sometimes demanded recalculation. Importantly, the thesis argues that the activity of reducing and calculating in general had the effect of bringing results into line with accepted knowledge, and to expunge outliers. A topic which requires more research is the popularity of the plane table which substituted calculation for direct drawing, and is likely to have been partly responsible for the reduction in emphasis on the subject of calculation from the 1890s.

The thesis found map drawing was a source of contention between the travellers and the draughtsmen. Maps could be created in the field by the travellers, especially using the plane table, or at the centre of calculation by the draughtsman, or outsourced to map-makers such as Arrowsmith or Ravenstein. As the maps represented considerable resource, their ownership and physical location were significant. The thesis argues that the map makers held powerful positions within the discipline, and that the Map Room was the heart of the institution, and the heart of geographical knowledge of the British Empire culturally.

Subjects of discussion regarding cartography prominent in the period were found to be scale, representation of height, and to a lesser extent projection and colour. Scale was an enduring battleground between travellers and map-makers, the former desiring large scales, the latter smaller ones. Height representation was becoming standardised, although contour lines did not suit all requirements. Projection grew in consequence as the areas covered increased, and large- scale collaborations dictated compromises.

The thesis has argued that the specific types of instrument used in the field gave rise to particular types of map. Route marches with compass, pacing, and dead reckoning gave rise to linear pathways with traverses illuminating small departures left and right. The other extreme was provided by the plane table which produced circular pictures centred on a series of points. Writers who have described maps as having multiple roles are supported by

the thesis which found examples of maps in direct contradiction to each other, and being used as evidence in conflicts.<sup>21</sup>

### **The Agency of Instruments**

The last phase of the cycle concerns knowledge production together with other, perhaps less obvious agency of instruments; the enhancement of the traveller, the contribution to empire and the supporting or otherwise of social relationships. It was found that Instruments in the physical field as the environment of practice influenced the field as a discipline: a consequence of specialised instruments on specific expeditions was to stimulate interest in new phenomena and practices. The magnetometer and seismograph opened up Earth's magnetism and the Earth's crust respectively to new investigation within geography.

Publication has been chosen as a mark of achievement in knowledge creation. In accordance with the considerable literature on consumption, audiences, and levels of education there is much evidence that geography was a tentative science.<sup>22</sup> While the RGS was wary of being too populist, as demonstrated by its treatment of Savage Landor, it recognised it needed a substantial public and academic audience in order to survive. Strategies therefore needed to be developed to accommodate the differing outputs presented by travellers. The thesis demonstrates that the data collected from travellers in the field could be very convincing, as in the case of Schomburgk, and on this occasion the findings correspond with ANT. This situation, however, was found in only a few instances. For the majority, the RGS had to devise strategies to suppress flawed data.

The thesis found that the style of narrative in the papers published in the *JRGS* and later the *PRGS* and *GJ* was very similar regardless of whether credible instrumental data was produced. Successful observers had tables of data and/or maps appended. This meant that numerical results could be added subsequently as they were not integral to the papers. It has been noted that in the twentieth century there was a move towards expeditions with specific interests other than the filling of blank spaces. These papers were less likely to produce numerical data. A consequence of borrowing instruments from the RGS that was not predicted by ANT or any other model was to increase the likelihood of publication, not necessarily to produce efficacious data. Thus the resource invested in instruments and training could corrupt the ideal of knowledge creation by privileging those who merely borrowed rather than those who assiduously observed and recorded.

The thesis investigated the agency of the instruments in terms of the reputation of the travellers. Portraits such as that of Speke and Humboldt represent instances of instruments used to enhance reputations. The thesis demonstrated a diminution in the publication of papers as a *result* of borrowing instruments by the twentieth century, but an

---

<sup>21</sup> Monmonier (1995) p.1, Akerman (2007) p. 4

<sup>22</sup> Driver (1998)



increase in borrowing following a *previous* publication, indicating that the instruments were being used to confer approval rather than a means of obtaining data. The awarding of medals was chosen to provide a sufficient data base in order to assess the agency of instruments in enhancing the reputation of the travellers.

The criteria for a medal included good observational practice, but another criterion stipulating the travellers supported themselves militated against success for borrowers of the Society's instruments. The instruments exerted a greater agency in raising the profiles of European gentlemen than it did of ladies or non-Europeans. Both Mrs Bishop and Fanny Bullock Workman, in spite of producing very similar results to many male travellers, were only allowed to claim their products were 'sketch maps'. Similarly the pundits surveyors associated with Stein struggled to have their considerable contributions recognised.

The third aspect of the agency of instruments considered is the relation to the British Empire. It can be difficult to disentangle the various aims of expeditions as often they were multiple and entwined. The Society had to work hard to gain governmental support for its larger projects, some of which, such as those concerning the North West Passage and Antarctica, had no obvious imperial benefit. The thesis found the relationship to be an unequal one, with the Government having the upper hand, although instances where it needed the expertise of the Society have been documented. Instruments were occasionally 'bargaining chips' to be offered to the government in return for admission to various otherwise inaccessible locations. The RGS repeatedly cited the threat of foreign intervention to obtain support. In a crisis, of which WW1 was the prime example, all the Society's resources, including the instruments, became in effect the property of the state.

The RGS became increasingly involved in boundary commission work in the twentieth century, and so the instruments lent to these projects worked directly for the British state overseas. The maps produced increasingly focused on borders: Holdich specifically linked boundaries, instruments and empire. However, the prevalent ambition at the RGS was for disinterested science. Driver notes that overly explicit links to Empire were sometimes discouraged, as was jingoistic attitudes of some travellers who borrowed instruments. When the RGS supported commercial ventures it was found the tensions were more complex. After WW1 it was revealed the international characteristic of altruistic knowledge suffered a setback with the RGS promoting a more nationalistic line, even in relation to specific instruments.

The fourth and final aspect of agency was in supporting, dictating, or confronting social hierarchies. This is the most challenging aspect of the thesis. Many images and a small number of archival texts support the conjecture that Europeans normally used the instruments. RGS instruments were intended to be used by RGS travellers. However, this is not straightforward. The status of surveying appears to have been in decline over the period so that instrumental work was increasingly delegated. While large-scale triangulation, such as that of the 30 degree meridian line, was performed using a hierarchy of instruments operated

by a hierarchy of users, less evidence of this correlation was found in the RGS expeditions. By the twentieth century, with surveying seen as increasingly routine, the agency of mathematical instruments was less evident in conferring status, and therefore the instruments were less likely to be the preserve of higher-ranking individuals.

In conclusion, the role of the instruments in exploration during this period has been shown to be very diverse. Immediately the RGS was founded, instruments were seen as desirable attributes, even if the Society's intentions were not acted upon. 'Proper' instruments defined the type of exploration undertaken, and so moulded the image of the Society. They were seen consistently as superior to human or animal measurements, not as extensions of human faculties. Increasingly large numbers were acquired to accompany hundreds of expeditions, particularly from the 1870s. The instruments and their users represented considerable resource which was mobilised in the field. Yet it has been demonstrated that the instruments became particularly fallible at this stage for a large number of reasons characteristic of field science, and that their fallibility remained an issue during the century in question.

Frequently the returning data was manipulated and moderated by professionals in a move towards consensus. Another centralising activity was map production in which previous results could increasingly be compared in a process of iteration. Publications were written in the form of travelogues to which instrumental data and maps could be attached, but if not would stand alone. An important agency of the instruments was to increase the chance of publication, not because of the quality of the data, but because of the resource invested in their use. Instruments enhanced the reputation of the borrowers, but of some borrowers more than others. The instruments contributed towards the aims of the British Empire, and in a crisis became possessions of the British state. They contributed towards 'othering' by requiring certain behaviours and privileged space.

To understand fully the role of instruments in exploration we need to consider a wide spectrum of activities. Instruments cannot be seen as merely tools for obtaining information regarding natural phenomena in the form of numbers. They were intrinsic to the RGS and crucial to a advocating a scientific approach. They helped to define exploration and dictated who performed it, adding a layer of difficulty to expeditions, bestowing approval and authority, and contributing to knowledge- creation in inconspicuous and ambiguous ways.

## **Bibliography**

### **Unpublished Primary Sources**

A wide range of material within the RGS-IBG collections has been investigated for the thesis. The current RGS-IBG collection incorporates five previous collections: the archives, maps, library, images, and artefacts, all of which have been utilised.

Central documents from the archives are the Council minutes, which begin in 1830, and the various Committee minutes which begin in 1841. Both the Council and the Committees sat during the season from October until June every year of the century. Both have been trawled for any references to issues connected with instruments. The Expedition Committee minutes, the various Instrument Committees' minutes, and occasionally the Library and Map Committee minutes contain information. The Finance Committee minutes reveal what was spent for each month.

Two documents in the RGS-IBG archives from the series of 'Additional Papers' (AP) provide specific information concerning instruments lent to expeditions: 'Instruments Lent To Travellers' lists the expeditions to which they were lent from 1860 to the end of the period. (AP 52 ILT) The more detailed document; 'Catalogue of Instruments' was started in 1879 and continues until the end of the period. (AP 52 CI). This document comprises two sections in one volume, the first of which lists the instruments by category, usually providing the year purchased, from whom, and the cost. The second part records the expedition history of each instrument, supplying the person to whom they were lent, where they went, and the dates which they went out and returned, if they were returned. If not, the manuscript records the reason.

'Instruments Lent to Travellers' has been transcribed and earlier expeditions provided with instruments have been added. The Catalogue of Instruments has been recorded on a spreadsheet giving instrument type and number, date acquired, from whom acquired, the cost when available, and the expeditions on which each instrument was sent. In this way itineraries of all the instruments have been built up. The instruments acquired before 1879 have also been put into a spreadsheet by trawling information in the Council and Committee minutes and the *JRGS*. Other additional papers consulted are AP 52 IIR, a record of the travellers taught by Coles and the expeditions they undertook with instruments between 1879 and 1883, AP 8, a manuscript by Julian Jackson recording the activities of the RGS in 1837, and AP 51, which concerns training in instrument use, and includes a memorandum on the subject by Clement Markham from 1879.

The journal manuscripts (JMS) are an important subset of the archival material consisting of papers submitted to the Society for publication. Their referee reports and subsequent approval, rejection, or amendment reveals the process by which knowledge was

constructed. A majority of the travellers considered submitted papers for publication. There are twenty one categories of JMS: the first number referring to the place with which the paper was concerned, or in the last three cases: maps, physical geography, and miscellaneous. The papers concerning instruments are usually assigned to the miscellaneous category. Other manuscripts not for publication are designated as Library Manuscripts and given the reference LMS. Several of these have been cited in the thesis.

The correspondence and other material relating to individual travellers has been catalogued in various ways. If there is a substantial quantity of material the traveller will be assigned a personal collection which is given their initials or a set of letters by which their personal archive is known. For example RSH stands for the Robert Shedden collection, DL for the David Livingstone collection etc. If the travellers selected for the survey in chapter 6 had a personal collection it was studied. Thus there are references to EWH, the Whympet collection, FJR, the Rodd collection, WMS, the Merse Strong collection, JHS the Speke collection, JAS, the Steers collection VLC, the Verney Lovett Cameron collection, HEO, the O'Neill collection, KW, the Kingdon Ward collection, and so on. Sometimes this type of reference is given to an expedition, for example BAE for the British Antarctic expedition, MEE21 for the Mount Everest Expedition in 1921. If a collection is smaller than the typical personal collection it is assigned the prefix SSC for Small Special Collection. Some of the travellers studied in chapter 6 have a small special collection, for example Harry Johnston, John Gregory, William McEwan, and several others.

If the quantity of material for a particular traveller does not warrant a personal collection the correspondence is assigned a Correspondence Block number (CB). The first number refers to the period within which the documents fall. CB1 covers 1830 to 1833, and CB2 from 1834 to 1840. From then each number refers to a decade until CB7 which covers 1881 until 1910. The final two decades of the century under question are referred to as CB8 and CB9. The Letters in the personal archives of many travellers are often more candid than what was presented as the narratives of their expeditions in prospective journal papers. Again, each of the fifty chosen for scrutiny has been studied.

The thesis has investigated the extant instruments in the collection, referred to by Artefact number, and used many of them in various demonstrations to students, special interest groups, desk case displays and a 'Be Inspired' talk. Images of them feature in the thesis and have appeared in many spoken papers and on a poster since 2013. Some instruments relating to the travellers held by other institutions were investigated, for example the temperature testing bath originally at Kew, and Sabine's magnetometer, both at the Science Museum.

The instruments being studied in the thesis are those acquired by the Society for use by travellers in the century 1830 to 1930, so are not a corresponding match with the extant collection. Many of the former have been lost or sold. Many of the latter were acquired later, or have been donated to the Museum, or have a personal connection to an illustrious

traveller but not one of those originally sponsored by the Society. The itineraries of the objects acquired for travellers between 1830 and 1930 have been individually documented and are available in the Society's reading room. It is recognised that more work needs to be done on the extant collection but this was outside the scope of the thesis.

As many of the maps in the collection are a result of work using the instruments taken on loan by the travellers, they also featured in the thesis. As well as those published or held in the map collection, usually referenced as MR, there are many sketch maps in the personal archival collections. Several of these were photographed and have been used to make specific points, for example the changes made to a map in the drawing office, or the differences in maps constructed using different instruments.

Another aspect of the RGS-IBG collection which has been incorporated into the thesis is the images, which can be in the form of paintings, drawings, photographs, or lantern slides. LS denotes a lantern slide, photographs in albums have references starting with a letter from A to G. A large photographic archive is that of Gerald D'Gaury denoted GDG. Some illustrations have been supplied from books in the library collection which have references BG/. Many of the images, including the paintings, have control numbers consisting of RGS followed by six digits. Some material which has been catalogued since 2013 has a reference K followed by six digits. The images in the picture library were searched in order to provide illustrations of various activities, for example surveying in thick forest, calculating in the field, or being supported by intermediaries. The images were also searched for each traveller of interest.

The last category considered by the thesis was the medals, which form part of the artefacts collection. These have been incorporated into the narrative as markers by which esteem can be measured. They have been shown to student groups, and were photographed in order to be illustrated in spoken papers.

While the material at collections level has been given control numbers, much of the material at a more detailed level has not. In many cases the call numbers are the most useful, and therefore appropriate, reference. The archives are documented on the National Archives discovery site using call numbers, and the other collections are catalogued on the society's site using call numbers and sometimes control numbers.

As the collection of the RGS-IBG is so rich and relatively unknown in parts, it was not thought necessary, and indeed would not have been possible within the time limit, to investigate other archives in any depth. There are connections which could be made in future in particular with archives held by the Royal Society, the British Association, and Greenwich Observatory.

## Published Primary Sources

Abraham, R.M. (1926). *Surveying Instruments; their Design, Construction, Testing & Adjustment*. London: C.F. Casella & Co.

Adams, G. (1813). *Geometrical and Graphical Essays: Containing a General Description of the Mathematical Instruments Used in Geometry, Civil and Military Surveying, Levelling, and Perspective; with Many New Practical Problems*. London: C. Baldwin

Adams, H. (1913). *Practical Surveying and Elementary Geodesy*. London: Macmillan & Co.

Adie, J. (1850). Experimental Investigations to Discover the Cause of the Change Which Takes Place in the Standard Points of Thermometers *Edinburgh Philosophical Journal* July 1850 pp. 122-125

Ainsworth, W. and Sabine, E. (1838). Report on Mr. Ainsworth's Observations on the Magnetic Intensity of the Earth, Made during a Journey across the Continent of Europe in 1838. *JRGS*. 8 pp. 367-370

Andre, G. (1874). *The Draughtman's Handbook of Plan and Map Drawing*. London and New York: Spon

American Academy of Arts and Sciences, (1857). Report on the Hedgecock Quadrant. *Proceedings of The American Academy Arts and Sciences*. 3 pp. 383-385

Alexander, J. E. (1836). E. Captain Alexander's Intended Visit to the Dámaras, South Africa. *JRGS*. pp. 443-445

Alexander, J.E. (1837). Latest Intelligence from Captain Alexander. *JRGS* 7 pp. 439-446

Alexander, J. E., O. W. and G. J. (1838). Report of an Expedition of Discovery, Through the Countries of the Great Namáguas, Boschmans, and the Hill Dámaras, in South Africa. *JRGS* 8 pp. 1-28

Alexander, J. (1977). *Whom the Gods Love; Boyd Alexander's expedition from the Niger to the Nile 1904-7, and his last journey, 1908-10*. London: William Heinemann Ltd.

Baily, F. (1827). *Astronomical Tables and Formulæ. Together with a Variety of Problems Explanatory of their Use and Application*. London: John Richardson

Baily, F. (1829). *Further Remarks on the Present Defective State of the Nautical Almanac*. London: Richard Taylor

Baker, T. (1902). *A Rudimentary Treatise on Land and Engineering Surveying for Students and Practical Use*. London: Crosby Lockwood and Son

Bell, G. L. (1910). The East Bank of the Euphrates From Tel Ahmar to Hit. *GJ* 36(5) pp. 513-537

Bell, G. L. (1914). A Journey in Northern Arabia. *GJ* 44(1) pp 76-77

Bertrand, A. (1900). *Methods of Survey Employed by the Chilean Boundary Commissions in the Cordillera of the Andes*. *GJ* 16(3) pp. 329-344

- Bhatt, U. and Pathak, S. (2006) *Asia Ki Peeth Par: Pundit Nain Singh Rawat*. Nainital, PAHAR
- Bishop, I. (1897). A Journey in Western Sze-Chuan. *GJ* 10(1) pp. 19-50
- British Antarctic Expedition, (1903a). Return of the "Morning." *GJ* 21(4) pp. 439-441
- British Antarctic Expedition, (1903b). The Antarctic Expedition *GJ* 21(6) pp. 655-658
- British Antarctic Expedition, (1903c). Report of the Commander R.F. Scott and Michael Barne. *GJ* 22(1) pp. 20-37
- British Antarctic Expedition, (1905). Preliminary Report on the Physical Observations Conducted on the National Antarctic Expedition, from 1902 to 1904: Discussion Captain Creak, Captain Chetwynd, Mr. Reeves and Mr. Bernacchi *GJ*. 26(6) pp. 656-661
- Boyd, A. (1907). From the Niger, by Lake Chad, to the Nile. *GJ* 30(2) pp. 119-149
- Bryce, Lord (1915). The Mental Training of a Traveller. *GJ* 45(2) pp. 110-122
- Buist, G. (1851). On the Adaption of the Aneroid for the purposes of Surveying in India. *JRGS* 21 pp 42-57
- Bullock Workman, F. (1912). Survey of the Siachen Glacier *Bulletin of the American Geographical Society* 44(12) pp. 897-903
- Burton, R. and Speke, J.H. (1858). A Coasting Voyage from Mombasa to the Pangani River; Visit to Sultan Kimwere; And Progress of the Expedition into the Interior. *JRGS* 28 pp. 188-226
- Butler Williams, J. (1842) *Practical Geodesy*. London: John W. Parker & Son
- Campbell Davidson, L. (1889). *Hints to Lady Travellers: At Home and Abroad*. London: Iliffe & Son
- Cartee, C. (1859). *Elements of Map Drawing*. Boston: Crosby, Nichols & Co.
- Carruthers, D. (1910). Notes on the Journey to the Arpa and Ak-Sai Plateaus in Russian Turkestan. *GJ* 36(5) pp. 563-570
- Carruthers, D. (1911). Exploration in North-West Mongolia. *GJ* 37(2) pp. 165-170
- Chauvenet, C. (1863). *Manual of Spherical and Practical Astronomy*. Philadelphia : J. B. Lippincott & Co
- Cheesman, R.E. (1936). *Lake Tana and the Blue Nile*. London : Macmillan
- Claude, A. and Driencourt, L. (1910). *Description et Usage de L'Astrolabe a Prisme*. Paris: Gauthier-Villars
- Close, C. F. (1913). *Text Book of Topographical and Geographical Surveying*. London: HMSO
- Colquhoun, A.R. (1882). Exploration Through the South China Borderlands, from the Mouth of the Si-Kiang to the Banks of the Irawadi. *PRGS and MRG* 4(12) pp. 713-730
- Colthurst, Miss (1849). Comparative View of the Various Standards Commonly Used to Express Vertical Distances. *JRGS* 19 p.192

- Conway, W.M. (1892). Mr. Conway's Karakoram Expedition. *PRGS and MRG* 14(11) pp. 753-770
- Cornish, V.(1899). On Kumatology. The Study of the Waves and Wavestructures of the Atmosphere, Hydrosphere, and Lithosphere ... From "The Geographical Journal," Etc. London: William Clowes & Sons
- Cornish, V. (1900). On Desert Sand-Dunes Bordering the Nile Delta *GJ* 15(1) pp. 1-30
- Cornish, V. (1908). The Jamaica Earthquake. *GJ.* 31(3) pp. 245-271
- Daly, C.P. (1877). English Arctic Expedition *The North American Review* 124, No. 255 pp. 229-245
- Darwin, C. R. (1874). *The Structure and Distribution of Coral Reefs*. Second edition. London: Smith Elder and Co
- Davis, R.E. (1915). *Manual of Surveying for Field and Office*. New York and London: McGraw-Hill Book Co
- Debenham, J. (1846). *A New Theory of the Tides: Together with remarks and observations useful to all who navigate the ocean*. London: Printed by H. D. Pite
- Drayson, A.W. (1869). *Practical Military Surveying and Sketching*. London: Chapman & Hall
- Duncan, J. (1846a). Note of a Journey from Cape Coast to Whyddah, on the West Coast of Africa. *JRGS* 16 pp. 143-153
- Duncan, J. (1846b). Notice of a Journey from Whyddah on the W. Coast of Africa to Adofoodiah in the Interior. *JRGS* 16 pp. 154-162
- Duncan, J. (1847) *Travels in western Africa in 1845 and 1846, Comprising a Journey from Whydah Through Dahomey to Adofoodia, in the Interior*. London: Richard Bentley. Map engraved by J & C Walker
- Dunkin, E. (1863-4). Note on the Frequent Omission of Readings of the Barometer and Thermometer in Sextant Observations for the Determination of Latitude and Longitude *PRGS* 8(4) pp. 155-156
- Elderton, W. A. (1890). *Maps and Map Drawing*. London: Macmillan
- Evans, F. J. (1877). The Magnetism of the Earth. A Lecture on the Distribution and Direction of the Earth's Magnetic Force at the Present Time. *PRGS* 22(3) pp. 188-216
- Everest, G. (1851). *A Manual of the Mode of Operations on the Revenue Surveys Surveying for India* Calcutta: W.Thacker and Co
- Everest, G. (1860). On Instruments and Observations for Longitude for Travellers on Land. *JRGS* 30 pp. 315-324
- Everest, G. (1958). *Biographical Notes Compiled for R.H. Phillimore, Historical Records of the Survey of India, volume IV (1830-1843)*. Dehra Dun: Office of the Northern Circle
- Everett, J.D. (1904). On a Flat Model Which Solves Problems in the Use of the Globes. *GJ* 23(2) pp. 234-241



- Exposition Internationale,(1910). Catalogue of Mathematical and Scientific Instruments. British Section of Brussels Exhibition. London
- Firebrace, F. (1868). *'Surveying': Part of a Series of Papers Prepared for the Thomason Civil Engineering College, 1868*. Roorkee: Thomason Civil Engineering College
- Freshfield, D. A. (1892). Exploration in the Central Caucasus in 1890. *PRGS and MRG* 14(2) pp. 100-116
- Gall, J. (1870-71). On a New Projection for a Map of the World *PRGS* 15(2)
- Galton, F. (1852). Recent Expedition into the Interior of South-Western Africa. *JRGS* 22 pp. 140-163
- Galton, F. (1856). *The Art of Travel*. Second edition. London: John Murray
- Galton, F. (1859). Sun Signals for the Use of Travellers (Hand Heliostat), *PRGS* 4 pp. 14-19
- Galton, F. (1861). *Vacation Tourists and Notes of Travel in 1860*. Cambridge and London: MacMillan and Co
- Galton, F. (1863). *Meteorographica or Methods of Mapping the Weather*. London and Cambridge: Macmillan
- Gilbert W. and T. (1829). *A concise Description of the Mountain Barometer; with Proper Tables for Facilitating the Computations, Adapted to the Formula by M. Biot*. London : printed by S. McDowall
- Gregory, J.W. and Gregory, C.J. (1923a). The Alps of Chinese Tibet and Their Geographical Relations. *GJ* 61(3) pp. 153-174
- Gregory, J.W. and Gregory, C.J (1923b). Note on the Map Illustrating the Journey of the Percy Sladen Expedition, 1922, in North-Western Yunnan. *GJ* 62(3) pp. 202-205
- Gregory, J.W. (1923). *To the Alps of Chinese Tibet. An account of a Journey of Exploration*. London: Seeley, Service & Co
- Harbord, J.B. (1863). *Glossary of Navigation: A Vade Mecum for Practical Navigators*. Edinburgh and London: William Blackwood and Sons
- Haines, S.B. (1854). Notice on the Variation of the Magnetic Needle at Aden. *JRGS* 24 pp. 225-226
- Harding King, W.J. (1913). The Libyan Desert from Native Information *GJ* 42(3) pp. 277-283
- Harris, R.A. (1909). Desiderata in Tidal Observations. *GJ* 34(5) pp. 549-550.
- Harvey Simmonds, G. (1861). *Meteorological Tables: For the Reduction of Barometrical and Hygrometrical Observations, Determination of Heights by the Barometer and Boiling Point Thermometer, etc*. London: Printed by Williams and Strahan and sold by J. D. Potter
- Hedgcock, T. (1859). <http://www.google.com/patents/US15162>. Quadrants. British Patent Number: 2009 published: 2 September 1859. London: Eyre and Spottiswood
- Hermann, A. and de Schlagintweit, R. (1861). Magnetic Survey of India and High Asia in *Results of a Scientific Mission to India and High Asia*.1(6). Leipzig: F.A. Brockhaus. London : Trubner and Co

- Herschel, J.F.W. (ed) (1849). *A Manual of Scientific Enquiry: Prepared for the Use of Her Majesty's Navy and Adapted for Travellers in General*. London: John Murray
- Herschel, J.F.W. (ed) ( 1851). *A Manual of Scientific Enquiry; Prepared for the Use of Her Majesty's Navy, and Adapted for Travellers in General*. London: Admiralty (2<sup>nd</sup> edition)
- Herschel, J. F. W. (1860). On a New Projection of the Sphere. *JRGS* 30 pp. 100-106
- Higgins, A. L. (1920). *The Field Manual. A Practical Treatise of Surveying Methods and Operations, etc.* London: Sir I. Pitman & Sons
- Hinks, A.R. (1921). *Map Projections*. Second edition. Cambridge: Cambridge University Press
- Holdich, T.H. (1891a). African Boundaries, and the Application of Indian Systems of Geographical Survey to Africa. *PRGS and MRG* 13(10) pp. 596-607
- Holdich, T. (1891b). The Prime Meridian. *GJ* 13 pp.615-616
- Holdich, T. (1897). The Perso-Baluch Boundary. *GJ* 9(4) pp. 416-420
- Holdich, T. (1899). The Proceedings of the Pamir Boundary Commission. *GJ*. 13(1) pp. 50-56
- Holloway, T. (1881). *The Practical Surveyor: a Treatise upon Surveying etc.* London: "The Field" Office
- Hughes, W. (1861). *The General Atlas*. London: the National society
- Humboldt, A. von (1838). On the Difference of Level between the Black Sea and the Caspian. *JRGS* 8 pp. 135-136
- Inman, J. A. (1821). *Treatise on Navigation and Nautical Astronomy ... for the Use of British Seamen*. Portsea: W.Woodward
- Ivory, J. (1822). On the Hygrometer by Evaporation. *Philosophical Magazine Series 1* 60 pp. 81-88
- Ivory, J. (1825). On the method of the least squares *Philosophical Magazine Series 1* 65 pp3-10
- Ivory, J. (1828). A Letter to the Editors Relating to the Ellipticity of the Earth as Deduced from Experiments with the Pendulum. *Philosophical Magazine Series 2* pp.241-243
- Jackson, B. (1853). *A Treatise on Military Surveying*. London: W.H. Allen
- Jackson, L. d'A. (1880). *Aids to Survey-Practice, for Reference in Surveying, Levelling and Setting Out; ... with tables, illustrations, etc.* London: Crosby, Lockwood & Co
- Jackson, J. (1841). *What to Observe, Or, The Traveller's Remembrancer*. London: John Marsden.
- James. H. (1860). Description of the Projection Used in the Topographical Department of the War Office for Maps Embracing Large Portions of the Earth's Surface. *JRGS* 30 pp. 106-111

- Jeans, H.W. (1849). *Problems in Astronomy, Surveying and Navigation*. London: Longman, Brown, Green and Longman's
- Johnson, J.B. (1885). *A Manual of the Theory and Practice of Topographical Surveying by Means of the Transit and Stadia*. New York and Boston: John Wiley & Son
- Johnston, K. (1875 - 1876). Notes on the Physical Geography of Paraguay *PRGS*. 20(6) pp. 494-504
- Johnston, K. Congreve, C.R. and Strachan, N. (1875-76) Report on the Hypsometrical Observations in Paraguay. *PRGS* 20(6) pp. 504-508
- Jones, T. (1820). *A Companion to the Mountain Barometer, Consisting of Tables, Whereby the Operation of Computing Heights with that Instrument is Rendered ... Easy ... With a description of the Englefield Mountain Barometer*. London: Printed by Richard Taylor
- Kelvin, Lord W. (1883). Electrical Units of Measurement. (3 May 1883). *Popular Lectures* I p. 73
- Landmann, I. (1805). *Practical Geometry for the Use of the Royal Military Academy at Woolwich*. London: Printed by I. Gold and sold by T. Egerton
- Laplace, P. S. (1799-1827). *Traité de Mécanique Céleste*. Paris: Crapelet for J.B.M. Duprat; Berlin: F.T. de la Garde 1799 (volumes 1-2); Paris: Crapelet for J.B.M. Duprat, (volume 3); Paris: Courcier, (Volume 4); Paris: Bachelier, (volume 5).
- Lendy, A.F. (1869). *A practical Course of Military Surveying, Including the Principles of Topographical Drawing*. London: Atchley and Co
- Lewis, T. (1902a). *A Map of journeys into Zombo Land. 1901*. Scale, 1 : 300,000. [Drawn by] E.G. Ravenstein. London
- Lewis, T. (1902b). The Ancient Kingdom of Kongo: Its Present Position and Possibilities. *GJ* 19(5) pp. 541-558
- Longitude (1906). Longitude by Telegraph Round the World. *GJ* 27(2) pp. 179-181
- Markham, C. R. (1876-77). The Arctic Expedition of 1875-76. *PRGS* 21(6) pp. 536-555
- Markham, C.R. (1882). On the Instruction at Present Supplied to this Country in Practical Astronomy, Navigation, Route Surveying , and Mapping. *PRGS* 4(5) pp. 296-314
- Martin, R. M. (1809). *Retrospect of Philosophical, Mechanical, Chemical, and Agricultural Discoveries*. 4. London; Royal Society
- Martineau, H. (1838). *How to Observe: Morals and Manners* London: Charles Knight
- Mason, H. B. (1908). *Encyclopaedia of Ships and Shipping*. London: Shipping Encyclopaedia 'A series of fourteen sketches made during the voyage up Wellington Channel in search of Sir John Franklin' by Walter W. May (London, 1855).

- Merriman, M. (1899). *Elements of Precise Surveying and Geodesy*. New York: J. Wiley & Sons,
- Middleton, G. A. (1894). *Surveying and surveying instruments*. New York: MacMillan and Co
- Milne, J. (1896). Movements of the Earth's Crust . *GJ* 7(3) pp. 229-247
- Nares, G. S. (1876 - 1877). On the North Circumpolar Sea. *PRGS* 21(2) pp. 96-106
- Nares, G. S. (1875-76). On the Navigation of Smith Sound, as a Route to the Polar Sea. *PRGS* 21(4) pp. 274-287
- Nesbit, A. (1889) *Nesbit's Practical Land Surveying*. London: Longmans Green and Co
- Newton, I. (1737). *A Treatise on the Method of Fluxions and Infinite Series, with its Application to the Geometry of Curved Lines*. London: T. Woodman and J. Millan
- Norie, J.W. (1822). *Formulæ for Finding the Longitude by Chronometers Or Timekeepers, with Rules for Working the Observations*. London: J.W. Norie and Company
- Nugent, P.C. (1902). *Plane Surveying. A Text and Reference Book, etc. [With maps.]* New York: John Wiley & Sons
- Park, J. (1911). *A Text-Book of Theodolite Surveying and Levelling ... Second edition, revised and enlarged, etc.* London: Charles Griffin & Co
- Parry, R. (1920). *An Elementary Text Book on Land Surveying*. London: Estates Gazette
- Paterson, W. (1873). *Notes on Military Surveying and Reconnaissance*. London: Trübner & Co
- Popplewell, W.C. (1915). *The Elements of Surveying and Geodesy ... With Diagrams*. London: Longmans & Co
- Rae, J. (1852). Recent Explorations along the South and East Coast of Victoria Land. *JRGS* 22 pp. 82-96
- Rae, J. (1855) Arctic Exploration, with Information Respecting Sir John Franklin's Missing Party *JRGS* 25 pp. 246-256
- Rae, J. (1860-61). Exploration of the Fœrøes and Iceland, &c. *PRGS* 5(2) pp. 80-90
- Rae, J. A (1862 - 1863), Visit to Red River and the Saskatchewan. *PRGS* 7(3) pp. 102-103
- Raper, H. (1849). *The Practice of Navigation*. Third edition. London: R.B. Bate
- Reeves, E. A. (1904). Van der Grinten's Projection. *GJ* 24(6) pp. 670-672
- Reeves, E. A (1905). Some Recent Improvements in Surveying Instruments. *GJ* 26(2) pp. 204-208
- Reeves, E.A. (1908a). A New Distance Finder. *GJ* 31(4) pp. 425-426
- Reeves, E.A. (1908b). New Instruments for Travellers and Surveyors *GJ* 32(6) pp. 607-610
- Reeves, E.A. (1911). New Proportional Dividers for Map Draughtsmen and Others. *GJ* 37(3)pp. 282-283

- Reeves E.A. (1935). *Recollections of a Geographer* London: Seeley, Service & Co
- Rennell, J. (1791). On the Rate of Travelling, as Performed by Camels; And Its Application, as a Scale, to the Purposes of Geography. *Philosophical Transactions of the Royal Society of London* 81 pp. 129-145
- Richards, W.H. (1873). *Military Surveying and Field Sketching. The various Methods of Contouring, Levelling, Sketching, etc.* London: W.H. Allen and Co
- Riddle, E. (1824). *A Treatise on Navigation and Nautical Astronomy, ... With ... all the Tables Requisite in Nautical Computations.* London: Baldwin, Craddock and Joy
- Roberts, F. (1878). *Military Surveying and Sketching.* Woolwich : Boddy & Co
- Robinson, H.N. (1852). *A Treatise of Surveying and Navigation.* Cincinnati: J.Ernst
- Salmon, V.G. (1918). *Practical Surveying and Field Work. Including the Mechanical Forms of Office Calculations, etc.* London: C. Griffin & Co
- Schomburgk, R.H. (1839). Report of an Expedition into the Interior of British Guayana, in 1835-6 *JRGS* 6 pp. 224-284
- Schomburgk, R.H. (1841). *Twelve Views in the Interior of Guiana from Drawings Executed by Mr. Charles Bentley with descriptive letter press by Robert H. Schomburgk.* London: Ackermann and Co
- Simms, F.W. (1834). *A Treatise on the Principal Mathematical Instruments Employed in Surveying, Levelling, and Astronomy: Explaining their Construction, Adjustments, and Use.* London: Troughton and Simms
- Skrimshire, S. (1901). *Land Surveying: its Theory and Practice ... Illustrated with Numerous Diagrams and Examples.* London: Frank P. Wilson
- Smyth, R. and Thuillier, T. (1855). *A Manual of Surveying for India.* London, Calcutta and Bombay: Thacker and Co
- Spottiswoode, W. (1861). 'On Typical Mountain Ranges: An Application of the Calculus of Probabilities to Physical Geography'. *JRGS* 31 pp. 149-155
- Stanley, W.F. (1895). *Surveying and Levelling Instruments Theoretically and Practically Described, etc.* London: E. & F. N. Spon
- Stein, M.A. (1907). Dr. Stein's Expedition in Central Asia. *GJ* 30(5) pp. 503-507
- Sykes, W.H. (1838). On the Use of Common Thermometers to Determine Heights. *JRGS* 8 pp. 435-442
- Symons G.J. (ed) (1888) 'The Eruption of Krakatoa' Report of the Krakatoa Committee.
- Tate, T. (1848). *Principles of Geometry, Mensuration, Trigonometry, Land-surveying and Levelling.* London: Longman, Brown, Green and Longman's.
- Taylor, H. (1836). *The Statesman.* London: Longman, Rees, Orme, Brown, Green, & Longman
- Taylor, J. (1833). Luni-solar and Horary Tables, with their Application in Nautical Astronomy. London: Longman Rees Orme Brown Green and Longman
- Tracy, J.C. (1907). *Plane Surveying: a Textbook and Pocket Manual.* New York: John Wiley & Sons

- Ure, A. (1853). *Dictionary of Arts, Manufactures and Mines* 1 (1)
- Usill, G.W. (1888). *Practical Surveying: a text book for students preparing for examination or for survey-work in the Colonies. With ... illustrations*. London: Crosby Lockwood & Son
- Walker, J.T. (1871) On Observations with Theodolites or Altazimuth Instruments. In *Hints To Travellers* London: RGS pp. 32-43
- Warne, F. (1870). *The College Atlas for Schools and Families new edition*. London: Frederick Warne and Co
- Watts, W. (1876). *Across the Vatna Jokull: or Scenes in Iceland*. London: Longman's and Co
- Webb, W.L. (1917). *Technic of Surveying Instruments and Methods, Including General and Detailed Instructions for Field and Office Work of Extended Students' Surveys*. New York: J. Wiley & Sons
- Whewell, W. (1836). On the Results of an Extensive System of Tide Observations Made on the Coasts of Europe and America in June 1835. London: printed by Richard Taylor
- Whewell (1868). Chart of Cotidal Lines Based Upon Dr Whewell's Chart. The National Encyclopaedia* London: William Mackenzie
- Whymper, E. (1892). *Travels Amongst the Great Andes of the Equator*. London: John Murray
- Whymper E. (1900) *Scrambles Amongst the Alps In The Years 1860-69*. 5<sup>th</sup> edition London: John Murray
- Wilson, H.M. (1900). *Topographic Surveying: Including Geographic, Exploratory, and Military Mapping. With Hints on Camping, Emergency Surgery, and Photography*. New York: J. Wiley & Sons
- Wollaston, F. J. H. (1817). Description of a Thermometrical Barometer for Measuring Altitudes. *PTRS* 107 pp.183-196
- Wollaston F. J. H. (1820). On The Measurement of Snowdon by the Thermometrical Barometer. *PTRS* 110 p.295
- Zagoskin, L.A. (1847-8). *Lieutenant Zagoskin's Travels in Russian America, 1842-44*. St. Petersburg translated 1967 Toronto: University of Toronto Press

### **Secondary Sources:**

- Adas, M. (1989). *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance*. Ithaca, London: Cornell University Press
- Ackermann, S. and Wess, J. (2003). Between Antiquarianism and Experiment: Hans Sloane, George III and Collecting Science. In K. Sloan (ed) *Enlightenment: Discovering the World in the Eighteenth Century*. London: The British Museum Press
- Agnew, D.C. (2002). History of Seismology. In W. Lee, P. Jennings, C. Kisslinger, H. Kanamori (eds) *International Handbook of Earthquake & Engineering Seismology Part A, International Geophysics* 81A London: Academic Press Elsevier. Introductory chapter
- Akerman, J. R. (2009). *The imperial map: cartography and the mastery of empire*. Chicago: University of Chicago Press

- Alder, K. (2002). *The measure of all things* New York: Free Press
- Alexander, A. R. (2002). *Geometrical landscapes: the voyages of discovery and the transformation of mathematical practice*. Stanford: Stanford University Press
- Allen, C. (2003). *A Mountain In Tibet: The Search for Mount Kailas and the Sources of the Great Rivers of Asia*. Paperback edition. London: Abacus
- Altick, R. D. (1967). *The English Common Reader: a Social History of the Mass Reading Public 1800-1900*. Chicago: Chicago University Press
- Altick, R. D. (1989). *Writers, Readers and Occasions: Selected Essays on Victorian Literature and Life*. Columbus: Ohio State University Press
- Arnold, D. (1971). *Britain, Europe and the World 1870-1955*. London: Edward Arnold
- Arnold, D. (1996). *The Problem of Nature: Environment, Culture and European Expansion*. Oxford: Blackwell
- Arnold, D. (2006) *The Tropics and the Traveling Gaze: India, Landscape, and Science, 1800-1856*. Seattle: University of Washington Press
- Ashworth, W. J. (1998). *John Herschel, George Airy, and the Roaming Eye of the State. History of Science*. 36 pp. 151–78
- Aubin, D. Bigg, C. and Sibum, H.O. (eds) (2010). *The Heavens on Earth: Observatories and Astronomy in Nineteenth-Century Science and Culture*. Durham N.C.: Duke University Press
- Bagrow, L. (2010). *History of Cartography*. New Brunswick: Transaction Publishers
- Baker, A. (2009). The Business of Life: the Socioeconomics of the “Scientific” Instrument Trade in Early Modern London, in F-E. Eliassen & K. Szende (eds.), *Generations in Towns: Succession and Success in Pre-Industrial Urban Societies*. Newcastle upon Tyne: Cambridge Scholars Press pp.175-180
- Ballantyne, T. and Burton, A.M. (2005). Introduction. In T. Ballantyne and A.M. Burton (eds) *Bodies in Contact: Rethinking Colonial Encounters in World History*. Durham, N.C.: Duke University Press
- Barczewski, S.L. (2007). *Antarctic Destinies: Scott, Shackleton and the Changing Face of Heroism* London: Hambledon Press
- Barnes, B. (1982). *Science in Context: Readings in the Sociology of Science*. Milton Keynes: Open University Press
- Barnes, B. (1996). *Scientific Knowledge: a Sociological Analysis*. London: Athlone
- Barnett, C. (1996). *Impure and Worldly Geography*. Oxford: Oxford University Press
- Barnett, C. (2008). *Geographies of Globalisation: a Demanding World*. London: SAGE
- Barnett, C. (1998). Impure and Worldly Geography: The Africanist Discourse of the Royal Geographical Society, 1831–73. *Transactions of the Institute of British Geographers* 23 pp.239–51.

- Baron, N. P. (2002). "Empire" and "Nation" as Categories of Spatial Practice and Historical Study: Methodological Notes *Ab Imperio*. 2, pp. 117-32
- Baron, N. (2013). Scales of Ambition: The Rise and Fall of Internationalism in Soviet Cartographic Culture and Practice, from Lenin to Stalin. (Unpublished talk) RGS-IBG Annual Conference, London Aug 2013
- Baron N., (2015). World Revolution and Cartography. In M. Monmonier (ed). *The History of Cartography, Volume 6: Cartography in the Twentieth Century* Chicago: The University of Chicago Press pp. 1766-1770
- Basha, M.Z.** (2003). *Travel Writing and the Empire / Essays by Mohammed Zaheer Basha ... [et al.]* S.Mohanty. (ed). New Delhi: Katha
- Bayly, C.A. (1989). *Imperial Meridian: the British Empire and the World, 1780-1830*. London and New York: Longman
- Bedeman, S.H. (2000). The Last and Not the Least: Lieutenant Boyd Alexander's Tragic African Journeys, 1904–07 and 1908–10 *Terrae Incognitae* 32 Abingdon: Taylor & Francis
- Bedini, S A. (2001). *With Compass and Chain: Early American Surveyors and their Instruments*. Frederick, Maryland: Professional Surveyors Publications Company
- Bell, M., Butlin, R. and Heffernan, M. (eds). (1996) *Geography and Imperialism 1820-1940* Manchester and New York: Manchester University Press.
- Bennett, B. M. (2011). The Consolidation and Reconfiguration of 'British' Networks of Science, 1800-1970. In B. M. Bennett & J. M. Hodge (Eds.) *Science and Empire: Knowledge and Networks of Science Across the British Empire, 1800-1970*. London: Palgrave MacMillan. pp. 30-43.
- Bennett, J.A. (1987). *The Divided Circle : a History of Instruments for Astronomy, Navigation and Surveying*. Oxford: Phaidon Christie's
- Berton, P. (1988). *The Arctic Grail; the Quest for the North West Passage and the North Pole 1818-1909*. New York: Viking Penguin
- Blok, A. and Jensen, T. E. (2011). *Bruno Latour: Hybrid thoughts in a Hybrid World*. New York: Routledge
- Bloor, D. (1991). *Knowledge and Social Imagery* Chicago: University of Chicago Press
- Bloor, D. (1999). Anti-Latour. *Studies in the History and Philosophy of Science* 30(1) pp. 113–129
- Bloor, D. (2001). *Idealism and the Sociology of Knowledge*. Edinburgh: University of Edinburgh
- Bourguet, M-N Lipocce, C. and Sibus, H.O. (eds) (2002). *Instruments, Travel and Science: Itineraries of Precision from the Seventeenth to the Twentieth Century*. Routledge; London
- Bourguet, M-N. (2010). A Portable World: The Notebooks of European Travellers (Eighteenth to Nineteenth Centuries) *Intellectual History Review* 20(3) pp.377-400
- Bowen, J. and Bowen, M. (2002) *The Great Barrier Reef: History, Science, Heritage*. Cambridge: Cambridge University Press



- Brailey, M. (1999). The Scramble for Concessions in 1880s Siam. *Modern Asian Studies* 33(3) pp.513-550
- Brantlinger, P. (1988). *Rule of Darkness; British Literature and Imperialism 1830-1914*. Ithaca and London: Cornell University Press
- Bravo, M.T. (1999). Ethnographic Navigation and the Geographical Gift in C.W. Withers and D.N.Livingstone (eds). *Geography and Enlightenment*. Chicago and London: University of Chicago Press pp.199-236
- Bridges, R. (2000). *Imperialism, Decolonization and Africa: Studies Presented to John Hargreaves: with an Academic Memoir and Bibliography*. R. Bridges (ed). London: St. Martin's Press
- Bridges, R. (2002). Exploration and travel outside Europe 1720-1914 in T.Youngs (ed). *The Cambridge Companion to Travel Writing*. Cambridge: Cambridge University Press
- Bridges, R. (2007). William Desborough Cooley 1795-1883. in C.W.Withers and H.Lorimer (eds). *Geographers Bibliographical Studies* 27 pp.43-62.
- Brisson, U. and Schweizer, B. (2009). *Not So Innocent Abroad: The Politics of Travel and Travel Writing*. Cambridge: Cambridge Scholars Publishing
- Brown, R.H. and Davis-Brown, B. (1998). The Making of Memory and the Politics of Archives, Libraries and Museums in the Construction of National Consciousness *History of the Human Sciences* 11(4) London: SAGE Publications pp.17-32
- Bud, R. and Cozzens, S. (eds) (1992). *Invisible Connections: Instruments, Institutions and Science*. Bellingham WA: Society of Photo-Optical Instrumentation Engineers
- Burnett, G. D. (2000). *Masters of all they Surveyed: Exploration, Geography, and a British El Dorado*. Chicago: University of Chicago Press
- Bunyan, I. Calder, J. Idiens, D. and Wilson, B. (1993). No Ordinary Journey: John Rae, Arctic Explorer 1813-1893. Edinburgh and Montreal: The National Museums of Scotland and McGill-Queen's University Press
- Butlin R.A. (2009). *Geographies of Empire: European Empires and Colonies, c.1880-1960*. Cambridge: Cambridge University Press
- Calder Wood, J. (1943). Sir David Gill and the Geodetic Survey of South Africa and the Arc of the 30<sup>th</sup> Meridian. *Empire Survey Review* 7(48) pp50-56
- Callon, M. (1999). 'ANT-the Market Test' in J. Law and J. Hassard (eds) *Actor Network Theory and After*. Sociological Review Monograph Series 47(S1) pp. 181-195
- Cameron, I. (1980). *To the Farthest Ends of the Earth: the History of the Royal Geographical Society 1830-1980*. London: Macdonald
- Cannon, S. (1978). *Science in Culture: The Early Victorian Period*. New York: Dawson and Science History Publications
- Carnochan, W.B. (2006). *The Sad Story of Burton, Speke and the Nile or was John Hanning Speke a Cad?* California: Stanford University Press
- Carr, H. (2002). Modernism and Travel 1880-1940. In P. Hulme and T.Youngs (eds). *The Cambridge Companion to Travel Writing*. Cambridge: Cambridge University Press pp. 70-86

- Carter, P. (1987). *The Road to Botany Bay: An Exploration of Landscape and History*. Minneapolis: University of Minnesota Press
- Cawood, J. (1979). The Magnetic Crusade: Science and Politics in Early Victorian Britain. *Isis* 70(4) pp. 492-518
- Chambers, D.W. and Gillespie, R. (2000). Locality in the History of Science: Colonial Science, Technoscience and Indigenous Knowledge. In R. MacLeod (ed). *Nature and Empire* pp.221-40
- Chapman, A. (1990). *Dividing the Circle: The Development of Critical Angular Measurement in Astronomy 1500-1850*. Chichester: Ellis Horwood
- Chauvin, M. E. (1993). Astronomy in the Sandwich Islands: The 1874 Transit of Venus, *The Hawaiian Journal of History*, 27 pp 185-225
- Clancey, G. (2006). *Earthquake Nation: The Cultural Politics of Japanese Seismicity, 1868–1930*. Berkeley: University of California Press
- Clifford, N. (2001). *A truthful Impression of the Country; British and American travel Writing in China 1880-1949*. Michigan: University of Michigan Press
- Clifford, D., Wadge, E., Warwick, A., and Willis, M.(eds).(2006) *Repositioning Victorian Sciences: Shifting Centres in 19<sup>th</sup> Century Thinking*
- Clifton, G. (1995). *Directory of British Scientific Instrument Makers, 1550-1851*. London: Zwemmer in association with the National Maritime Museum
- Cline Cohen, P. (1982). *A Calculating People: the Spread of Numeracy in Early America*. Chicago: Chicago University Press
- Coates, K. (1984). Best Left as Indians: Native-White Relations in the Yukon Territories 1840-1973. PhD University of British Columbia
- Cock, R. (2005). *Scientific Servicemen in the Royal Navy and the Professionalisation of Science 1816-1855*. In D.M Knight, and M.D. Eddy, (eds). *Science and Beliefs: From Natural Philosophy to Natural Science 1700-1900*. Aldershot: Ashgate pp. 95–112
- Colletta, L. (ed). (2015). *The Legacy of the Grand Tour: new essays on Travel, Literature, and Culture*. Madison: Fairleigh Dickinson University Press
- Colley, A.C. (2010). *Victorians in the Mountains: Sinking the Sublime*. Farnham: Ashgate
- Collier, P. (2013a). The Role of Networks in Changing Survey Teaching and Practice in Nineteenth Century Britain and the British Empire.  
[http://www.fig.net/resources/proceedings/fig\\_proceedings/fig2009/papers/hs02/hs02\\_collier\\_3190.pdf](http://www.fig.net/resources/proceedings/fig_proceedings/fig2009/papers/hs02/hs02_collier_3190.pdf)
- Collier, P. (2013b). Edward Sabine and the 'Magnetic Crusade' In E. Liebenberg, P.Collier, Z. G.Török (eds). *History of Cartography* part of series *Lecture Notes in Geoinformation and Cartography*. New York: Springer pp. 309-323
- Collier, P. and Inkpen, R. (2002). The RGS, exploration and Empire and the contested nature of surveying. *Area* 34(3) pp. 273–283
- Conrad, J. (1924). Geography and Some Explorers. *National Geographic*, 45(3) pp.239-274

- Cook, T. (2001). Archival Science and Postmodernism: New Formulations for Old Concepts. *Archival Science* 1(1) pp.3-24.
- Cook, T. (2013). Evidence, Memory, Identity, and Community: Four Shifting Archival Paradigms. *Archival Science* 13(2-3) pp.95-120.
- Cook, T. and Schwartz, J.M. (2002). Archives, Records, and Power: From (Postmodern) Theory to (Archival) Performance. *Archival Science* 2(3-4) pp.171–185
- Cooper, A. (1998). From the Alps to Egypt (and Back Again): Dolomieu, Scientific Voyaging, and the Construction of the Field in Eighteenth-Century Natural History. In C. Smith, and J. Agar (eds). *Making Space for Science: Territorial Themes in the Shaping of Knowledge*. New York: Springer pp. 39-63
- Cotter, C.H. (1968) *History of Nautical Astronomy*. London: Hollis & Carter
- Cox, N. (2016). 'Armchair Geography: Speculation, Synthesis and the British Culture of Exploration'. PhD University of Warwick, Warwick UK
- Craciun, A. (2011). What Is an Explorer? *Eighteenth-Century Studies*, 45 (1) pp. 29-51.
- Crease, R. P. (2011). *World in the Balance: The Historic Quest for an Absolute System of Measurement*. London: W. W. Norton & Company
- Croarken, M. (2003). Astronomical Labourers: Maskelyne's Assistants at the Royal Observatory, Greenwich, 1765-1811. *Notes and Records of the Royal Society of London* 57(3) pp. 285-298
- Crone, R.G. (1953). *Maps and Their Makers* London: Hutchinson's University Library
- Curtin, P.D. (1964). *The Image of Africa; British Ideas and Action 1780-1850*. Madison: University of Wisconsin Press
- Curtin, P. (2002). *The World and the West: The European Challenge and the Overseas Response in the Age of Empire*. Cambridge: Cambridge University Press
- Daston, L. (2000). The Coming Into Being of Scientific Objects. In L. Daston (ed). *Biographies of Scientific Objects*. Chicago and London: University of Chicago Press pp.
- De Clercq, P. (1997). The Leiden Cabinet of Physics: A Descriptive Catalogue. *Museum Boerhaave Communication* 271. Leiden: Museum Boerhaave
- Dekker, E. (1999). *Globes at Greenwich: A Catalogue of the Globes and Armillary Spheres in the National Maritime Museum*. Oxford and London: Oxford University Press and the National Maritime Museum
- Derrida, J. (1995). Archive Fever: A Freudian Impression. E. Prenowitz (trans) *Diacritics* 25 pp. 9-63.
- Dettelbach, M. (1996). Humboltean Science. in *Cultures of Natural History* N. Jardine, J. Secord, E. Spary. (eds). Cambridge: Cambridge University Press
- Dirks, N. (1992). *Colonialism and Culture*. Michigan: University of Michigan
- Dodds, K-J. (1994). Eugenics, Fantasies of Empire and Inverted Whiggism; an Essay on the Political Geography of Vaughan Cornish. *Political Geography* 13(1) pp. 85-99

- Drayton, R. (2002). *Nature's government: Science, Imperial Britain, and the 'Improvement of the World'*. New Haven and London; Yale university Press
- Dritsas, L. (2010). *Zambesi: David Livingstone and Expeditionary Science in Africa*. London: I.B. Tauris
- Dritsas, L. (2011). Expeditionary Science; Conflicts of Method in Mid- Nineteenth Century Geographical Discovery. In D.Livingstone and C.W.Withers, (eds). *Geographies of 19<sup>th</sup> Century Science*. Chicago and London: University of Chicago Press
- Driver, F. (1998). Scientific Exploration and the Construction of Geographical Knowledge. *Finisterra* 65 pp.21–30
- Driver, F. (2001). *Geography Militant: Cultures of Exploration and Empire*. Oxford: Blackwell
- Driver, F. and Jones, L. (2009). *Hidden Histories of Exploration*. London: Royal Holloway and RGS-IBG
- Driver, F. (2011) *The World and Africa: Rediscovering African Geographies*. London: The Royal Geographical Society
- Driver, F. (2015). Intermediaries and the Archive of Exploration. In S. Konishi, M. Nugent and T. Shellam (eds) *Indigenous Intermediaries: New Perspectives on Exploration Archives*. Acton Australia: Australian National University Press. pp. 11-29
- Ducheyne, S. (2010). Whewell's Tidal Researches; Scientific Practice and Philosophical Methodology. *Studies in History and Philosophy of Science* 41 pp. 26-40
- Duncan, J. and Gregory, D. (1999). *Writes of Passage: Reading Travel Writing*. Basingstoke: Psychology Press
- Dunn, R. (2016). *Navigational Instruments*. London: Bloomsbury Shire Publications
- Dym, J. (2004). More Calculated to Mislead than Inform': Travel Writers and the Mapping of Central America, 1821–1945 *Journal of Historical Geography*, 30(2) pp. 340-366
- Edney, M. H. (1997). *Mapping an Empire: The Geographical Construction of British India, 1765-1843*. University of Chicago Press: Chicago and London
- Edney, M. (2014). Academic Cartography, Internal Map History, and the Critical Study of Mapping Processes. *Imago Mundi* 66 Issue supplement 1 pp. 83-106
- Ellis, R. (2001). *Vertical Margins: Mountaineering and the Landscapes of Neoimperialism*. Winsconsin: University of Winconsin Press
- Enebak, V. (2014). 'Hansteen's Magnetometer and the Origin of the Magnetic Crusade' *The British Journal for the History of Science* 47(4) pp. 587-608
- Fenna, D. (2006). *Cartographic Science: A Compendium of Map Projections, with Derivations*. Oxford: CRC Publishing, Taylor and Francis Group
- Fialovszky, L. (2013). *Surveying Instruments and their Operational Principles*. Amsterdam: Elsevier (English translation)
- Finnegan, D. (2008). The Spatial Turn: Geographical Approaches in the History of Science. *Journal of the History of Biology* 41 pp.369–88

- Finkelstein, D. (2003). Unravelling Speke: The Unknown Revision of an African Exploration Classic. *History in Africa* 30(1) pp. 117-132
- Fisher, J. (2002) *Gentleman Spies: Intelligence Agents in the British Empire and Beyond* Stroud: Sutton
- Fisher, J. (2006). British Responses to Mahdist and Other Unrest in North and West Africa, 1919–1930. *Australian Journal of Politics & History* 52(3) pp.347-361
- Foliard, D. (2017). *Dislocating the Orient: British Maps and the Making of the Middle East, 1854 -1921* Chicago: Chicago University Press.
- Fremd, V.M. (1997). Historical Seismometers as Predecessors of Modern Instruments. In G.Ferrari, (ed). *Proceedings of the Workshop : Historical Seismic Instruments and Documents: a Heritage of Great Scientific and Cultural Value, May 16 to 18th, 1995, Walferdange, Luxembourg.* Luxembourg: European Seismological Commission
- Gardner, R. (2004). Unlocking the Archives: Dr Rita Gardner, Director of the Royal Geographical Society (with the Institute of British Geographers) Introduces a New Initiative to Make Its Holdings Accessible to All *History Today* 54(6) pp. 2-3
- Galison, P. (2003). *Einstein's Clocks and Poincaré's Maps: Empires of Time.* New York: W.W. Norton
- Gardner, R. (ed). (2005). *To the Ends of the Earth: Visions of a Changing World: 175 Years of Exploration and Photography.* London: Bloomsbury Publishers
- Gascoigne, J. (2003). Joseph Banks and the English Enlightenment: *Useful Knowledge and Polite Culture.* Cambridge: Cambridge University Press
- Gascoigne, J. (2015). Cross-Cultural Knowledge Exchange in the Age of Enlightenment. In S. Konishi, M. Nugent and T. Shellam (eds). *Indigenous Intermediaries; New Perspectives on Exploration Archives.* Acton Australia: Australian National University Press
- Godlewska, A. (1996). From Enlightenment Vision to Modern Science? Humboldt's Visual Thinking. In D.N. Livingstone, and C.W. Withers (eds). *Geography and Enlightenment.* Chicago and London: University of Chicago Press. pp.236-280
- Godlewska A and Martin, J.G. (2011). Map in SAGE pp. 357-368
- Golinski, J. (1998). *Making Natural Knowledge: Constructivism and the History of Science.* Cambridge: Cambridge University Press
- Gooday, G. (2004). *The Morals of Measurement: Accuracy, Irony, and Trust in Late Victorian Electrical Practice.* Cambridge: Cambridge University Press
- Goren, H. (2011). Dead Sea Level: Science, Exploration and Imperial Interests in the Near East, *Tauris Historical Geography Series 6,* London: I. B. Tauris
- A. Goudie, A. (1972) Vaughan Cornish: Geographer *Transactions of the Institute of British Geographers,* 55 pp. 1-16
- Graham, I. (2002). *Alfred Maudslay and the Maya.* London: British Museum Press
- Gray, C. (2004). In Defence of the Heartland: Sir Halford Mackinder and his Critics a Hundred Years on. *Comparative Strategy* 23(9) pp. 9-25

- Griffiths, A. (2002). *Wondrous Difference; Cinema, Anthropology and Turn-of-the-Century Visual Culture*. New York: Columbia University Press
- Gunn, M. and Codd, L.E. (1981). *Botanical Exploration of Southern Africa*. Cape Town: Balkema
- Hacking, I. (1990). *The Taming of Chance*. Cambridge: Cambridge University Press
- Hammond, J.H. and Austin, J. (1987). *The Camera Lucida in Art and Science*. Bristol: Institute of Physics
- Hansen P.H. (1996). Vertical Boundaries, National Identities: British Mountaineering on the Frontiers of Europe and the Empire, 1868–1914. *The Journal of Imperial and Commonwealth History* 4 pp. 48–71
- Harbsmeier, M., Ries, C. J., and Nielsen, K. H. (eds). (2012). *Scientists and Scholars in the Field: Studies in the History of Fieldwork and Expeditions*. Aarhus: Aarhus Universitetsforlag
- Harley, J.B. (2001). The New Nature of Maps. In P. Laxton (ed) *Essays in the History of Cartography 2*. Baltimore: John Hopkins University Press
- Headrick, D.R. (1988). *Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940*. USA: Oxford University Press
- Heffernan, M. (2011). Learned Societies. In J.A. Agnew and N. Livingstone (eds). *The SAGE handbook of Geographical Knowledge*. London: Sage Publications pp.111-125
- Henry, E. (2011). *Triumph and Tragedy: The Life of Edward Whymper*. Leicester: Matador
- Herle, A and Rouse, S. (1998). *Cambridge and the Torres Strait* Cambridge: Cambridge University Press
- Higgitt, R. Dunn, R. Jones, P. (eds) (2015).. *Navigational Enterprises in Europe and its Empires, 1730–1850*. Basingstoke: Palgrave MacMillan
- Higton, H. with contributions from Ackermann, S. (2002). *Sundials at Greenwich: a Catalogue of the Sundials, Nocturnals and Horary Quadrants in the National Maritime Museum, Greenwich*. Oxford and New York: Oxford University Press and the National Maritime Museum
- Hodge, J. M. (2011). Science and Empire: An Overview of the Historical Scholarship. In B.M. Bennett and J.M. Hodge (eds). *Science and Empire*. Basingstoke: Palgrave and Macmillan
- Hokkanen, M. (2007). 'Medicine and Scottish missionaries in the Northern Malawi Region 1875-1930: Quests for Health in a Colonial Society.' Jyvaskyla: Edwin Mellen Press
- Holland, G.S. (1980). The Centenary of the Society's Drawing Office *GJ* vol 146(2) pp. 210-217
- Holt-Jensen, A. (1999). *Geography - History and Concepts: A Student's Guide*. London: SAGE
- Hopkirk, P. (1982). *Trespassers on the Roof of the World*. London: John Murray
- Hulme, P. and Youngs, T. (eds). (2002). *The Cambridge Companion to Travel Writing*. Cambridge: Cambridge University Press

- Iliffe, R. (2007). *Newton: A Very Short Introduction*. Oxford: Oxford University Press
- Inkpen, R. (2002). The RGS, Exploration, Empire, and the Contested Nature of Surveying. *Area* 34(3) pp.273-283
- Jacob, M. (2004). *Practical Matter: Newton's Science in the Service of Industry and Empire*. Cambridge Mass and London: Cambridge University Press
- Jenkins, K. (1991). *Re-thinking History*. London: Routledge
- Jones, D. (2005) <https://www.scribd.com/document/147058184/JONES-David-In-Conversation-With-Bruno-Latour-Historiography-of-Science-in-Action> viewed April 2017
- Jones, L. M. (2010) 'Local Knowledge and Indigenous Agency in the History of Exploration: Studies from the RGS-IBG Collections'. PhD. Royal Holloway, University of London, Egham, Surrey
- Jones, M. (2005). Measuring the World: Exploration, Empire and the Reform of the Royal Geographical Society c. 1874-93. In M.J. Daunton, (ed). *The Organisation of Knowledge in Victorian Britain* British Academy centenary monographs. Oxford: Oxford University Press pp 313-337
- Jones, M.K. (2014). From Explorer to Expert: Sir William Martin Conway's Delightful Sense of Something Accomplished. *Polar Record* 50(3) pp.319 -329
- Jöns, H. Livingstone, D. N. and Meusburger, P. (2010). Interdisciplinary Geographies of Science. In P. Meusburger, D. N. Livingstone, and H. Jöns (eds). *Geographies of Science* Dordrecht: Springer pp. ix–xvii
- Jöns, H. (2011). Centre of Calculation. In J. Agnew, and D. Livingstone, (eds). *The Sage Handbook of Geographical Knowledge*. London: SAGE pp.158-170
- Kearns, G. (2009). *Geopolitics and Empire; the Legacy of Halford MacKinder*. Oxford: Oxford University Press
- Keighren, I. Withers, C.W. Bell, B. (2015). *Travels into Print: Exploration, Writing, and Publishing with John Murray 1773-1859*. Chicago: Chicago University Press
- Kennedy, D. (2002). *Britain and Empire, 1880-1945*. Boston USA: Pearson Education
- Kennedy, D. (2014). *The Last Blank Spaces: Exploring Africa and Australia*. New Jersey: Harvard University Press
- King, C. (2008). *The Ghost of Freedom: a History of the Caucasus*. Oxford: Oxford University Press
- King, H.C. (1955). *The History of the Telescope*. London: Griffin
- Knowles Middleton, W.E. (1964). *The History of the Barometer*. Baltimore: John Hopkins Press
- Koelsch, W. A. (2013). *Geography and the Classical World: Unearthing Historical Geography's Forgotten Past*. London: I. B. Tauris.
- Kollestrom, N. (2000). *Newton's Forgotten Lunar Theory: His Contribution to the Quest for Longitude*. Santa Fe: Green Lion

- Koyre, A. (1957). *From the Closed World to the Infinite Universe* Baltimore: Johns Hopkins Press
- Knowles Middleton, W.E. (1966). *The History of the Thermometer and its Uses in Meteorology*. Baltimore: The Johns Hopkins Press
- Latour B. (1986). Drawing Things Together in M. Lynch and S. Woolgar (eds) *Representation in Scientific Activity*, Cambridge Mass, pp.19-68,
- Latour, B. (1987). *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge Mass: Harvard University Press
- Latour, B. (1996). On Actor Network Theory: A Few Clarifications. *Soziale Welt* 47 pp.369-381
- Latour, B. (2005). *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press
- Latour, B. (2011) Drawing Things Together in *The Map Reader, Theories of Mapping Practice and Cartographic Representation* M. Dodge, R. Kitchin and C. Perkins.(eds). Chichester: Wiley Blackwell, pp.65-73
- Laudan, R. (2003). Instrumentalism and Realism. In J.L. Heilbron (ed). *The Oxford Companion to the History of Modern Science*. Oxford: Oxford University Press
- Law, J. and Hassard, J.(1999) *Actor Network Theory and After*. Oxford: Blackwell
- Lawrence. D. (2006).The Early Ethnographic Writings of EW Pearson Chinnery: Government Anthropologist of New Guinea. [http://history.prm.ox.ac.uk/collector\\_seligman.html](http://history.prm.ox.ac.uk/collector_seligman.html) Viewed March 2017
- Leake, B.L. (2011). *The Life and Work of Professor JW Gregory FRS (1864-1932), Geologist, Writer, and Explorer*. London: The Geological Society
- Lee, N. et al (1994). Otherness and the Actor Network; the Undiscovered Continent. *American Behavioural Scientist* 37 pp.772-790
- Leigh Star, S. (1991). Power, Technologies and the Phenomenology of Standards: On Being Allergic to Onions, in J. Law ed. *A Sociology of Monsters? Power, Technology and the Modern World, Sociological Review Monograph no 38*. London: Routledge pp.27-57
- Levere, T. (1993). *Science and the Canadian Arctic*. Cambridge: Cambridge University Press
- Lightman, B. (2007). Introduction. In *Science in the Marketplace: Nineteenth-Century Sites and Experiences* A. Fyfe and B. Lightman (eds) Chicago: University of Chicago Press
- Livingstone, D. N. (1992). *The Geographical Tradition: Episodes in the History of a Contested Enterprise*. Chichester: Wiley-Blackwell
- Livingstone, D. (1995).The Spaces of Knowledge: Contributions Towards a Historical Geography of Science. *Environment and Planning D: Society and Space* 13 pp. 5–34.
- Livingstone, D. (2003). *Putting Science in its Place: Geographies of Scientific Knowledge* .Chicago: University of Chicago Press



- Livingstone, D. N. (2010). Landscapes of Knowledge. In P. Meusburger, D.N. Livingstone, and H. Jöns (eds). *Geographies of Science*. New York and Heidelberg: Springer
- Locher, F. (2007). The Observatory, the Land-based Ship and the Crusades: Earth Sciences in European Context, 1830–50. *British Journal for the History of Science* 40(4) pp. 491-504
- Lorimer, D. (2013). *Science, Race Relations and Resistance, Britain, 1870–1914*. Manchester: Manchester University Press
- Lorimer, D.A. (1997). Science and the Secularisation of Victorian Images of Race. In B. Lightman,(ed). *Victorian Science in Context*. Chicago and London: University of Chicago Press
- Michael Lynch and Steve Woolgar (eds) *Representation in Scientific Activity*, MIT Press, Cambridge Mass, pp.19-68
- Mandiringana, E., Stapleton, T.J. (1998). The Literary Legacy of Frederick Courteney Selous. *History in Africa* 25 pp.199-218
- McAlear, J. (2010). Representing Africa: Landscape, Exploration and Empire in Southern Africa, 1780-1870. Manchester: Manchester University Press
- Macgregor Wise, J. (1997). *Exploring Technology and Social Space*. London: SAGE
- MacLachlan, J.M. (2004). *Peak Performances: Cultural and Autobiographical Constructions of the Victorian Female Mountaineer*. PhD University of British Columbia
- MacLeod, R. (1982). On Visiting the “Moving Metropolis”: Reflections on the Architecture of Imperial Science. *Historical Records of Australian Science* 5(3) pp.1-16
- MacLeod, R. (2000a). *The Creed of Science in Victorian England*. Aldershot: Ashgate
- MacLeod, R. (2000b). Introduction. Nature and Empire: Science and the Colonial Enterprise  
*Osiris* 15 pp. 1-13
- MacLeod, R. (2003). *Government and Expertise: Specialists, Administrators and Professionals, 1860-1919*. Cambridge: Cambridge University Press
- MacNair, J.I. (1976). *Livingstone the Liberator: A Study of a Dynamic Personality*. Glasgow: Reprinted by The David Livingstone Trust
- Mahoney, M. (2016). For an Empire of ‘All Types of Climate’: Meteorology as an Imperial Science. *Journal of Historical Geography* 51 pp.29-39
- Markham, C.R. (1881). *The Fifty Years Work of the Royal Geographical Society*. London: John Murray
- Matless, D. (1991). Nature, the Modern and the Mystic: Tales from Early Twentieth Century Geography. *Transactions of the Institute of British Geographers* 16(3) pp.272-286
- Mawer, G.W. (2006) *South by Northwest: The Magnetic Crusade and the Contest for Antarctica*. Kent Town, South Australia: Wakefield Press
- McCarthy, J. (2004). *Journey Into Africa; the Life and Death of Keith Johnston, Scottish Cartographer and Explorer 1844-79*. Caithness: Whittles Publishing

- McConnell, A. (1980a). *Geomagnetic Instruments Before 1900: An Illustrated Account of Their Construction and Use* London: Harriet Wynter Ltd
- McConnell, A. (1980b). *Additional Material for Six, J, The Construction and Use of a Thermometer* London: Nimbus Books
- McConnell, A. (1981). *Historical Instruments in Oceanography: Background to the Oceanography Collection at the Science Museum*. London: HMSO
- McConnell, A. (1982). *No Sea Too Deep: The History of Oceanographic Instruments*. Bristol: Adam Hilger Ltd
- McConnell, A. and Lambert, D. (1985). *Seas and Oceans*. London: Orbis Publications
- McConnell, A. (1986a). *Geophysics & Geomagnetism: Catalogue of the Science Museum Collection* London: HMSO
- McConnell, A. (1986b). The Scientific Life of William Scoresby Jnr., with a Catalogue of his Instruments and Apparatus in the Whitby Museum. *Annals of Science* 43 pp.257-86
- McConnell, A. (1988). *Barometers*. Princes Risborough: Shire Publications
- McConnell, A. (1992a). *Instrument Makers to the World: A History of Cooke, Troughton & Simms*. York: William Sessions and the University of York
- McConnell, A., (1992b). *Assessing the Value of Historical Temperature Measurements*. London: Endeavour
- McConnell, A. (1998). *King of the Clinicals, The Life and Times of J J Hicks*. York: William Sessions
- McConnell, A. (2005). Origins of the Marine Barometer *Annals of Science* 62(1) pp.83-101
- McConnell, A. (2007). *Jesse Ramsden 1735 to 1800, London's Leading Scientific Instrument Maker* Aldershot: Ashgate
- McLaughlin, M. (1981). *The Complete Neurotic's Notebook*. London: Castle Books
- Mercer, V. (1972). *John Arnold & Son, Chronometer Makers, 1762-1843, With an Introduction by Randall, A.* London: Antiquarian Horological Society
- Merton, R.K. (1973). *The Sociology of Science: Theoretical and Empirical Investigations*. N.W. Storer, (Ed). Chicago and London: University of Chicago Press
- Mill, H.R. (1930). *The Record of the Royal Geographical Society, 1830–1930*. London: Royal Geographical Society
- Millburn, J.R. (2000). *Adams of Fleet Street: Instrument Makers to King George III*. Aldershot: Ashgate
- Monmonier, M.(1995). *Drawing the Line; Tales of Maps and Cartocontroversy*. Henry Holt and Co, New York

- Monmonier, M. (2004). *Rhumb Lines and Map Wars*. Chicago: Chicago University Press
- Mordavsky C. (ed). (2007). *(Re)Creating Science in 19<sup>th</sup> Century Britain*
- Moore-Harell, A. (2010). *Egypt's African empire; Samuel Baker, Charles Gordon and the creation of Equatoria*. Eastbourne: Sussex Academic Press
- Morrell, J.B. (1990). Professionalisation. In R. C. Olby, G. N. Cantor, J. R. R. Christie & M. J. S. Hodge (eds.). *Companion to the History of Modern Science*. London: Routledge. pp. 980-989
- Morrison-Low, A.D. (2007). *Making Scientific Instruments in the Industrial Revolution*. Aldershot: Ashgate
- Morton, A.Q. and Wess J.A. (1993). *Public and Private Science: The King George III Collection*. Oxford: Oxford University Press in association with the Science Museum
- Morus, I.(2006). Bodily Disciplines and Disciplined Bodies: Instruments, Skills and Victorian Therapeutics. *Social History of Medicine* **19**(2) pp. 241-259
- Mörzer Bruyns W. F. J. and Dunn, R. (2009). *Sextants at Greenwich: A Catalogue of the Mariner's Quadrants, Mariner's Astrolabes Cross-staffs, Backstaffs, Octants, Sextants, Quintants, Reflecting Circles and Artificial Horizons in the National Maritime Museum, Greenwich*. Oxford: Oxford University Press
- Musson, R. M. (2013). A History of British Seismology. *Bulletin of Earthquake Engineering* **11**(3) pp. 715-861. New York: Springer Science and Business Media
- Naylor, S. (2005a). Introduction: Historical Geographies of Science: Places, Contexts, Cartographies. *British Journal for the History of Science* **38**(1) pp.1–12
- Naylor, S. (2005b). Historical Geography: Knowledge in Place and on the Move. *Progress in Human Geography* **29** pp.626-634
- Naylor, S. (2010). *Regionalizing Science: Placing Knowledges in Victorian England*. London: Pickering & Chatto
- Naylor, S. (2015). Weather Instruments All at Sea: Meteorology and the Royal Navy in the Nineteenth- Century. In F. MacDonald, and C.W. Withers, (eds). *Geography, Technology and Instruments of Exploration*. London: Routledge. pp.77-97
- O'Connor, D. (2006). *The King's Stranger: A Biography of John Duncan, Scotland's Forgotten Explorer*. Geneva: The Long Rider's Guild Press
- Ogborn M (2002). Writing Travels: Power, Knowledge and Ritual on the English East India Company's Early Voyages. *Transactions of the Institute of British Geographers* **27**(2) pp.155-171.
- Ophir, A., Shapin, S. (1991). The Place of Knowledge: A Methodological Survey. *Science in Context* **4**(1) pp.3-21
- Osborne, T. (1999). The Ordinarity of the Archive. *History of the Human Sciences* **12** pp.51-64
- Outram, D. (1995). *The Enlightenment: New Approaches to European History*. Cambridge: Cambridge University Press

- Outram, D. (1999). On Being Perseus: New Knowledge, Dislocation, and Enlightenment Exploration. In *Geography and Enlightenment*. D. N. Livingstone, and C. W. Withers (eds). Chicago and London: University of Chicago Press. pp.281–94
- Outram, D. (2006). *Panorama of the Enlightenment*. Los Angeles: Getty Publications
- Overweel, J.A. (1998). Systematic Activity: Military Exploration in Western New Guinea, 1907–1915. In J.Meidema, C. Ode, and R. Dam,( eds). *Perspectives on the Bird's Head of Irian, Jaya, Proceedings of the Conference, Leiden, 13-17 October 1997*. Leiden: Brill. pp 455-478
- Owen, T. and Pilbeam, E. (1992). *Ordnance Survey: Map Makers to Britain since 1791*. London: HMSO
- Pang, A. and Soojung, K. (2002). *Empire and the Sun: Victorian Solar Eclipse Expeditions*. Stanford: Stanford University Press
- Park, J. (2002). Land of the Morning Calm, Land of the Rising Sun: The East Asia Travel Writings of Isabella Bird and George Curzon. *Modern Asian Studies*, 36(3) pp. 513-534
- Parsons E. J. S. (1980) chapters 9 and 10 in W.A. Seymour (ed). *A History of the Ordnance Survey*. Folkstone: Dawson.
- Pearson, A. and Heffernan, M. (2009) The American Geographical Society's Map of Hispanic America: Million-Scale Mapping between the Wars *Imago mundi* 61(2); pp. 215-243
- Pickering, A. (1995). *The Mangle of Practice: Time, Agency, and Science*. Chicago, Illinois: University of Chicago Press
- Pickstone, J. (2005). Science in Nineteenth Century England: Plural Configurations and Singular Politics in M.J. Daunton, (ed). *The Organisation of Knowledge in Victorian Britain* British Academy centenary monographs. Oxford: Oxford University Press pp. 29-61
- Pettitt, C. (2007) *Dr. Livingstone I Presume? Missionaries, Journalists, Explorers and Empire* Exmouth: Profile books
- Philo, C. (2000). Foucault's Geography. In M.Crang and N. Thrift (eds). *Thinking Space*. London and New York: Routledge
- Poovey, M. (1998). *A History of the Modern Fact*. Chicago: University of Chicago Press
- Popper, K. (1934). The Logic of Scientific Discovery*. First published as *Logik Der Forschung* Vienna: Springer, First English Edition New York: Hutchinson, 1959
- Porter, T. M. (1995). *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*. New Jersey: Princeton University Press
- Porter, A. (1999). *The Oxford History of the British Empire: Volume III: The Nineteenth Century*. Oxford: Oxford University Press
- Powell, R. (2007). Geographies of Science: Histories, Localities, Practices, Futures. *Progress in Human Geography* 31 pp.309–30.
- Pratt, M.L. (2007). *Imperial Eyes: Travel Writing and Transculturation*. London: Routledge
- Prior, A. (2012). British Cartographic Representations of Africa c. 1880–c. 1915. *Imago Mundi*, 64(2) pp.242-243

- Prior A.D. (2013). *British Mapping of Africa; Publishing Histories of Imperial Cartography c.1880-1915*. PhD University of Edinburgh.
- Rae, E. Souch, C. and Withers, C. W. (2015). Instruments in the Hands of Others: The Life and Liveliness of Instruments of British Geographical Exploration, c.1860–c.1930. In F. MacDonald, and C.W. Withers (eds). *Geography, Technology and Instruments of Exploration*. London: Routledge
- Raj, K. (2000). Colonial Encounters and the Forging of New Knowledge and National Identities: Great Britain and India, 1760-1850. *Osiris*, 2nd Series, 15 *Nature and Empire: Science and the Colonial Enterprise*. pp. 119-134.
- Raj, K. (2002). When Human Travellers Become Instruments: The Indo-British Exploration of Central Asia in the Nineteenth Century. In eds. M-N. Bourguet, C. Licoppe and H. O. Sibum (eds). *Instruments, Travel and Science: Itineraries of Precision from the Seventeenth to the Twentieth Century*. London: Taylor and Francis pp. 156–88
- Raj, K (2007). *Re-locating Modern Science*. Basingstoke: Palgrave MacMillan
- Raj, K. (2009). Mapping Knowledge Go-betweens in Calcutta, 1770–1820. in S. Schaffer, K.Raj, L. Roberts & J. Delbourgo (eds), *The Brokered World : Go-betweens and Global Intelligence, 1770-1820, Uppsala Studies in the History of Science*, 35 Sagamore Beach, MA, Science History Publications
- Regard, F. (2009). *British Narratives of Exploration: Case Studies of the Self and Other*. London: Pickering and Chatto
- Reidy, M. S. (2008). *Tides of History: Ocean Science and Her Majesty's Navy*. Chicago: University of Chicago Press
- Richards, G. (1998.) Getting A Result: The Expedition's Psychological Research 1898-1913. In A. Herle and S.Rouse *Cambridge and the Torres Strait* Cambridge; Cambridge University Press pp. 136-158
- Richards, K. (2011a). The Field. In J. Agnew, and D. Livingstone (eds). *The Sage Handbook of geographical Knowledge*. London: SAGE pp.53-64
- Richards, K. (2011b). The Weather Station and the Meteorological Office. In J. Agnew, and D.Livingstone (eds). *The Sage Handbook of Geographical Knowledge*. London: SAGE pp. 149-158
- Richards, T. (1993). *The Imperial Archive: Knowledge and the Fantasy of Empire*. London: Verso
- Riviere, P. (2006). *The Guiana Travels of Robert Schomburgk 1835–1844*. 2 vols. Aldershot: Ashgate for the Hakluyt Society
- Ross, A. (2002). *David Livingstone: Mission and Empire*. London: Hambledon Press
- Rusnock, A. (2002). *Vital Accounts: Quantifying Health and Population in Nineteenth-Century England and France*. Cambridge: Cambridge University Press
- Russell, A. (2000). *Crossing Boundaries: Postmodern Travel Literature*. Basingstoke: Palgrave McMillan
- Ryan, J. (1997). *Picturing Empire; Photography and the Visualization of the British Empire* London: Reaction books

- Ryan, J. (2003). History and Philosophy of Geography: Bringing Geography to Book, 2000–2001. *Progress in Human Geography* 27 (2) pp.195-202
- Ryan, J. (2010). Photography, Visual Revolutions and Victorian Geography. In *Geography and Revolution* D. Livingstone, C. Withers (eds) Chicago: University of Chicago Press pp. 199-239
- Said, E. (1978). *Orientalism*. New York: Pantheon Books.
- Scott, R.H. (1885). 'History of the Kew Observatory.' *Proceedings of The Royal Society of London* 39 pp.37-86.
- Schaffer, S. (1991). The Eighteenth Brumaire of Bruno Latour. *Studies in History and Philosophy of Science* 22 pp. 174-192
- Schaffer, S. (1992a). Self Evidence *Critical Inquiry* 18(2) pp. 327-362
- Schaffer, S. (1992b). Late Victorian Metrology and Its Instrumentation: A Manufactory of Ohms In R.Bud and S.Cozzens (eds). *Invisible Connections: Instruments, Institutions, and Science*. Bellingham: SPIE
- Schaffer, S. (1994a). *From Physics to Anthropology and Back Again*. Cambridge: Prickly Pear
- Schaffer, S. (1994b). Rayleigh and the Establishment of Electrical Standards. *European Journal of Physics* 15 pp.277-285
- Schaffer, S. (1995). Accurate Measurement is an English Science. In M. Norton Wise (ed). *Values of Precision*. Princeton: Princeton University Press
- Schaffer, S. (1997). Metrology, Metrication, and Victorian Values. In B. Lightman (ed). *Victorian Science in Context*. Chicago: University of Chicago Press
- Schaffer, S. (1998). The Decline (and Success) of Science in England *RSA Journal* 146 pp. 46-53
- Schaffer, S. (2011). Easily Cracked: Scientific Instruments in States of Disrepair. *Isis* 102(4) pp. 706-717
- Schwartz, J. and Ryan, J. (2003). Introduction in J. Schwartz and J. Ryan (eds) *Picturing Place: Photography and the Geographical Imagination*. London: I.B. Tauris pp. 1-18
- Schuster J.and Yeo, R. (1986). *The Politics and Rhetoric of Scientific Method*. In J.Schuster, R. Yeo (eds.) *The Politics and Rhetoric of Scientific Method: Historical Studies* New York: Springer
- Secord, J. A. (2004). Knowledge in Transit, *Isis* 95 pp.654-72
- Shapin, S. (1994). *A Social History of Truth: Civility and Science in Seventeenth-Century England*. Chicago: Chicago University Press
- Shapin, S. (1995). Here and Everywhere: Sociology of Scientific Knowledge. *Annual Review of Sociology* 21 289–321.
- Shapin, S. (1998). Placing the View from Nowhere: Historical and Sociological Problems in the Location of Science. *Transactions of the Institute of British Geographers* 23 pp. 5–12

- Shapin, S. (2010). *Never Pure: Historical Studies of Science as if It Was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority*. Baltimore MD: Johns Hopkins University Press
- Sivasundaram, S. (2011). Islanded: Natural history in the British colonisation of Ceylon. In D. Livingstone and C.W. Withers (eds). *Geographies of Nineteenth Century Science*. Chicago and London: University of Chicago Press
- Skelton, R.A. (1958). Cartography. *History of Technology* 6 pp. 612-614
- Slater, B. (2005). *The Astronomer of Rousdon: Charles Grover 1842-1921*. Bury St. Edmund's: Courseware Publications in association with Steam Mill Publishing
- Smith, C. and Wise, M. Norton (1989) *Energy and Empire: William Thomson, Lord Kelvin, 1824-1907* Cambridge: Cambridge University Press
- Smith, C. and Agar, J. (eds). (2016). *Making Space for Science: Territorial Themes in the Shaping of Knowledge*. New York: Springer
- Snyder, J.P. (1993). *Flattening the Earth*. Chicago: Chicago University Press
- Sorlin, S. (2002). Introduction. In M. Bravo and S. Sörlin (eds). *Narrating the Arctic: A Cultural History of Nordic Scientific Practices*. Cambridge: Science History Publications
- Stafford, R. (1989). *Scientist of Empire: Sir Roderick Murchison, Scientific Exploration and Victorian Imperialism*. Cambridge: Cambridge University Press
- Steinmann, B. (1998). The Opening of the sBas Yul 'Bras Mo'l gshongs according to the Chronicle of the Rulers of Sikkim: Pilgrimage as a Metaphor Model of the Submission of Foreign Populations. In A. MacKay (ed). *Pilgrimage in Tibet*. Richmond: Curzon press.
- Stewart Howe, K (2003). Mapping a Sacred Geography: photographic surveys by the Royal Engineers in the Holy Land, 1864-68 in J. Schwartz and J. Ryan (eds) *Picturing Place: Photography and the Geographical Imagination*. London: I.B. Tauris pp. 226-242
- Stocking, G.W. (1996). *After Tylor; British Social Anthropology 1888-1951*. London: Athlone Press
- Stoddart, D.R. (1980). The RGS and the 'New Geography': Changing Aims and Changing Roles in Nineteenth Century Science *GJ* 146(2) pp. 190-202
- Taylor, E.G.R. (1966). *Mathematical Practitioners of Hanoverian England, 1714–1840*. Cambridge: Cambridge University Press for the Institute of Navigation
- Tennant, W.J. (1999). Charles Morris Woodford C.M.G. (1852-1927): Pacific Adventurer and Forgotten Solomon Islands Naturalist. *Archives of Natural History* 26(3) pp 419-433.
- Thompson, C. (2011). *Travel Writing*. London: Routledge
- Thrift, N. J & Bingham, N. (2001). Some new Instructions for Travellers: The Geography of Bruno Latour and Michel Serres. In Crang M. and Thrift N.J. (eds), *Thinking Space*. London: Routledge pp. 281 - 301.
- Tilley, H. (2011). *Africa as a Living Laboratory : Empire, Development, and the Problem of Scientific knowledge, 1870-1950* Chicago : University of Chicago Press,

- Tresch, J. (2010). Even the Tools Will Be Free: Humboldt's Romantic Technologies. In *The Heavens on Earth: Observatories and Astronomy in Nineteenth Century Science and Culture* D. Aubin, C. Bigg and O.Sibum. Durham: Duke University Press pp. 253-285
- Turner, G.L'E. (1973). *Descriptive Catalogue of Van Marum's Scientific Instruments*  
Leiden: Noordhoff international Publications. [for] Hollandsche Maatschappij der Wetenschappen
- Walker, M. (2011). *History of the Meteorological Office*. Cambridge: Cambridge University Press
- Waller, D. (1990). *The Pundits; British Exploration of Tibet and Central Asia*. Kentucky: University Press of Kentucky
- Ward Gasque, (1966). *Sir William M. Ramsay: Archaeologist and New Testament Scholar: A Survey of His Contribution to the Study of the New Testament Michigan: Michigan Baker Book House*
- Warner, D. (1994). *Terrestrial Magnetism: For the Glory of God and the Benefit of Mankind*. Osiris 9 pp. 66-84
- Warner, D. (2015) *Seismic Instruments in Geographical Perspective*. In F. MacDonald, and C.W. Withers, (eds).  
*Geography, Technology and Instruments of Exploration*. London: Routledge pp.161-179
- Wess, J. (2015). *Navigation and Mathematics: A Marriage made in the Heavens?* In R.Higgitt, R.Dunn
- P.Jones, (eds).*Navigational Enterprises in Europe and its Empires, 1730–1850*. Basingstoke: Palgrave  
McMillan
- Westfall, R. (1981). *Never at Rest: A Biography of Isaac Newton*. Cambridge: Cambridge University Press
- Widmalm, S. (1990). *Accuracy, Rhetoric, and Technology: The Paris-Greenwich triangulation, 1784-8* In T. Frängsmyr, J. L. Heilbron, and R. E. Rider, (eds). *The Quantifying Spirit in the 18th Century*. Berkeley: University of California Press
- Wise, M. Norton and Smith, C. (1986). *Measurement, Work and Industry in Lord Kelvin's Britain*. *Historical Studies in the Physical and Biological Sciences* 17 (1) pp. 147-173.
- Wise, M. Norton (1995). *Introduction and synthetic essay: Precision: Agent of Unity, Product of Agreement*. In M. Norton Wise (ed). *The Values of Precision* Princeton New Jersey: Princeton University Press. pp. 3-12, 92- 100, 222-235, 352-361
- Wisnicki, A.S. (2008). *Cartographical Quandaries: the Limits of Knowledge Production in Burton's and Speke's Search for the Source of the Nile*. Cambridge: Cambridge University Press
- Wisnicki, A.S. (2010). *Rewriting Agency: Samuel Baker, Bunyoro-Kitara and the Egyptian Slave Trade*. *Studies in Travel Writing* 14(1) pp.1-27



- Withers C.W. (1995). in D. Outram, (ed) *The Enlightenment: New Approaches to European History*. Cambridge: Cambridge University Press
- Withers, C. W. (2002). Constructing 'The Geographical Archive' *Area*. 34(3) pp. 303-311
- Withers, C.W. (2004a). 'Memory and the History of Geographical Knowledge; The Commemoration of Mungo Park, African Explorer' *JHG* 30(4) pp. 316-339
- C.W.Withers (2004b). Mapping The Niger 1798-1832: Trust, Testimony and 'Ocular Demonstration' in the Late Enlightenment. *Imago Mundi* 56(2) pp.170-193
- Withers, C.W. Finnigan, D. and Higgitt, R. (2006) Geography's other histories? Geography and science in the British Association for the Advancement of Science, 1831–c. 1933 *Transactions of the Institute of British Geographers* 31(4) 433-451
- Withers, C. W. (2010a). Geographies of Science and Public Understanding? Exploring the Reception of the British Association for the Advancement of Science in Britain and Ireland, c.1845 – 1900. in P. Meusburger, D. Livingstone and H. Jöns (eds). *Geographies of Science*. New York/Heidelberg: Springer
- Withers, C.W. (2010b). *Geography and Science in Britain, 1831-1939: A study of the British Association for the Advancement of Science*. Manchester: Manchester University Press
- Withers, C. W. (2011a). Geography's Narratives and Intellectual history. In J. A. Agnew and N. Livingstone (eds). *The SAGE handbook of geographical knowledge*. London: Sage Publications pp. 39-51
- Withers, C. W. and Livingstone, D.N. (2011b). Introduction: Thinking Geographically about Nineteenth-Century Science. In *Geographies of Nineteenth-Century Science*. D.N. Livingstone and C.W. Withers (eds) Chicago: University of Chicago Press pp.1-19
- Withers, C.W.J. (2011). Introduction: Practices and Performances. In *Geographies of Nineteenth-Century Science* (eds).Chicago: University of Chicago Press p.149-151
- Withers, C.W. (2013). Science, Scientific Instruments and Questions of Method in Nineteenth-Century British Geography. *Transactions of the Institute of British Geographers* 38(1) pp.167-179
- Withers, C.W. (2017). *Zero Degrees: Geographies of the Prime Meridian*. Cambridge Mass and London: Harvard University Press
- Worboys, M. (2011). Epilogue. In B. Bennett, J. Hodge (eds). *Science and Empire: Knowledge and Networks of Science across the British Empire*. Basingstoke: Palgrave MacMillan
- Wright Gilham, N. (2001). *A Life of Sir Francis Galton: From African Exploration to the Birth of Eugenics*. Oxford: Oxford University Press
- Yeo, R. (1993). *Defining Science: William Whewell, Natural Knowledge and Public Debate in Early Victorian Britain* Cambridge: Cambridge University Press
- Yeo, R. (1985). An Idol of the Market-Place: Baconianism in Nineteenth Century Britain. *History of Science* 23(3) pp. 251–298
- Yeo, R. (2001). *Science in the Public Sphere: Natural Knowledge in British Culture, 1800-60*, London: Ashgate, Variorum series, 2001.
- Young D.M. (1961). *The Colonial Office in the Early 19<sup>th</sup> Century*. Plymouth: Longmans

Youngs, T. (1994). *Travellers in Africa: British Travelogues 1850-1900*. Manchester: Manchester University Press

Youngs, T. (2004). *Africa: Travels, Explorations & Empires 1835-1900*. London: Pickering & Chatto

Youngs, T. (2006). *Travel Writing in the Nineteenth Century: Filling the Blank Spaces*. London: Anthem Press

Youngs, T. (2013). *The Cambridge Introduction to Travel Writing*. Cambridge: Cambridge University Press

## **Extant Instruments**

The extant instruments in the RGS-IBG collection do not correspond exactly to those acquired by the RGS for loan in the period 1830-1930, the latter of which are the subject of the thesis. Those extant instruments positively identified as being within the scope of the thesis have been listed first, and where possible their provenance has been provided. These include instruments acquired for loan even if not actually dispatched. The list is based on the existing catalogue records of the RGS-IBG. Provenance has been added when available.

### **Instruments Acquired for Loan 1830-1930**

#### **Compasses:**

##### **Dry-plate four and a half inch compass by Elliot Bros.,**

Control Number: rgs701115

RGS-IBG Collections [Artefact A 6] (1)

Provenance: The instrument was purchased from Elliot Bros in 1861 for £3 13s 6d. It was used by John Rae in Canada

##### **Two-inch compass by Cary, inscribed with the name Sir Samuel W. Baker**

Control Number: rgs700506

RGS-IBG Collections [Artefact E 1 (4)] (1)

Provenance: This is almost certainly one of a considerable set of instruments purchased for Baker in 1869 to visit the Nile Lakes. In total over £111 was spent.

##### **Two and a half inch prismatic compass by Cary, Inscribed RGS No. 7**

Control Number: rgs701001

RGS-IBG Collections [Artefact E 27] (1)

Provenance: This compass was used by David Livingstone on his last journey in search of the sources of the Nile, 1867-73

##### **Two and a half inch prismatic compass by Elliot Bros., inscribed RGS, No. 6**

Control Number: rgs701312

RGS-IBG Collections [Artefact E 1 (2)] (1)

Provenance: used by W.J. Gill and purchased from him in 1881

**Two and three quarter inch dry plate compass by Elliot Bros.,** Inscribed RGS No. 8

Control Number: rgs701117

RGS-IBG Collections [Artefact A 6 (4)] (1)

Provenance: the compass was bought for £4 from Elliot Bros in 1881. Used by:

Mr. A.R. Colquhoun	China and Burmah	1883-1887
Rev Spotswood Green	British Columbia	1888-1889
Mr. H.T. Watkins	Labrador	1928-1929
Dr. E.B. Worthington	Lake Rudolf Region	1930-1932

**Four inch dry plate four inch prismatic compass by Cary, in leather case,** Inscribed RGS No. 30

Control Number: rgs701215 and rgs700637 (The same instrument has been catalogued twice)

RGS-IBG Collections [Artefact A 6] (1) and [Artefact D 11 (7)] (1)

Provenance: The instrument was purchased from Cary for £4 10s in 1894. Used by:

Mr. H.C. Robinson	New Guinea	1896-1897
Mr. A.L. Fletcher	Siberia	1898-1898
Lt Col F.R. Maunsell	European Turkey	1908-1909
Lt L. Alymer	East Africa	1911-1913
Dr. Vaughan Cornish	Panama	1913-1914
C.B and F.B Pratt	British New Guinea	1919-1923
Major A. Douglas	Expeditionary research Association	1924-1925
Dr. Gordon Thompson	China	1926-

**Four inch dry plate prismatic compass by Cary, in leather case,** Inscribed RGS No. 41

Control Number: rgs701109

RGS-IBG Collections [Artefact A 6] (1)

Provenance: Bought from Cary for 4Gns in 1896. Used by:

Major J.R.L. MacDonald (transferred)	Uganda	1897-1900
Mr. C.P. Chermaye	British Central Africa	1901-1905
Col F.R. Maunsell	Syria	1907-1907
Sir W.M. Ramsay	Asia Minor	1908-1913
Mr. E.W.P. Chimmery	New Guinea	1920-1931
Mr. L.S.B. Leakey	East Africa Rift Valley	1931-1932
Mr. J.H. Martin	North Canada	1932-

**Two inch prismatic compass by Cary, Inscribed RGS No. 12**

Control Number: rgs701311

RGS-IBG Collections [Artefact A 3 (3)] (1)

Provenance: 2 inch compass No 12 was listed as being by Casella. It was purchased for £1 6s for instructional purposes in 1914.

**Prismatic compasses by Cary 35 and 41**

Control Number: rgs700467

RGS-IBG Collections [6.1] (1)

Provenance: The compass listed as 35 was acquired from Cary in 1895. Used by:

Mr. J.E.S. Moore	African Lakes Region	1899-1900
Capt P. Maud R.E.	southern Abyssinia	1902-1903
Mr. W.J. Harding King	Libyan Dessert	1909-1911
Dr. F Oswald	Asia Minor	1911-1912
Mr. J.M. Ainscough	Western China	1913-1914
Capt C.H. B. Grant	Tanganika Territory	1921-1924
Sir W.M. Ramsay	Asia Minor	1925-1925
Mr. Leakey	Kenya	1928-1930

Note; There is no record of a connection with the Imperial British East Africa Company's Expedition up the River Tana in 1889, as stated in the catalogue

Compass 41 is listed as having been purchased from J. Revilliard in 1896. Used by:

Major J.R.L. MacDonald (transferred)	Uganda	1897-1900
Mr. C.P. Chermaye	British Central Africa	1901-1905
Col F.R. Maunsell	Syria	1907-1907
Sir W.M. Ramsay	Asia Minor	1908-1913
Mr. E.W.P. Chimmery	New Guinea	1920-1931
Mr. L.S.B. Leakey	East Africa Rift Valley	Later in 1931-1932

Note; There is a connection with Leakey but not with the Imperial British East Africa Company's Expedition up the River Tana in 1889, as stated in the catalogue

**Two and three quarter inch prismatic compass by Cary, Inscribed RGS No. 51**

Control Number: rgs701310

RGS-IBG Collections [Artefact A 6 (1)] (1)

Provenance: Prismatic compass 51 was acquired from Cary Porter for £1 10s in 1913 and recorded as lost by pupils.

**Two and three quarter inch prismatic compass by Cary, Inscribed RGS No. 54**

Control Number: rgs242748

RGS-IBG Collections [Artefact A 6 (2)] (1)

Provenance: Prismatic compass 54 was acquired from Cary Porter for £1 10s in 1913 and claimed to be lost by pupils.

**Two and a half inch Elliot dry plate compass**

Control Number: rgs701196

RGS-IBG Collections [65] (1)

**Prismatic compass by Cary**

Control Number: rgs700438

RGS-IBG Collections [Artefact E 1 (5)] (1)

Provenance: used by Commander Lovett Cameron on his journey across Africa, 1875

### **Two and a half inch Elliot dry plate compass**

Control Number: rgs701197

RGS-IBG Collections [Artefact A 6] (1)

Provenance: Two Elliot compasses of this size were purchased from Elliot for £4 each in 1881. One of which was used by:

Mr. A.R. Colquhoun	China and Burmah	1883-1887
Rev Spotswood Green	British Columbia	1888-1889
Mr. H.T. Watkins	Labrador	1928-1929
Dr. E.B. Worthington	Lake Rudolf Region	1930-1932

### **Two inch compass by Casella, Inscribed RGS No. 33**

Control Number: rgs701229

RGS-IBG Collections [Artefact A 3 (1)] (1)

Provenance: This instrument was purchased from Casella for £2 14s in 1921 but there is no record of it being lent out.

### **Sextants and Artificial Horizons**

#### **Eight inch sextant by Troughton & Simms, London, and used by Speke in Africa**

Control Number: rgs700659

RGS-IBG Collections [Artefact E 24] (1)

Note: Said to be used by Speke in Africa. A 6 inch sextant was recorded for Burton in 1856 but not an 8 inch sextant.

#### **Eight inch sextant by J. Dalton, Hartlepool, listed as RGS No. 5**

Control Number: rgs700706

RGS-IBG Collections [Artefact E 3] (1)

Provenance: It was used by Livingstone during his final African journey

**Three inch sextant in wooden case by Cary**, inscribed RGS No. 5

Control Number: rgs701136

RGS-IBG Collections [Artefact A 21] (1)

Provenance: The instrument was bought from Cary in 1884 for 8gns. Used by:

Mr. W.S. Bruce	At home	1886-1887
Mr. Jenning Bramley	Wadai	1898-1899
Dr. Mawson	Antarctic Regions	1911-1914

**Box sextant (base only), artificial Horizon (dark glass)**, Control Number: rgs700732

RGS-IBG Collections [Artefact F 11]

Provenance: both belonged to Clements Markham and used by him in Peru. An artificial horizon was bought from Markham in 1879

**Artificial horizon**

Control Number: rgs700658

RGS-IBG Collections [Artefact E 17 (1)] (1)

Provenance: used by Speke in Africa

**Artificial horizon by Cary**, inscribed RGS No. 14

Control Number: rgs701155

RGS-IBG Collections [Artefact A] (1)

Provenance: Ordinary and folding roof artificial horizon was purchased from Cary in 1898 for 6Gns. Used by:

Capt A.F. Towshend	Asia Minor	1903-1905
Mr. W.j. Garnett	China	1907-1908
Dr Mawson	Antarctic Regions	1911-1914
Lt E.W. P. Chinnery	Solomon Islands	1920-1927
mr. H.G. Watkins	Labrador	1928-1929



**Artificial horizon by Cary in wooden box**, inscribed RGS No. 4

Control Number: rgs701160

RGS-IBG Collections [Artefact A 22] (1)

Provenance: The instrument was purchased from Cary in 1905 for £2 10s. It was loaned to Mr. A.H. Harrison for an expedition to arctic America.

**Barometers and Aneroids**

**Two inch aneroid barometer in case by Casella,**

Control Number: rgs700437

RGS-IBG Collections [Artefact E 1 (3)] (1)

Provenance: This is very likely to have been part of a set of instruments purchased in 1872 from Casella for £5 4s for Cameron's Livingstone relief expedition as it is claimed to have been used by Verney Lovett Cameron in Africa.

**Aneroid**

Control Number: rgs700602

RGS-IBG Collections [Artefact G 1 (4)] (1)

Provenance: used by Markham on the Arctic Expedition of 1875-6a set of instruments was purchased for Clement Markham in 1869, and two sets were donated by him in 1873.

**Two inch aneroid barometer by Casella, in case,**

Control Number: rgs700474

RGS-IBG Collections [Artefact E 29 (1)] (1)

Provenance: used by General Gordon in the Sudan, on his survey of the Nile, 1874-76

**One and a half inch aneroid barometer** by Negretti & Zambra, Inscribed RGS No. 1

Control Number: rgs701128

RGS-IBG Collections [Artefact A 3 (9)] (1)

Note: The instrument was purchased from Cary for 3Gns but the date was not recorded

**One and three quarter inch aneroid barometer, by Cary**, Inscribed RGS No. 9

Control Number: rgs701120

RGS-IBG Collections [Artefact A 3 (5)] (1)

Provenance: small aneroid barometer no 9 was bought from Cary for 3Gns and used by Hinks from 1905 for instruction

**Three inch aneroid in wooden frame by Negretti & Zambra, inscribed RGS no 39**

Control Number: rgs242891

RGS-IBG Collections [Artefact E 35] (1)

Provenance: Aneroid 39 is recorded as having been purchased from Cary Porter in 1909 for 6Gns. It was said to have been sold to Philby in 1931. Used by:

Dr. Mawson	Antarctic Regions	1911-1914
Major St.J. Maddox	England for military purposes	1915-1915
Mrs Rosila Forbes	Arabia	1921-1921
Mr. H. St.J. Philby	Northern Arabia	1921-

**Hypsometers**

**Hypsometrical apparatus with two thermometers**

Control Number: rgs700758

RGS-IBG Collections [Artefact E 14] (1)

Provenance: used by Dr Livingstone and subsequently by Commander Lovett Cameron

**Hypsometrical apparatus**

Control Number: rgs700757

RGS-IBG Collections [Artefact E 29 (2)] (1)

Provenance: used by Gordon in the Sudan. A set of instruments was bought for Gordon in 1874

**Hypsometer by Cary, Inscribed RGS No. 17**

Control Number: rgs701159

RGS-IBG Collections [Artefact A 12 (1)] (1)

Note: This instrument was acquired between 1883 and 1891. There is no record of it being loaned out.

**Hypsometer**, Inscribed RGS No. 18

Control Number: rgs701162

RGS-IBG Collections [Artefact A] (1)

Note: As no 17 above

**Hypsometer with three thermometers by Cary**, Inscribed RGS No. 22

Control Number: rgs701108

RGS-IBG Collections [Artefact A 11] (1)

Provenance: It was purchased from Cary for £4 5s by 1886.

Used by:

Mr. C.M. Woodford	New Hebrides	1886-1888
Mr. J. Thomson	Morocco	1888-1888
Mr. A.P. Maudsley	Central America	1890-1892
Capt Picot ISE	Central Asia	1892-1893
Lt Green	Asia Minor	1894-1895
Mr. D. Carruthers	Central Asia	1910-1911
Lt E.W.P. Chinnery	New Guinea	1920-1931

**Hypsometer in leather case by Cary**, Inscribed RGS No. 37

Control Number: rgs242779

RGS-IBG Collections [Artefact A 13 (1)] (1)

Provenance: Purchased from Cary in 1898 for £5. Used by:

Capt H.W. Dowding	South America	1898-1899
Mr. J.J. Harrison	Abyssinia	1899-1900
Rev Thomas Lewis	Congo Region	1902-1906
Mr. W.J. Harding King	Egypt	1908-1909
Mr. E. Hutchins	British East Africa	1909-1914

**Hypsometer by Cary**, Inscribed RGS, No. 40

Control Number: rgs701199

RGS-IBG Collections [Artefact A 13 (2)] (1)

Provenance: This instrument was bought from Cary for £2 in 1904. It was used by Dr. Mersh Strong in New Guinea from 1905 until 1913

**Hypsometer in leather case by Cary Porter, Inscribed RGS No. 44,**

Control Number: rgs242780

RGS-IBG Collections [Artefact A 13 (3)] (1)

Provenance: presented by Mr. Cockburn in 1909. Used by:

Mr. Cockburn's expedition	British East Africa and Abyssinia	1909-
Dr J.W. Gregory	South West China	1922-1922
Major Holt	Iraq	1923-1931

**Thermometers**

**Thermometer** Control Number: rgs700726

RGS-IBG Collections [Artefact E 1 (1)] (1)

Provenance: used by Du Chaillu in Africa. Instruments were purchased for Du Chaillu in 1866

**Two deep sea thermometers**

Control Number: rgs700598

RGS-IBG Collections [Artefact G 10] (1)

Provenance: these thermometers were used in the Arctic expedition of 1875 (the 'Alert') and presented to the RGS Museum in 1918 by Markham.

**Thermometer, base made from a piece of sledge**

Control Number: rgs700651

RGS-IBG Collections [7.0] (1)

Provenance: carried by Commander Markham, 12th May, 1876, in latitude 83 20' 26' N on the Arctic Expedition of 1875-6.

### Maximum and minimum thermometers

Control Number: rgs700513

RGS-IBG Collections [Artefact E 9] (1)

Provenance: used by Joseph Thomson on the R.G.S. Expedition through Masailand, 1883. Thermometers were purchased as part of a set for Joseph Thomson in 1878 and used by him in East Africa in 1883.

### Wet and dry thermometers in wooden case by Cary, RGS No. 6

Control Number: rgs701207

RGS-IBG Collections [Artefact A 33] (1)

Provenance: These were purchased from Cary for £3 in 1885. Used by:

Capt H.W. Dowding	South America	1898-1899
Sir Martin Conway	Bolivia	1901-1902
Mr. R. Glennie	Brazil	1908-1914

### Maximum and Minimum thermometers by Cary, RGS No. 18 and RGS No. 28

Control Number: rgs701203

RGS-IBG Collections [Artefact A 26 (2)] (1)

Provenance: No 18 was bought from Cary in 1897 for £1 17s. No 28 was bought from Cary Porter Ltd in 1912 for £2 10s.

No 18 was used by:

Sir W.M. Conway	Spitzbergen	1897-1897
Rev Thomas Lewis	Angola	1908-1925
Major H.J. Mosshead	Spitzbergen	1927-1927

No 28 was used by:

Mr. A.F. R. Wollaston	New Guinea	1912-1913
-----------------------	------------	-----------

**Ice thermometer by Hicks**

Control Number: rgs700805

RGS-IBG Collections [Artefact G 2] (1)

Provenance: used on the British National Antarctic Expedition, 1901-04

**Maximum and minimum thermometers in case**, Inscribed RGS, No. 30

Control Number: rgs701206

RGS-IBG Collections [Artefact A 10 (4)] (1)

Provenance: these were presented by Lt Col Call in 1926

**Drawing Instruments**

**Box of drawing instruments**

Control Number: rgs700785

RGS-IBG Collections [102.0] (1)

Provenance: The set belonged to Lovett Cameron

**Two Circular Protractors**

Control Number: rgs700649

RGS-IBG Collections [8.0] (1)

Provenance: used by Nares on Arctic expedition, 1875-6

**Six inch diameter circular brass protractor by Cary**, inscribed RGS No. 8

Control Number: rgs701129

RGS-IBG Collections [Artefact B 4] (1)

Provenance: This instrument was purchased from Cary in 1892 for 16s 6d. Used by:

Mr. N.M. Conway	Himalayas	1891-1892?
Sir William MacGregor	New Guinea	1893-1894
Mr. W.A.L. Fletcher	Siberia	1898-1898
Capt C.G. Rowling	Dutch New Guinea	1909-1911
Dr. Gordon Thompson	China	1926-

**Planimeter in case by Elliott Bros.,** Inscribed RGS No. 1

Control Number: rgs701163

RGS-IBG Collections [Artefact A 7 (3)] (1)

Provenance: The instrument was purchased from Elliot Bros in 1896 for £3 13s 6d. Used by:

Mr. T. Gunther	England	1896-1896
Mr. Darbisher	England	1896-1897
Mr. T. Gunther	England	1899-1899
Dr. A.G. Herberloon		1906-1907

**Planimeter in case by Stanley,** Inscribed RGS No. 3

Control Number: rgs242930

RGS-IBG Collections [Artefact A 15 (1)] (1)

Provenance: Purchased from Stanley in 1916 for £3 13s 6d. Used by Col. F.W. Pirrie in 1916 for 'special work'.

**Folding arm vernier protractor by Troughton and Simms,** Inscribed, RGS No. 18

Control Number: rgs701220

RGS-IBG Collections [Artefact A 30] (1)

Provenance: The instrument was presented by Rodd in 1928. There is no record of it being loaned out.

**Length Measurers**

**Small Passometer by Cary, inscribed RGS No. 2**

Control Number: rgs242718

RGS-IBG Collections [Artefact D 11 (6)] (1)

Provenance: Purchased from Cary for £1 15s in 1894. Used by:

Mr. St.G.R. Littledale	Central Asia	1894-1896
------------------------	--------------	-----------

Mr. Jennings Bramley	Arabia	1899-1905
----------------------	--------	-----------

**Passometer by Cary, Inscribed RGS No. 3**

Control Number: rgs701151

RGS-IBG Collections [Artefact A 3 (4)] (1)

Provenance: The instrument has the same provenance as no 2 above

**Large leather cased Chesterman Constantia 100m linen tape measure, Inscribed RGS No. 13**

Control Number: rgs701185

RGS-IBG Collections [Artefact A 28 (1)] (1)

Provenance: The instrument was purchased from Sir George Newnes for £3 in 1902 and used by Captain Colbeck in the Arctic Relief expedition of 1902-4

**Four inch Trocheameter by Cary in metal tin,**

Control Number: rgs700999

RGS-IBG Collections [2] (1)

Provenance: purchased from Cary in April 1904 for £2 5s for Professor Ramsay to use in Asia Minor in 1904, 1905 and 1906

**Eight inch Trocheameter by Cary in metal tin,**

Control Number: rgs701000

RGS-IBG Collections [3] (1)



Provenance: purchased from Cary in April 1904 for £2 5s for Professor Ramsay for use in Asia Minor in 1904, 1905 and 1906

### **Alidades**

**Alidade by Cary**, Inscribed RGS No. 15

Control Number: rgs701224

RGS-IBG Collections [Artefact A 7 (1)] (1)

Provenance: This is likely to be the alidade for plane table number 15. In which case it was purchased from Cary in 1898 for £7 15s and used by:

Sir W.M. Conway	South America	1898-1899
Mr. A.Silva White	Libyan Dessert	1899-1900
Dr. Workman	Himalyas	1902-1902
Mr. G.W. Bury	Arabia	1908-1909
Kingdom Ward	North East Indian trans-frontier Region	1913-1923

### **Reeves folding telescopic alidade**

Control Number: rgs701246

RGS-IBG Collections [Artefact A 35] (1)

### **Reeves folding telescopic alidade**

Control Number: rgs701245

RGS-IBG Collections [23] (1)

### **Reeves folding telescopic alidade**

Control Number: rgs701156

RGS-IBG Collections [705] (1)

Provenance: two alidades were recorded as being acquired, one was purchased from Casella for £32 in 1909, a second was presented in 1910 by Cockburn. The first was used by:

Capt C.G. Rawling	Dutch New Guinea	1909-1911
Dr. Mawson	Antarctic Regions	1911-1914

**Other Types of Instrument**

**Abney level by Cary, Inscribed RGS, No. 3**

Control Number: rgs701208

RGS-IBG Collections [Artefact A 10 (1)] (1)

Note: The instrument was purchased from Cary in 1892 for 2Gns

**Anemometer by Cary, inscribed RGS, No. 1**

Control Number: rgs243997

RGS-IBG Collections [Artefact A] (1)

Provenance: Purchased from Cary for 5Gns in 1880. Used by Dr. Peden in East Africa 1880-1887 but returned broken by Dr. Milne of Blantyre.

**Anemometer by Cary, inscribed RGS No. 2**

Control Number: rgs243985

RGS-IBG Collections [Artefact A] (1)

Provenance: The instrument was purchased from Cary for 5Gns in 1885. Used by:

Mr. J.T. Last	RGS East African expedition	1885-1887
Mr. W.J. Harding King	Egypt	1908-1909
Mr. S.K. Hutton	Labrador	1911-1914

**Two foot Telescope by J. Hammersley, 1900**

Control Number: rgs700711

RGS-IBG Collections [Artefact G 28] (1)

Note: Used on the National Antarctic Expedition, 1901-04

**Sand glass (25 seconds) in metal case inscribed RGS No.2**

Control Number: rgs701235

RGS-IBG Collections [Artefact A] (1)

Provenance: Time glass number 2 was presented by the Royal Niger Company in 1900

**Station pointer**

Control Number: rgs701244

RGS-IBG Collections [2] (1)

Note: Three station pointers were acquired between 1899 and 1912

**Station pointer in wooden box**

Control Number: rgs701252

RGS-IBG Collections [3] (1)

Note: Three station pointers were acquired between 1899 and 1912

**Wild photo-theodolite in 3 boxes, Inscribed RGS No. 1**

Control Number: rgs701255

RGS-IBG Collections [Artefact A] (1)

Note: Purchased from Wild in 1926 for £98.10s

**Wild photo-theodoite**

Control Number: rgs701258

RGS-IBG Collections [809] (1)

Note: A second theodolite was purchased in 1926 for £305. This was used by:

Major Kenneth Mason	north West Indian frontier	1926-1927
	Boundary expedition	1927-1927
Mr. R. van R Woolley	Drakenberg expedition	1928-1929

Connington Swirl

## **Instruments Listed as Acquired 1830-1930 but not for Loan**

### **Planimeter in case by Stanley, Inscribed RGS No. 4**

Control Number: rgs242751

RGS-IBG Collections [Artefact A 7 (4)] (1)

Provenance: Purchased from Stanley in 1916 for £3 13s 6d. Presumably used in the map room

### **Reeves diagonal scale No. 1**

Control Number: rgs701179

RGS-IBG Collections [21.0] (1)

Provenance: The instrument was purchased from Cary for £5 in 1892 for the Draughtsman's office.

### **Reeves proportional dividers**

Control Number: rgs701221

RGS-IBG Collections [Artefact A 3] (1)

Note: five Reeves proportional dividers were purchased from Casella in 1912 and 1918. They were not lent out so presumably they were for the drawing office

### **Barograph B.M.O. by Casella**

Control Number: rgs701302

RGS-IBG Collections [Artefact A 32] (1)

Note: Two barographs were acquired from Casella, one was located in the entrance hall and the other was purchased for £10 in 1927. The second was used by:

Mr F.Rodd	Sahara	1927-1928
Mr. J.M. Wordie	Greenland	1929-1929

## **Instruments Not Specifically Identifiable as Within the Scope of the Thesis**

### **Compasses**

**Compass** Control Number: rgs700594

RGS-IBG Collections [Artefact G 1 (6)] (1)

Provenance: presented by Robert M'Cormick, R.N. William Parry is said to have worn it in conducting the expedition over the ice towards to North Pole, in 1827

**Small compass in wooden case**

Control Number: K234422

RGS-IBG Collections [Artefact G 1 (11)] (1)

Provenance: Said to have been used by Dr David Lyall during the Antarctic expedition of Erebus and Terror, 1839-43 under the command of James Clark Ross

**Small compass in wooden case**, Control Number: rgs700509

RGS-IBG Collections [Artefact G 1 (5)] (1)

Note: Within the case is written 'Omne tulit punctum' from Horace's 'Ars Poetica'

Provenance: given to Sir Clements Markham in 1844 when he first went to sea by Dr S. Goodenough.

**Boat's compass**

Control Number: rgs700630

RGS-IBG Collections [Artefact E/213] (1)

Note: Said to be used by Livingstone on his first journey down the Zambezi Valley in 1856. Several instruments were provided for Livingstone but there is no record of this compass

**Boat's Compass**

Control Number: rgs701127

RGS-IBG Collections [Artefact A 2.1] (1)

**Ship's Compass**

Control Number: rgs701152

RGS-IBG Collections [25.0] (1)

### **Ship's Compass**

Control Number: rgs701167

RGS-IBG Collections [25.0] (1)

Note: Associated with the Antarctic expedition of 1901-4

### **Pocket compass**

Control Number: rgs700466

RGS-IBG Collections [Artefact D 1] (1)

Provenance: carried by Ney Elias on his journeys in China

### **Compass**

Control Number: rgs700605

RGS-IBG Collections [Artefact D] (1)

Provenance: used by Rich during his travels in the Middle East

### **Prismatic compass**

Control Number: rgs700603

RGS-IBG Collections [9.1] (1)

Provenance: used by Holdich. A number of instruments were recorded as having been used by Holdich, but not a compass

### **Four inch dry plate Prismatic compass by Elliott Bros., RGS No. 42**

Control Number: K233816

RGS-IBG Collections [Artefact A 6] (1)

Note: A smaller prismatic compass with the number 42 was presented by the Royal Niger Company in 1900

### **Compass, 954**

Control Number: rgs242747

RGS-IBG Collections [Artefact A 3] (1)

**Two and a half inch dry plate compass in box, RGS no 65**

Control Number: rgs701116

RGS-IBG Collections [5] (1)

Note: this instrument was purchased after 1930.

**Two and a half inch dry plate Compass**

Control Number: rgs701118

RGS-IBG Collections [68] (1)

**Two and three quarter inch prismatic compass and clinometer by J. H. Steward,  
Inscribed RGS No. 70**

Control Number: rgs701122

RGS-IBG Collections [Artefact A 6 (3)] (1)

Note: This instrument was purchased after 1930

**Compass**

Control Number: rgs701131

RGS-IBG Collections [66] (1)

**Astro compass (AM).6.A/1174**

Control Number: rgs701174

RGS-IBG Collections [17.0] (1)

**Astro Compass**

Control Number: rgs701182

RGS-IBG Collections [17.0] (1)

**Astro Compass**

Control Number: rgs701183

RGS-IBG Collections [17.0] (1)

**Two and a quarter inch Creagh-Osborne lensatic compass, by H. Hughes & Co.,**  
Inscribed RGS, No. 2

Control Number: rgs701217

RGS-IBG Collections [Artefact A 3 (2)] (1)

**Compass, dry plate**

Control Number: rgs701232

RGS-IBG Collections [Artefact A 3] (1)

**Compass, with box**

Control Number: rgs701233

RGS-IBG Collections [20.1] (1)

**Prismatic compass**

Control Number: rgs701237

RGS-IBG Collections [Artefact A 3] (1)

**Japanese compass in wooden case**

Control Number: rgs700458

RGS-IBG Collections [Artefact D 11 (1)] (1)

**Compass made by Stanley, with spirit levels**

Control Number: rgs701309

RGS-IBG Collections [20.1] (1)

**Ten trough compasses** of different makes and sizes



Control Number: rgs701313

RGS-IBG Collections [Artefact A 3] (1)

.

### **Sextants and Artificial Horizons**

#### **Charles Darwin's box sextant**

Control Number: rgs700695

RGS-IBG Collections [Artefact F 14] (1)

Note: carried on the voyage of H.M.S. 'Beagle', 1831-36 by Fitzroy, Robert.

#### **Box sextant**

Control Number: rgs700977

RGS-IBG Collections [11.1] (1)

Provenance: awarded to Cadet J.F.D. Donnelly RMA Woolwich, 1852

#### **Box sextant**

Control Number: rgs700696

RGS-IBG Collections [Artefact F 1 (7)] (1)

Provenance: used by Octavius C. Stone in Papua New Guinea, 1870

#### **Box sextant with telescope**

Control Number: rgs233582

RGS-IBG Collections [Artefact D] (1)

Provenance: used by Rich during his travels in the Middle East

#### **Six inch sextant in wooden box by Henry Hughes,**

Control Number: rgs700646

RGS-IBG Collections [Artefact E 37] (1)

Note: Said to be used by Grenfell in the Congo. A six inch sextant by Cary was used by Grenfell in the Congo, but a sextant by Hughes is not recorded

**Box sextant**

Control Number: rgs701214

RGS-IBG Collections [Artefact A 5] (1)

Note: awarded to Richard H. Stotherd

**Box sextant by Bass**

Control Number: rgs700697

RGS-IBG Collections [4.1] (1)

Provenance: used during the construction of the Nairobi railway in 1900

**George's double sextant by Cary no 34**

Control Number: rgs701114

RGS-IBG Collections [34] (1)

**Sextant by Heath & Co. Ltd**

Control Number: rgs701201

RGS-IBG Collections [Artefact B 5] (1)

Note: No instruments by Heath were recorded before 1930

**Heath seven inch navigational sextant in wooden box, Inscribed RGS No. 2**

Control Number: rgs701308

RGS-IBG Collections [Artefact B 6] (1)

Note: As above

**Six and a half inch sextant**

Control Number: rgs701305

RGS-IBG Collections [850] (1)

**Bubble sextant: Mark IX**

by -- Henry Hughes and Son Ltd

Control Number: K701434

RGS-IBG Collections [Artefact A] (1)

**Telescopic eyepiece of a sextant,**

Control Number: rgs700727

RGS-IBG Collections [Artefact G 1 (2)] (1)

Provenance: left by Roald Admundsen at the South Pole and found by Robert Falcon Scott

**Artificial horizon in a wooden carrying box**

Control Number: rgs700998

RGS-IBG Collections [Artefact B] (1)

**George artificial horizon by Cary with mercury, no 66**

Control Number: rgs701130

RGS-IBG Collections [66] (1)

Note; this instrument was purchased after 1930.

**Artificial horizon without mercury**

Control Number: rgs701202

RGS-IBG Collections [5] (1)

**Barometers and Aneroids**

**Aneroid barometer**

Control Number: rgs700635

RGS-IBG Collections [Artefact D 11 (3)] (1)

Provenance: used by Doughty in Arabia, 1876-78

**One and three quarter inch aneroid barometer by Cary**, Inscribed RGS No. 110

Control Number: rgs701194

RGS-IBG Collections [Artefact A 3 (6)] (1)

Note: The instrument was acquired after 1930

**One and a half inch aneroid barometer by L. Casella**, Inscribed RGS No. 21

Control Number: rgs701242

RGS-IBG Collections [Artefact A 3 (8)] (1)

Note: The instrument was acquired after 1930

**Marine barometer 2430 by Patrick Adie**, Inscribed RGS No. 1

Control Number: rgs242736

RGS-IBG Collections [Artefact A 6] (1)

Provenance: The instrument was purchased from Sir George Newnes for £3 in 1902 and used by Captain Colbeck in the Arctic Relief expedition of 1902-4

**Aneroid**

Control Number: rgs700465

RGS-IBG Collections [Artefact F 1 (3)] (1)

Note: Said to be used by Fawcett in Brazil in 1924 but not recorded as being lent to him

**One and a half inch aneroid by Cary**, Inscribed RGS No. 5

Control Number: rgs701195

RGS-IBG Collections [Artefact A 3](1)

Note: The instrument was acquired after 1930

**Surveying Aneroid Altimeter A458**

Control Number: rgs701171

RGS-IBG Collections [2] (1)

## **Hypsometers**

### **Hypsometer in leather case**

Control Number: rgs701198

RGS-IBG Collections [22.0] (1)

### **Horizontal hypsometer by Elliot Bros.**

Control Number: rgs701200

RGS-IBG Collections [Artefact A 14] (1)

### **Spirit burner for use with hypsometer**

Control Number: rgs701132

RGS-IBG Collections [Artefact A 12 (2)] (1)

## **Thermometers**

### **Wet and dry Bulb Thermometer**

Control Number: rgs701175

RGS-IBG Collections [1] (1)

### **Maximum and minimum thermometers by Casella, (49195 and 49169)**

Control Number: rgs701204

RGS-IBG Collections [Artefact A 10 (3)] (1)

Note: The serial numbers indicate a date after 1930

### **Deep sea thermometer by Negretti and Zambra, Inscribed RGS No. 1**

Control Number: rgs701223

RGS-IBG Collections [Artefact A] (1)

**Maximum and Minimum thermometers and visiting card**

Control Number: rgs700444

RGS-IBG Collections [13.2] (1)

Note: left on the summit of Aconcagua by Mr W.S.M. Vines of the Fitzgerald expedition

**Maximum and minimum thermometers by Casella, in wooden case**, Inscribed RGS No. 43

Control Number: rgs701230

RGS-IBG Collections [Artefact A] (1)

Note: These were acquired after 1930

**Maximum and minimum thermometers by Casella**, Inscribed RGS No. 45

Control Number: rgs701205

RGS-IBG Collections [Artefact A 10 (2)] (1)

Note: These date from after 1930

**Metal cased thermometer**. Inscribed RGS, No. 104

Control Number: rgs701260

RGS-IBG Collections [Artefact A 7 (2)] (1)

**Drawing Instruments**

**Ruler**

Control Number: rgs700542

RGS-IBG Collections [6.0] (1)

Provenance: used by J. Rebmann in preparing his map of East Africa in 1856

**Standard scale by John Walker**

Control Number: rgs700639

RGS-IBG Collections [221] (1)

Provenance: used by John Walker in the construction of the Indian Atlas

**Pair of dividers**

Control Number: rgs701126

RGS-IBG Collections [Artefact A 3] (1)

**Protractor**

Control Number: rgs700910

RGS-IBG Collections [13.2] (1)

Note: used by Hamilton-Rice and given to Wilson at Manaus in 1910

**Beam Compass**

Control Number: rgs701240

RGS-IBG Collections [20.3] (1)

**Cary 180° brass protractor in box**

Control Number: rgs701243

RGS-IBG Collections [793] (1)

**Draughtsman's scale and setsquare box**

Control Number: rgs701218

RGS-IBG Collections [3] (1)

**Draughtsman's scale and setsquare box**

Control Number: rgs701219

RGS-IBG Collections [4] (1)

**Camera Lucida by Troughton & Sims, Inscribed RGS, No. 1**

Control Number: rgs701125

RGS-IBG Collections [Artefact A 26 (1)] (1)

Provenance: The instrument was presented by Rodd in 1928

### **Six boxes of Drawing Instruments**

Control Number: rgs701301

RGS-IBG Collections [Artefact A 9 (B23/01A+01E)] (1)

Provenance: previously used in RGS Drawing Office. Moved to Museum in 1993

### **Sundials 1800 onwards**

#### **Sundial invented by Loftus**

Control Number: rgs700656

RGS-IBG Collections [238] (1)

#### **Chinese sundial of the Nuremberg pattern**

Control Number: rgs700679

RGS-IBG Collections [Artefact D 11 (2)] (1)

Note: catalogue records the compass was used by a Chinese junk arriving at Hong Kong from Australia in September 1883, having passed through the straits of Sunda at the time of the Krakatoa eruption

#### **Japanese dial**

Control Number: rgs700680

RGS-IBG Collections [10.2] (1)

Note: with letter from Mr. Weston of October 19, 1927 to Mr. Reynolds

#### **Portable sundial and compass in box, by Negretti & Zambra**

Control Number: rgs700996

RGS-IBG Collections [1] (1)

Provenance: Presented by Rodd April 14, 1928



### **Original sun compass**

Control Number: rgs701157

RGS-IBG Collections [706] (1)

**Reeves patent astronomical compass in leather case**, inscribed RGS No. 61 by Reeves, E. A.

Control Number: rgs701168

RGS-IBG Collections [Artefact A 29] (1)

Note: This was purchased after 1930

### **Cole Universal Sun Compass Mk 3**.in black box

Control Number: rgs701306

RGS-IBG Collections [Artefact E/851] (1)

Note; box labelled "Property of Col. H.W. Mirehouse c/o Royal Geographical Society. Presented to him by the inventor, J. Cole Esq. - Survey of Egypt, Cairo 1942."

### **Howard pattern sun compass in green painted box**

Control Number: rgs232775

RGS-IBG Collections [Artefact E 15] (1)

### **Levels and Clinometers**

#### **Watkin clinometer in leather case**

Control Number: rgs700601

RGS-IBG Collections [Artefact D 11 (4)] (1)

Provenance: used by Shakespear in Arabia

**Niveau de Poche de Mr Chairgrasse, Dijon**. Brass instrument in wooden box. (pocket level)

by Chairgrasse (Mr);

Control Number: rgs701004

RGS-IBG Collections [13.0] (1)

**Indian clinometer**

Control Number: rgs701133

RGS-IBG Collections [869] (1)

**Troughton & Simms Surveyors Level & Compass**

Control Number: K232275

RGS-IBG Collections [Artefact C] (1)

**Clinazimter**

Control Number: rgs701119

RGS-IBG Collections [1] (1)

**Steward Clinometer**

Control Number: rgs701166

RGS-IBG Collections [715] (1)

Note: Associated with an expedition by Hugh John Llewellyn Beadnell in 1921 to Sinai

**Half clinometer, 1395514**

Control Number: rgs701236

RGS-IBG Collections [19.1] (1)

**Clinometer (Indian pattern) made by T. Cooke & Sons, Inscribed RGS No. 12**

Control Number: rgs701234

RGS-IBG Collections [Artefact A 25] (1)

**"Buck" astronomical Abney level, inscribed RGS, No.13**

Control Number: K233962

RGS-IBG Collections [Artefact A] (1)

**Tangent clinometer by J. Casartelli and Son, No. 869 1919**, Inscribed RGS No. 14

Control Number: rgs242720

RGS-IBG Collections [Artefact A] (1)

Note: Acquired after 1930

**Clinometer, service pattern, in leather case**

Control Number: rgs701225

RGS-IBG Collections [19.1] (1)

**Cary clinometer and compass, with telescope**

Control Number: rgs701209

RGS-IBG Collections [1] (1)

**Abney level**

Control Number: rgs701172

RGS-IBG Collections [Artefact A 5 (4)] (1)

**Abney level in leather case**, Inscribed RGS No. 21

Control Number: rgs701173

RGS-IBG Collections [Artefact A 5] (1)

Note: This was purchased after 1930

**Theodolites**

**The Gill Memorial 1913 in the form of a three inch theodolite**

Control Number: rgs700617

RGS-IBG Collections [Artefact D 3] (1)

Note: awarded to Gertrude Bell

**Theodolite by Sanderson**

Control Number: rgs700913

RGS-IBG Collections [465] (1)

**Three inch Theodolite**

Control Number: rgs701158

RGS-IBG Collections [3] (1)

**Theodolite by Cox**

Control Number: rgs700881

RGS-IBG Collections [12.0] (1)

Provenance: used by Kitchener during his survey of Cyprus in 1882

**Watts Three and a quarter inch Theodolite. No. 16122 (3/7/35), in leather case**

Control Number: rgs701303

RGS-IBG Collections [20] (1)

**Watts three and a quarter inch Theodolite (No. 18568), Inscribed RGS No. 25**

Control Number: rgs701304

RGS-IBG Collections [Artefact B] (1)

Note: These instruments were acquired after 1930

**Zeiss theodolite 40591**

Control Number: rgs701257

RGS-IBG Collections [808] (1)

**Telescopes**

**Richard Lander's two foot telescope**

Control Number: rgs700558

RGS-IBG Collections [Artefact E 8] (1)

Note: given to him by W.M.G. Colebrooke

### **Telescope one foot with leather case**

Control Number: rgs700749

RGS-IBG Collections [102.0] (1 (1))

Provenance: belonging to Galton and used by him in his exploration of Damaraland in 1850

### **Length Measurement**

**Measuring tape** Control Number: rgs700606

RGS-IBG Collections [Artefact D 1] (1)

Provenance: used by Sven Hedin in central Asia, 1901

### **Pedometer in leather case**

Control Number: rgs239731

RGS-IBG Collections [Artefact D 22 (2)] (1)

Provenance: used by Sir Mark Aurel Stein and given to Ida May Brown

### **Small leather cased Chesterman 100 ft metal tape measure**

Control Number: rgs701314

RGS-IBG Collections [Artefact A 28 (2)] (1)

### **Calculation**

#### **Three Slide rules**

Control Number: rgs701164

RGS-IBG Collections [Artefact A 8] (1)

### **Air Temperature Scale**

Control Number: rgs701153

RGS-IBG Collections [3] (1)

**Double Brunsviga calculator 33217**

Control Number: rgs701248

RGS-IBG Collections [798] (1)

**Single Facit calculator**

Control Number: rgs701249

RGS-IBG Collections [799] (1)

**Everest Calculator**

Control Number: rgs701250

RGS-IBG Collections [800] (1)

Note: associated with the Swiss Foundation for Alpine Research.

**Calculator by Barrett**

Control Number: rgs701251

RGS-IBG Collections [801] (1)

**Curta non-electronic pocket calculator**

Control Number: rgs701213

RGS-IBG Collections [Artefact A 5] (1)

**Slide rule**

Control Number: rgs701228

RGS-IBG Collections [Artefact A 4] (1)

**Meteorological slide rule**

Control Number: rgs701227

RGS-IBG Collections [26.0] (1)

**Wind speed indicator**

Control Number: rgs701176

RGS-IBG Collections [1] (1)

**Watches and Stop Watches**

**Stop-watch**

Control Number: rgs701146

RGS-IBG Collections [Artefact A 3] (1)

**Stop-watch, AM6B - 117**

Control Number: rgs701147

RGS-IBG Collections [Artefact A 3] (1)

**Pocket watch, Elgin 3593**

Control Number: rgs701148

RGS-IBG Collections [Artefact A 3] (1)

**Pocket watch, HS 85887**

Control Number: rgs701149

RGS-IBG Collections [26.1] (1)

**Pocket watch, Elgin 40631410**

Control Number: rgs701150

RGS-IBG Collections [26.1] (1)

### **Altimeters**

**Altimeter** Casella No. 10775

Control Number: rgs701121

RGS-IBG Collections [58] (1)

Provenance: this instrument was purchased from Casella for £4 10s for the Mt Karmel expedition in 1931

### **Four altimeters by Fuchs**

Control Number: rgs701181

RGS-IBG Collections [7.0] (1)

Provenance: from Trans Antarctic Expedition, 1958

### **Watkin four and a half inch altimeter**

Control Number: rgs701187

RGS-IBG Collections [Artefact A 5 (1)] (1)

### **Watkin three inch altimeter**

Control Number: rgs701188

RGS-IBG Collections [102] (1)

### **Watkin three inch altimeter**

Control Number: rgs701189

RGS-IBG Collections [122] (1)

### **Watkin three inch altimeter**

Control Number: rgs701190

RGS-IBG Collections [104] (1)

### **Watkin three inch altimeter**



Control Number: rgs701191

RGS-IBG Collections [404] (1)

Note: These altimeters could be the Watkins new patent aneroids purchased for £6 each from J. Hicks in 1889.

**Three inch Paulin altimeter (in leather case),**

Control Number: rgs701193

RGS-IBG Collections [Artefact A 5 (2)] (1)

Note: Ten Paulin altimeters were purchased between 1928 and 1930 from Paulin in Stockholm

**Three inch Paulin altimeter made in Sweden by C.E. Johansson, RGS no. 9**

Control Number: rgs701192

RGS-IBG Collections [Artefact E 36] (1)

**Steward altimeter, case no. 462**

Control Number: rgs701226

RGS-IBG Collections [460] (1)

Provenance: used by Smythe in the Himalayas, 1931

**Telemeters**

**Telemeter**

Control Number: rgs701261

RGS-IBG Collections [Artefact A 5 (5)] (1)

**Telemeter**

Control Number: rgs701111

RGS-IBG Collections [Artefact A 5 (7)] (1)

**Telemeter,**

Control Number: rgs701123

RGS-IBG Collections [Artefact A 5 (6)] (1)

## **Alidades and Sight-Rules**

### **Sight rule**

Control Number: rgs701154

RGS-IBG Collections [5] (1)

### **Sight Rule, US**

Control Number: rgs701161

RGS-IBG Collections [26.0] (1)

### **Alidade**

Control Number: rgs701247

RGS-IBG Collections [24] (1)

## **Other Types of Instrument**

### **Self- recording barograph, by Short and Mason, H.O. 16., M.O. 11**

Control Number: rgs701012

RGS-IBG Collections [Artefact G 37] (1)

Note: there is no record of this instrument in the archives although the catalogue states it was used on National Antarctic Expedition, 1901-04

### **Binoculars in leather case**

Control Number: rgs701169

RGS-IBG Collections [Artefact D] (1)

### **Sinclair Range Finder No. 424**

Control Number: rgs701170

RGS-IBG Collections [1] (1)

**Artillery circle**

Control Number: rgs701180

RGS-IBG Collections [17.0] (1)

**Heliograph**

Control Number: rgs701184

RGS-IBG Collections [21.0] (1)

**ERWS Micrometer**

Control Number: rgs701222

RGS-IBG Collections [21.0] (1)

**Map counter and revolution counter in brass**

Control Number: rgs701231

RGS-IBG Collections [Artefact A 3] (1)

**Universal 'Setometer' in leather case made by E. F. Buchi, Inscribed RGS No. 1**

Control Number: rgs701262

RGS-IBG Collections [Artefact A 3 (7)] (1)

Note: The instrument was presented by Buchi in 1923

**Anemometer by Negretti and Zambra**

Control Number: rgs243991

RGS-IBG Collections [Artefact A] (1)

Note: No anemometers by Negretti and Zambra were recorded as being acquired 1830-1930

**Lendy's Patent Topograph in leather case with instructions on use, dated Dec 1864**

Control Number: rgs701002

RGS-IBG Collections [Artefact A 27 (1)] (1)

Note: The topograph is a wooden board incorporating a prismatic compass, a plane table with sight ruler, and a clinometer

#### **Instruments Made Before 1800**

##### **Pocket dial, adjustable gnomon with table of latitudes, Gunter's Quadrant (broken) and nocturnal by Wiseman; F.**

Control Number: rgs700515

RGS-IBG Collections [Artefact A 1 (3)] (1)

Note: These types of instrument were popular in the 17<sup>th</sup> and 18<sup>th</sup> centuries but not lent out in the 19<sup>th</sup> or 20<sup>th</sup> centuries

##### **Ruler**

Control Number: rgs700547

RGS-IBG Collections [105.0] (1)

Note: made from wood of one of the canoes in Champlain's Expedition, 1609

##### **Orrery**

Control Number: rgs700652

RGS-IBG Collections [14.0] (1)

Note: probably dates from the late 18<sup>th</sup> century

##### **Italian astrolabe from about 1500 A.D**

Control Number: rgs700699

RGS-IBG Collections [Artefact A 1 (1)] (1)

##### **Davis' quadrant, and back staff**

Control Number: rgs700700

RGS-IBG Collections [Artefact A] (1)

##### **Hadley's quadrant with diagonal scale for reading the angles**

Control Number: rgs700702

RGS-IBG Collections [281] (1)

**Hadley's quadrant with vernier for reading the angles**

Control Number: rgs700703

RGS-IBG Collections [282] (1)

Note; there is no record of the RGS using a Hadley's quadrant

**Pocket sundial by Butterfield,**

Control Number: rgs700883

RGS-IBG Collections [Artefact A 3] (1)

**Universal pocket sundial, made by Vogue, (1766-1808)**

Control Number: rgs700948

RGS-IBG Collections [Artefact A 3 (10)] (1)

**Portable sundial and compass in leather case, made by G. Adams, London, Undated**

Control Number: rgs700997

RGS-IBG Collections [2] (1)

**Wooden quadrant with Arabic script**

Control Number: rgs701051

RGS-IBG Collections [Artefact A 1 (2)] (1)

**Theodolite by Dixon**

Control Number: rgs700681

RGS-IBG Collections [261] (1)

Note: believed to have been used by Jeremiah Dixon in the Mason-Dixon survey of the Maryland-Pennsylvania boundary 1763-69

**Two slide rules; made by Henry Balden, 1756**

Control Number: rgs700613

RGS-IBG Collections [Artefact F 3] (1)

**Miscellaneous**

**Part of the line** used by Dr Livingstone to sound the River Chobe

Control Number: rgs700936

RGS-IBG Collections [Artefact E 12] (1)

**Protractor in German silver, by Troughton and Simms b) Pendulum level c) Lead plumb bob. d) Prismatic Compass**

Control Number: rgs700568

RGS-IBG Collections [11.1] (1)

Provenance: these belonged to William Petrie, and after to W.M. Flinders Petrie, explorer.

**Prism, 90°**

Control Number: rgs701112

RGS-IBG Collections [1] (1)

**Prism, 90<sup>0</sup>**

Control Number: rgs701113

RGS-IBG Collections [23.1] (1)

**Planimeter board**

Control Number: rgs701178

RGS-IBG Collections [23.0] (1)

Note; Tied to the arm so that maps could be made in transit

**Wrist map board**

Control Number: rgs701177

RGS-IBG Collections [553] (1)

Note: As above

**Tripod for 3 inch Scott theodolite**

Control Number: rgs701253

RGS-IBG Collections [803] (1)

**Tripod for heliograph**

Control Number: rgs701254

RGS-IBG Collections [805] (1)

**Kamal** [nautical navigational] instrument used by Maldives islanders

Control Number: rgs700759

RGS-IBG Collections [Artefact E 39] (1)

Note: doubled length of irregularly knotted string with two wooden 'tablets'; associated with MacKinnon

**1) Clinical thermometer. 2) Measuring tape, 66 feet woven**

Control Number: rgs700618

RGS-IBG Collections [Artefact E 38] (1)

Note; associated with Robert Felkin

**Collimating eye-piece made by Mr Bolton and b) silvered discs of glass in a round tin**

Control Number: rgs700421

RGS-IBG Collections [501] (1)

Note: forwarded to General Walker of Survey of India, April 29 1889, then donated with sketches, now in archives

**Compass (needle missing) and clinometer with rotating telescope**

Control Number: rgs700701

RGS-IBG Collections [11.4] (1)