ROBERT HOOKE, CITY SURVEYOR

An assessment of the importance of his work as Surveyor for the City of London in the aftermath (1667-74) of the Great Fire

Michael Alan Ralph Cooper

Submitted for the award of Doctor of Philosophy

City University, London
Department of Civil Engineering

May 1999

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

ACKNOWLEDGEMENTS

The idea that research into Hooke's surveying might be interesting had been with me since I wrote about Edward Worsop and his book in 1993.[1] The idea became an intention following a challenging talk on Hooke at City University by the late Edmund Hambly when he was President of the Institution of Civil Engineers. Research was then made possible by a grant from Gresham College to City University which enabled me to take sabbatical leave. I am grateful to the Academic Board and the Chairman and Council of Gresham College without whose financial support this work could not have been undertaken.

Fully aware that I was intending to enter an area of scholarship that was new to me I sought assurances that what I planned to do had not already been done and was worth doing. I consulted Michael Hunter, Vanessa Harding and Derek Keene about my intentions. I had found their work particularly helpful in my preparatory reading about the Royal Society and London in Hooke's time. I hope they now think the courteous encouragement they gave was not misplaced. I also acknowledge with particular gratitude and affection the advice and support given me by the late Peter Nailor, when Provost of Gresham College and suffering from his final illness. Ann Saunders was willing to answer all my questions on London, sometimes before I realised I should ask them. Assistance from Richard Bowden and Peter Evans in extracting specific data from the archives is acknowledged. James Sewell and staff at the Corporation of London Records Office, Ralph Hyde and staff at the Guildhall Library Manuscripts Department, Mary Sampson at the Royal Society Library, Ursula Carlisle at the Mercers' Company Archives and my colleagues in the Library at City University (particularly Peter Williams with inter-library loans) were very helpful over a long period. Maggie Butcher, now Academic Registrar at Gresham College, was a valued link with the College during my sabbatical leave. My Advisor, Jim Bennett, in reading drafts of this dissertation and discussing them with subtle

---

1 Cooper, M.A.R. "Edward Worsop; from the Black Art and Sundrie Errours to True Geometricall Demonstration" *Survey Review* 32(248) pp.67-79 (April 1993).

and constructive criticism has given generously of his time and knowledge of seventeenth-century experimental philosophy. I have received much encouragement before, during and after the research for this dissertation through Jennifer Cooper's good humour and steadfast forbearance.

DECLARATION

I hereby authorise the Librarian of City University to exercise discretion before making available a copy of all or part of this thesis to a particular individual applicant who intends to use it subject to the usual form of acknowledgement solely for personal research and scholarship.

ABSTRACT

A review of what has been published so far on Hooke's work as Surveyor to the City of London in the aftermath (1666-1674) of the Great Fire shows that what he did has not been subjected to detailed investigation and that the mainly incidental references in the literature to his work as Surveyor are generally brief, sometimes misleading, and occasionally wrong.

Some light has been brought to this lacuna in the life of one of the greatest figures in scientific and civic life of seventeenth-century London mainly through research into the archives of the Corporation of London Records Office. They were found to contain thousands of contemporary references to Hooke's surveying and many hundreds of his manuscripts. This rich source has been used to assess the importance of his surveying by first finding answers to the questions: what did he do? how did he do it? how long did it take? and how much was he paid?

Further work on archives at the Royal Society and the Mercers' Company allowed his surveying to be placed in the context of his other salaried employments at the time as Curator of Experiments for the Royal Society, Cutlerian Lecturer and Professor of Geometry at Gresham College.

This research has reinforced the accepted view that Hooke's energy was exceptional. Detailed records of innumerable daily acts by him in the ruins of London have been discovered, summarised and discussed. They show that he was highly efficient and zealously scrupulous in his dealings with the City and its citizens. These characteristics are not commonly attributed to Hooke. It is argued that by his innumerable daily acts and involvement with drafting and implementing the rebuilding legislation, he did more than any other individual to re-make the city and that his other employments suffered little from the time he spent as City Surveyor.

ABBREVIATIONS

AB I	Acquittance Book Volume I (1661-1671)
AB II	Acquittance Book Volume II (1671-1682)
AB III	Acquittance Book Volume III (1683-1707)
Add.	Additional
BL	British Library
CCAB	City Cash Account Book
CB I	Cash Book Volume I (1659-1670)
CB II	Cash Book Volume II (1670-1683)
CB III	Cash Book Volume III (1683-1694)
CB IV	Cash Book Volume IV (1694-1702)
CD	Comptroller's Deeds
CDAB	Coal Duty Account Books
CLC	City Lands Committee
CLCM(R)	City Lands Committee Minute Book (Rough) with un-numbered folios
CLCO	City Lands Committee Orders
CLCP	City Lands Committee Papers
CLRO	Corporation of London Records Office
CM(C)	Council Minutes (Copy)
CP	Classified Papers
Diary (G)	"The Diary of Robert Hooke 1688-1693" in Gunther, R.T. *Early Science in Oxford Volume X* pp.69-265 (Oxford, 1935)
Diary (R&A)	Robinson, H.W. & Adams, W. *The Diary of Robert Hooke 1672-1680* (London, Taylor & Francis, 1935)
DS	Duplicate Series
f(f).	folio(s)
GL	Guildhall Library
GCAB	Gresham College & Royal Exchange Accounts Book
GR	Gresham Repertory

Jor.	Journal of the Court of Common Council
LTS	London Topographical Society
MC	The Honourable Company of Mercers
Misc.	Miscellaneous
MS I	Main Series Volume I (1667-1677)
Ms(s).	Manuscript(s)
M(R)	Minute Book (Rough)
NGICR	Numerical General Index to Comptroller's Records
OED	Oxford English Dictionary
PD	Printed Document
p(p).	page(s)
RB	Register Book
Rep.	Repertory of the Court of Aldermen
RGA	Renterwardens Gresham Accounts
RS	The Royal Society of London
TAB I	Treasurer's Accounts Book Volume I (1660-1672, no accounts for 1668)
TAB II	Treasurer's Accounts Book Volume II (1672-1682)
VR	Viewers' Reports

A NOTE ON DATES
AND TRANSCRIPTION OF MANUSCRIPTS

Passages transcribed from manuscripts and printed sources

are indicated by text which is one point smaller than the main text, and

indented left and right with respect to it, thus,

except for some short passages which are shown "thus". In transcribing manuscripts the original spelling has been retained, except that "ye" etc. have been transcribed as "the" etc. Original abbreviations such as Comtee have been expanded, but given modern spelling. Original usage of upper and lower case and punctuation has been adhered to. Within a transcribed passage, words in the original which have been omitted in transcription are denoted by ... and comments by the present author are placed in square brackets [thus].

Dates given here are as they appear in the records, except the year is taken to start on 1 January. In transcribing a manuscript where the year is shown as $167^{0}/_{1}$ for example this form has been replicated in the transcript.

PREAMBLE

The fact that such an important figure as Robert Hooke has not given rise to a new biography in the last 45 years can be explained in part by Margaret 'Espinasse's accurate but brief account of most of the main events in his life.[1] Current research into Hooke's activities in science, mechanical and optical instrumentation, and architecture reveals more facts and enables diverse opinions about his life and work to be put forward, but until now his surveying has not received similar scholarly attention. Perhaps soon a new and substantial biography could be written; with every new research finding his importance grows and the need for a new biography increases.

This dissertation is mainly about Hooke's work in London as a surveyor in the aftermath of the Great Fire of 1666. Although it is generally known that Hooke was appointed City Surveyor, little research has been done on this aspect of his life. Reddaway's detailed and substantial account of the rebuilding[2] does not however pay particular attention to Hooke. When he is discussed by Reddaway, it is usually in conjunction with the other two City Surveyors Mills and Oliver, or in connection with Wren. Hooke's contribution to the rebuilding has been regarded by others as significant, not in itself, but for the effect it had on his employment by the Royal Society at the time. Waller writes

> The Rebuilding of the City, [after the Great Fire of 1666] according to the Act of Parliament, requiring an able Person to set out the Ground to the several Proprietors, Mr. Hooke was pitch'd upon, and appointed City-Surveyor for that difficult Work, which being very great, took up a large proportion of his Time, to the no small hindrance of his Philosophical Disquisitions.[3]

and 'Espinasse

> Of the lasting importance of Hooke's day-to-day labours on the routine of surveying and supervising the rebuilding of streets and ordinary private houses it is impossible to make more than a general estimate.[4]

This dissertation describes the nature of the "difficult Work", makes more than a "general estimate" of the lasting importance of Hooke's work as City Surveyor in rebuilding the city[5] and examines that work in relation to his other appointments as Professor of Geometry at Gresham College and Curator of Experiments to the Royal Society. The years 1667-1674 were by far the busiest for Hooke in his capacity as City Surveyor, so most of the research is concerned with those years. Much use has been made of archives in the Corporation of London Records Office, the Royal Society and the Mercers' Company to find out what Hooke did, how he did it, how long it took him to do it and what he was paid for doing it.

Chapter 1 is a brief review of Hooke studies since the 1930's when interest in him was revived more than 250 years after his death. In Chapter 2 the events leading to Hooke's association with the City are described. Chapter 3 presents the results of research to discover what Hooke did as Surveyor in the aftermath of the Fire, how he went about it and for how long. Most of the information in Chapter 3 is new, but much of the material in Sections 3.1-3.3 has already been published by the author[6] and is re-presented here, with some additions and minor alterations. Chapter 4 is a review of Hooke's activities during the period he was at his busiest as Surveyor. Comparisons are made between the practices and financial rewards of experimenting and surveying. Conclusions about the extent and importance of Hooke's surveying are given in Chapter 5.

CHAPTER 1

TWENTIETH-CENTURY VIEWS OF HOOKE

Although Hooke's name appears often in modern biographies of his contemporaries, and in accounts of seventeenth-century science and technology, Margaret 'Espinasse's is the only biography of Hooke[7] published since Richard Waller's biographical essay appeared as an introduction to Hooke's posthumous works 250 years earlier.[8] A brief biography was published by John Ward in 1740[9] based largely on Waller's essay. The Dictionary of National Biography has 3½ pages on Hooke, fewer than 100 words of which are on his role as City Surveyor; such a brief treatment is open to misunderstanding.[10]

A few details of Hooke's surveying appeared in a book on the history of the Mansion House published in 1922 by Sydney Perks.[11] Despite being City Surveyor to the Corporation of London, Perks had to receive formal permission from the Corporation's General Purposes Committee before he could search records in Guildhall to write his history. If any earlier authors intending to write about Hooke's surveying had tried to discover records of it in the archives of the Corporation of London they may have been denied access. Nobody appears to have tried, so the reason that little has been done on the topic until now is likely to be lack of interest in it rather than denial of access to archival records.

The absence of a recent biography of Hooke does not mean that there is little interest in him. On the contrary, interest has grown since the 1930s and continues to increase. During his lifetime he was often engaged in argument and dispute. He is now a subject for argument and dispute. This is not surprising. The great range of his activities and the intensity with which he went about his work, together with his unusual social position in late seventeenth-century London, offer scholars opportunities for interpreting him and his work in different ways. Some recent writings on Hooke are now reviewed, not by any means exhaustively, but to illustrate the growth and diversity of current views

of Hooke and to demonstrate that in his role of City Surveyor he has received comparatively little attention.

Modern writings on Hooke began in the decade prior to the Second World War. Interest in him, particularly in his science, continued to grow in the four decades after the War, but a conference on Hooke held in London in 1988 marked significant developments in Hooke studies that are still in progress. These three phases of writing are now reviewed to see what attention has so far been given to his surveying.

1.1 The First (Seminal) Phase of Publications

In 1930, R.T. Gunther (Keeper of the Museum of the History of Science at Oxford) began the modern revival of interest in Hooke when he published Volumes VI and VII of *Early Science in Oxford*. These two volumes are subtitled *The Life and Work of Robert Hooke Parts 1 and 2* respectively.[12, 13] Gunther's intention was

> To show the diversity of [Hooke's] work ... with the express object of focusing attention upon his remarkable achievements ... [and] to suggest possible reasons for the undeserved neglect under which he and his work have suffered[14]

by reprinting a mélange of biographical writings by Richard Waller, John Ward and John Aubrey, re-paginated extracts from Thomas Birch's four-volume *History of the Royal Society* (published 1756-1757) and Hooke's *Philosophical Experiments and Observations* edited by W. Derham (published 1726) together with miscellaneous illustrations, some of which are unattributed.

At this time Gunther intended to include in his *Early Science in Oxford* series some illustrations of Hooke's scientific manuscripts from the archives of the Royal Society and from Hooke's earlier manuscript diary, kept by the Corporation of London in Guildhall Library, but permission was refused in both cases. Gunther deplored such obstacles being put in the way of his intentions to do justice to a member of his own University. He accused the Royal Society of not keeping Hooke's papers in order and of allowing them to deteriorate

with age and the dirt of London.[15]

An Oxford/London rivalry to lay claim to Hooke had begun.

Three further volumes in Gunther's series[16, 17, 18] were published in the 1930's. They included copies of works which had been published by Hooke, including his first, known as *Tract on Capillary Attraction* (1661), an edited version of his later diary (1688-1693), *Lectiones Cutlerianæ* (1679) and *Micrographia*, originally published in 1665. These re-publications went some way towards satisfying Gunther's intention to show the diversity of Hooke's work. Unfortunately, a general lack of appropriate editorial comments and of a rigorous and scholarly form of presentation (the original page numbers were changed to conform to each newly published volume) laid them open to the sort of criticism that Hooke himself had been subjected to and which in part accounted for his "undeserved neglect."

The Royal Society, having thwarted Gunther in his ambition to edit and include in his series of publications some of Hooke's scientific papers from its archives, made arrangements to publish Hooke's earlier manuscript diary[19] which had been in the possession of the Corporation of London Guildhall Library since its purchase from Moor Hall, Harlow in 1891 and which the Corporation had denied to Gunther. The diary was edited and published, with the aid of funds from the Royal Society, to mark the tercentenary of Hooke's birth in 1935.[20] One of the editors was Henry William Robinson, the Royal Society's Librarian who died in 1960.[21] The President of the Royal Society, Sir Frederick Gowland Hopkins, wrote the Foreword. Gunther was displeased, his words an echo of Hooke's irascibility

> Great assistance would and could undoubtedly have been given had I been permitted to copy the other and more legible parts of the Diary that belongs to the City of London ... Had the permission to make a copy been granted to me when requested, the Royal Society would not have been put to so great an expense, the Public would have had the Complete Diary in their hands four years ago, many of the outstanding architectural problems would have been solved, the text now printed would have been more

> correct, and the whole work would have been accessible by a single index.[22]

On the tercentenary day of Hooke's birth an anonymous article was published in *The Times Literary Supplement*. The author wrote briefly, but perceptively at the time, of Hooke's surveying

> The variety and importance of Hooke's scientific work appear all the more remarkable when we see from the Diary how seriously he took his duties as one of the surveyors appointed to supervise the rebuilding of London after the Great Fire.[23]

The seriousness with which Hooke undertook his surveying duties and what those duties were have not been fully examined until now.

The author of the anonymous article in *The Times Literary Supplement* was probably the Quain Professor of Physics at University College London, E.N.da C. Andrade who reviewed *Diary* (R&A) in *Nature*, commending the achievements of the editors.[24] He wrote that the diary's publication increased understanding of Hooke's scientific work and made available evidence about his personal life and health which helped to explain his reputation for sourness and a hasty temper. But Andrade did not say much about the many entries in the diary that refer to Hooke's daily surveying, and when he did mention them it was usually in connection with Wren. Andrade showed himself to be in accord with Gunther's assessment of Hooke's importance as a great scientist, but this did not stop him from increasing the Oxford/London dispute by writing scathingly of Gunther's scholarship in a review of *Diary* (G).[25] Andrade's concluding sentences give the tenor of his review

> But from Dr. Gunther's scholarship we crave a respite. Surely his shining temple to the Goddess of Inaccuracy should by now be complete.[26]

Even the title *Early Science in Oxford* under which Gunther had chosen to present Hooke's life and work came in for Andrade's urbane critical comment. Referring to the fact that Hooke had spent most of his life in London since leaving his boyhood home in the Isle of Wight, Andrade wrote

> The diary of 1688-93 might with equal justice appear under the heading

> "Early Science in the Isle of Wight."[27]

By citing many examples, Andrade took issue with Gunther's scholarship and ability to transcribe a manuscript accurately, even going so far as to say (apropos Gunther's complaint about not being allowed to edit Hooke's earlier diary)

> it behoves us to examine a little Dr. Gunther's claim to have a right to be the editor of anything pertaining to Hooke.[28]

and concluded Gunther's editing was

> a deplorable performance.[29]

The two protagonists continued the Oxford/London controversy in letters to *Nature*.[30] Gunther responded to Andrade's devastating attack on his scholarship by mildly congratulating him for the interpretation of some of the more difficult passages in Hooke's 1688-1693 diary. Andrade said he was glad to add Gunther's congratulations to many others he had received on his review. Except for an occasional example[31] to illustrate a critical point, neither Gunther nor Andrade considered Hooke's surveying as a matter for study, but gave their attention mainly to his science and to contending for or against London or Oxford as Hooke's intellectual home.

Some months before the publication in 1935 of *Diary* (R&A) an article in *The Times* by M.I. Batten on Hooke's architectural activities drew on the contents of *Diary* (R&A).[32] She followed this with a publication[33] which has been the basis of later studies of Hooke's architecture and is still regarded as indispensable in that context.[34] These seminal publications in the 1930s are predominantly concerned with Hooke as scientist or architect. Batten does have more to say than others about Hooke's surveying, but she discusses it mainly in relation to his architectural work in partnership with Wren. At the time *Diary* (R&A) was published an anonymous article referred to Hooke's appointment as a surveyor, but sees that as involving him in architecture.[35] In these publications little interest is shown in Hooke's surveying, which is generally seen as a minor part of his architectural practice.

The publication which marks the end of the seminal phase of modern Hooke studies is Reddaway's book on the rebuilding of London after the Fire,[36] a substantial

account of a frantic period in London's history when much was achieved. Reddaway made extensive use of the Corporation of London Records Office Archives, including those cited by Perks.[37] Reddaway found some of the manuscripts to be so crabbed he had to abandon his research for some months to allow his sight to recover.[38] An Introduction dated February 1943 is pasted-in the copy of Reddaway's book referred to for this research. It was written when London once again was burning; Reddaway drew some lessons for post-war planning and rebuilding based on his study of what happened after 1666. His foresight was not impaired and what he wrote in the Introduction to his book continues to be relevant to building in London today. As a description of what was done by the City the book can be improved only by adding more details and revising some of Reddaway's account of Hooke's role. It also deals with the relations between the City, the King and Parliament before and during rebuilding and with the workings of the Fire Court. It is an indispensable source for anyone who wishes to understand how and why London was rebuilt in the way it was. As far as Hooke is concerned, Reddaway discusses his work either as part of the surveying undertaken also by the other City Surveyors Mills and Oliver, or in relation to Wren's activities in the city.

1.2 The Second (Consolidation) Phase of Publications

On 19 December 1949 Andrade made Hooke the subject of his Royal Society Wilkins Lecture.[39] This is a substantial summary, based on evidence and expressed with clarity, of Hooke's major scientific achievements, his disputes and his character. It demonstrates the breadth and intensity of Hooke's thought and experiments in connection with the Royal Society. Mention is made of his surveying and of his work with Wren in rebuilding the city, but Andrade does not go beyond noting that at the time of these activities Hooke was particularly active scientifically. Andrade's closing words in a radio talk on Hooke broadcast in 1951 on the BBC Third Programme were

> all those who had gone direct to his writing and to the records of the time had conceived the highest admiration for his astonishing industry, his wholehearted devotion to science, his inventiveness, his ingenuity, his fertility and his brilliant theoretical insight. But those who have gone direct to his writings and to the records of the Royal Society are

> comparatively few and in general I feel that he has not had his due.[40]

In a subsequent paper[41] (resembling a biographical synopsis and published 250 years after Hooke's death) written by Andrade, passing mention is made of Hooke's surveying and association with Wren

> [Hooke's] financial circumstances were much improved after the Great Fire of 1666 by the lucrative work which he carried out as City Surveyor, in which capacity he was chief assistant to Christopher Wren in the matter of rebuilding the City of London.[42]

the first part of which is partly true, but the second is a superficial (and substantively incorrect) statement about Hooke's appointment as City Surveyor and the relationship between Wren and Hooke.

Margaret 'Espinasse's 1956 biography of Hooke is a volume in "The Contemporary Science Series" edited by Jacob Bronowski who, according to 'Espinasse's Preface, gave advice and encouragement without which the book would not have come into existence. 'Espinasse makes clear her reason for writing it

> When I first read his Diary I was enchanted by the personality which seemed to emerge so clearly, and I have hoped to convey something of my own image of this brilliant, generous, unlucky man.[43]

The first four chapters deal with Hooke's scientific work and the last two with his social, domestic and personal life. Chapter 5 is specifically about his architecture and surveying for which 'Espinasse made extensive use of *Diary* (R&A), W.G. Bell's book on the Great Fire of London,[44] publications by Reddaway and Batten, and Hooke's manuscripts in the British Library. From these mainly secondary sources of the details of his surveying, 'Espinasse came to the general conclusion that Hooke was

> an excellent administrator - honest, energetic, and terrifyingly thorough[45]

which is substantiated by results of the present research into his surveying activities using primary sources, but another of 'Espinasse's conclusions, that his work

> involved personal surveys ('views') of hundreds of sites which were to be built on.[46]

is now seen to be too vague and incomplete as a statement of what Hooke did as a City Surveyor. Nevertheless, 'Espinasse's biography stands as a major contribution to modern Hooke studies.

Publications on Hooke which appeared in the four decades or so following the Second World War were influenced in one way or another by Andrade's, Batten's and 'Espinasse's accounts, but they have added significant detailed descriptions and interpretations of his writings on mechanical and experimental philosophy. The conference on Hooke held at the Royal Society under the auspices of the British Society for the History of Science from 19 to 21 July 1988 marks the end of the consolidation phase of twentieth century Hooke studies and the beginning of what might be called the fully post-modern phase where sociologists have brought new perspectives to a debate on science in general and discussion of who and what Hooke was.

The book which came out of the British Society for the History of Science 1988 conference on Hooke[47] includes a comprehensive bibliography[48] of more than 200 published items on Hooke, the main themes of which are discussed in the Introduction to the book.[49] None of the papers presented at the conference and subsequently published in the book deals in any significant way with Hooke's surveying. The main sections of the book show the diversity of Hooke's activities and the different approaches taken by the writers to discuss him and his work. Instrumentation for astronomy, navigation, microscopy and timekeeping; rhetoric and graphics; mechanical philosophy; dynamics; geology; medicine; and personal identity are the aspects of Hooke that engaged scholars' attention at the conference. His surveying did not arise as a topic of relevance to any of these matters.

1.3 The Third (Current) Phase of Publications

Scholarly attention to people and practice in the formative years of the Royal Society has become less concentrated on the instruments and methods of early science and more focussed on seeing an individual's position in society and how that position was

related to acceptance of the individual's views and opinions on natural phenomena. Examination and analysis of science by scholars from areas not hitherto associated with the history and philosophy of science, such as sociology and literary criticism, have been a recent feature of academic publishing.[50] Of relevance to Hooke studies is a recent book by Steven Shapin which examines the social fabric of seventeenth-century England as a way of understanding the origins of scientific authority.[51] Shapin argues and speculates that general acceptance of (or trust in) explanations of natural phenomena were based on the social position of the English gentlemen (such as Robert Boyle) who proposed them; the credibility of their scientific accounts was grounded in their gentlemanly attributes of honour, civility and integrity. The nature of the authority which those gentlemen themselves took as indicators of truth was quite different. Shapin does not claim to show that all scientific explanation of natural phenomena at that time was determined by the social context of those who studied nature, but that acceptance of scientific explanations was. He also examines relationships between knowing about people and knowing about things in arguments on explicitly moral or explicitly epistemic grounds for acceptance of accounts as representing truth.

Robert Boyle is a pivotal figure in Shapin's book; the chapter entitled "Who was Robert Boyle? The Creation and Presentation of an Experimental Identity" is one of the two longest, exemplifying the importance Shapin attaches to personal identities of seventeenth-century English practitioners of scientific investigation. Hooke is considered only incidentally, mainly as a technician, but in an earlier publication[52] Shapin had written on Hooke from the same viewpoint and in the same manner that he would later write about Boyle; the title too is similar: "Who was Robert Hooke?". Here Shapin draws together evidence from seventeenth-century sources to illustrate vividly the complexity of Hooke's character and the ambiguity of his social position. Unlike Boyle, whose standing as a gentleman was impeccable, Hooke is said by Shapin to have been known

> as a person dependent upon others, a person of at best compromised freedom of action, of ambiguous autonomy, and of doubtful integrity[53]

who was treated

> as a mechanic, as a tradesman, as a servant.[54]

In coming to such conclusions Shapin ignored Hooke's surveying activities beyond mentioning that he was known as

> one of the 'surveyors' [sic] of the City[55]

and worked in various parts of the City

> taking 'views' [sic] and supervising building work[56]

in each case by the use of quotation marks betraying a lack of knowledge and understanding of Hooke's surveying and continuing scholars' ignorance of, and inattention to, Hooke's work for the City that have already been noted above. If who Hooke was is important, then anything that has been said on the matter to date can be regarded as incomplete, perhaps seriously so, if it fails to take into account Hooke as Surveyor. Conclusions based on an incomplete understanding of Hooke's social position continue to be made.[57] This research is intended to add to the understanding of who Hooke was by discovering what he did as City Surveyor, how he did it, how much time he spent on it and how much he was paid for doing it, by reference to original contemporary manuscripts and other primary sources as far as possible, thereby adding something to Pumfrey's study of Hooke as Curator to the Royal Society.[58] The importance of Hooke's surveying will then be assessed and conclusions drawn in Chapter 5 which show that revision of some statements about who Hooke was is necessary.

CHAPTER 2

THE BEGINNINGS OF HOOKE'S ASSOCIATION WITH THE CITY OF LONDON

The interests of the City and of the Royal Society coincided in Gresham College. Gresham Professors were appointed by and received their accommodation and salaries from the City under the terms of Sir Thomas Gresham's will; in Hooke's time many Gresham Professors were also Fellows of the Royal Society. The City often called for certificates and testimonies from Fellows and from other academics at Oxford and Cambridge to assist its committees in deciding between contenders for appointment as Gresham Professors (and still does so). Hooke had connections with all three institutions in London. He was employed by the Royal Society in various roles from 1662, was a Gresham Professor from 1665 and a City Surveyor from 1667. Each of these engagements lasted until his death in 1703. No other person had such close and continuous associations with all three institutions. They brought him into personal and professional contact with a huge number of individuals from all strands of late seventeenth-century London society. The beginnings of his associations with the Royal Society, Gresham College and the City are now examined to show how inter-related his appointments were.

2.1 Curator of Experiments to the Royal Society

It is generally accepted that the Royal Society had its origins in London around 1645 when several men with an interest in the new experimental philosophy and who were generally favourable to the Parliamentary cause agreed to meet weekly for discussions about natural philosophy and experimentation.[59] This is the date when John Wallis, later Savilian Professor of Geometry at Oxford, says he began to take part in the London meetings, but they may by then have been in progress for some time.[60] Amongst these early experimental philosophers were also John Wilkins, Jonathan Goddard and Theodore Haak, all of whom, with Wallis, were to become prominent Fellows of the Royal Society.

Haak, from the Palatinate, appears to have been the originator of the idea to hold regular meetings. He later became a friend of Hooke and they spent many evenings together playing chess.[61]

The London meetings of the formative members of the Royal Society took place informally at Goddard's lodgings in Wood Street (where he employed a lens grinder in his workshop to make telescopes), in Cheapside and at Gresham College where one of the group, Samuel Foster, was Professor of Astronomy. In 1648 the group divided when Wilkins left London for Oxford (on being appointed Warden of Wadham College) to be followed soon after by Wallis and Goddard. The meetings in London continued as before, attended by members of the group from Oxford when occasion brought them to London,[62] but the Oxford meetings were more regular, taking place in Wilkins's lodgings at Wadham College by the end of the Civil War. Members of the group in Oxford included Ward, Petty, and Boyle, in whose rooms some of the later meetings were held. It was during this period that Hooke in 1655 according to Waller[63] first became aware of the meetings of the group at Wadham where his most important achievement was to design and make an air pump with parts he obtained from London, and then use it successfully in the experiments which led to what is now known as "Boyle's Law".[64]

When reading Waller's account of Hooke at this time one gets the impression of a highly active young man, brimming with ideas for mechanical devices of all kinds who has realised that his mental energy and practical skills are useful to those in authority, and who intends to let them know it. He showed his designs and mechanisms for moving on land, or water, or through the air, to John Wilkins. He told Seth Ward how, following a suggestion by Riccioli, he had put into effect a method for improving the pendulum in timing mechanisms for more accurate astronomical observations. Enthused by the prospect of success in solving the problem of how to find accurate longitude at sea, he devised a spring and lever escapement for a pocket watch which he showed to Boyle who later, with Lord Brouncker and Sir Robert Moray, encouraged him to patent his device.[65] But it came to nothing, lost through Hooke's insistence on receiving financial reward for himself despite not having the patience to perfect the device, and in disputes with

Huygens as to the originator of the idea.

Many other mechanical devices Hooke later would demonstrate to the Royal Society were originally made by him when he was at Oxford. One of these was a wheel barometer, suggested to Robert Boyle by Christopher Wren in order to test Descartes's hypothesis about the tides being caused by changes in atmospheric pressure brought about by the changing position of the moon.[66] Boyle and Wren each had a close working relationship with Hooke. Boyle's appreciation of Hooke's mechanical and experimental ideas and skills is clear from his employment of Hooke and later by agreeing to the Royal Society taking him away from Oxford for curator of the Society's experiments. Evidence has been presented recently which shows that Boyle saw Hooke as more than an ingenious mechanic and useful employee by learning from him about aspects of Descartes's philosophy and then seeking his opinion on his (Boyle's) philosophical propositions before publication, and taking his advice.[67] Hooke and Wren were scientific and architectural colleagues for many years. It is possible they first met as pupils at Westminster School; Wren was the elder by about three years and went on to Wadham College. By the time Hooke went to work there Wren was a Fellow of All Souls, but they had probably renewed their acquaintance in the late 1650s at one of the Wednesday meetings between the formative members of the Royal Society which were arranged to follow Wren's public lectures on Astronomy at Gresham College.

By 1660 the number of people attending the meetings in London had grown. They agreed to form a society to promote experimental learning, appointed a chairman, treasurer and registrar and resolved to meet weekly in Gresham College. Robert Boyle, at that time living in Oxford and employing Hooke there as his laboratory assistant, was one of the founder members. Demonstrations were uncommon in the first year or so of the Society's existence and those that were performed were generally inconsequential. Debates on written reports and discussions on objects that had been brought in or sent to the Society were the main activities of Fellows at the early meetings. The amanuensis was sometimes ordered to perform experiments and make equipment in addition to the normal clerical duties for which he was appointed, but he was unable to do more than make the

simplest apparatus and he needed careful instructions on how to proceed. Hooke's name is mentioned for the first time in Royal Society records[68] on 10 April 1661 when Fellows decided to debate his first publication, known as *Tract on Capillary Attraction*.[69] On the same day the amanuensis was ordered to make glass containers for air and water, but he was unable to perform duties like these in good time: at the next meeting he was instructed to make a list of all the orders that had not yet been executed.[70]

Many experiments by Fellows, nominated "curator" for the purpose, were planned and some were performed at meetings during 1661 and 1662, but they were often not completed or not followed up. The amanuensis continued to be called upon to perform duties which seemed beyond his abilities. Sir Robert Moray probably decided that the Society should do more than carry out only simple experiments of little consequence, for on 5 November 1662 at a meeting of the Royal Society in Gresham College, he proposed

> a person willing to be employed as a curator by the society, and offering to furnish them every day, on which they met, with three or four considerable experiments, and expecting no recompense till the society should get a stock enabling them to give it.
>
> The proposition was received unanimously, Mr. Robert Hooke being named to be the person.[71]

The custom of nominating a Fellow as curator for a specific experiment or demonstration had not been successful. A regular custodian of the Society's experiments was thought to be necessary. That Hooke was named is not surprising; many of the Fellows present knew or came to hear of his abilities through his work for Boyle at Wadham, or through their proposed discussion of *Tract on Capillary Attraction* at a meeting of the Society the previous year.

Following Moray's proposal, someone, probably Moray himself, was quick to ask Boyle if he would release Hooke from his employment in Oxford, for at the next meeting (on 12 November 1662) Sir Robert Moray formally proposed Hooke as Curator of Experiments to the Society, Boyle having agreed to release him from employment so that the Society could use him. It is hard to see Hooke refusing such an opportunity once

Boyle had agreed, even though no financial remuneration was imminent. Hooke's appointment was unanimously accepted and the Society

> ordered that Mr Boyle should have the thanks of the society for dispensing with him for their use; and that Mr. Hooke should come and sit amongst them, and both bring in every day of the meeting three or four experiments of his own, and take care of such others, as should be mentioned to him by the society.[72]

This record gives no indication that Hooke was invited; there was probably no doubt in the minds of the Fellows that he would accept, given the acquaintance many of them had had with him at Oxford. Although he was clearly to take orders, he was also expected to "sit amongst them" so his position was ambiguous, sitting with the Fellows as an intellectual equal, taking instructions as their employee, but with no prospect of any remuneration in the near future. His name is recorded in the list of Registered Fellows approved by the Council at its second meeting,[73] but his was a special case because as a Fellow he was specifically exempt from charges and not required to pay the quarterly subscription of 13s-00d and other fees.[74]

Hooke lost no time. Only a week later he was in front of the Society demonstrating the different sounds glass bubbles containing a partial vacuum made when they were broken - another use for his air pump, but the demonstration would have been more for entertainment of the Fellows than instructive. Hooke put down in writing some questions arising from what had been observed during experiments and how to design further experiments to provide answers. He was ordered to bring to the Society's meeting the following week a written report on weighing glass bubbles, some filled with air and some partially evacuated. He told the Society that he would show an experiment on the "tenacity" (compressibility) of air and also spoke of an engine for experiments on condensation. He was ordered to make it as soon as possible.[75]

Thus began Hooke's activities for the Royal Society which were to continue for many years. When he was ordered to make what were entertaining demonstrations rather than experimental investigations he did not argue against performing them. Instead he

often ignored them and put forward his own ideas for demonstrations and experiments, but he found himself from time to time reprimanded and reminded that he had not yet performed what had been ordered and had failed to do what he had himself proposed. He could not resist the urge to design and perform experiments to achieve his own particular objectives, nor could he refuse outright the Society's orders to do work that he thought less useful. The outcome was that he often had to make new instruments without having enough time to test them before using them in experiments. Partly as a result of his own enthusiasm, partly through incomplete conceptual and procedural strategies in relation to the new learning and for other reasons discussed by Pumfrey,[76] the Royal Society did not benefit as much as it might have done from its employee. It will be shown that the City was more successful at getting what it wanted from Hooke; the City's objectives and organisational procedures to meet them were however far advanced when Hooke started his employment as Surveyor.

2.2 Gresham Professor of Geometry

Gresham College was founded in 1597 by the Will of Sir Thomas Gresham the Elizabethan financier and builder of the first Royal Exchange. His foundation provided accommodation in his former house in Bishopsgate Street for Professors of Divinity, Astronomy, Music, Geometry, Law, Physic and Rhetoric. Each Professor was required to give free public lectures in Latin (and expected to repeat them later in English) in return for an annual salary of £50 and lifetime use, provided he remained celibate, of lodgings in Gresham College. The site is now occupied by what is commonly known as the NatWest Tower.

Gresham nominated the City (now the Corporation of the City of London) and the Worshipful Company of Mercers as Trustees of his estate. Individuals were appointed by the City's Court of Common Council and by the Mercers' Company to the Joint Grand Gresham Committee which decided all matters relating to the appointment of Professors and payment of their salaries. In particular the City Side (members of the Joint Grand Gresham Committee appointed by the Court of Common Council) were responsible for

matters concerning the Professors of Divinity, Astronomy, Music and Geometry. The Law, Physic and Rhetoric Professors were the responsibility of the Mercers' Side. It was customary for each Side of the Joint Committee to meet independently of the other when deciding on matters relating to the Professors under their aegis. The Joint Committee met when more general matters had to be settled, such as maintenance of the fabric of the College.

Before the founding of the Royal Society in 1660, meetings of its formative members had been taking place in London and Oxford for about 15 years (Section 2.1). The London meetings were centred on the activities and lodgings of the Professors at Gresham College. Three of the founder Fellows of the Royal Society were Gresham Professors in 1660: Jonathan Goddard (Physic) had been appointed by the Mercers' Side, Christopher Wren (Astronomy) and Laurence Rooke (Geometry) by the City Side. For more than 60 years the financiers, merchants and tradesmen of the City had been interviewing and deciding between contenders for the Gresham appointments. By its administration of Gresham's estate, the City provided a meeting place, accommodation and salaries for some of the major figures in the formation of the Royal Society, without charge.

Although the City's day-to-day supervision of the College was often lax and provided opportunities, frequently taken, for the Professors (Hooke was an exception) to exploit their positions for financial gain of dubious legality,[77] the minutes of the Joint Grand Gresham Committee in the Archives of the Mercers' Company show that the appointments were generally not lightly decided upon. The City and Mercers' Sides often called for additional testimonials from Oxford or Cambridge Universities to help them decide between applicants. Elections were sometimes made by a form of transferable voting by the relevant Sub Committee, but usually a majority vote was enough. In the case of Hooke's appointment as Gresham Professor of Geometry however, irregular procedures for election were followed, but later rectified.

Laurence Rooke was Gresham Professor of Geometry from 1657 until his death

at the age of forty in 1662. He was elected Fellow of King's College Cambridge on obtaining his BA there in 1643 and his MA four years later. By 1650 he was at Wadham College, Oxford working with the Warden John Wilkins and Seth Ward, Savilian Professor of Astronomy. There he later met and worked with Robert Boyle, but by the time Hooke arrived at Wadham, Rooke was at Gresham College as Professor of Astronomy, a post he held for five years until 7 August 1657 when he changed his appointment to Professor of Geometry (on the resignation of Dr Whistler through marriage)[78] and was succeeded by Christopher Wren. A probable reason for Rooke's decision to change was that the Geometry Professor's lodgings, which opened into the Reading Hall, were more useful for the informal meetings at Gresham College of the group of individuals who were later to form the Royal Society. A preference for Geometry is not a likely reason for his decision to change his appointment. Rooke was present at the first meeting of the Royal Society on 28 November 1660 and was actively involved in Society affairs for the rest of his life. Hooke thought highly of Rooke's astronomy[79] and other Fellows found him scholarly and of an agreeable disposition.

Only a few days after Rooke's death in the night of 26/27 June 1662 the City Side of the Joint Grand Gresham Committee met at Gresham College on 3 July 1662 to elect his successor. There were two candidates: Dr Arthur Dacres and Mr Isaac Barrow. Petitions and testimonies from their respective supporters were read to the Committee. The abilities of each candidate were clearly seen to be adequate for the post, but the City Side could not determine which of the two was "most learned in Geometry" and accordingly deferred its decision for two weeks.[80]

To help them come to a decision, members of the City Side sought opinions on the candidates not only from other Gresham Professors, but also from the growing number of Fellows of the Royal Society who were at hand in the College. However it turned out that it was not necessary this time to decide which of the two contenders was "most learned in Geometry". Despite more certificates being produced to show the high merit of Dacres, he was prevailed upon by Sir Richard Browne, a member of the City Side, to withdraw his application. As a consequence, on 16 July 1662 at Gresham

College, the City Side of the Joint Grand Gresham Committee had no difficulty in unanimously electing Barrow as Professor of Geometry.[81] A year later he resigned to take up an appointment as the first Lucasian Professor at Cambridge, a position he was subsequently to relinquish in favour of his brilliant pupil Isaac Newton.

This time the City Side of the Joint Grand Gresham Committee delayed an appointment. It was not until its meeting at the College on 20 May 1664 that the election of Barrow's successor was considered. Again the Physician Dr Arthur Dacres was an applicant, but this time Hooke was a contender. There is no record in the Council Minutes of the Royal Society around this time that Hooke was put forward for the Professorship, but it is very unlikely that he would have put himself forward without the encouragement, or at least the permission, of the Society. There is evidence that the Society wanted Hooke to live in Gresham College so that he would be more readily available to work on his experiments.[82, 83] It seems as if by August 1664 he occupied lodgings there,[84] but his residence in College would have been of dubious legality and the Society wanted a permanent and legal arrangement. The vacant chair offered an opportunity; the Geometry Professorship would be particularly attractive because of the proximity of the incumbent's lodgings to the room where the Society met. Ward later recorded that

> the royal society, who met [in Gresham College], were very desirous Mr Robert Hooke, one of their members, and curator of their experiments, might be chosen to succeed [Dacres]; since by that means he would be near at hand to attend that service with greater readiness for them, and less trouble to himself.[85]

The Lord Mayor Sir Anthony Bateman took the chair at the meeting to decide between Dacres and Hooke. Sir Richard Browne who, nearly two years earlier, had prevailed upon Dacres to stand down in favour of Barrow, was also present. Following normal procedures, the candidates' petitions and testimonies were read and their merits were debated. It was recorded that

> The Court proceeded to election and made theyreof the said Dr Dacres to supply the said place of Geomitry Reader in the College.[86]

The names of the nine City representatives present are also recorded (Sir Thomas Adams, Sir Richard Browne, Alderman Thomas Bateman, Sir William Bateman, Samuel Foote Esq., Colonel Neville, Deputy Llewellyn, Deputy Tivill and Mr Nicholas Penning) in addition to the Lord Mayor, but details of how they voted are not given.

The validity of the election of Dacres was soon questioned. At a meeting of the Royal Society Council on 8 June 1664 it was reported (anonymously) that the Lord Mayor was not properly a member of the City Side which had appointed Dacres and that Hooke had received five votes to Dacres's four. The Royal Society Council nominated three of its Fellows to consult with Mr Ellis (a Fellow whose opinion on legal matters was sometimes sought by the Society) to determine whether or not the Lord Mayor had been nominated as a member of the City Side, or was otherwise entitled to attend.[87] No outcome of their findings has been found in Royal Society records, but Hooke, probably at the Society's instigation, petitioned the City to look into the matter of Dacres's appointment. He would not have done so, had not he and the Society been confident that they had been informed correctly about the irregularities. Such information is most likely to have come from one or more of the five members of the City Side who had voted for Hooke - they would have known who was entitled to be a member of that committee and who not, and they may well have disclosed their votes to one another. That one or more of them informed the Royal Society Council of the illegality is an indication that the Society was not unimportant to the City. It also shows that Hooke was regarded by some in the City as a man of some consequence and worthy of support.

On 20 March 1665 the City Side, meeting at the College with the Lord Mayor (now Sir John Lawrence) in the chair, heard Hooke's petition that at their meeting of 20 May 1664 he had received the majority of the votes cast by those present and entitled to vote, Dacres had been unjustly elected and he (Hooke) sought redress. The response of the City Side to Hooke's petition is unequivocal:

> The Comittee that they might satisfy themselves of the trueth of the petitioners Allegations, examined as well the Act of Comon Councell holden the 7th May 1664 by which the late Committee was appointed &

> authorized as also the Order of the 20th of the same mentioned in the Courte booke of this Comittee, by which Dr. Dacres the other Competitor was declared chosen; and Did thereby finde that onely nyne of the said chosen Committee weare then present viz. Sir Thomas Adams Sir Richard Browne Thomas Bateman Alderman Sir William Bateman Samuel ffoote Esq. Col Nevill Deputy ffluellyn Deputy Tivill & Mr Nicholas Penning whose votes (as by sufficient evidence appeared) were decided as followeth viz.
>
> | for Dr Dacres | for Mr Hooke |
> |---|---|
> | Sir Richard Browne | Sir Tho Adams |
> | Tho. Bateman Aldrmn | Col Nevill |
> | Sir Willm. Bateman | Dep. fluellyn |
> | Sam ffoote Esq. | Dep. Tivill |
> | | Mr. Nic. Penning[88] |

The City Side was satisfied that Hooke had been elected by five votes to four at its earlier meeting. The Court of Common Council was the City's primary legislative body and its minutes showed that Sir Anthony Bateman had not been nominated as a member of the appointment committee.[89] The record of the meeting which considered Hooke's petition continues

> But the then Lord Mayor being present in the said Comittee of 20th May aforesaid, and giveing the vote though not appointed one of that Comittee by the Said Act of Comon Councell was then pleased to Declared [sic] the Election for Dr Dacres. Which mistake occasioning the petition before recited to bee presented to the Comittee now Sitting They after due Consideration of the Principles did unanimously Declare that Robert Hooke was the person legally elected and accordingly ought to enjoy the same with the Lodgings proffits and all accomodations to the place of Geomitry Reader appertaining .[90]

So it was confirmed that Sir Anthony Bateman chaired and received the votes at a meeting he was not entitled to attend and then misreported them to the meeting, as the Royal Society had been informed less than three weeks after the event. It has been

stated[91, 92] that the Lord Mayor, Sir Anthony Bateman, gave his casting vote in favour of Dacres, but was not entitled to do so. This is only partially true. He was not entitled to be at the meeting, but he did not vote. Instead he misreported the votes of others. This could have been a "mistake", as described in the above record, but another explanation is that three members of the Bateman family, possibly assisted by Sir Richard Browne, intended that Hooke should not be elected Gresham Professor and that Sir Anthony Bateman acted illegally to achieve that objective when legal means failed to do so. John Ward is unusually taciturn on this matter, saying only

> the election being declared for [Dacres] May the 20, 1664, he was accordingly admitted; but resigned again upon the 20 of March following, and was succeeded by Hooke.[93]

Following the City's decision that Dacres had not been legally elected, Hooke now was entitled to use the Geometry Professor's lodgings in Gresham College in place of the lodgings he had probably occupied in the College since August 1664.[94] He spent hardly a night away from his rooms in Gresham College, and died there nearly forty years later. The lodgings were on the first floor in the south-east corner of the quadrangle adjacent to the Royal Society's meeting place. He lived, made his instruments, prepared and demonstrated his experiments and gave his public lectures all under the same roof. It was an arrangement that the Royal Society found most appropriate for its Curator, and it was without charge to itself.

2.3 City Surveyor

On Thursday 6 September 1666 when parts of London were still smouldering and likely to catch fire again, the City's Court of Aldermen met in Gresham College because Guildhall had been made uninhabitable. The City wasted no time before beginning the formidable task of keeping order and gaining the confidence of the citizens in its ability quickly to re-establish regular commerce and trade. The first Proclamation by the Lord Mayor was that markets should continue to trade according to law and custom, without unfair charging.[95] Orders were issued to Aldermen and Deputies to clear rubbish from the approaches to the bridge and ensure that fire did not re-kindle in their wards. The City

decided also to wait upon the King to acknowledge his expressed regard and affection and beg for continued grace and favour, in particular by supplying tents in Finsbury Square for citizens without habitation. Orders were also issued that the Lord Mayor and Sheriffs who had lost their houses should make use of rooms in Gresham College for lodgings and accommodation.[96] This was the only way for the City to proceed. The stone-built College buildings in Bishopsgate Street were in the north-east corner of the city which had escaped the worst effects of the Fire. The City was responsible for the administration of Sir Thomas Gresham's will in relation to Gresham College and was in no doubt that occupation of the College was not only necessary, but proper. The Professors were given instructions which, unusually, they were forced to obey.

Those of them like Hooke who resided in the College rather than let their accommodation, were faced with eviction. Others who had illegally let their lodgings, lost income. On 7 September 1666, the City ordered the lodgings of Dr Jonathan Goddard FRS, Gresham Professor of Physic to be taken and used by the City Chamberlain, and the rooms formerly occupied by Dr Horton to be taken by the Deputy Town Clerk and the City Swordbearer for lodgings and offices.[97] There seems to have been some resistance to this order, for on the next day, Saturday 8 September, the City re-ordered Horton's former lodgings and some other rooms to be cleared by Monday morning

> And in case of any contempt or neglect of this Order the Citty Artificers are to breake open the Doors and see it executed accordingly.[98]

The City did not need to issue more orders of this kind. George Gifford, the incumbent Professor of Divinity who had instigated the removal of Horton was himself removed, albeit temporarily.

Never a tranquil place, nor one suitable for quiet contemplation, the College was now London's hub, where those who governed London lived, met and had their administrative offices. It was soon to become also the place where the business of the Royal Exchange and the trades of its tenants were carried on while the rebuilding of the Royal Exchange took place. There is no evidence that Hooke was removed from the College so it can be assumed that he remained in his rooms where he had lodged legally

(except for a spell in Surrey during the plague year) since his appointment by the City as Gresham Professor of Geometry in March 1665, but he may have resided illegally in the College since August 1664 (section 2.2). He was known to members of the Court of Common Council and was now living and working amongst them and other Aldermen and officials of the City as they strove to rehabilitate the citizens and resume trade and commerce. He was well placed to put himself forward as somebody who could be useful to them in their endeavours. He knew to whom he should speak and what to offer - he had acted similarly ten years earlier at Wadham College, with success. He now seized the first opportunity that came his way by preparing and putting forward to the City a plan for rebuilding London.

Plans for new layouts were prepared independently by Hooke and at least five others, some of whom produced more than one.[99] Hooke showed his plan, or 'model' first to the City, in particular to Sir John Lawrence, Merchant, who was Lord Mayor in 1665 and Chairman of the meeting of the City Side of the Joint Grand Gresham Committee (Section 2.2) which rectified the improper election which took place almost a year previously of Dacres instead of Hooke as Geometry Professor.[100] Hooke then showed his layout plan to the Royal Society at its meeting on 19 September 1666. This meeting was held in the lodgings of Dr Walter Pope FRS, Gresham Professor of Astronomy, because the City had been using Gresham College instead of the ruined Guildhall for nearly two weeks[101] and occupied the room formerly used for Royal Society meetings.[102]

> Mr. Hooke shewed his model for rebuilding the city to the society, who were well pleased with it; and Sir John Laurence, late lord mayor of London, having addressed himself to the society, and expressed the present lord mayor's [Sir Thomas Bludworth] and aldermen's approbation of the said model, and their desire, that it might be shewn to the King, they preferring it very much to that, which was drawn up by the surveyor of the city [Peter Mills]; the president answered, that the society would be very glad, if they or any of their members could do any service for the good of the city; and that Mr. Hooke should wait upon them with his model to the King, if they thought fit to present it: which was accepted

with expressions of thanks to the society.[103]

Hooke's plan is now lost. Waller says he heard it was in the form of a rectangular grid of streets, but is not certain.[104] Reddaway, intriguingly, records that Hooke's plan has survived, but does not say where it can be found.[105] A plan attributed to Hooke, similar to that described by Waller, appeared in the upper left-hand corner of a print by Marcus Willemsz Doornick published in Amsterdam in 1666, but was truncated.[106] Subsequently a very similar, but complete, layout plan appeared in the upper left-hand corner of a print by Jacob Venckel published in Amsterdam in 1667.[107] This layout plan and others published in Amsterdam in the aftermath of the Fire have been attributed to Hooke,[108] even quite recently.[109]

It is very unlikely that the layout plan is Hooke's. It does not make any provision for a rebuilt St Pauls. The site of old St Pauls is to be used for general building; the nearest proposed church is to the west, outside the old wall on the slope down to the Fleet River. Although *de Buers* is shown close to the site of the old Royal Exchange, Guildhall (shown as *Stadts huys*) lies north of old St Pauls. A piazza, market and fountain are shown at the old Guildhall site. Hooke's close association with Wren at the Royal Society, the fact that Wren at that time was working on a plan for repair of old St Pauls, and the importance of the Guildhall and St Pauls sites to the City make it difficult to accept that any plan produced by Hooke would re-locate these buildings and inconceivable that it would be approved by the City. It is more probable that the layout plan used by Doornick and Venckel is a decorative invention (perhaps loosely based on Hooke's plan) by a draughtsman engaged on the major plan. It has received the accolade of being Hooke's probably because it resembles Waller's uncertain description and is unlike any of the other known plans. Hooke's is still missing, *pace* Reddaway.

Neither the King nor the City could afford the cost of rebuilding London anew after the Fire, but they both wished to do so. The need to resume normal trade and commerce as soon as possible was overwhelming, so none of the proposed new layouts was implemented. Instead, rebuilding on the old foundations, paid for mainly by private

money, would be permitted. Regulations were necessary to ensure that the new buildings and streets would be cleaner, healthier and safer than the old. A proposal to undertake an ambitious survey to serve as a basis for planning and administering the rebuilt city was put by the King to the City. Had it been possible to complete the survey, London would have had the first urban land information system.[110] The intentions were to make a new and accurate large scale map of the existing property boundaries and to discover and record the ownership of all houses and land demarcated on the map, the terms and rents of each occupier, and to whom (or to which company or corporation) the inheritance or reversion appertained.[111]

After being informed at a meeting with the Privy Council that the King had appointed Dr Christopher Wren FRS, Hugh May and Roger Pratt as King's Commissioners for Rebuilding to work with the City's nominees on the survey, the City on 4 October 1666 nominated Peter Mills, Hooke and Edward Jerman as its representatives.[112] This announcement of Hooke's nomination was not an official appointment. That was not to be made for another five months, but in the interim Hooke worked as if he had been appointed to an official position by the City. Once again he agreed to undertake work without any certainty that he would receive financial reward for it. In this respect his appointment by the City was similar to his appointment by the Royal Society. His services were needed, but remuneration was not certain. He would however have been more confident of due remuneration from the City than from the Royal Society.

Of the six individuals nominated by the King and the City to work on the survey of London, Hooke had by far the least experience of land and building surveying and construction, so it might be a matter for surprise that the City chose him as one of their three representatives in the great task of rebuilding London. Of the King's Commissioners, Hugh May was the King's Paymaster (later Controller) of the Works and had dealt with the repair of the royal palaces after the Restoration; Roger Pratt was a gentleman architect, having built Clarendon's residence in Piccadilly and other grand mansions; and Christopher Wren was Savilian Professor of Astronomy and Fellow of the

Royal Society, beginning to make a name for himself as designer of the Sheldonian Theatre and other buildings in Oxford and Cambridge. All three King's Commissioners were working together on a survey of St Pauls at the time of the Fire. On the City's side, Peter Mills was a craftsman, appointed City Bricklayer in 1643 and a year later City Viewer (supervising and reporting on the City's building works) before his appointment to the new post of City Surveyor in 1654; Edward Jerman[113] was also a craftsman, appointed City Carpenter, later Viewer (1650) and, with Mills, Surveyor (1654), a post he had resigned in 1657 to return to more lucrative private practice.[114]

Although Hooke was the youngest and least experienced of the City's nominees he had carried out experiments for the Royal Society on the strengths of different kinds of wood[115] and had investigated Kettering-stone as a building material for Wren, illustrating their common interest in building materials and architecture before the Fire.[116] Further evidence of Hooke's interest in and knowledge of building construction can be found in a report[117] he presented to the Royal Society on 8 June 1664 about damage done to a building in Piccadilly during a thunderstorm the previous afternoon in which he shows detailed knowledge of building construction. He visited the site, examined the building, spoke about the storm with brickmakers, carpenters and others who witnessed it and based his report on what he saw and what he heard.[118] Incidentally, his report shows a compassionate side of his character. He reported that a man had received injuries in the storm and was prevented by a bloodied mouth from speaking. But the following day, when Hooke presented his report to the Royal Society, he stated that the man had recovered well from his injuries. This means that Hooke had taken the trouble to find out the state of the man's health and report on it. For several years Hooke had instructed and supervised craftsmen making instruments first for Boyle and later for the Royal Society's experiments, often working alongside them, and had gained an understanding of different craft and trade practices and their practitioners that would be useful when he came to supervise the rebuilding of London.

Hooke was called upon to make an estimate of the cost of rebuilding the Royal Exchange. On 2 November 1666 at its meeting in Gresham College the Joint Grand

Gresham Committee ordered Hooke, Mills and Jerman to report a week later on the cost of rebuilding.[119] Mills and Jerman appeared to be indifferent and no report was submitted, but Hooke was asked on 9 November 1666 to make an independent report and present it the following week.[120] He lost no time. His findings were before the Joint Committee at its next meeting on 16 November 1666.[121] By 7 December Mills and Jerman had submitted their plans for rebuilding which the Joint Committee, after removing the prices estimated by Mills and Jerman, passed on to Hooke for his appraisal and independent estimates, an early indication that men in the City looked upon Hooke as someone who was trustworthy and competent to judge the opinions of the older and much more experienced Mills and Jerman.[122]

The Joint Committee continued its efforts to obtain reasonable estimates from Mills, Jerman and some craftsmen, but Jerman was becoming difficult, insisting on equality with Mills as a City Surveyor - an appointment he had earlier declined in an attempt to make a higher income from private commissions.[123] Rebuilding of the Royal Exchange was delayed because of Mills's duties as City Surveyor and Jerman's dissatisfaction with the Joint Committee's terms. Hooke was no longer considered as someone who could regularly assist the Joint Committee in the matter, perhaps because it was clear to many of the members that, like Mills, he had other duties concerning rebuilding, and even more as Gresham Professor and the Royal Society's Curator of Experiments.[124] On 25 April 1667 the Joint Committee resolved to pay Mills & Jerman £20 each for having drawn a plan of the Royal Exchange and prepared an estimate of the cost of rebuilding and for attendance on the Committee. Hooke, who had done no further work on rebuilding the Royal Exchange after he reviewed Mills's and Jerman's proposals in November 1666, was ordered to be paid £10 for his pains.[125] From time to time in the years following the completion of the rebuilding of the Royal Exchange, Hooke was consulted by the Joint Committee about unusual matters such as the clock chimes[126] and siting a statue of William and Mary.[127]

It has been stated[128] that the King showed foresight in appointing Wren as one of the Commissioners for Rebuilding that was later justified. In nominating Hooke as one of

its Surveyors, the City showed similar foresight. As Gresham Professor he was already well known to the Lord Mayor and Aldermen of the City whose mercantile and business instincts probably led them to appreciate him as an able and willing 31-year old in need of an income and who alone could provide an intellectual presence for the City equal to that of Wren, one of the King's Commissioners. The burgeoning friendship between the two men as a result of their common scientific interests would have been recognised as important for good working relations with the King that were so necessary for speedy reconstruction of the city's buildings and resumption of its trade and commerce. The long partnership (in science, architecture and building construction) between Wren and Hooke appears to have been very important to both men, but has not yet been fully analysed and assessed.[129]

Many attempts were made to undertake the survey and compile records (under Hooke's supervision) of all interests in land and property for what would now be called "a land information system", but they foundered. Clearance of rubble to reveal the old foundations so they could be identified and measured was too slow. The accurate and detailed plan necessary for defining and locating each holding could not be made quickly.[130] A map[131, 132] was produced by December 1666, but the scale was too small and the surveyed detail much too sparse for it to be used for cadastre as was intended.

The City relied again on Hooke for technical expertise when it nominated him, Mills and Jerman to work with the King's Commissioners to decide on the building regulations for the new Act of Parliament

> This Court doth nominate & appoint Mr [blank] Hooke of the Mathematicks in Gresham house Mr Peter Mills & Mr Jermyn from time to time to meete & Consult with Mr May Dr Wren & Mr Pratt Commissioners appointed by his Majesty concerneing the manner forme & highth of Buildings in this City the Scantlings of Timber removeing of Conduits and Churches and Alteration of the Streetes And it is ordered that from time to time they report such their Consultation to this Court and give noe Consent or make any Agreement therein without the speciall

> Order of this Court.[133]

The latter proviso was a formality; the City's three nominees were left to decide matters on its behalf. In effect, this meant Hooke alone. Jerman seems to have played no part. Mills was growing old and would soon become ill. At the same meeting, the Court of Common Council considered a Parliamentary Bill on the making of bricks and lime. It is worth noting that on that same afternoon at a meeting of the Royal Society

> Mr Hooke took notice, that those earths, which will vitrify, make the more lasting bricks.
>
> It was ordered, that Mr Hooke should make trials of several earths by burning them in a wind furnace, to see, which kind would yield the best brick.[134]

The directions to Hooke by the City were not yet accompanied by an official appointment, nor has any mention of a salary or other form of payment to him been found in the City records up to this time. Hooke nevertheless was active during the winter months of 1666/1667 on the work the City had nominated him to undertake. In the four weeks beginning 4 October 1666 Hooke had received orders (but no official City appointment) to compile a land information system for London, draw up building regulations for an Act of Parliament governing the rebuilding of the city, and (by the Royal Society) conduct experiments to find which material would make the best bricks. The urgency and magnitude of these tasks were too much even for Hooke. Only the second was completed. The first has only recently been seriously attempted and work on the third is still in progress.

Throughout the winter months of 1666-1667 meetings took place between the City's three nominees, the King's Commissioners, the City and the Privy Council. On 8th February 1667 the Royal Assent was given to the first Act of Parliament for rebuilding.[135] This Act incorporated the building regulations devised by Hooke, Mills, Jerman and the King's Commissioners, but it left the City to determine the widths of the streets to be enlarged under the Act, subject to the King's approval. Hooke and Mills were ordered[136] to assist the City in this and by 13th March 1667 the City was ready to present to the King its Acts of Common Council governing the street widening

> His Majesty haveing heard the two Acts of the Comon Councell read distinctly to him, of the 26th and 27th of ffebruary last, the Map[137] of the Citty lying before him, his Majesty lookeing upon the lines drawne out in the said Map according to the Orders mentioned & deliberating & discoursing much thereupon; his Majesty doth fully approve & commend all the Particulars mentioned in the said Orders with these Animadversions upon some of them.[138]

The King also appointed his Commissioners to be ready at all times to assist the City and its three nominees. The seven animadversions by the King were not all feasible under the Act of Parliament, but the City did what it could to meet them. Those that were feasible were incorporated in an Act of Common Council dated 29th April 1667.[139]

The City's confidence and trust in Hooke during the hectic months from its approbation in September 1666 of his plan for rebuilding to the publication of the Act of Common Council in April 1667 is remarkable. A man, with as yet no formal connection with the City except his appointment at Gresham College, was trusted effectively to determine on the City's behalf all technical aspects relating to the rebuilding of the city and to take charge of surveys for a new map of the existing streets. Conversely, Hooke trusted the City to treat him fairly in matters of remuneration. Although Mills and Jerman were also involved and had already held City appointments, Hooke's later working relationship with Mills and the lack of evidence in the City records of Jerman's activities at that time (other than in connection with the Royal Exchange) indicate that Hooke played the major role despite holding no office. This was finally rectified at a Court of Common Council on 13 March 1667

> Mr Peter Mills Mr Edward Jarman Mr Robert Hooke & Mr John Oliver are chosen to be surveyors & supervisors of the houses to be new built in this Citty & destroyed by the late fire according to the late Act of Parliament in that behalfe
>
> And it is ordered that the said surveyors doe forthwith proceed to the stakeing out the streets as is ordered & directed by this Court in pursuance of the said Act. ...
>
> The Aldermen Deputies & Common Councell men of the severall wards

> of this Citty destroyed by the late fire are desired to be present in their severall wards at the stakeing out of the streetes.[140]

and at a Court of Aldermen (Figure 1) on the following day Mills and Hooke were sworn as the City's Surveyors. Jerman was absent, Oliver had earlier asked to be excused, but offered to assist Mills, gratis. The Court accepted his offer.[141] Hooke received no similar assistance, but took his full burden with no apparent objection

> This day Robert Hooke Master of Arts and Mr Peter Mills two of the Surveyors elected by Common Councell in pursuance of the Late Act of Parliament for rebuilding for the purposes in the same Act mentioned and declared, were here swome for the due Execution of the said place in form following viz:
>
> You shall sweare that you shall well and duly see that the Rules and Scantlings sett downe and prescribed in an Act of this present Parliament for building within the Citty of London and Libertyes thereof bee well and truly observed And that in all other things you shall truly and Impartially Execute the place or office of Surveyor or Supervisor within the said Citty and Libertyes as by the same Act of Parliament is directed and intended according to the best of your skill knowledge and Power Soe helpe you God.[142]

and six days later the City sealed an Instrument authorizing them to stake out the streets.[143] Hooke was about to embark on another onerous period of work. He continued to work as Surveyor with diligence and efficiency until near the end of his life when infirmity brought this work to an end.

CHAPTER 3

REBUILDING THE CITY IN THE AFTERMATH OF THE GREAT FIRE

3.1 Staking Out the Streets and New Foundations

On 27 March 1667 Hooke and Mills began staking out the streets, starting with Fleet Street.[144] An account[145] written by the City's Clerk of Works lists expenses incurred in the week ending 30 March. It shows that workmen were paid for each of the seven days and that six carpenters and seven labourers used 1220 feet of timber for stakes. In subsequent weeks a carter was engaged to carry the timber around the City. The major part of staking out the streets was completed in about nine weeks,[146] but work continued intermittently for the next few years in response to specific requests to the Court of Aldermen from individuals, groups of neighbours and corporate bodies.

The procedure followed by the person responsible for rebuilding a particular private property[147] was defined in the Act of Common Council dated 29 April 1667.[148] The sum of 6s 8d for each foundation was paid into the Chamber where details of the payer's name and the number and locations of the foundations were entered into Chamberlain's Day Books (Figure 2).[149] The payer was thereupon issued with a receipt which was passed on to one of the Surveyors who accepted it as authorisation by the City to undertake the foundation survey and write a certificate. The person undertaking the rebuilding was responsible for clearing all rubbish from the foundations prior to the survey.

The Surveyor and his client met upon the site at an arranged time. The Surveyor identified the old foundations by inspection and if necessary by hearing evidence presented by his client, neighbours and other witnesses. Deeds giving dimensions were sometimes available and used as additional evidence by the Surveyor. When satisfied that the foundations had been located, the Surveyor staked out the building lines, party walls and

piers, allowing for the effects of any street widening, and measured the lengths of the boundary lines. He recorded in his survey book information such as the date, client's name, location and dimensions of the site, number of foundations, names of neighbours and sometimes a sketch. The certificate was probably written soon afterwards from information recorded in the survey book, and handed to the client. Only then could rebuilding begin.

Owners were anxious to start rebuilding. Mills and Hooke could not keep pace with the rate at which payments were coming into the Chamber, so delays of one or two months built up. The backlog became worse at the end of July 1667 when Mills fell ill for a few weeks. Oliver then helped Hooke with the onerous task.[150] Either Oliver or the City delayed a formal appointment until 28 January 1668 when Oliver was sworn as the third City Surveyor.[151] Mills, Hooke and Oliver then shared the work which the City had intended to be undertaken by four Surveyors, but Mills was ailing. He carried out his last survey on 19 July 1670[152] and died within the next three months.[153] He was not replaced. Thereafter Hooke and Oliver together shared the duties of City Surveyor.

Entries to the Day Books are arranged chronologically, each recording the date, the name of the person who paid the survey fee, the location and number of foundations to be certified, the sum paid into the Chamber and sometimes the initials of the Surveyor to whom the survey was allocated. These Day Books are a careful and systematic record of the progress of rebuilding. The first entry is dated 13 May 1667 (allocated to Mills) and the last 28 July 1696 (allocated to Hooke), but by the end of 1671, 95% of the foundations had been surveyed. The Day Books record a total of 8,394 foundations and £2,798 00s 00d as the total sum received.

Very few of the certificates issued to individuals can now be located. The Day Books are almost the only available primary records of the foundation surveys. Each Surveyor recorded details of his surveys in his own book. These books, containing not only details of surveys of 8,394 foundations, but also aides mémoires and records about other official activities considered in section 3.2, such as measurement of areas of land

taken by the City for widening the streets, are now lost. Mills and Oliver each handed in ten survey books to the City which were transcribed into four volumes.[154] The twenty original survey books are now lost, but facsimiles of the transcriptions have been published by the London Topographical Society.[155] Hooke did not hand in his survey books to the City, despite orders to do so,[156] and they are now lost.

It is possible to make a reasoned estimate of the number of foundations set out and certified by Hooke, even though none of his certificates or survey books is available. His diary gives very little indication of the magnitude of this work because entries begin in 1672, by which time more than 95% of the foundation surveys had been completed. Samples of evidence from the Day Books show that where a particular foundation was allocated to a particular Surveyor, the transcripts of Mills's and Oliver's survey books are in good general agreement. It therefore is reasonable to assume that all 1,582 foundations allocated in the Day Books to Hooke were surveyed by him. There are however 3,829 foundations in the Day Books which are not allocated to any Surveyor. If these are distributed equally between the two, or three, Surveyors working at the time, 1,413 would be allocated to Hooke, giving an estimated total of 2,995 foundations surveyed by him. Evidence has been found that Hooke carried out particular unallocated surveys. For example, on 8 February 1673 John Oliver and Joseph Anis paid for their foundation surveys at Fleet Bridge[157] and Hooke notes in his diary for 27 March 1673

> set out Oliver and Anis.[158]

Similar examples can be found.

Other ways of apportioning the 3,829 unallocated foundations are possible. They would be time-consuming, but unlikely to lead to better estimates. The city was loosely divided between the Surveyors,[159] but the divisions were not strictly adhered to. To apportion the unallocated foundations according to their geographical positions in the city would not necessarily lead to a better estimate than that already made. The transcriptions of Mills's and Oliver's survey books could be searched for each foundation not allocated in the Day Books and then, if not found, assumed to have been surveyed by Hooke. Such a procedure would not be simple; some transcription errors have been noted,[160] omissions

are probable and it has been pointed above that some of the entries in Mills's book are known to be surveys by Oliver and Hooke. The simple method used here to apportion the 3,829 foundations equally between Surveyors working at the time has been tested by taking 43 sample Day Book folios containing records of more than 600 sites, nearly every one of which is allocated to one of the three Surveyors. It was found that the aggregate for any Surveyor did not differ from the mean by more than about 11% (Hooke's aggregate was within 1% of the mean). There is no indication in the Day books that the distribution of sites between the Surveyors was intended to be as equitable as it has been found to have been from the sample examined, but the Chamberlain's Clerk may well have kept elsewhere a record of running totals. Table 1[161] shows the estimated number of foundations staked out and certified by Hooke for each year, following the above procedure.

Having estimated the number of foundations surveyed by Hooke, it is possible to estimate the time he spent surveying them, based on personal experience and indirect evidence presented in the Appendix. From a study of the transcriptions of Mills's and Oliver's survey books, 30 minutes seems a reasonable minimum time for staking out, measuring and recording a single foundation once the boundary lines had been located by the Surveyor. Time spent locating foundations, listening to witnesses, examining deeds, clearing lines for measurement (this was not always done beforehand), travelling from one site to another and writing a certificate can only be guessed at; say a minimum of another 30 minutes. Therefore time spent on each single foundation is unlikely to have been less than one hour.

A complication arises when multiple contiguous foundations were staked out, surveyed and certified. Usually one certificate was issued, giving measurements of only the perimeter of all foundations staked out, not of each foundation separately. Such work would take less time than for the same number of separate foundations. Of the 1,582 foundations allocated to Hooke in the Day Books, 579 (37%) are multiple foundations, 284 of which are double, 87 triple etc. (Table 2[162]). From personal experience of the practicalities of multiple foundation surveys, about 25% of time spent is independent of

the number of measurements and the remainder is in direct proportion to it. The consequence is that the average minimum time for each of the 1,582 foundations allocated to Hooke is just over 50 minutes, only a little less than the minimum time spent on surveying a single foundation.

In particular the Day Books show that in March, April and May 1669 Hooke was allocated 100 foundations plus a third of 514 unallocated: an average of about 90 foundations to survey in each of the three months, not counting any backlog. By working six days a week, Hooke would have spent at least 3 hours each day on foundation surveys alone. He also did other work almost daily for the City which is not included in this assessment, but is discussed in the next five Sections.

3.2 Certification of Ground Taken Away

It is possible to estimate Hooke's contribution to the work of the City Surveyors in measuring, calculating and certifying areas of private ground taken away for building widened streets and other new works, based primarily on the City of London's contemporary records. Evidence shows that Hooke issued more than 300 such certificates, nearly 90% of them before 1675. Some conclusions can be drawn about the income he received from this activity (in addition to his salary from the City) and his efforts can be compared with those of the better-known Mills and Oliver, the other two City Surveyors at the time. The many examples of Hooke's certificates found in the archives give evidence not only of how he reported his measurements to the City, but of how he responded to the exigencies of the time which were quite different from the demands made on him by the Fellows of the Royal Society.

In the rebuilding of London after the Great Fire of 1666, private land was taken by the City for new and widened streets, new markets, wharves alongside the new Fleet Channel, and quays and wharves along the northern bank of the Thames. The amount of compensation paid by the City to owners of property depended on the location of the site and the area of ground taken away. In Section 3.1 and elsewhere,[163] evidence of Hooke's

work staking out widened streets and new building foundations is presented. A certificate of area of ground taken away was sometimes issued at the same time as the new foundation was set out and certified, but more often it was issued some time later. This called for careful records to be kept by the Surveyor which could be referred to years later when a new or copy certificate was required.

The City had to decide not only on the amount of compensation and the procedures for paying it, but also to ensure that the procedures were properly carried out and generally accepted by the citizens. Hooke and the other two City Surveyors were ordered to undertake this crucial task. On 22 January 1668 the Committee for Letting the City Lands (commonly called the City Lands Committee, but known since 6 February 1969 as the City Lands & Bridge House Estates Committee) was empowered[164] by the Court of Common Council according to the Rebuilding Act then in force to reach agreement on compensation with owners and tenants of ground taken away and used for making new streets or for enlarging old ones, taking into account any melioration of loss. The Rebuilding Acts[165] allowed compensation for private land taken by the City to be paid from monies raised by a tax on coal (often referred to as "the Coal Monies" in City documents) levied specifically to pay for rebuilding. The Committee was also empowered to call on Counsel and other assistance, and to pay for such services from the Foundation Cash.[166] The City Surveyors were ordered to attend the City Lands Committee from time to time.[167]

The procedure adopted by the Committee was for the Surveyors to measure and certify areas of private ground taken away by the City. The area certificate, for which the claimant paid a negotiable fee to the Surveyor, was taken by the claimant and handed in to the City Lands Committee where the claim was registered to be heard. At the hearing, the Committee treated with the claimant and reached agreement on the rate of compensation, (sometimes taking into account melioration of the loss of ground by improvements by the City such as easier access to buildings or a better prospect) but always based on the certified area of ground lost. When the City and the claimant agreed on compensation, the claimant was given a signed warrant instructing the Chamberlain to

pay the agreed sum at the end of six months from the date of the warrant. This delay was intended to allow time for any other person who had a lawful interest in the compensation money to lay a claim. Upon receiving the money, a conveyance of the ground to the City was made and the payee was required to indemnify the City against any further claims in relation to the certified ground.

In cases when a party (landlord, lessee, or tenant) had a grievance, the matter could be referred to the Fire Court for judgement. The speed, efficiency and impartiality with which the Court reached its decisions and issued decrees, and the citizens' confidence in its processes were important reasons why the city was rebuilt without civil unrest.[168] Hooke and the other City Surveyors were sometimes ordered by the Fire Court to undertake a specific survey relating to a case and report their findings. For example, parties in dispute about the effects of proposed rebuilding on an occupier's rights to light were ordered by the Fire Court Justices to get the City Surveyors to visit the sight, take measurements and report their findings in writing to the Court. Mills and Hooke undertook the survey and on 30 May 1667 a Court settlement was reached on the basis of their findings.[169] No disputes about the Surveyors' routine certifications of ground lost came before the Fire Court.

More than 650 area certificates written by the City Surveyors Mills, Hooke and Oliver are extant in the Corporation of London Records Office[170] where other documents to be found include some of the bonds signed by claimants who received payment for ground taken away indemnifying the City. There are many more certificates than bonds, but not every bond has a corresponding certificate. Therefore more certificates than are at present in the archives were issued by the Surveyors. There is other evidence that even more certificates were issued than are extant in the archives. A decade or so after the majority of the certificates had been issued, a list of them was made by the City.[171] This list includes details of a few certificates that are no longer extant.

Although Peter Mills and Robert Hooke had staked out the majority of widened and new streets by the end of May 1667,[172] the City did not start paying for land taken

away until almost a year later when agreement was reached with Richard Hodilow on a sum of £600 to be paid from the Coal Monies for the loss of his ground in Cheapside for the making of the new street.[173] However, no record of a Surveyor's certificate or any record of the area of ground has been found, so this settlement can be regarded as exceptional. Two weeks later, on 18 March 1668, the Court of Common Council repeated its order made on 22 January empowering the City Lands Committee to satisfy claimants for loss of ground, but added that compensation was to be paid by the Chamberlain from the Coal Monies, thus rectifying an omission from the earlier order.[174] Thereafter payments were based on Surveyors' certificates. The earliest certificate recorded is by Mills, dated 4 April 1667.[175] Hooke's earliest recorded certificate is dated 16 July 1668.[176] His last is dated 11 March 1687.[177]

The main sources for estimating the number of area certificates written by Hooke are the manuscript certificates and the manuscript list of certificates. Very nearly half the 643 certificates are Hooke's, some of which refer to 11 others that he wrote, but which are neither extant nor listed. When these 11 lost certificates are included, it is found that Hooke issued at least 323 area certificates (Table 3[178]). Somewhat less reliable evidence that he wrote even more area certificates can be found in his diary. An example is the entry for 4 February 1673, written in the terse, almost cryptic style Hooke used in noting events in his busy life

> Lems certificate guinny. Hauslopes 10sh. St. Peters cornhill 20sh.[179]

An area certificate by Hooke dated 3 February 1673 was issued to Joseph Lem for ground taken from the south-west corner of Suffolk Lane and Cross Lane.[180] Another area certificate, also by Hooke and dated 3 February 1673, was issued for ground taken from St Peters Church at the corner of Cornhill and Gracechurch Street.[181] These two certificates are almost certainly those for which Hooke received the payments he recorded in his diary. However, no record of an area certificate issued to Hauslope has been found in the CLRO.[182] Given its context and the implied possessive form of the names of the two individuals, the diary entry seems to refer to payment by Hauslope for an area certificate,

but it could refer to some other service carried out for Hauslope by Hooke (such as advice on rebuilding) or even to a payment by Hooke of Hauslope's account - he was a coal merchant to whom Hooke paid 18 shillings on 9 March 1675 for a load of coal.[183] On 1 February 1673, Hooke wrote

> Hauslopes, Cole harbour.[184]

which suggests that he visited Hauslope at his wharf three days before the diary entry which mentions the sum of 10 shillings, but the purpose of the visit, reason for the payment and who paid whom remain undecided. Similarly terse and ambiguous entries related to sums of money can be found throughout the diary. Samples of entries show that those which *might* refer to payment for a certificate of area not already counted are few: less than 10% of the total already found. For this reason, and for the fact that the diary was not begun until after Hooke had issued more than half his area certificates, evidence from it has not been used in the compilation of the data in Table 3.

Despite many ambiguous minutiae in the diary of the kind just discussed (and the pedantry they invite illustrated) their style and abundance show clearly the intensity of Hooke's work in rebuilding the city and the steady income from that activity which was in addition to his annual salary of £150 at this time as one of the City's Surveyors[185].

Each area certificate gives the claimant's name, the location of the site, a statement of the dimensions and aspects of the boundary lines and the area of ground taken away. When the old foundations could be clearly identified and measured, the certificate was simple. Figure 3 is one example of Hooke's straightforward certifications of area.[186]

> These are to certify that I have admeasured the ground taken off from a foundation belonging to Mr. King Lying at the South west corner of Buttolph Lane fronting the said Lane and Thamstreet and I find that there is taken away for the Inlargment of Thamstreet eight foot in Depth at the east end and eight foot and eight inches at the west and the bredth of the old front to Thamstreet is twenty foot. the superficiall content whereof is one hundred sixty and six foot and two thirds of a foot I find also that

> there is taken for the inlargment of Buttolph Lane two foot and eight inches at the south end and one foot fowr inches at the north the bredth of the said front being fowrty one foot ten inches Little more or Less the superficiall content wherof is Eighty three foot and three quarters. the whole together amounts to two hundred and fifty foot and almost an half. In testimony whereof I have hereunto set my hand the 1st of December 1670. Rob:Hooke

Hooke gives no sketch or other graphical representation of the foundations in this certificate. Unlike the other two Surveyors, Mills and Oliver, Hooke rarely chose to do so, relying instead on written information alone. A rare example of Hooke's use of a sketch in an area certificate is illustrated in Figure 4.[187] Without the sketch, the certificate would be too verbose as it deals with several contiguous foundations. It shows measurements of ground taken for the Monument and adjacent piazza. Hooke regularly visited the Monument (which he usually referred to as "the piller") during its construction, engaged on work which would now be undertaken by architect, quantity surveyor, resident engineer and their teams. He gives a sketch on another certificate[188] which also refers to several foundations, and to different owners. It is known that Mills and particularly Oliver drew sketches in their survey books because, although the originals are now lost, they were copied by the City in the eighteenth century and the copies have been published.[189] It would be surprising if Hooke too did not draw sketches as a matter of course in his survey books, if only as aides mémoires, not to be used as formal evidence to the City in certifying the amount of compensation to be paid. He found the survey information they contained of financial benefit, as when he wrote copy certificates for payment,[190] but given his continuous curiosity, observing and recording what was going on around him, he may well have used his survey books to note names, purchases, details of the weather and other natural phenomena.

Hooke's diary is written in the form of a note book. He started it in 1672, by which time the urgency of his survey work for the City had diminished. In the years preceding the start of the diary, Hooke was engaged on his survey tasks almost daily and

carried his survey books with him as he went from place to place. It would have been easy for him to use them not only for recording details of his surveying, but also for noting down items of general philosophical interest or of importance to him in his work for the Royal Society. As he came to make much less use of his survey books, so he started his diary. The opening words in it are

> Memoranda begun: March 10 167½.[191]

His reason for writing the diary is clear; it also admits the possibility that he had until then used his survey books for similar purposes. Their disappearance is a great loss, not so much for what they would reveal about his surveying, but for what they might reveal about his less mundane and more intellectual preoccupations.

Typically, admeasurements given by Hooke (such as those in Figure 3) are insufficient to define uniquely the area of ground enclosed by the six boundary lines, or foundations. Some additional information about the shape of the ground is needed. Measurement of horizontal angles between adjacent boundary lines would suffice, but was not necessary. Calculation of area could be carried out by assuming pairs of boundary lines to be parallel, or orthogonal. No unreasonable or unfair payment would arise by making such assumptions. They would therefore be as appropriate as measuring angles, much more practicable, and generally as accurate, given the instruments readily available at that time. This mathematically non-rigorous method for calculating areas of ground is fully in accord with the City's intent in all matters relating to rebuilding: to devise and put into practice speedy, fair and reasonable procedures, acceptable to the citizens in general. The absence of sketches from nearly all Hooke's area certificates is therefore not surprising. Not only was a sketch unnecessary, but it could mislead others into accepting and using it as a representation of the true size and shape of the area.

Hooke's calculations in the left-hand margin of Figure 3 show that he assumed the eastern and western boundaries (8ft 0in & 8ft 8in respectively) were orthogonal to the 20ft boundary fronting Thames Street and calculated part of the area on that assumption as (8ft 4in) × (20ft) giving the result as "166.8". Similarly the remaining contiguous area fronting Botolph Lane is calculated as (2ft) × (41ft 10in) and shown as "83.8". The total

area, or "superficiall content" is the sum 166.8 + 83.8, given as "250.4" and written as "two hundred and fifty foot and almost a half." The numerical representation is hybrid: digits to the right of the point are duodecimal fractions, not decimal, with 0.1ft "superficial content" being equivalent to $^1/_{12}$ ft^2, or 12 in^2. Such representation simplified calculation by the Comptroller's clerk of the value of the ground, usually reckoned at a rate of a given number of shillings per square foot. So, for example, a rate of 5s per ft^2 (or 1 foot superficial content) corresponds to 5d per $^1/_{12}$ ft^2 (or 0.1 foot superficial content). The simplicity is illustrated on another area certificate of ground taken from a toft in Bearbinder Lane for Woolchurch Market where Hooke certifies a superficial content of

> one thousand and twelve f[torn]t and an half.[192]

The Clerk's handwriting shows division of 1012 by 4 to give 253 (pounds), multiplication of 6 by 5 to give 30 (pence) and a total of £253-02s-06d.

Hooke's work for the area certificate illustrated in Figure 3 was straightforward, but problems often arose which required more than an ability to undertake simple linear measurements and perform accurate calculations. Often on arriving at a site he found that the old foundations had been obliterated by new building, or had been taken up or covered over when a road was widened or a new one made, so it was impossible to measure them. He then had to resort to other sources of evidence for his certificate. Old leases were examined to see whether the dimensions given in them were still acceptable. On 16 May 1671 Hooke had to refer to a lease of 1663 in order to write a certificate for a Mr Hogsflesh of Fish Street Hill.[193] He took dimensions (in ells) from a charter written in the reign of Edward VI to calculate an area in Bearbinder Lane. He added the following statement to his calculation of the area as 1012 square feet

> And I have examined the foundations as far as I could And conceive that the Said dimensions are very near the said content of the said Ground, and it seemeth to be rather more than what is here expressed.[194]

and he used dimensions taken from the Christchurch Hospital Survey Book to certify an area of ground taken away at Fish Street Hill.[195] Anthony Tanner ("Citizen & Tyler and Bricklayer of London") surveyed a nine-sided toft in Black Horse Alley near Fleet Bridge and drew a plan at a scale of 1in to 8ft for a Mr Henry Dixon. Tanner swore an oath that

the measurements were made by him and are as shown on the plot. Hooke then used the dimensions to calculate and certify the area on the reverse side of the plot. He calculated the area to be "one thousand and fifty foot or thereabouts" which is only 3% less than Tanner's value. The discrepancy is insignificant (except it shows that Hooke did not accept Tanner's area, but recalculated it) given the scale of the plan and the indeterminate shape of the ground - all of which is covered by Hooke's "thereabouts".[196] In March 1676 he had to refer to an entry made in April 1669 in Mills's survey book in order to write a certificate for ground taken from two houses on the west side of Foster Lane belonging to Lady Alice Viner, having found no record in his own books.[197]

Sometimes Hooke was asked by a claimant to write a new certificate because the original was said to be lost. In such cases he would refer to his survey books and write a "repeat certificate" as he did for a Mr Selby on 12 July 1672 for a toft at the corner of Harp Lane and Cross Lane, replacing one he had written on 14 July 1671.[198] There was a need to ensure that a repeat certificate did not lead to compensation being paid twice for the same ground. When Hooke wrote a certificate to replace one he had written earlier for a Mr Howland of Grant's Key in Thames Street, now lost, he thought it pertinent to add a note for the Comptroller

> pray take notice Least it [the original certificate] be brought in by some other hand into whom it may have fallen.[199]

The careful records kept by the City and by the Surveyors ensured that payment twice for the same ground was very unlikely. Hooke certified an area of ground lost in New Fish Street Hill for Arthur Wind Esquire on 31 January 1671.[200] Following Wind's death, the Parishioners of St Margarets, New Fish Street Hill asked Hooke to write a repeat certificate. He did as requested, making use of

> my book of surveys

and stating clearly that the certificate he had written for Wing was lost

> as is affirmed

and because

> interest of the said Lost ground being now claimed by the Parish

he had been asked to write the present certificate.[201] In due course, this certificate was handed in to the City, but no payment to the Parish was authorised. A clerical addition to the certificate states that a warrant for payment had been issued to Wind on 15 February 1671. Comparison of these two certificates for the same lost ground, one written almost 6 years after the first, shows a slight discrepancy between the areas certified by Hooke, although the linear dimensions given in each certificate are identical.[202] This discrepancy shows that he did not record the area in his survey book, but calculated it later when writing the certificates. The certified written descriptions in the two certificates of the positions and aspects of the boundaries of the ground lost are quite different. This indicates that in his survey book Hooke had recorded the layout and dimensions of the site in the form of an annotated sketch which he later used as the basis for the verbal descriptions.

Hooke's knowledge of details of the legislation concerning payments for ground taken away is apparent from a certificate relating to four separate foundations belonging to a Mrs Merrick. It concludes with a note by Hooke pointing out that payment for the loss from only two of them is covered by existing legislation

> The 162 foot and the 127 foot are to be paid for by the Act of Parliament already past but the preceding quantitys of ground cannot be payd for till the additional act passe.[203]

The Additional Act would not be passed for another ten months, but Hooke was aware of its contents, recognised that it would be relevant to the particular survey he was working on and gave warning of the effect it would have on compensation to be paid.

When foundations could not be measured and no suitable written evidence could be found, Hooke required sworn evidence by appropriate and reliable witnesses to be taken. He used the affidavits, sometimes with circumstantial evidence, for writing an area certificate. An affidavit[204] sworn by George Hodgkin, Citizen and Carpenter, was used by Hooke to certify an area of ground taken away for widening St Michaels Lane because the old foundations had been removed and Hooke wrote he

> could not certainly Measure the depth of the lost ground

After stating in the certificate the area sworn to by Hodgkin, Hooke wrote

> which I judge to be very probable.[205]

Old foundations belonging to a Mr Parsons at the corner of St. Clements Lane and Cannon Street had been removed by workmen when the streets were cleared immediately following the Fire. In the area certificate for Parsons, Hooke judged the dimensions given in an affidavit by the bricklayer and carpenter who rebuilt Parson's house in 1669 to be acceptable because they corresponded to the ground he knew had been taken away from the opposite side of the street.[206]

Hooke was generally scrupulous in stating in a certificate his opinion of the reliability of oral and other evidence, but not always. In certifying an area of lost ground for Sir George Waterman who had been Lord Mayor two years earlier, Hooke accepted and used without comment Sir George's affirmation of one dimension that could not be measured.[207] Sir George was said to be

> a person almost voide of understanding, but not of will. He is very weake in the one and very perverse in the other.[208]

Hooke may have known him to be honest too, but the dimension was affirmed to be only 18 inches so Hooke may have found other reasons for unqualified acceptance of Sir George's evidence. In writing an area certificate (Figure 5) for the Parishioners of St Andrew Hubbard Church, Hooke was able to measure the south and west sides of the foundations as 85½ft and 44½ft respectively, but sought both oral and documentary evidence about the dimensions of the other two

> but the old foundations being Pluckd up at the North east Corner I could not certainly find the Length of the North and east sides but by the testimony of many of the Antients of the Parish & by a Ground platt of the said church and churchyard made by Mr. Street an accurate measurer whilst the walls were yet standing I find that the church and churchyard had Square corners and that the north side was very near equall to the south & the east side very near equall to the west. Whence the superficiall content of the whole must bee three thousand eight hundred and fowre foot[209]

Sometimes Hooke shows sympathy for a claimant who might suffer undue hardship, by adding a sentence or two to an area certificate pointing this out to the Committee and suggesting ways in which it might be alleviated. A Mr Martindale owned land adjacent to the Fleet Channel, part of which was taken away to make the new wharf. Hooke visited the site and reported that Martindale showed him where the ground lay for which he was seeking compensation, but it was buried so deep in rubbish that its dimensions could not be taken. Hooke wrote two inessential, but helpful, statements in the certificate. He suggested that Martindale's deeds and sworn statements by his tenants might suffice as evidence, adding that it would be a great expense for Martindale to clear the ground so that it could be surveyed.[210] He wrote similar sympathetic words in a replacement certificate for the Parishioners of All Hallows Barking Church, expressing

> the Great and extraordinary Expense ... first for the taking Downe a wall which was substantiall and next for the Rebuilding the same in an other place for the Inlargement of the street, which they would otherwise not have been necessitated to doe and thirdly for the Removing a great quantity of earth for Reducing the same to the Levell of the street the charge of all which as I am credibly informed doth amount to one hundred pounds or thereabouts. whereby they have sustained a Double loss to what any other person hath susteined whose buildings being burnt the ground only is taken away.

In an addendum he added some information that had come to light after the original certificate had been written

> [the Parishioners] have been necessitated both to pull downe the old wall of their churchyard which might otherwise have served a long time, and to Rebuild the same anew and Also to Remove much earth wherein severall corps had been not long before buried which hath been a great and extraordinary charge to the said Parish and I humbly conceive the same may be taken into consideration by this Committee and the said Parish allowd soe much more for their Ground than what is ordinarily allowed they having been doubly Damnifyd by the aforesaid Inlargment of the street and noe wise at all meliorated

Feb:4:167⅔ Rob:Hooke[211]

It was not necessary for Hooke to write such comments in his reports. The fact that he did so from time to time shows that he saw examples of hardship which in his opinion went beyond what most citizens suffered from the Fire. He then took the trouble to report the circumstances and ask the City for special consideration in such cases. Evidence of whether or not the City acted as he requested has not been found, but it is unlikely that Hooke would have troubled to report these matters if he expected that nothing would come of it. In any case, he showed compassion to those who were suffering and acted accordingly.

3.3 Views

"View" has been used indiscriminately by most writers on Hooke in connection with all or any of the surveying tasks he undertook for the City,[212] but it has a particular connotation. In his diaries[213] Hooke followed the custom of the City in using "view" to refer to a site visit and written report on what was found. Views were generally ordered by, undertaken for, and reported to the City, but they could be carried out as a result of a request by a citizen or organisation. Before the Fire, views were undertaken not by the City Surveyor, but by the five or six men appointed as City Viewers.[214] These were craftsmen who had had experience working as City Artificers and had then become Master Bricklayers, or Carpenters or Masons. Peter Mills and Edward Jerman who, with Hooke and John Oliver were chosen as City Surveyors[215] had previously held appointments as City Viewers. Mills had been a City Bricklayer before becoming a City Viewer in 1643 and Jerman was a City Viewer in 1650 having been a City Carpenter.[216] No evidence has been found that Oliver had been a City Viewer before being appointed City Surveyor, but he was a Glazier.[217]

By 1668 the rate of rebuilding had begun to increase rapidly. The new regulations were much more rigorous than those in force before the Fire. Administration of the sections of the Rebuilding Acts[218] which defined materials and the types of new buildings permitted after the Great Fire of 1666 was primarily the responsibility of the City. Only after new and widened streets had been staked out and foundation certificates issued[219]

could owners start to rebuild. The City Viewers were unable to cope with the new complexity, urgency and large numbers of complaints. The first Rebuilding Act made the City responsible for ensuring the building regulations were enforced, so Hooke and the other two City Surveyors Peter Mills and John Oliver were given the responsibility of reporting to the City on all matters in dispute and advising on their settlement. The City Viewers gradually resumed their role after 1674 when most of the rebuilding had ceased.

Most of the views Hooke and the other Surveyors were ordered to undertake arose as a result of a citizen's complaint to the City that a neighbour's rebuilding was not in accordance with the Acts, or was to the damage or detriment of the complainant's property. In such a case, the viewers would visit the site, examine the work, question the parties involved and recommend in their report to the City how the dispute should be resolved. The City almost always accepted the viewers' recommendations and so did the parties in the dispute. The person who asked for the view paid a negotiable fee to the viewers for their attention to the matter. At least two men, sometimes more, were ordered to view each site; all those who were so ordered had to agree on the recommendations for settling the dispute and sign the report. Often the Alderman and Deputy of the Ward in which the view took place were appointed viewers, ad hoc.

Another kind of view arose when the City required a report on the progress of its own building work. Viewers were appointed to report on such matters as the suitability of materials, workmanship and contractors' bills and recommend what should be done about payments and settlement of any disputes arising from the building work. Such views were usually undertaken for the City, but Hooke sometimes received commissions to undertake similar views from private citizens or institutions in connection with their own building work.

Having already acted for the City first by drafting (with the King's Commissioners) the technical details of the Rebuilding Acts, then by staking out streets and foundations of new buildings, measuring and certifying areas of ground lost,[220] Hooke was now required to view and report on disputes between neighbours, and on allegations

of irregularities in rebuilding. The Rebuilding Acts were intended to produce a new city that was healthier, safer, and more regular than its predecessor. These objectives were achieved not by a new layout of streets and buildings, but by allowing the citizens to rebuild mainly on their old foundations, but in strict accordance with the new building regulations. Some streets were widened or straightened and wharves and quays were laid out. Although compensation was paid by the City to those who thereby lost ground, the new building regulations did not allow all tenants to recover fully the rights and occupation of spaces that they enjoyed before the Fire. For example, occupants of adjoining properties often lived in rooms that lay over or under their neighbours' accommodation. One of the new building regulations was that party walls must be vertical and entire from the ground, so the intermixture of interests that existed was no longer possible. Disputes about loss of space could arise as soon as a neighbour began to build a party wall on the foundations that a Surveyor had located, staked out and certified. Neighbours had to share the cost of rebuilding the party wall separating their new interests. The one to rebuild first sometimes did not receive moiety payment, or perhaps did not leave spaces in the brickwork for the joists and beams of the adjoining building. Intermixture of interests and new party walls were common causes of dispute.

Rights of access and light were often matters for argument and complaint. The old city had many narrow passageways and small inner courtyards into which occupiers had rights of light and entry. Upper stories of houses had often been "jetted-out" (extended, sometimes without support, beyond the old timber-framed load-bearing walls) into and above these small yards and main thoroughfares. One of the intentions of the Rebuilding Acts was to remove such small open spaces and irregular frontages. Light, entry, and water drainage gullies were often removed at the same time, so disputes arose which had to be speedily settled.

Fires and furnaces necessary for trade practices, such as metalworking, were often objected to by neighbours as a nuisance. In some specific places they were forbidden by the Rebuilding Acts and if built had to be taken down. People who formerly lived near churches sometimes claimed when rebuilding that their new properties and even their lives

were in peril from collapsing masonry and asked for damaged spires and towers to be taken down.

The City ordered the Surveyors to look out for and report weekly in writing to the Lord Mayor any irregular building whether or not neighbours had made a complaint.[221] The City Lands Committee ordered the Surveyors to send in lists of names of persons who had built against the city walls, and stop them from proceeding until the City had considered the matter.[222] Hooke spent much of his time engaged with others in detailed investigations of alleged irregularities and complaints arising from rebuilding and in reporting their findings and recommendations to the City. Sources of evidence that Hooke had a major role in settling these disputes are now described.

Three main sources have been used to estimate the number and describe the form of Hooke's reports of views of disputes between citizens during rebuilding after the Fire: two boxes of Viewers' manuscript reports[223] and three volumes of transcripts of Viewers' reports[224] in the Corporation of London Records Office; and Hooke's diary.[225] Other sources, such as the Repertories of the Court of Aldermen, record orders to view and transcripts of reports, but many of these records relate to views reported or recorded in the main sources.

The first volume of transcripts of reports starts with a view by the City's three Surveyors (Mills, Hooke and Oliver) at Jewin Street on 13 March 1668.[226] The dispute was about ancient lights. A total of 263 different reports are transcribed in this first volume, of which 229 include Hooke's name as one of the Viewers. The last report in the volume[227] is of a view by Hooke and Oliver on 10 February 1671 concerning a party wall in dispute. The second volume covers the period from November 1674 to June 1684 and contains 196 transcriptions, of which 57 include Hooke's name. The third and last volume covers the period from the end of the previous volume to November 1691. It contains 110 transcripts of which 42 include Hooke's name. It appears as if there was once another volume of transcripts, now lost, covering the period between the end of the first volume and the beginning of the second, i.e. from February 1671 to November 1674.

The contents of the first box of manuscripts are arranged more or less chronologically from 1659 to 1675. The first 18 items are reports of views by the City Viewers made before the City Surveyors were called upon to undertake most of this work. The first manuscript bearing Hooke's name and signature[228] is dated 9 September 1669 and is one of several manuscript reports that have been found, but not transcribed into the volumes of Viewers' reports. The box contains a total of 53 reports of views by Hooke. The contents of the second box are arranged similarly, covering the period from 1676 to 1704, but with some undated items and some dated 1668 or 1669. This box contains 44 reports with which Hooke was involved, not all of which are transcribed in the volumes of Viewers' reports.

An independent source of details of Hooke's views is his diary in which he recorded a multitude of names, places and sums of money paid to him for his survey work in London, both privately commissioned and for the City. His style is terse, giving the impression that he treated his diary primarily as an aide mémoire. It is often quite difficult to decide what kind of survey work he is referring to in any particular entry. For example

> Rossington, Smither lane, 10sh. Bland and Taylor, Mincing Lane ... Meynell 13s 6d.[229]

gives no details of what he did for each of the three clients. He might have viewed and written a report to the City about a building alleged by a neighbour to be prejudicial to his interests, or given private technical advice to a client about rebuilding, or examined a builder's work and accounts on behalf of a client to see whether they were reasonable. On the other hand sometimes Hooke is more explicit

> Capt. Looks view at the Bridge. ... to Committee at Guildhall. View at Laurence Lane 10sh.[230]

but even here he does not give the name of his client in Laurence Lane. Despite the lack of specific detail in so many of his diary notes, they have been used in the estimation of the number of his views of disputes and complaints for the City in 1673, the first complete calendar year in his diary and one of the 3½ years missing from the volumes of transcripts of viewers' reports. Only his diary entries which specifically mention "view" and can reasonably be accepted as referring to work undertaken on behalf of the City in response

to a dispute or complaint brought by a citizen have been used in the estimate. Many other views recorded in his diary (such as those undertaken of the City's own buildings and works) have been ignored in this context.

By examining the volumes of transcripts of reports of views, manuscript reports, and the diary entries for 1673, the number of Hooke's views of disputes and complaints brought by citizens to the City for settlement in each year from March 1668 to the end of 1693 (no evidence of a report of a view by Hooke has been found after this date) have been estimated and shown in Table 4.[231] It can be seen from this Table and accompanying text that Hooke played a major role for the City in viewing and reporting on citizens' disputes about rebuilding until the end of 1674, by which time he had reported on about 550 disputes. Thereafter the rate of rebuilding decreased to the level where the City Viewers could resume their traditional role. The Surveyors, Hooke and Oliver, continued occasionally for the next 20 years to view together disputes between citizens and report to the City, but probably not more than once or twice a month on average.

Plenty of evidence has been found that Hooke carried out periods of work, often called "views", but which were different from those ordered by the Court of Aldermen to settle disputes between neighbours and allegations of irregular building. For example, the first of these was a survey by Mills and Hooke ordered by the Fire Court. The Surveyors were required to measure and certify the dimensions of a yard belonging to a defendant and value the portion of it to be taken away. Their findings formed part of Fire Court Decree A-137 of 30 May 1667.[232] The records of the City Lands Committee are additional sources. On 31 March 1669 Mills and Hooke were ordered[233] to attend every meeting of the Committee. Consequently Hooke was ordered to view (and supervise surveys relating to) markets, gateways, sewers and conduits. The Committee also had the responsibility for the construction of wharves and quays along the Thames and making the Fleet River (sometimes referred to as the Fleet Ditch) navigable to Holborn Bridge.[234] Each of these projects was specified in the Rebuilding Acts. Hooke and Wren on behalf of the City and the King respectively viewed and reported on these (Section 3.4), but none of these views has been included in the totals shown in Table 4 which refer solely to settlement of

complaints and disputes brought by citizens to the City for satisfaction.

At least two people, sometimes more, were responsible for each view and report. The manuscript reports have been examined for evidence of the extent of Hooke's participation in this collective activity. Amongst the manuscripts are some which are clearly certified copies by a clerk[235] of the original reports (and signatures) which are now lost. The identity of the person who wrote the original report is now unknown. All the evidence available from manuscripts of Hooke's views found in the CLRO shows that when Hooke took part in a view, he wrote the report which the others signed. Furthermore, no original report of a view by Hooke and others, written by one of the others, has been found with Hooke's signature on it. This evidence indicates that Hooke always assumed responsibility for reporting the views in which he took part.

The order in which signatures are written on reports of views is consistent. The City Surveyors' signatures are in the order of their first appointment by the City: Mills; Hooke; Oliver. When one or more of the City Viewers was ordered to view with the Surveyors, as occurred occasionally, their signatures follow those of the Surveyors. When an Alderman and Deputy also viewed, their signatures precede those of the Surveyors. This hierarchy is strictly followed in all original reports, copies and transcripts, but does not show Hooke's predominance in writing the reports in which he participated. Further evidence of his dominant contribution is seen in some reports of views[236] signed only by the Aldermen and Deputies who were nominated by the Court of Aldermen to view, but which have been written by Hooke, even though he was not ordered to take any part in the view. Figure 6 illustrates an example of one of these reports written by Hooke, but not signed by him. They have not been included in the estimates shown in Table 4 because it is impossible to make an acceptable estimate of their number when most of the original manuscripts are now lost.

A small, but significant, indication of Hooke's attention to detail in reports of views can be seen in a clerical copy of an original report by Hooke to the City Lands Committee.[237] The copy was signed by Hooke, but the insertion, in his handwriting, of a

small almost insignificant correction to the text shows that he read the manuscript copy very carefully. An illustration of the formal manner in which Hooke wrote his reports is shown in Figure 7. The report proposes settlement of disputes between three neighbours who formerly had intermixtures of interests which can now not be maintained because party walls must be vertical from the lowest to the highest level of each premises. A transcription of the report follows (with abbreviations expanded)

> Whereas the Right honourable Sir Richard Ford, Knight Lord mayor of the City of London was pleased by an order bearing Date July. 5. 1671 to summon the Surveyors of the City of London to view the intermixture between the interests of Mr. Edward Harvy, Mr. John Jackson & Mr. John Neave situate on the south side of Goldsmiths hall & on the north of Kerry [Carey] Lane: and to act and doe therein as in and by the Additionall Act of Parliament for building the City of London is Limited and appointed. we the said Surveyors having accordingly mett upon the place and viewd the said Interests and understood from the severall partys concernd their severall intermixtures upon the whole matter we doe order and appoint that Mr. Harvy shall build the Remaining part of the ground that is left in the first story intire and upright making use of the walls built by Mr. Neave and Mr. Jackson as party walls. he the said Harvy paying unto them the said partys Respectively the moyetys of their said party walls. and further that Mr. Harvy shall carry the party wall between the outlet of Mr. Jackson New [?] made and his own grownd upright upon the same foundations that are now set, returning the same at the west end thereof upon a sqare to the party wall now built by Mr. Jacson. and that Mr. Jackson shall have liberty to come home to the said wall with that part of his house where he hath now placed windowes. but whether he shall soe think fitt or not yet that he shall pay the said Harvy for the moyety of the said party wall being about five foot in Length east & west & two foot north and south. And further that all Differences touching any former intermixtures between the said Harvy & the said Jacson shall cease. Moreover we doe order that Mr. Neave shall pay unto Mr. Harvy in Compensation of the washouse and part of the yard built Upon by him

> the said Neave the summe of three pounds, and that all Differences between the said partys touching any former intermixtures or yards shall cease in testimony whereof we have hereunto set our hands this 8th of July 1671.
>
> [signed] Rob: Hooke
>
> Jo. Oliver.[238]

Often Hooke had to examine small details of building construction in order to decide how the dispute could be settled fairly. The length of time he spent viewing premises, listening to evidence and writing reports can be inferred from the following report which he wrote. It is not unusually long or complicated

> In pursuance of an order of your Lordship bearing date June 10th 1686 we whose names are underwritten have met upon the place and have viewd all the matters Complayned of by Mr Linch against Mr Harford about pulling down as he alledged a whole pair of stairs belonging to his the said Linch his house and for breaking holes into one of his chimnys. And upon the whole matter we find that the said Hartford in the repairing of a flight of stairs from the ground into the 2d story hath set the same contiguous to the back side of a chimny belonging to the said Linch and we find that the old stairs which he tooke away had a bearing into the said chimney but the workman in setting up the new ones hath not put the Bearers into the same holes but into some new ones they have made whereby we find that they have Loosned some of the brick on the back side of the chimney of the said Linch. we find also that the said Linch had a flight of stepps from his second story into his 3d which flight of steps did appear in the second story of the said Hartford. and we upon examination of all particulars doe find that the said flight of steps was two foot and two inches broad between the main timbers and that the Lowest step of the said flight was 8 inches above the floor of the 2d story. and was soe Raysed as to leave the head way of the Door case towards the east full 7 foot high and two foot and half wide. how the same comes to be pulled down we know not but it is our opinion that the said Harford doe againe put up a flight of steps in the same place & of the same dimensions as before, and likewise that he doe take Care to stop

> up any breack or crack that may have been made in the back of the chimny and to take care that there may not be any danger of fire caused thereby. We further find that the said Hartford complaineth against the said Linch first for putting in a water course into the said Harford's sink where he hath no right to have any. and secondly for removing and taking quite away an old post placed in the street ranging to the party partition between the entry and the shop. and hath layed and inclosed all the said Room into his own shop and hath thereby inlarged the same and hath also inlarged his shop by making the said party partition thinner than it was before, for which complaint, we find the said Harford had good Reason. But we find that the said Linch hath declared that he will remove the said water course, and It is our opinion he the said Linch ought to set up the post in the place where it was before, and that the said hartford doe forthwith satisfy himself about the substantiallness of the partition and pay the said Linch the money due. upon reward. All which &c. Dated the 14th of June 1686.
>
> [signed] Joseph Titcombe. Robert Hooke
> George Hatton. Jo: Oliver.[239]

Many of Hooke's reports are concerned with disputes of this kind. Allegations and counter-allegations had to be heard. Each party in a dispute often produced witnesses whose testimonies (sometimes made on oath) had to be judged for truthfulness in the absence of sufficient material evidence. When significant doubt about the facts remained after inspection and measurement of the site, listening to witnesses and sometimes examining leases, the Viewers made no recommendations for settlement, but left the matter for the City to decide. For example after a view of a dispute between Bent and Thomas in Paternoster Row, Mills, Hooke and Oliver reported in December 1668

> To the Right honorable Sir William Turner Knight Lord Maior of the Citty of London
>
> In pursuance of an order of your Lordshipp beareing date wensday the 16th day of December 1668 to us directed wee the three Surveyors of the Citie of London whose names are subscribed here have accordingly met

> upon the place in Paternoster row and have examined the writeings and witnesses produced by both parties And we doe find that Mr Mills was called to sett out the foundation belonging to Esq. Thomas in Paternoster row upon the 8 May 1667 before which time they had brought upp the Cellar wall now in dispute and had laid the shopp floor thereupon Wee also have examined the Lease of the grounde belonging to Mr Bent lyeing on the east side thereof and wee find that there is now two foote lesse in breadth from East to West of that foundation than is specified in the aforesaid Lease: which was formerly made to Mr Thomas from Mr Bonham from whom Mr Bent did purchase the said foundation, the which mensuration wee find was made by Mr Whiteing att the desire of both Mr Bonham and Esq. Thomas All which he[r]e was now present and certified unto us. Wee doe not find that Mr Thomas hath any dimensions of his ground specified in his writeings. But wee doe presume that the Company of Haberdashers whose inheritance it is may have the dimensions of the said grounds, And therefore wee doe humbly propose that the Haberdashers bookes may bee searched Wee have not beene able to discover any remarkable circumstance in the foundation that might enable us to put an end to this controversie; Onely we find that the breadth of the said howse of the Esq. Thomas is five inches more in breadth than it was sett out for, by Mr Mills, Wee are of opinion that if the Mensuration mentioned in the said Lease here produced by Mr Bent be approved to your Lordshipp to bee the measures made by Mr Whiteing att that tyme, there is a losse of ground to Mr Bents of two foote and somewhat better All which notwithstanding wee leave to your Lordshipps grave wisdome and consideration.[240]

Although the original manuscript report is now lost, it is very probable from evidence described above that it was originally written by Hooke. On a few occasions the matter of dispute was alleged to be a mistake in the staking out of a party wall by Hooke or one of the other Surveyors. Generally a different explanation came to light. A report by Mills, Hooke and Oliver dated 13 June 1668 of a view of a dispute between Conyers and Hawkes states

> we find that the north Howse of Mr Hawks is built upon the walls that were errected before the fire and according to the setting out thereof by Mr Hooke And whereas there is some dispute about a parte of the said ground whether it were Mr Conniers ground or Mr Hawkes's It being a matter of title we leave it to the determination of the law. As for the incroachment complained off by Mr Conniers to be made by Mr Hawkes upon the south parte of his said grounds Wee find it to have proceeded from a mensuration made of the ground of the said Mr Coniers by Mr Jones Bricklayer Which mensuration we find to have beene made by guesse before the cleering of the said ground as it is confirmed to us by the said Mr Jones who doth affirme also that he doth imagine notwithstanding that it was pretty neere the truth.[241]

This report illustrates that disputes about ownership were decided by courts of law whereas Surveyors were concerned with recommending settlement of disputes about boundaries.

From time to time Hooke faced physical danger when viewing buildings in progress. This was especially so when he had to examine some details of construction underground in cellars and vaults

> In pursuance of an order of your Lordship bearing date August 26 1671 we whose names are underwritten have mett upon the place and viewd the matters complaind of by Mr. John Davys against a building of Mr. Nathaniell Stanton in Love Lane in Aldermanbury and have Discoursd with both the said partys and have examind the foundations. and upon the whole we find that the wall of Mr. Davys house is set upon an old chalk wall which is about two foot and an half Deep and noe more whereby upon the building of Mr. Stanton upon the east side thereof and his Digging of a celler we find that he hath dugg below the bottom of the same soe that the said wall is much idangerd [sic], thereby it is therefore our opinion that the said wall ought to be underpinn'd and sufficiently Securd at a party charge. All which notwithstanding we humbly Leave to your Good Lordship.

Dated August 30. 1671 [signed] Rob: Hooke

Jo: Oliver[242]

The last of Hooke's reports (Figure 8) to be transcribed in the volume of Viewers' Reports is dated 6 November 1691 and has a few interesting features. Unnumbered, it was discovered in the Corporation of London Records Office in the third volume of transcripts of Viewers' Reports, laid-in at the place where a clerk had left it after transcribing only the first half. This partial transcript is the last entry in the volume and is followed by several blank folios. The difference in the handwriting Hooke used for reports to the City in the 1670's from the style he used in the 1690's can be seen by comparing Figure 8 with Figures 7 and 6. The style of handwriting he used in his diary in the 1670's is closer to the 1691 report than it is to the reports he wrote in the 1670's, so what might be taken as an indication of deterioration in his handwriting brought about by increasing age is mainly a deliberate change of style.

There is certainly no change over the years in Hooke's careful attention to detail in his views and reports. The matter in dispute in the November 1691 view (Figure 8) was Nicholas Clark's complaint that the wooden shed his neighbour, William Sheldon, had built in a yard obscured his light and was a fire hazard. Hooke decided that the complaint was justified, but went further, noticing and reporting other hazards that had not been complained of

> Shelden hath newly erected a shed of timber which hath Covered the Greatest part of the said yard and thereby not only Darkned a Cellar light and a light in the first story of the said Mr. Clarks house but is very dagerous in case of fire, there being a very great pile of faggots & bavins adjoyning to the said shed, and is dangerous also as to Robbing Busnes [?] parts of the shedd in the said yard Reaching very neer to the windows of the said Mr. Clarks house in the second Story. besides it doth anoy & hinder the air to the said house, all which particulars as I conceive they are irregular and contrary to the Act of Parliament for Rebuilding the City, soe they are very injurious to the said Mr. Clarks Interest.[243]

Hooke did not only carry out important experiments to try to understand the properties

and nature of the atmosphere, but also acted to ensure that in rebuilding their houses citizens such as Clark enjoyed the benefits of circulation of the air. The reference to robbing also shows Hooke acting for the general well-being of his fellow citizens.

Some of the last reports of views by Hooke which have been found are dated 6 May 1693.[244] They are manuscript reports by Hooke and Oliver. The first was ordered on 21 April 1693 and is written by Hooke and signed by him and Oliver. The second view was ordered on 4 May 1693 and relates to a building complained of by a Mr. Houblon. In his diary entry for 6 May 1693 Hooke has written

> At Hublons View 1 G⊙.[245] I paid J. Oliv. for yesterdays View 10.[246] Viewed it again with J.O. I drew Report at Jonathans,[247] we both signed it.[248]

The practice of writing reports in the coffee houses of the city could have been common practice throughout Hooke's work for the City. His diary shows that hardly a day passed when he did not go to at least one of them. In this instance at least, Hooke received full payment from the plaintiff and paid Oliver his share. It is further confirmation of the evidence described above that Hooke and nobody else wrote the reports of the views in which he was engaged and that he took the lead in organising and carrying out the procedures, including collection of fees and disbursements to the other Surveyors.

3.4 The City's Secular Rebuilding

The main work of the City Surveyors in the four years or so after the Fire was intended to enable private property to be rebuilt as quickly as possible, but in accordance with regulations. Table 1 shows that by the end of 1671 nearly 90% of the foundations for private rebuilding had been set out and certified. When the City could see that the needs of its citizens to re-establish quickly their normal business were largely satisfied, the Surveyors were required to give more time to the City's secular rebuilding programme. Hooke was ordered to attend meetings of the City Lands Committee where he received his instructions. He was directed to work closely with Wren, the King's nominee, on two major schemes included in the Rebuilding Acts: to make the Fleet Ditch navigable for trade by lighters and barges from the Thames to Holborn Bridge; and to construct a new

quay and wharves along the north bank of the Thames from Temple Gardens to London Bridge and from there to the Tower. Each of these projects was grand in concept; a matter of both civic and regal pride. They were designed to enhance the appearance and commerce of the city, but each ultimately ended in failure.

The Fleet Channel replaced the Fleet Ditch (which had been used as a sewer and dump for the city's waste for centuries) by a navigable channel flanked by wide quays and wharves. It was eventually completed by the end of October 1674 at a cost of more than £50,000.[249] Delays and continually increasing costs were brought about by the magnitude of technical problems which were beyond the capacities of even Hooke and Wren to foresee or solve quickly, given the constraints of legislation, money, materials, labour and contemporary construction techniques. By 1766 the Fleet Channel had been covered by a road running from the site of what is now Blackfriars Bridge to Holborn Bridge.

The Thames Quay scheme was intended to replace the low and irregular shore line and landing places (reached by steep descents along an irregular network of narrow lanes through a jumble of laystalls and houses) by a quay, forty feet wide, built up above high-water mark. If completed it would have created a stretch of open promenade flanked by the river on the south side and by new imposing and well-regulated buildings on the north. Wide streets passing down between the buildings would have led to stairs giving access to river craft. No longer at low tide would banks of detritus-laden mud have been exposed. The main reason for the failure of the project was lack of money to pay compensation to the "wharfingers" whose old wharves and buildings were to be removed to provide a clear space for the quay. The City intended to offset the costs of building against dues to be levied for using the quay, but most of the river trade was taking place downstream, following a trend which had begun some years before the Fire and continued for two centuries after it. The expense of building quays at the Fleet Channel had made the City cautious about entering upon another project of that kind, and the Coal Monies did not accrue to the level needed for compensation for ground taken away for the Thames Quay. The Lord Chancellor acted to order clearance, but only disconnected parts of the quay were ever built.

The Monument however, for which Hooke carried out much of the design and supervised the construction, stands today, one of very few of Hooke's buildings to do so. He was also engaged in siting, designing and supervising the construction of more mundane but necessary civic amenities such as markets, gateways, sewers, latrines ("houses of common easement") and slaughterhouses. Reddaway has described the building of the Fleet Channel and the attempts to build the Thames Quay.[250] Although he gives much accurate detail derived from primary sources, some additional particulars, corrections and interpretations concerning Hooke's part in these works are now necessary.

3.4(a) The Fleet Channel

Before the Fire the City Lands Committee was responsible for matters relating to letting the City's properties, but in the aftermath of the Fire it assumed increasing responsibility for managing the programme of public rebuilding works. Its first instruction to Hooke in the matter of the Fleet Channel was given in November 1670 when he was ordered to meet with Wren and make a written report to the Committee on what work should be done.[251] In early February 1671 Hooke and Oliver were ordered to attend every meeting of the Committee,[252] but within a month they had to be reminded of the order.[253] The Committee met every Wednesday afternoon. The Royal Society at that time met on Thursday afternoons (changing to Wednesday afternoons in April 1672[254]) so Hooke was not immediately faced with a direct conflict of interests. However, he usually spent his mornings mainly on work for the City, leaving the afternoons and evenings for his many other activities. Oliver too had private work which he attended to mostly in the afternoons, but his role in rebuilding the City was secondary to Hooke's. Despite these difficulties, correct procedures were followed and the Committee did not have to repeat its order to the Surveyors, although it is doubtful that they attended every meeting.

The report by Hooke and Wren ordered in November 1670 was presented to the City Lands Committee at the end of the winter, on 22 March 1671.[255] It starts with a very detailed technical design specification, defining gradients, heights of wharves, and dimensions and locations of the piles, campshotts, punchins, mudsills and other structural

components to be made and put in place. The written description is not easy to comprehend, which perhaps explains why Hooke and Wren said it would be necessary to have a model at a scale of 2 inches to 1 foot (whether drawn and/or made from wood is unclear) of the more complicated constructional details to which reference would be made in contracts between the City and the craftsmen. An alternative suggestion was to build under direct supervision at full scale, a length of the wharf one hundred feet long at a cost of £6 per square foot to serve as a prototype.

The report goes on to recommend and certify the organisation, supervision and wages to be paid to between 100 and 200 men to dig out the mud and old brick and stonework. It describes how to make use of tides for transporting the mud to the Thames using fourteen lighters. Hooke and Wren went on to recommend the employment of skilled carpenters to work under their supervision to put in place pumps and drains (for ground storm water and sewage) and of someone to carry out the levelling surveys for setting out the changing gradient of the bed of the channel and ensuring it was properly laid.

The Committee decided to act. It ordered workmen to be employed forthwith to do the work according to the proposals. Hooke was ordered to

> draw and make the said modell propounded

and individuals were nominated to undertake the carpentry and levelling surveys. From that time until beyond the end of the period studied here Hooke spent many hours, often with Wren, at the Fleet Channel dealing with all practical matters relating to the construction works. They met with City Workmen, discussed and decided upon detailed re-design and construction procedures for the Fleet Channel, its quays, wharves and bridges; drew up articles of agreement between contractors and the City; specified new gradients for the channel bed and supervised levelling surveys; examined built walls and wharves and damage to them caused by excessive lateral pressure from underground watercourses after rain; re-designed piles, footings and retaining walls in the channel; decided to change from predominantly timber to mainly brick construction; chose locations and specified the structure of new vaults for use as warehouses; gave

instructions for removal from the river bed by lighters of mud and rubbish dumped by citizens and by people living upstream outside the jurisdiction of the City; investigated and recommended resolution of conflicts between City workmen and traders wanting access to bring goods up the river; checked the quality of all workmanship and materials; certified bills of quantity and wage rates; and reported, often at length, on these matters for the City.[256] The following transcript of a report presented to the City Lands Committee on Wednesday 20 November 1672 illustrates the detail and formality of such reports.

> To the Right honorable The Committee for City Lands
>
> Wee whose names are subscribed in pursuance of an Order of this Committee dated the 13th instant Have together with Christopher Wren Esqr his Majesty's Surveyor Generall and the City Surveyors viewed and considered, and debated concerning the severall additional particulars of the New Work at Fleet River and the Wharfs thereof and such Rates as might be reasonably contracted for betweene the City and Mr Fitch. Which although they were all principally referred to the judgment & determination of Mr Surveyor generall, yet in great modestie & civility he was pleased to desire this View and conference to be ordered as above for the more particular and ample satisfaction of this Committee to whom Wee now Certify that Mr Surveyor generall after severall Views upon the place and conferences with the City Surveyors was pleased himself to read to Us this following draught of his and their thoughts & judgments and communicate to Us the nature and reason of every particular
>
> In pursuance of severall orders of the Committee for City Lands wherein severall Works performed and to be performed by Mr Thomas Fitch & the rates thereof were referred to the consideration of Christopher Wren Esqr his Majesties Surveyor generall, Robert Hooke and John Oliver the two Surveyors of this City, Wee upon the View of the said Workes and a serious Examination and consideration of the same, do certifie as follows, Upon the severall Articles referred.
>
> For the clearing of the mouth of the Channell to the Lowe Water-mark with sufficient Depth for Navigation and about Forty three foot

broad by reason the same is lyable to continuall accidents by being choaked up with the drift of Mudd from above and haveing been often already cleansed, Wee conceive it may be reasonable to allow the same by the foot running according to the Rates which by the contract are already allowed for the rest of the Dock discounting for such Wharfing Levelling & paveing as shall be here omitted. The lowe wharfing being made with Piles at every Eighteene inches dista[?nce] and plancked with Two inch Planck from the depth of the Channel to half a foot above the [?Mud] towards the River; and one course of planck outwards towards the Mud; and one course of planck upon the sides of the piles Wee estimate at 8s-06d per foot Running.

For takeing downe the old Wall belowe Bridwell bridg, Wee conceive it may be worth 2s-00d per yard Sollid And for carrying away the earth to be abated there and for new bringing up the same wall of brick the Rat[?es] may be the same as have been already allowed.

For repairing & underpinning the old Wall the aforesaid usuall Rates of Brick work may be allowed and for the trouble of often moving Scaffolds for the same nothing is to be allowed, The old materialls of the [?Same] taken downe defraying that charge.

For filling up the Groynes or Spandrells of the Arches with Rubble stone & course Morter, may be allow'd £4 per [obscured] reduced to a Brick & half.

For laying over the Vaults a foot in thickness, may be allowed 12d per yard, And where the paving is of pebble may be allowed 15d per yard over and above the paving of Rag-stone, included in the Contract.

For the Sellar doores being Oake lined with Elme, and the doore cases of Oake of good scantling Wee judge Each Doore and doore Case at 35s-00d, and each Curb at 15s-00d.

For Lintelling of large scantling may be allowed per foot sollid 12d. For paveing the Sellars with hard [obscured] Bricks Edgwaers and Morter 2s-04d per yard.

For the Brick-work done at and neare Mr Youngs Wharf the same Rates may be allowed, with those for the same kinde of Work at Dowgate

Dock & Puddle Dock And for the Pyling and plancking Campshoting and Timber Wharfing the same Rates as are already allowed for Pyling Plancking Campshoting and additional Wharfing at Fleet River in the former Contracts.

[signed] Chr. Wren
Rob. Hooke
Jo: Oliver[257]

The above text, in a secretarial hand and signed by Wren, Hooke and Oliver, was followed by a lengthier report, continuing to the end of a second page and signed by Sir John Lawrence, Sir Thomas Player the City Chamberlain and two Committee members, setting out for the full Committee the reasons why the earlier contract with Thomas Fitch should be revised. The City had already spent several thousands of pounds trying to meet the requirements of the Rebuilding Acts by making the Fleet Ditch navigable, but much of the new work had turned out to be too insubstantial to stand up to the forces acting on it. The reason for this was not poor workmanship, or excessive profits by the contractor, or inefficient management and control, but lack of knowledge on the part of Wren and Hooke of what are now understood as geotechnical and hydrological processes at work in the valley, coupled with the continuing usage of the channel by citizens and residents upstream of the city as a dumping ground. The experimental investigations at the Royal Society by Hooke and Wren and their colleagues were the beginnings of the understanding and knowledge which now enable engineers to avoid the mistakes made by Hooke and Wren at the Fleet Channel.

By the end of 1672, the City realised that the cost of work at the Fleet Channel was going to increase even beyond what had been expected. The City had to be satisfied that everything possible was being done to achieve the aim of the Rebuilding Act and that nothing improper was taking place. The addition by Sir John Lawrence and others to the above report was intended to satisfy the Committee on this matter. It gives detailed reasons for much of the reconstruction that had already been found necessary, praises Fitch, Wren (particularly) and Hooke for their continued diligence on behalf of the City

and relies heavily on the authority of Wren as the King's Surveyor General as a reason for continuing to pay more money to the present contractor, Thomas Fitch, and to revise the existing contract. Fitch was present at the Committee meeting on 20 November 1672 when the full report was well received. The Committee ordered new Articles of Agreement for the work in and about Fleet Channel to be drawn up as recommended and in the manner of the former Articles.[258]

A crisis in the rebuilding programme was avoided, but the part played by Hooke in the affair has, as so often in the past, been obscured by Wren's reputation. It is possible to look behind the formal report, in which Wren's name was used to such good effect, to see how significant Hooke's actions were. Sir John Lawrence had been a supporter of Hooke at least from the time Lawrence was chairman of the Joint Grand Gresham Committee which appointed Hooke Professor of Geometry in 1665 (Section 2.2). It was Lawrence to whom Hooke in 1666 first showed his layout plan for rebuilding the city (Section 2.3) and who approved it in preference to Mills's. Hooke regarded him as

> my good and sure freind.[259]

They met frequently, Hooke often dining at Lawrence's home, usually on a Saturday. In the frequency of their meetings and the apparent amiability of their relationship there is a resemblance to that between Hooke and Wren: although Hooke often made disparaging remarks in his diary about others with whom he worked, Lawrence and Wren hardly ever received similar obloquy. Hooke's congenial relationship with each of the two men and the mutual trust and respect which it engendered were important factors in the efficient rebuilding of London; the events leading to the City's acceptance of the report presented to the City Lands Committee on 20 November 1672 exemplify Hooke's important, but hitherto obscure role in the daily management and execution of the business of rebuilding the city, evidence for which follows.

The report was ordered on 13 November 1672, but at least six weeks before that date it was evident to Hooke that a revision of the contract was necessary. On 2 October 1672 he was at Lawrence's and later that day was with the City Lands Committee until 8 p.m., an unusually late time for formal City business. The following day he was again

at Lawrence's and later dined at Wren's.[260] On 8 October 1672 Fitch and Wren went to see Hooke at Gresham College; a day later Hooke met Fitch again.[261] On Saturday 12 October 1672 he visited the Fleet Channel to see about Fitch's work and afterwards dined at Wren's before going with him to St Pauls.[262] Hooke was at the Fleet Channel again in the afternoon of Wednesday16 October 1672 certifying two areas of ground belonging to Dr Barton (or Barbon) taken away for the new wharves on the east side.[263] On the same day at the weekly meeting of the City Lands Committee the City Surveyors were ordered to meet Wren to examine the stairs newly erected at the end of Temple Lane and to certify whether or not they were in accordance with the specification.[264] Although this task was not to do with work at the Fleet Channel, it was closely related to it and provided an opportunity for the three men to discuss the latter. At its next meeting on 23 October 1672, the City Lands Committee received a request from Thomas Fitch for his completed work in & about the Fleet Channel to be surveyed and measured as a preliminary to payment. The Surveyors were ordered to appoint Leybourn & Shortgrave to undertake this routine task under their supervision.[265] In then going on to decide that Wren, Hooke and Oliver should judge what charges would be reasonable for additional work by Fitch at the Fleet Channel, the Committee showed that it was already aware of the need for rebuilding and that the cost would be significant. Although there is no evidence that either Hooke or Oliver was at that meeting, two days earlier Hooke had visited Guildhall and the following day he had met Wren and visited Guildhall again (where he collected his Surveyor's salary for the quarter). Around the time of the Committee meeting, Shortgrave and John Fitch (Thomas Fitch's brother, a bricklayer, who was contracted for work upstream of Holborn Bridge) visited Hooke at Gresham College and Hooke visited Sir John Lawrence.[266]

Hooke continued during the early days of November to meet Wren and Lawrence; he was at Lawrence's on 2 November 1672 after which he dined with Wren who showed him the plan for rebuilding St Pauls which had been approved by the King. Three days later he was with Wren again; on 9 November 1672 he went with Wren to Guildhall on the matter of the Thames waterfront; on 12 November 1672 he dined at the Lord Mayor's with Wren and then went to the Fleet Channel where he estimated the value of Fitch's

work there and elsewhere, taking time to eat meat and apples at the Rose Tavern, Fleet Bridge, where he probably made a draft of his estimates. By means of these informal meetings the Lord Mayor was confronted by Hooke and Wren with the extent of the problems now faced by the City; Sir John Lawrence's informal endorsements of their findings and recommendations was an assurance to the Lord Mayor that the extra burden was unavoidable and not brought about by lax procedures in management or workmanship. The City Lands Committee now had to be satisfied on these matters. It met on 13 November 1672, the day after Hooke had prepared his estimates of Fitch's charges. At this meeting Wren asked for an additional meeting and a view of the site with the Committee so that the interests of the Committee in connection with work at the Fleet Channel could be better served. The Committee ordered a report to be presented at its meeting a week later and agreed to meet the following day at 3pm.[267]

On the following morning, 14 November 1672, Hooke carried out two commissions (probably views) in Crutched Friars, receiving 10s-00d for each, met Dr Ralph Cudworth,[268] dined in his own rooms at Gresham College and then went to the Rose Tavern at Fleet bridge where he met with Sir John Lawrence, Sir Thomas Player, William Llewellyn (or ffluellin) and Joseph Sibley (who would later write the endorsement of the report to the City Lands Committee by Wren, Hooke and Oliver) and with Wren, Sir William Hooker and Thomas and John Fitch. Oliver's name is not mentioned.[269] The Committee's representatives viewed the work and so the way was prepared for the endorsement of the formal report by Wren, Hooke and Oliver by the full City Lands Committee at its next weekly meeting on 20 November 1672.

In the weeks leading up to the Committee meeting on 20 November 1672, Hooke's frequent presence in places relevant to work at the Fleet Channel, and his meetings with the men most closely involved in it, gave him opportunities to prepare the ground for the Committee's acceptance of the additional costs and the of the need for a new contract with Fitch. Hooke had time and opportunity to draft a preliminary report and discuss it with Wren, Lawrence, the Lord Mayor and Fitch (all of whom had to agree to the proposals) but his usual style of diary entries makes anything more than highly

circumstantial evidence from that source impossible to obtain. In the absence of evidence to the contrary it is reasonable to assume that he was at the centre of the business of preparing the report to the City, acknowledged by Wren, the King's Surveyor General, as an intellectual equal and someone whose understanding of the ramifications of building contracts and techniques and sense of civic responsibility he could rely on and to whom he could leave much of his routine site investigations and estimating. His friendship with the former Lord Mayor Sir John Lawrence was another important part of the process of convincing the City Lands Committee of the necessity of further expenditure on the Fleet Channel.[270] Furthermore, Hooke's mechanical genius allied to practical abilities and his interest in working with materials was useful in his dealings with the City's Master Craftsmen and contractors such as Fitch. Hooke's role in building the Fleet Channel has been seen as not particularly important, but a different view should now be taken.[271]

3.4(b) The Thames Quay

Once the second Rebuilding Act was passed by Parliament in April 1670, work began on the Thames Quay below the Bridge. The following year, the City decided that from the Bridge upstream to the Temple a continuous quay, clear of all buildings and varying from twenty to eighty feet in depth should be built by extending the bank of the river southwards. Rubble excavated for the Fleet Channel would be used to build up the new quay to five feet above high-water mark. To save expense, the City decided that the areas of ground would remain in private ownership, boundaries marked only by denter stones. The owners would be responsible for clearing their sites, but would later receive income from levies on the use of their portion of the quay for merchandise brought ashore.

In a manner resembling his instruction to consult with Wren at the start of the Fleet Channel scheme, Hooke in May 1671 received the following order from the City Lands Committee:

> Whereas this Committee intend speedily to sett about & perfect the Water line upon the River of Thames according to the Prescription of the Act of Parliament, Itt is therefore ordered that Mr Hooke doe attend upon Dr

> Wren his Majesty's Surveyor for his concurrence & advice therein And further that he would bee pleased to consider what designe may be most apt & convenient for that purpose And acquaint this Committee with his Opinion.[272]

Within three weeks Hooke had consulted with Wren and a plan of the proposed waterline had been made. Hooke and Oliver were ordered to show the plan to Wren and seek his approbation of it so that the work could go ahead.[273] By 5 July 1671 the City was ready to proceed as quickly as possible.[274] At a special meeting five days later the City ordered work to start as soon as the King could be persuaded to agree to its proposals and authorise the letters patent. The Lord Mayor, Wren and Hooke were ordered to meet with the King at Windsor to achieve that end.[275] The King approved the scheme and letters patent were issued on 4 December 1671.[276]

Hooke's work on the Thames Quay continued as the City struggled to proceed with the project. Caught up in the disputes between the Lord Chancellor, the City and the citizens, he spent many hours in fruitless attempts to make progress on the quay which the following details exemplify. He went from Dowgate Dock to Guildhall where he discussed the waterline with Wren and the City.[277] After a meeting at the Lord Chancellor's Hooke, Wren and a bricklayer visited the quay.[278] Five days later, after visits to the Lord Mayor and the Lord Chancellor, the latter ordered a map of the quay from London Bridge to Dowgate to be made.[279] Within a week Hooke had taken the measurements,[280] and drawn the map.[281] The Chancellor then issued orders to clear all but one part of the waterside. This proved ineffective and the Chancellor had to act again.[282] He then accused Hooke of some unknown misbehaviour, possibly thinking that he was partly responsible for the failure of the wharfingers to clear their ground as ordered; later that day Hooke warned them.[283] The following day, after Hooke had dined with the Lord Mayor, the wharfingers were summoned; some of them were then bound over to clear their ground.[284] The day after, Hooke was with the Lord Chancellor until 1 pm,[285] probably to report what action he and the City had taken. Hooke's actions may have resulted in at least some clearance taking place because three weeks later he visited the wharfingers again and told them to start paving.[286] Attempts by the City and the

Chancellor to proceed with the project gradually became less intensive, but by the end of 1674 Hooke was still engaged in surveying the old wharves and reporting to the Chancellor, sometimes only to discover after travelling by water to Whitehall that there was no Council meeting.[287]

Although the wharfingers were to receive an income from others using their sites for bringing ashore merchandise once the quay had been completed, it was already becoming clear that trade below the bridge was moving further downstream and that it was unlikely much trade would take place upstream of the bridge. Many wharfingers had already lost income through having to clear away their buildings which before the Fire had been used for commerce. The City was unable to pay compensation for this loss, despite many attempts to find money for the purpose. It was hoped at one time that a surplus from the Coal Money would serve, but none accrued. Encroachments onto ground intended for the quay continued and the City was unable to prevent them. The Thames Quay was never to be completed, but parts of it were, particularly at the mouth of the Fleet Channel, Blackfriars, Dowgate Dock and Puddle Dock. Hooke had helped to draft the technical details of the Rebuilding Acts and he knew of the great problems the City faced in going ahead with the Thames Quay and that it was unlikely it would ever be completed. This did not deter him from conscientiously performing his civic duties in relation to it, which were often onerous, but the Lord Chancellor's rebuke leaves a small element of doubt in the matter.

3.4(c) The Monument

Both Wren and Hooke were involved in the design of the Monument and the supervision of its construction. M.I Batten in the 1930's was not sure about the respective contributions of Wren and Hooke to the Monument.[288] Analysis of evidence in the design drawings for the Monument is thought to be in progress.[289] Some evidence from other contemporary sources of the extent of Hooke's involvement in the Monument in the years up to 1675 is now presented.

The first (1666) Rebuilding Act empowered The Lord Mayor and Court of

Aldermen to erect a column or pillar to be a permanent memorial of the Fire, the pillar to be sited as close as possible to the place where the Fire had started. The idea to do so originated with the City[290], but it had to deal with more urgent rebuilding in the years immediately following the Fire before it turned its attention to the memorial. However the proposed site was borne in mind during the early years of rebuilding to ensure that it was not rebuilt on by private citizens.[291] The pillar came under the direction of the City Lands Committee which was instructed on 10 June 1669 to consider a place for it and arrange for the pillar to be built.[292] Land had to be taken from and around St Margarets Church, Fish Street Hill in the Parish of St Magnus.[293]

On 26 January 1671 the Court of Aldermen considered Hooke's design for the pillar:

> Upon view of the draught now produced by Mr Hooke one of the Surveyors of new buildings of the Pillar to be erected in memory of the Late dismall ffire the same was well Liked and approved, And it is referred to the said Surveyors to estimate and certifye unto this Court the charge of the said Pillar.[294]

About two weeks later the Court of Aldermen approved the cost and recommended the City Lands Committee proceed "with all expedition" to build the pillar according to Hooke's draft.[295] No similarly explicit reference to a draft by Wren has been found in the City records.[296] Furthermore, no record of any *ex gratia* payment by the City to Wren for such a draft has been found.[297] John Aubrey includes "the Piller on Fish-street-hill" amongst a list of buildings built by Hooke.[298] He was a close friend of both Hooke and Wren, so it is unlikely that he would have erred in the matter of who built the Monument. For the present it is safe to assume that the Monument is the result of Hooke's design, although there can be little doubt that he discussed the project with Wren and that the City consulted Wren on the matter.

Hooke continued to be involved in the detailed design of, acquisition of land for and the construction of the Monument. On 9 October 1672 the City Surveyors (Hooke and Oliver only by this time) were ordered to set out and enclose an area of ground

adjoining the pillar at Fish Street Hill to be used for scaffolding and carving the base panels, taking care for the convenience of passage of carts.[299] On 6 November 1672 the parishioners of St Magnus were told by the City that they would have a warrant for payment for loss of their ground taken away for the pillar as soon as Hooke had completed and certified the certificate which they had presented to the City;[300] Hooke was at the site on 8 August 1673;[301] he discussed the pillar with Sir Thomas Player, the City Chamberlain, on 11 September 1673;[302] by 19 October 1673 he had completed a detailed design;[303] he discussed it with Abraham Story, master mason and others, possibly including Wren, on 28 March 1674;[304] he visited the site and recorded that the pillar was 210 steps above the ground on 1 June 1674;[305] visited again on 7 August 1674 and recorded that the pillar was 250 steps above the ground;[306] he dined at the pillar with Joshua Marshall, master mason (and son of the King's mason) who was in charge of the pillar stonework on 8 September 1674;[307] on 6 November he visited the Lord Mayor to discuss the iron railings for the pillar balcony;[308] and on 16 December 1674 he was first at the Lord Mayor's with Caius Cibber and later at the pillar, presumably about sculpting the bas reliefs on the west panel at the pillar base.[309] The pillar was completed by the end of 1676,[310] but Hooke continued to be engaged on work relating to it (see Figure 4 for example). Hooke and Oliver were called upon to certify the workmen's and artificers' accounts for wages and bills of quantity,[311] but a year later, in December 1677, the matter had not been settled.[312] Eighteen months later, Hooke was still investigating and reporting on the quantities of materials used in the construction of the pillar.[313]

3.4(d) Gateways

The City did not hasten to rebuild the damaged gateways. They were generally of substantial stone construction and most were able to serve their original purpose for a few years. On 17 July 1672 the City Lands Committee ordered the Surveyors to assist in designing and estimating the cost of rebuilding Moorgate, to value Little Moorfields and decide how it could be disposed of for use as a hay market, and to view the work in progress at Newgate.[314] The report on the Newgate view was presented to the Committee on 14 August 1672 when the Committee decided that the west front of Newgate should be taken down and rebuilt according to a design by Hooke[315] and that the Committee

members who had reported on the view were to be responsible for overseeing the building construction, dealing with the workmen and preparing the accounts for repair work done at Newgate since the Fire.[316] At a meeting on 27 August 1672 the City Lands Committee who had been made responsible for overseeing work at Newgate had become the "Newgate Committee" and as such decided to delegate their responsibility to the City Surveyors.[317] This meeting took place on a Tuesday; the regular meetings of the City Lands Committee took place on Wednesdays, so the business of rebuilding Newgate necessitated special consideration by the City. Unpaid repair work had been in progress for at least two years. The City now decided to pay for the repairs and go ahead with rebuilding the more severely damaged parts. Hooke responded by submitting the estimate for rebuilding to the Newgate Committee on 5 September 1672[318] and was with the Committee again on 11 September 1672 when they recorded that the bill proposed for the rebuilding amounted to £2279.[319] The fact that Hooke quotes the estimate to four significant figures indicates that most of the design of the west front had been completed by this time, but to what extent Hooke assisted the Committee members in the design is unclear.

On the orders of the City Lands Committee, Hooke continued working on Newgate and other city gateways. He was ordered to view the work at Newgate with Oliver and two of the City's master masons and investigate the source of stone being used, following a complaint to the City that it was of poor quality.[320] One of the Surveyors (un-named) was ordered with Shortgrave to measure Tanner's work at Newgate.[321] The design of Moorgate and estimates of the cost of building ordered by the City Lands Committee to be made by some of its members with the assistance of the Surveyors[322] was presented to the Committee on 9 October 1672. Once again the form of the estimate (£2,013-12s-00d) shows that the design was at that time complete, or nearly so, confirmation coming from the Committee's comment that the design (or "model") was ornamental and useful. They also agreed that the charge was necessary and reasonable.[323] To what extent Hooke and Oliver contributed to the design of Moorgate is unclear. The work was approved by the City Lands Committee on 16 October 1672 when it was ordered to be performed.[324] Hooke continued to visit Newgate: he was there

with the City Chamberlain on13 June 1673[325] and he made many views of adjacent tofts as the rebuilding progressed.

3.4(e) Sewers, Conduits and Other Works for Public Health

The City Surveyors were called upon by the City Lands Committee to advise on and take part in what would now be called Public Health Engineering, in particular the rebuilding of sewers and water conduits and siting of houses of common easement. The rebuilding of sewers was overseen by the Commissioners for Sewers (and paving) whose members included Aldermen and Deputies appointed by the City. In the spring of 1667 Hooke, with Mills and Oliver, worked with the Commissioners to produce rules and directions for setting the gradients of the streets and lanes.[326] The Commissioners were authorised to levy rates on the inhabitants living in the areas served by new sewers and paving, and to remove trade practices that were dangerous or noxious. They directed the City's workmen in locating sewers and paving streets, calling upon the City Surveyors from time to time to view and report on the works and supervise such technical matters as levelling surveys, setting out gradients of streets and sewers, and constructing drains.

Much of Hooke's work on new sewers centred around the Fleet Channel and was closely related to the arduous and costly task of making it navigable. He and Wren had included a proposal about building sewers (which was accepted and implemented by the City) amongst their first detailed technical proposals for the Fleet Channel to the City Lands Committee on 22 March 1671 (Section 3.4(a) above).[327] Hooke's services were subsequently called upon for specific activities in the vicinity of the Fleet Channel[328] and elsewhere in the City.[329] On 3 May 1671 Hooke and others were ordered by the City Lands Committee to view and report on a dispute about a sewer above Holborn Bridge.[330] A report was presented to the Committee on 24 May 1671, but it dealt with only part of the matter, so it was ordered to be completed. It is not possible to determine who wrote and signed the first report, but the second (Figure 9) is an example of a report written by Hooke, but signed by others and not by him;[331] Figure 6 is another example of Hooke writing, but not signing, a report to the City.

The City Lands Committee later ordered the sewer above Holborn Bridge to be cleaned and arched over from the bridge northwards as far as the limit of the City's Liberties and that grates be placed at the upper limit to prevent rubbish from being carried downstream. The City agreed with John Fitch that he would do the work according to rates to be decided by Wren, Hooke and Oliver who were to see that the work be "done strong and substantial".[332] The use of Wren's name in this connection shows that the work was related to the Fleet Channel and intended to prevent continued use of the upper reaches of the Fleet as a dumping ground for rubbish which added to construction problems downstream. The problems however continued and Hooke was given more to do. On 12 July 1672 the Commissioners for Sewers reported to the City Lands Committee that work on the Fleet Channel had blocked some drains. Twelve days later the Committee ordered Hooke, Oliver and some Committee members to look into the matter at the same time as they viewed and reported on Fitch's work.[333] Hooke viewed the site in the morning of 11 September 1672 [334] and reported in writing his findings to the City Lands Committee at their meeting later that day.[335]

Another matter of public health was the siting of houses of common easement. Hooke contributed to ameliorating the worst effects of these necessary public facilities. The following examples illustrate problems faced by the City and the part Hooke played in the procedures for solving them. The Surveyors were ordered to find a way of removing the noxious consequences of unregulated public usage as a latrine of a place against the south wall of Guildhall.[336] The area around Guildhall continued to be a nuisance. A house of common easement in a narrow passage at the end of Guildhall Yard was ordered to be removed by the City Surveyors (or one of them) and re-located in a place where it would be less offensive.[337] Citizens of Queenhithe asked the City Lands Committee for a house of common easement to be erected in their parish; the City Surveyors were ordered to decide on the site and method of construction.[338] Laystalls (depositories for sweepings from the streets, refuse and ashes from houses, dung and straw from stables and waste from trade practices, the contents of which were taken by barge to market gardens along the Thames outside the city) and slaughterhouses were also sources of nuisance. In its rebuilding, the City, with the assistance of the Surveyors,

had to find and stake out sites for laystalls, paid for from the Coal Money.[339] The responsibility for siting slaughterhouses in places permitted by the Rebuilding Act, but with least offence or annoyance, was given to the Surveyors in consultation with the Master and Wardens of the Company of Butchers.[340]

Containment and removal of waste through sewers, latrines and laystalls was one aspect of the public health of the City to which Hooke contributed. He was also involved in another - the distribution of clean water through newly built conduits. The City had difficulty before the Fire in locating its underground water distribution conduits and decided that both old and new conduits should be shown on a map; Hooke was expected to participate in producing one.[341] In June 1671 the City Surveyors were ordered to stake out a site (formerly occupied by the Church of St Pancras in Soper Lane) prior to constructing there a general cistern intended to be of use to the whole city. The Surveyors were ordered to design the cistern and the City Plumber was ordered to make it.[342] Hooke continued from time to time at the City's behest to work on conduits at least until 1683.[343]

3.4(f) Markets

It was the King, not the City, who decided that sites for new markets should be found which would not hinder traffic passing along main thoroughfares in the way the street markets had done before the Fire. The City readily agreed to the proposal which was included in the first Rebuilding Act. Land was taken by the City for new markets and compensation paid from the Coal Money. Hooke and the other Surveyors surveyed and certified areas of land taken away for markets as they did for land taken for streets and quays, but Hooke in particular was also called upon by the City Lands Committee to undertake additional work on the new markets.

The first of these orders by the City Lands Committee was given on 28 April 1669 when Hooke went with nominated Committee members to meet Wren at Billingsgate dock to seek his opinion on enlarging the adjacent Romeland to include a place for storing coal and for a fish market. Hooke and the three Committee members were ordered to

engage workmen for speedy completion of the work.[344] Their report dated 26 May 1669 shows that they had lengthy debates at the site with each other and with citizens in the neighbourhood before deciding on recommendations for extending Romeland into the dock and providing widened access from the street. They put their proposals to Wren who would not approve them until he had taken them to the King whose approval was duly given, with some additional recommendations for protecting the buildings fronting the dock from damage by ships.[345]

From that time the City hastened to build the new markets and the City Surveyors were given much to do, especially Hooke who was often nominated to undertake work on his own; Mills and Oliver were nominated individually in the orders of the City Lands Committee much less often. The Surveyors were ordered to see to the preparation of level ground for the market house at Newgate and agree rates with workmen for paving the area.[346] After about three weeks they reported that they had agreed a rate of seven pounds per (square) rod.[347] On 1 September 1669 they were ordered to do similar work at Woolchurch Market and Hooke was specifically ordered to stake out ground for one of the markets at Leadenhall, and measure the dimensions of an area of ground bought by the City from a Mr Farrington with the intention of including it as part of the market. At the same time, Hooke and Oliver were ordered by the City Lands Committee to consult with Miles Temple (a grocer who had just been granted the lease of Leadenhall Markets for thirty one years at £2,100 per annum, but he surrendered it two years later[348]) on designs for the markets and present them to the Committee.[349] The following month the City Surveyors were ordered to meet at Woolchurch Market, draw a design for the market and present it to the Committee. At the same time Hooke and Oliver were specifically ordered to go to Romeland at Billingsgate, agree with the inhabitants there on a design for building and report to the Committee.[350]

As spring 1670 drew nearer similar work continued to be given with increasing urgency. On 10 February 1670 the Surveyors were ordered to (inter alia): consider the designs earlier ordered to be prepared in consultation with Miles Temple (but apparently not yet in the hands of the Committee); draw the design for a piazza on the south side of

Woolchurch Market; measure the dimensions and examine the workmanship of cellars being dug at Leadenhall to see if they are fit for use by the market people; consider and report on Temple's plan for a building above the piazza at Woolchurch Market; consider what should be done at Honey Lane Market; and not fail to report all in writing to the Committee in six days.[351] The minutes of the City Lands Committee (CLRO CLCM(R)) have no entries after 10 February 1670 until they begin again in13 March 1672, so it is not possible to obtain evidence from that source about how Hooke and the other two Surveyors managed to deal with the orders about markets heaped upon them.

By the time records resume in the minutes, markets no longer appear to be a matter of urgency to the Committee, so it is likely that the Surveyors did all that was necessary. However, the Committee continued to place a heavy burden on the Surveyors (now Hooke and Oliver, Mills having died). On 19 November 1672 they were ordered to make surveys of Newgate, Honey Lane and Woolchurch Markets and draw plans showing also the bounding streets, the houses fronting them, names of their inhabitants, or if unoccupied or unbuilt, the details of the proprietor. The dimensions of each of the surrounding houses and their areas were also required to be shown. It is highly unlikely that any such surveys were carried out by Hooke and Oliver, although in the months following the order Hooke gives indications that he might have done a little of what was required. He was at Newgate Market in the morning of the day after the plans were ordered, but does not say why.[352] On 7 February 1673 he records

> measured woolchurch market[353]

He was at Newgate Market for an unspecified purpose on 29 May 1673,[354] and again on 23 September 1673 with John Wise, clockmaker, specifically to view the market clock.[355] At none of these visits could he have made anything other than a few measurements. The work ordered by the City Lands Committee would have taken many days to complete at each market. There is no evidence that any plans of the kind ordered by the Committee were made before 1677 when William Leybourn surveyed and drew plans of six markets: three at Leadenhall (the Beef Market, the Greenyard and the Herb Market), the Stocks Market at Woolchurch, Honey Lane or Milk Street Market and Newgate Market.[356] These plans omit much of the detail that was specified for Hooke and Oliver. They were

later annotated with the inscription

> The dimensions written into this Mapp were examined by us. November the 3. 1692.

followed by what purport to be the signatures of Hooke and Oliver, but Oliver's name is not his signature; and Hooke's name is very probably a careful copy of the form of his signature at that time. Possible reasons why Hooke (and Oliver) did not undertake the surveying and drafting ordered are discussed in Section 4.3 below.

3.5 The City Churches

The second (1670) Rebuilding Act designated the Archbishop of Canterbury, the Bishop of London and the Lord Mayor of London as responsible for rebuilding the parish churches. They came to be known as the Commissioners for Churches. Their responsibilities included deciding which churches should be built, their dimensions, design and manner of rebuilding. The cost of rebuilding the fabric would be borne by the Coal Tax, at the insistence of the King.[357] The Commissioners quickly nominated Wren to take charge of design and construction matters, assisted by Hooke and Edward Woodroffe, a Master Mason. Woodroffe died in 1675 and was not replaced. Wren and Hooke bore most of the burden thereafter, similar to the way in which Hooke and Oliver continued working when the third City Surveyor Mills died in 1670 without being replaced. Although Hooke was referred to by the Commissioners for Churches as one of Wren's two assistants, both Wren and Hooke seem to have regarded their relationship in connection with rebuilding the churches as more like that between partners in a modern professional practice.

A detailed study of the relationship between the two men in connection with explaining planetary motion[358] has shown that each man gained from the ideas of the other. It is possible that a similar interaction in relation to the properties of structural materials and structural design, if not in architectural design, took place during their frequent meetings in and around the building sites of the city, including the Fleet Channel, the Monument and St Pauls. The extent of Hooke's contribution to the architecture of the City churches is currently under investigation, but without as yet any useful, or generally

acceptable conclusions.[359]

There is however evidence of Hooke's considerable contribution to the management and direction of building work on site. In the year and a half from the beginning of *Diary* (R&A) in 1672 until the end of the period studied here, Hooke recorded more than 60 visits to 24 different churches,[360] but did so in his usual terse style - nothing more was necessary for aides mémoires. Sometimes he visited a site alone, sometimes with Wren. The purpose of a visit is generally not clear from Hooke's record of it. If he was accompanied by Wren, the purpose was almost certainly to oversee the rebuilding. When Hooke gives the names of Ward Aldermen and Deputies who accompanied him, the visit was probably a view by Hooke as City Surveyor to examine and report to the City on matters such as damaged and allegedly dangerous church walls, towers and spires. In any case, accompanied or not, Hooke's participation in the rebuilding of the City churches was extensive and an important contribution to the efficient management of day-to-day site procedures and resources.

3.6 Private Commissions

As Hooke's salary for his duties as City Surveyor and the additional payments which derived directly from those duties decreased from the middle of the 1670's, so his income from private commissions began to increase. Although these private commissions did not arise directly from his appointment as City Surveyor, and might therefore be considered to lie outside the scope of this investigation, they occupied a significant amount of his time and energy in the aftermath of the Fire and provided him with another source of income which held out the prospect of increasing financial independence from the Royal Society Council and the City. Some of the more important private commissions on which he worked during the period studied here have been investigated to discover how significant this kind of work was and what the financial rewards were. Most of the evidence is taken from *Diary* (R&A), but further evidence could possibly be found in the archives of the organisations for which Hooke worked.

3.6(a) The College of Physicians

The Physicians' College in Amen Row, near St Pauls, had been destroyed in the Fire. On 22 December 1670 the Committee of the College of Physicians appointed Hooke to assist in building its new College in Warwick Lane by managing on their behalf the rebuilding works. The College Committee also agreed to pay Hooke a gratuity of twenty guineas for his care and pains.[361] Sir George Ent, President of the College, was a founder Fellow of the Royal Society and active in its affairs until around the time the rebuilding started and he knew Hooke well. The engagement of Hooke by the Physicians' College through Ent's knowledge of his abilities and capacity for hard work resembles the ways in which the Royal Society had earlier employed him through Boyle's recommendation, and the City (and Gresham College) through Lawrence's.

During the next few months Hooke was frequently called upon by a sub committee set up by the Physicians' College to deal with day-to-day matters relating to the rebuilding. He was engaged to draw up contracts, appoint and supervise workmen to undertake the College rebuilding, negotiate the costs of building houses for the Fellows, the Beadle and the Chemist, and (as City Surveyor with John Oliver) settle an intermixture of interests according to the Parliamentary Act.[362] In the performance of these tasks Hooke visited the site in Warwick Lane several times in the four years following his appointment by the Physicians' College until the main College rebuilding was completed at the end of 1674.[363]

At the time when Hooke began his earlier diary and throughout the rebuilding of the Physicians' College he dined frequently with Sir George Ent, usually on a Saturday, nearly always at Ent's, but sometimes in one of the city coffee houses or elsewhere. Hooke's diary entries during these years are written in their normally terse style and give few details of what took place at these meetings, but there can be little doubt that Hooke and Ent discussed the rebuilding.[364] Taken in conjunction with the number of his recorded visits to the site in Warwick Lane they show that he ensured through his congenial relationship with Ent, his frequent presence at the site and his knowledge of building technology, individual master craftsmen and their practices, costs of materials and wage

rates that his client's interests were properly served and the work satisfactorily completed. He linked his client's world of physicians and their aristocratic and regal patients with the world of London's craftsmen and labourers, eating at the dinner tables of one class and setting out foundations and measuring stonework amidst the tools, building materials and trenches of the other. Evidence shows that he alone fulfilled the roles of what would now be called project manager, land, building and quantity surveyors and resident engineer.

He was probably also the architect, but confirmation that he was can not be obtained from *Diary* (R&A) which was begun more than eighteen months after his appointment by the College in December 1670. Foundations were laid in March 1671[365] so Hooke would have had time in the three months between his appointment and the beginning of the next building period in the following spring to prepare and submit the architectural drawings or a model for approval. There is however clear evidence that he was the architect of the anatomy theatre at the Physicians' College. The President of the College engaged Hooke directly for this work which began four years after Hooke's initial appointment by the College.[366] Sir John Cutler, who ten years earlier had promised to pay Hooke's salary as Cutlerian Lecturer, promised a benefaction to the Physicians' College for the theatre, but later refused to pay, denying that he had done anything more than lend them some money.[367]

In the spring of 1674 when building work could resume after the winter, Hooke quickly turned to practical details. Within a week he had set out the foundations for the theatre, drawn up a detailed design, agreed a contract with Joseph Lem, visited the site with his nephew Harry (presumably to make some measurements as before) and given a sketch of the theatre to Dr Daniel Whistler, Fellow of the Royal Society and Physician, who seems to have been charged by the Physicians' Company to oversee on its behalf the building of the new theatre.[368] The rebuilding work however did not proceed quickly. Three times in four days Hooke met Ent and others who had an interest in the theatre,[369] probably because the Physicians were having second thoughts about where it should be located. At the end of May 1674 they decided it should be located not as planned and already set out by Hooke at the front of the building, but at the rear.[370] Hooke sought out

Sir John Cutler who said that the theatre should be located at the front as was originally intended,[371] but when Hooke reported this to Ent he was told that no decision would be made in Whistler's absence.[372] By the middle of July 1674 Whistler had returned. He went with Hooke to see Cutler. Hooke and Whistler then called on Ent to inform him that agreement had been reached - the theatre was to be built at the front.[373]

The theatre was eventually built at the front of the College, against the street, but not without more uncertainties about its location which Hooke had to deal with.[374] As soon as the setting out for construction of the outer walls had been settled, he turned his attention to the interior form. First he discussed it with Wren[375] and a few days later Ent and Scarburgh approved an open internal plan[376] which Hooke promptly set out.[377] The building was open from the first floor up to the domed roof which carried a spire with skylights set around its base. Windows around the base of the dome were an additional source of light into the airy interior. Five rows of wooden benches with standing room behind the topmost row provided places for viewing the investigations in progress, with direct and uninterrupted illumination from above. Throughout late summer and early autumn of 1674 Hooke visited the theatre building site at least once a week, sometimes almost daily, giving instructions and correcting work which was done contrary to orders. Individual Physicians expressed to him their preferences for internal and external ornamental and decorative features which he then designed and employed craftsmen or artists to make. He continued to meet Ent frequently, especially on Saturdays, to report on progress, approve bills of quantity and workmen's wages and generally see to many detailed alterations of design and variations in costs. He even tried to persuade Cutler to pay to him a first instalment for the theatre. In this he was as unsuccessful as he was in getting Cutler to pay him his arrears of Salary as Cutlerian Lecturer.[378] Hooke's work for the Physicians' College and Theatre was not completed until June 1679 when he approved the final bills.[379] The buildings survived until 1876 when they were destroyed by fire. By then they were believed to have been by Wren and were lauded as a perfect study of acoustical and optical architecture.[380] As recently as 1923 the theatre was described as delightful and worthy of its architect, Wren.[381]

The Physicians' College was one of the first of Hooke's architectural commissions by corporate bodies and citizens, but the foregoing shows that his work went far beyond architectural design. He gave regular attention to the technical and economic details of building construction and through his care and direction on site ensured that the work was completed to the satisfaction of the Physicians, particularly in relation to the theatre. In this he had the advantage of understanding what was required, being actively engaged with Physicians who were also Fellows of the Royal Society in experimental investigations and philosophical debate on their practice.

3.6(b) Bridewell Workhouse and Bedlam Hospital

Another important private commission which engaged his attention during the period 1672-1674 was the building of a new Bedlam Hospital in Moorfields. Sometimes called Bethlem, or Bethlehem Hospital, its governors were also governors of Bridewell, the City's workhouse for the poor. Ambiguities in relation to Hooke's descriptions of work at Bedlam and Bridewell similar to those mentioned above relating to the Physicians' and Barber-Surgeons' theatres are found again in *Diary* (R&A), but his contribution to the new Bedlam Hospital was more important than his contribution to Bridewell which was only partially destroyed in the Fire and was repaired, not rebuilt. Hooke first mentions Bridewell when he visited the site on 15 August 1672.[382] He was there again on 31 August 1672[383] and on 18 September 1672.[384] He gives no reasons for these three visits, but he was there next on 25 September 1672[385] to see about the waterline and Thames Quay, not about repairs to Bridewell workhouse. On 28 November 1672 Hooke noted

> Received from Sir W. Turner for Bridewell £5, gave Monox 5sh.[386]

which indicates that he had rendered some service to the governors of Bridewell in the preceding months which went beyond what he might have been expected to perform as part of his duties as City Surveyor. Turner, who was chairman of the governors of Bedlam and of Bridewell, a former Lord Mayor and Past Master of the Merchant Taylors' Company, through personal knowledge of Hooke's work as City Surveyor probably commissioned Hooke to direct repair work at Bridewell and to design and supervise the construction of a new Bedlam - another example of someone in authority recognising

Hooke as someone who had the attributes necessary to do something useful and engaging him to act accordingly. In early spring 1673 when rebuilding might soon begin again after the winter, Hooke made more visits to Bridewell. He spent an afternoon there on 10 March 1673[387] and four days later with Turner he calculated the area of ground taken away.[388] On 18 March 1673 he visited the site with the bricklayer John Fitch[389] and recorded further visits, without indicating the purpose, on 4 & 18 April 1673.[390] His next recorded visit to Bridewell took place six months later, on 22 October 1673, when he discovered that several alterations were necessary and directed them to be made.[391] Eight months later, on 25 June 1674, he showed Turner his design for some more work at Bridewell[392] which, on 2 October 1674 was ordered to take place.[393] Hooke continued after 1674 to work on the repair of Bridewell workhouse (and its chapel) which stood until 1863 when it was sold and the area rebuilt.[394]

Bedlam Hospital was rebuilt to Hooke's design on a new site. His first record of work for Bedlam is dated 14 April 1674:

> With Dr Allen at Bedlam. Viewd Morefields for new Bedlam. Drew up report for him. At Sir W. Turner. Undertook new Designe of it.[395]

Dr Thomas Allen was Physician to Bedlam Hospital and a Fellow of the Royal Society. There are similarities between this new commission by Turner and the commission by Ent to design the Physicians' Theatre. In each case design and supervisory commissions followed Hooke's supervision of repair work for the respective institutions. Ent and Turner, each with the support of the members of their governing bodies, readily engaged Hooke for further and more important work. They did this despite knowing that he was also employed by the City, by Gresham College and by the Royal Society for other onerous duties. The men who knew all this in some detail, mostly through membership of and active participation in City committees and in the Royal Society, were eager to engage him for further work. Their actions show a high regard for Hooke's organisational abilities, energy and integrity.

Although Bedlam's final façade was an imposing 540 feet long, the building contained a separate room for each patient. In the grounds Hooke laid out gardens and

trees which enabled Londoners to continue the walks at Moorgate they had enjoyed before the Fire. These two quite different aspects of Hooke's design show that he had in mind the privacy of each hospital patient and the London citizens' enjoyment of walking in a large garden as much as an ambition to create an imposing edifice. Almost a century after it was built Bedlam was described as "among the noblest ornaments of this city, a building of great delicacy."[396] The numerous entries in *Diary* (R&A) show that Hooke was involved not only in design, but also in close supervision and direction of all stages in construction, from setting out the foundations to installing external and internal decorative features. On 11 July 1674 he went to Bridewell where his design for Bedlam was approved.[397] On 28 September 1674 he recorded

> Set out Morefield for Bethlehem with Sir W. Turner, Sir Thomas Player, [City Chamberlain] &c. - 30 and 350 west and 390 East.[398]

which implies a ceremonial visit by the City for the inaugural staking out. The quoted dimensions are smaller than those of the finished building, but the design changed as construction got under way. A fortnight later, further (unspecified) agreement about the hospital was reached[399] and on 29 October 1674 Hooke went with John Fitch the bricklayer to Moorfields where he set out the wall immediately in front of the main building.[400] He was at the site again on 2 & 3 November 1674 where he had hoped to meet Wren.[401] On 13 November 1674 he visited Moorfields in the morning and did some more design work at Gresham College in the afternoon.[402] A week later he first went to see the progress of the wall and then visited Fitch.[403] These incidents were soon followed by a visit to the site by Hooke and the governors to look at Fitch's work on building the wall and approve his estimate of (or account for) bricklaying charges.[404] Hooke visited the site again on 15 December 1674 to examine the wall and gratings and later met Turner.[405] Hooke continued to design and oversee the construction of Bedlam Hospital until the building was completed in 1676, only two years after the staking out ceremony at what would now be called a "green-field" site. The King visited Bedlam on 29 August 1676,[406] but Hooke continued to work there for at least eighteen months: for example in January 1678 he designed a chapel for Bedlam.[407]

3.6(c) Ralph Montague's House

Towards the end of 1674, Hooke began six years work designing and building a house for Ralph Montague in Bloomsbury.[408] Montague was a fastidious, but lavish host who nevertheless called on Hooke at Gresham College when Hooke was designing his house. The first mention of Montague in *Diary* (R&A) occurs in connection with a meeting on 31 July 1674 in a coffee house

> To Flamstead at Tower and Coffee house in Mark Lane. He spoke about
> R. Montacues house and new quadrant.[409]

The incident exemplifies the way in which city coffee houses provided a means of exchange of scientific and social information and raises the interesting questions of what Flamsteed knew about Montague and his house and whether in mentioning the matter to Hooke he was engaged in more than idle gossip. In any case, within a month Hooke had met Montague and arranged a further meeting with him.[410] This meeting took place on 2 September 1674 when Hooke went with Montague to the site and recorded its dimensions as 350 feet from east to west and 700 feet from north to south.[411] Hooke received a letter from Montague on 10 September 1674[412] which was probably a formal appointment because on the following Saturday Hooke worked on a layout plan[413] which he gave to Montague on 24 September 1674.[414] On 9 October 1674 Hooke received two letters from Montague and at the same time he noted that John Fitch had returned.[415] The next day Hooke went with Fitch and Povey, a marbler, to Montague's.[416] Two days later Hooke recorded:

> At Mr. Montacues with Mr. Fitch and agreed upon setting out ground &c.
> At the Ground and drank with Mullet and Fitch[417]

(about eighteen months later Mullet was appointed under-Surveyor for the work).[418] On 14 October 1674 Hooke met Fitch at Povey's house[419] and three days later Hooke recorded:

> At Mr. Montacues. With Povey, Samuell, Mullet, Fitch, agreed module.[420]

Samuels, like Fitch, was a master bricklayer. Hooke continued to work on the design details and went with Fitch to Montague's on 30 October 1674 where he presented his design drawings.[421] On 5 November 1674 Hooke discussed with Montague the need to make a model of the house, presumably based on the design drawings he had recently completed. Montague authorised £20 to be spent on it.[422] Hooke prepared another design

drawing for Montague on 1 December 1674[423] which Montague discussed with Hooke at Gresham College on Thursday 3 December 1674 when the Royal Society Council were displeased that Hooke was absent from their dinner. However, he was at the meeting of the Society in the afternoon when he read his lecture on his quadrant.[424] It is notable that Hooke generally managed to avoid censure arising from his conflicting obligations. On 9 December 1674 he worked all day on the model for Montague[425] and made some drawings of the elevations of the wings of the building on 13 December 1674, a Sunday.[426]

On 15 December 1674 at Gresham College he presented his latest designs to Montague, Fitch, Davies (a master joiner) and Sidley (whose role is unclear) and received Montague's approval and order that all haste be made - following which he made his way to Moorfields to oversee the building of the wall of Bedlam Hospital and then spent the rest of the day in typically frantic activity, going from place to place, dining, recording the names of men he met from a wide range of social positions, buying prints and commenting on his digestion which was generally, and unsurprisingly, not good.[427] He continued to work on the design of Montague's house in this way for the next three years, responding to his client's many changes of mind as the building proceeded and decorative internal and external features were added. 'Espinasse has counted more than three hundred entries in *Diary* (R&A) between the first on 31 July 1674 and the last on 16 February 1681 which relate to Montague House.[428] Only the first twenty or so of these are quoted here. The rapidity with which Hooke undertook the major work for Montague whilst still engaged in building the Physicians' Theatre and Bedlam Hospital in addition to his salaried employment by the City, Gresham College and the Royal Society shows he was still confident that he could balance these different commitments. It probably also indicates that he recognised his salary from the City was going to decrease further in the coming years and so took action to mitigate the effects of this loss. Hooke's income from private commissions is discussed further in Section 4.4(f) and summarised in Table 8.

3.6(d) City Livery Companies' Property

Hooke also was involved in the restoration of Livery Halls, usually by certification

of area or a view in his capacity as City Surveyor, but not in all cases. From the time Hooke began to make entries in *Diary* (R&A) until the end of 1674 he made about twenty references to his work for ten Livery Companies (excluding the Merchant Taylors and the Barber-Surgeons which are considered separately here). Generally the work involved checking workmen's bills and the quality of their work on behalf of the Company's Council or sub-committee responsible for rebuilding its hall. For example, on 27 July 1674 Hooke recorded

> Me to Grocers Hall for Young. Valued work[429]

and on 7 October 1674 Hooke recorded

> Gave Sir J. Frederick account of Mercers hall[430]

At least two Livery Companies however engaged him privately before 1675 for architecture: the Barber-Surgeons for architectural restoration of their theatre (originally designed by Inigo Jones) and the Merchant Taylors for various tasks including the design of their great screen which survived until the London Blitz.

Although clear evidence has been presented above that Hooke designed and supervised the construction of the Physicians' theatre, equally clear evidence of the extent of his involvement in the restoration of the Barber-Surgeons' theatre has not been discovered. Hooke's terse records often mention "theatre" without a qualifying adjective. It is therefore difficult to differentiate in *Diary* (R&A) between entries referring to the Physicians' theatre and those referring to the Barber-Surgeons'. Hooke was at the Barber-Surgeons' theatre on 17 September 1672 for an unspecified purpose, but in a footnote the Editors incorrectly gloss this as "i.e. the Theatre of the College of Physicians in Warwick Lane".[431] Sir Charles Scarburgh, King's physician, Barber-Surgeons' anatomical reader and inactive Fellow of the Royal Society visited Hooke at Gresham College on 13 November 1672.[432] Hooke viewed the Barber-Surgeons' hall as City Surveyor on 29 November 1672[433] and viewed their theatre on 23 January 1673.[434] These views took place during the period covered by the missing volume of CLRO Viewers' Reports and since no manuscript records of the views have been found it is not possible to say what the purposes of these views were. Hooke visited the theatre with Scarburgh and dined there on 8 March 1673.[435] He dined with Barber-Surgeons Page on 5 November 1672[436]

and Lamot on 23 December 1672[437] and met Scarburgh again on 13 November 1672[438] and on 15 February 1673.[439] On 8 May 1673 Hooke went with Scarburgh to the house of Robert Streater, a painter, and then to a new playhouse.[440] Scarburgh visited Hooke at Gresham College on 4 July 1673 and they met again later that day at the Lord Mayor's where Ent was also present.[441] Eleven days later Hooke received a payment from Scarburgh

> Nell [Nell Young was Hooke's domestic servant at the time] Received from Sir Ch. Scarborough 50sh.[442]

Six months later he received another payment

> Doll [Doll Lord was Hooke's domestic servant at the time] received from Sir Ch. Scarborough and paid me 40sh. for theater, making in all £20[443]

and a few days later Hooke noted

> Gave Sir Ch. Scarborough acquittance for the last £5 in full of £20 for module for theatre[444]

later noting

> Sir Ch. Scarborough here and pleased[445]

Once again it is seen that Hooke was engaged to good effect by a man who knew him well and was aware of how much work he was already managing efficiently. Confusion between Hooke's work on the two theatres has been clarified. Sir Charles Scarburgh paid Hooke for the Barber-Surgeons' theatre; payments for the Physicians' theatre were always made by or through Sir George Ent. However the extent and nature of Hooke's work for the Barber-Surgeons is not clear.

For the Merchant Taylors Hooke was given a variety of tasks at the instigation of Sir William Turner who was a past Master of the Company and who commissioned Hooke's work for Bridewell workhouse and Bedlam hospital. On 1 August 1673 he recorded

> Sent for to Merchant taylors about viewing the Hall by Sir W. Turner and Sir W. Pritchard and about screen[446]

and a fortnight later Hooke had completed his design of the screen and the surrounding floor

at Merchant Taylors Hall. Designe of Screen and pavement accepted at Clipsams[447]

but the Company changed its mind

at Merchant Taylors hall about raising the new pavement[448]

and gave Hooke another task which he completed the following Sunday

Designed Merchant Taylors Garden[449]

but the following day the Company sent for him for an unspecified purpose.[450] He handed over the design of the garden on 1 October 1673

Gave Milner the Draught of Merchant Taylors Garden[451]

In the new year he was commissioned to prepare a design for rebuilding the Merchant Taylors School in Suffolk Lane

At Merchant Taylors School. Ordered to draw up platt[452]

The very next day he

Contrived with Lem Designe of Merchant Taylors School[453]

which he had completed five days later

Delivered Sir W. Turner Merchant Taylors School Draft[454]

He was at the school and at the hall on 11 February 1674[455]at the hall on 23 February 1674[456] and at the school again on 28 July 1674,[457] but no further evidence has been found that he went further with the Company's rebuilding. Such evidence as has been presented illustrates the alacrity with which Hooke set about making his designs and models once he had received orders to do so.

CHAPTER 4

EXPERIMENTING AND SURVEYING

At the time of the Fire, Hooke was fully engaged working for the Royal Society and giving his Gresham and Cutlerian Lectures. If an assessment of the importance of his surveying[458] is to be made it is necessary to discover to what extent his expertise in mechanical and optical engineering and experimental philosophy influenced his surveying, and, conversely, the impact of his work as City Surveyor on his scientific endeavours.

4.1 Hooke's Experiments for the Royal Society Before the Fire

The Royal Society nominated individual Fellows to be curators of experiments before and after it appointed Hooke to fulfil that general role. Fellows who from time to time were appointed curators of a particular experiment or series of experiments neither expected nor received payment; they were gentlemen virtuosi, liable for subscriptions and other fees to the Society. Hooke was employed by the Royal Society who paid his salary from fees contributed by the other Fellows, and he was exempt from all charges. The social differences between Hooke and the other Fellows have been described recently by a number of scholars who have given new insights into his position in the Royal Society. These differences have been discussed in Chapter 1 above,[459] but two other distinctions are important.

The first of these was that Hooke, more than most other Fellows, recognised the practical importance in experimental philosophy of defining and stating questions that were answerable by experiment. He then designed experiments to answer the questions, performed the experiments, reported what he had done, stated the results and his conclusions, and suggested how the experimental procedures might be improved and performed by himself or by others seeking to confirm or contradict the original conclusions. Other Fellows generally did not pose answerable questions, or design, perform and report experiments in the same way; they were often simply curious or seeking entertainment by being confronted by wonders.[460]

An early example of how Hooke went about performing and reporting an experiment is his first attempt to measure the variation of gravitational force with distance from the earth's surface. He made the investigation at the end of 1662, only a month after he had been admitted to the Royal Society as its unofficial curator. On 3 December 1662 Dr Henry Power had reported[461] to the Royal Society the results of some experiments he had made in coal mines (in Yorkshire, probably - Power's home was in Halifax) including one when he weighed a 1lb piece of brass at the top and then lowered it on a thread to the bottom of a shaft 68 yards deep and re-weighed it. He reported it weighed at least an ounce less at the bottom than at the top. Power did not offer any explanation or comment on either the outcome or the procedure. Three weeks later, on Christmas Eve, Hooke reported to the Royal Society a similar experiment he had made from the roof of Westminster Abbey. Numerous small details of his account[462] quoted below show that in the first weeks of his curatorship he adopted a very different state of mind in philosophical investigation than did most of his colleagues. He cited Francis Bacon as the originator of the method underlying his experiment and defined the question to be answered as whether any difference[463]

> in the weight of bodys could be found by their nearer or further removall from [the earth's] surface upwards.

He selected

> a pair of exact scales and weights

and went to the roof of Westminster Abbey where he found

> a convenient place ... [at] a height above the leads of a subadjacent building, which by measure I found three score and eleven foot.

Using the balance he counterpoised a piece of iron and a length of thread and found their weight to be

> of troy weight seventeen ounces and thirty grains.

After attaching the piece of iron by the thread to one of the balance pans he lowered it to just above the leads beneath, re-weighed the iron and thread

> and found, that the iron preponderated the former counterpoise somewhat more than 10 grains.

He did not then stop the experiment as Power had done; there was much more to do and

record. He drew up

> the iron and thread with all the diligence possibly I could, that it might neither get nor lose any thing by touching the perpendicular wall

and re-weighed the iron and thread, finding

> that it kept its last equilibrium; and therefore concluded, that it had not received any sensible difference of weight from its nearness to or distance from the earth.

But he was not satisfied. A significant difference of weight had been found between the first and second weighings, but not between the second and third. Therefore

> I repeated the trial in the same place, but found, that it had not altered its equilibrium (as in the first trial) neither at the bottom, nor after I had drawn it up again; which made me guess, that the first preponderating of the scale was from the moisture of the air, or the like, that had stuck to the string, and so made it heavier.

He was not yet satisfied with his "guess" so he went to another place on the roof, which was about the same distance above the ground as the former place was above the leads below, where

> upon repeating the trial there with the former diligence, I found not any sensible alteration of the equilibrium, either before or after I had drawn it up; which farther confirmed me, that the first alteration proceeded from some other accident, and not from the differing gravity of the same body.

He then went on to discuss Power's experiment in which a change in weight was found. Hooke put forward possible reasons for that phenomenon and suggested many new experiments that could give an explanation of it. For example, he proposed that pressure, density and temperature of the air might affect the weight so these should be measured during trials using objects of different sizes and materials which would have different "buoyancy". He also suggested that if a difference in weight with height were to be found, then the variation of weight every ten feet or so should be measured. He concluded his critique:

> These trials, if accurately made, would afford a great help to guess at the cause of this strange phenomenon.

It is socially significant that the most likely reasons for the outcome of Power's

experiment (inadequate procedures and inappropriate equipment) were not put forward by Hooke to the Royal Society, even though he would have recognised these shortcomings in Power's procedures.[464]

Hooke's account exemplifies procedures and attitudes that were later adopted with great success by experimental scientists: defining the purpose of the experiment; finding an appropriate location or environment for the experiment; selecting (or making) and testing instruments; careful measuring and recording; devising independent procedures and measurements as checks; seeking and proposing explanations of anomalous results; recognising the limitation of measurement sensitivity and accuracy; qualifying any conclusions; analysing critically the present experiment and those of others; and making suggestions for further experiments. His attention to detail in reporting what he had done and observed can also be seen in his reports to the City, particularly on his views (Section 3.3 above).

The second important, non-social, distinction between Hooke and many of the other Fellows of the Royal Society at that time was his ability to design and make instruments for investigations. In mechanical and optical ingenuity he was exceptional and sometimes painstaking in his investigations. The earliest well-known examples of these characteristics are the microscopical investigations he presented weekly to the Royal Society and which were later engraved and published in 1665 as *Micrographia*.[465] The illustrations are so detailed and well known that the great difficulties which Hooke had to overcome in order to see and illustrate what had never been seen before are often unrecognised. Having decided on the form and positioning of the microscope lenses relative to each other it was necessary to grind and polish the lenses and mount them so that the combination could be focussed on the illuminated specimen. Aberrations, especially chromatic, low levels of light transmission, narrow depth of field and the frequent need to re-focus the microscope and re-position the specimen would have made viewing and sketching tedious and slow. Many trials were necessary, probably including examinations with a single lens (which would have less chromatic aberration, but lower magnification than the compound microscope) and with different objective lenses to

change magnification. The technical skill, including draughtsmanship, and concentrated effort needed to depict in great detail a wide variety of objects is astonishing. His lengthy written descriptions and conjectures which accompany the illustrations often show prescience. Another confirmation of the accuracy of his pictorial and written observations (of Kettering-stone in this case) has recently been made.[466]

When carrying out his duties as Curator of Experiments before the Fire, Hooke received instructions at almost every meeting of the Royal Society to perform experiments (most of which could be better described as demonstrations, or even entertainments) at the following meeting. In many cases he put forward proposals himself that were seized on and ordered to be prosecuted by a specific date. Before the Fire his responses to these demands, including those that were self-imposed, were generally prompt, despite covering a wide range of topics. One example is chosen to illustrate how he carried out his routine work and its relation to other investigations at Royal Society meetings.

On 22 July 1663 at a meeting of the Royal Society he suggested a better way for sounding at sea and collecting water samples than by using a line. He was ordered to "bring it in". The following week he showed some diagrams of his ideas and was ordered to explain in writing how the two devices would work. At the same time the Royal Society's Operator (Richard Shortgrave) was ordered to make them according to Hooke's design. A month later Hooke produced written explanations, but was ordered to make some larger drawings of his designs. He presented them on 30 September 1663 when the Royal Society was finally satisfied and ordered the details to be entered in its records. Then on 19 October 1663 the Royal Society Council decided that Hooke's device for sounding without a line should be made and shown to the King on his planned visit to the Society (which probably did not take place). The sounding device comprised a heavy weight, to the top of which a hollow ball was attached by a linkage designed by Hooke so that when the weight struck the sea bottom the linkage automatically released the ball which then ascended through the water to the surface. At the meeting on 28 October 1663 Hooke was ordered to arrange for a dozen of his sounding devices to be made and tested in the River Thames. The order was repeated a week later with the added

instruction to report on the results of the tests. At the next meeting, on 11 November, Hooke was asked if the trials were successful. He

> said that he had tried them and found them to do exceeding well. Oozy ground was observed to be the most likely to make them unsuccessful. [467]

Nothing more appears to have been done by Hooke or by the Royal Society with the sounding device.[468] This is not surprising. For the device to be useful for accurate measurement of depths at sea it would require more knowledge of the dynamics of bodies in water than was available at the time. Although Hooke is not reported as saying so, a measured time interval between releasing the weight and ball from the water surface and the re-appearance of the ball is related to the depth of water. However, the relationship is not linear: it depends upon the masses, sizes and shapes of the weight and ball used. It was impossible then (and very difficult now) to derive and use an adequate mathematical function relating a measured time interval to depth. Hooke would probably have suggested trials over known depths to calibrate the device, which would have been feasible, but of limited value. Other practical difficulties were currents, which would affect the measured time intervals, and (as Hooke noted) the need for the linkage to be sensitive to small impacts so that the ball would be released when the sea bottom was soft. This too was practicable, given more time.

The reason why nothing further appears to have been done to make the sounding device more accurate and useful was the quantity of work loaded on Hooke by the Royal Society (and by himself) and the speed with which he was always required to produce results. At the time of his work on the sounding device he also prepared and showed to the Royal Society about twenty of his microscopical observations, but in addition he was ordered to: investigate a spring at Chertsey which was reported to contain oleaginous matter, and distil some of the spring water; investigate insects found in water at Barnet; test Prince Rupert's rotary water pump; use the air pump he had made for Boyle (referred to as "Mr Boyle's Engine") in an experiment on the height of the water column; draw and make plaster casts of four stones taken from the heart of the Earl of Balcarres; devise a machine for testing the strength of gunpowder; help prepare a letter from the Society in

reply to one received from Leichner, author of a book he (Leichner) had sent to the King proposing all sciences and divinity be reduced to demonstrable truths; make constant observations of changes in the weather; carry out a skin graft on a dog and graft feathers and a cock's spur to a cock's head; make a hygroscope from the beard of a wild oat; make two thermometers designed by Wren, an artificial eye and a camera lucida; keep the Society's Repository in the west gallery of Gresham College and fix descriptive labels to each of its contents; improve Prince Rupert's machine for perspective drawing; and see whether or not Dr Henry Power's design of an instrument for demonstrating the Copernican system was practicable.

The extent of such random investigations and frequently inconsequential activities militated against either a systematic approach to a particular philosophical investigation, or to the design and production of a number of machines and other artifacts which would be of use and to the benefit of trade, commerce and exploration. Hooke as much as the other Fellows of the Royal Society was culpable in this. However the Society's records show that from the middle of 1664 he increasingly turned to more systematic experimenting in a few areas which were all related to (but not restricted to) his investigations into gravity. He had learned from his experiment at Westminster Abbey at the end of 1662 (discussed above in this Section) that the variation of gravitational attraction with change in height was smaller than could be measured by weighing objects in a balance at heights differing by no more than seventy feet. A larger height difference and a more accurate balance were needed, or a different mechanism such as a pendulum or a freely falling body. Use of such mechanisms would mean that accurate measurements of differences in time would replace accurate measurements of differences in weight. A complication in timing a body falling freely through the atmosphere would be that its velocity would be slowed according to its size and shape and the properties of the atmosphere, so it would be necessary to carry out experiments on bodies falling in different media and to investigate changes in the atmosphere at different heights. A possible effect of the earth's magnetic field on gravity experiments was suspected, so magnetical experiments were also relevant.

In the autumn of 1664 Hooke and others from the Royal Society used the full height of St Pauls (he measured the vertical distance from the steeple to the floor below and found it to be almost two hundred and four feet[469]) for experiments on timing falling bodies and the oscillations of pendulums, weighing, and recording atmospheric pressure with a mercury barometer. He reported on his experiments to the Royal Society and in letters to Boyle who was then staying in Oxford. The work was beset by many difficulties: vibration of the pendulum suspension caused by wind blowing about the steeple; the lack of a stable platform vertically above the floor; failure of the device for automatically starting and stopping the clock used for timing the fall of a body; and the weight of the string used to suspend the pendulum bob and lack of daylight in the steeple caused the measurements to be inconclusive and not worth reporting to Boyle.[470] By early October attempts to undertake experiments in St Pauls were abandoned until the next spring because of the conditions.[471]

Hooke continued working at Gresham College on falling bodies, pendulums[472] and timekeeping (particularly for finding longitude at sea), a machine for grinding lenses, astronomical and atmospheric observations and use of his mechanism to measure systematically the refractive indices of fluids, in particular, solutes. These activities were interspersed with dissections of a viper and artificial respiration of a dog (following which, incidentally, in a letter to Boyle[473] he reveals a compassionate aspect of his character), but significantly fewer new topics were given to Hooke to investigate than in the preceding two years. He showed more consistency in what he chose to investigate, but from time to time put forward ideas for new devices. In June 1665 he proposed a wheel to convey a load across land, bogs and water and a three-foot telescopic sextant with a tangent screw for measuring angles with high accuracy.[474] Despite objections from some Fellows about the feasibility of the wheel, he was asked to make and test one, but nothing came of it. However his ideas for the telescopic sextant received more support and were developed by Hooke and others into standard opto-mechanical components which were used in surveying instruments for the next three hundred years.

The planned resumption of gravity investigations at St Pauls in the spring of 1665

did not take place. By May 1665 the Plague had spread eastwards to reach the city. The Royal Society decided on 21 June 1665 to discontinue their Wednesday meetings until such time as the President and Council should determine.[475] The last meeting before the recess took place a week later when Fellows were told by the President that they were expected to give a good account on their return of the tasks laid upon them. In particular Hooke was ordered to continue work on three devices: a machine for grinding lenses; chariot wheels; and watches. Only the first and last of these had occupied him for some time. He was not required to continue his experiments related directly or indirectly to the earth's gravitational attraction.

Boyle and several other leading Fellows of the Royal Society had left London for Oxford, but Oldenburg, the Secretary, stayed on and continued to correspond with absent Fellows and foreign virtuosi, including Huygens. On 8 July 1665, before leaving Gresham College, Hooke wrote to Boyle saying that having made very few experiments since the time Boyle was last in London, he (Hooke), Petty and Wilkins are going with their implements and the Royal Society's Operator Richard Shortgrave to "Nonsuch", a royal palace near Ewell in Surrey, owned at the time by the Queen Mother Henrietta-Maria. This building was however taken over by the Exchequer of Receipt, removed from the Palace of Westminster, so Hooke and the others went instead to Durdens, near Epsom in Surrey, the seat of George, the ninth Baron (later first Earl of) Berkeley and Fellow of the Royal Society. In the letter of 8 July, Hooke told Boyle that he intended to give him

> an account of some considerable [experiments] we having designed to prosecute the business of motion through all kinds of mediums [and] I hope we shall be able to prosecute there as well almost as at London.[476]

Hooke also stated that he would take away a sextant he had recently received from Thompson[477] at a charge of £1-12s-00d, and finish, adjust and test it. The sextant was designed by Hooke, shown by him to the Royal Society at its last meeting before adjournment, but apparently made for Boyle.

At Durdens Hooke received his mail weekly from Gresham College and corresponded with Boyle. His letters give no indication that he worked on either his

machine for grinding lenses or his watches, but he repeated Power's 1662 experiment which had preceded his own at Westminster Abbey and St Pauls. He reported in a letter to Boyle dated 15 August 1665 that he had weighed a piece of brass at the top and at the bottom of a well eighty feet deep and found

> not the least part of a grain difference in a weight of half a pound.[478]

but intended to repeat that experiment and some others at a nearby well more than three hundred feet deep (near Banstead Downs). At the same time he reported that an angle measuring device (described as a quadrant) had proved successful in trials and could be used for triangulation surveys (first proposed by Gemma Frisius more than a hundred years earlier) but he expected when he had completed work on Boyle's sextant that it would prove to be even more accurate. A letter from Hooke to Boyle relating the results of experiments made made at the deep well was lost between Epsom and Oxford, so in a later letter[479] sent from Durdens, dated 26 September 1665, Hooke briefly summarised his earlier findings. He measured the usable depth of the well and found it to be three hundred and fifteen feet at least, with another one hundred feet of rubbish below according to local knowledge. Hooke stated

> One of the experiments I tried in it was that of gravity, which upon accurate trial I found to succeed altogether as the former, whereof I gave you an account before.

which can be assumed to mean that no weight difference was detected. He also lowered into the well a board carrying lighted candles which became extinguished two hundred and forty feet from the top

> as if suddenly quenched by their sinking into a damp.

Hooke was clearly greatly enthused by the possibilities for further experiments

> it being such an opportunity, as it is scarce to be met with in any other place I know

and he went on to list a plethora of experimental topics: measurements of air temperature, pressure, density and humidity, weights (despite having already detected no change), pendulum oscillations, velocities of falling bodies and of sound (the latter would be necessary for accurate measurement of the former); and investigations of the effects of depth on fire, respiration and smoke. He says that these trials will suggest many others he

has not yet thought of, especially if a man can be lowered safely to the bottom.

Unfortunately two letters to Boyle in which Hooke reported the results of at least some of these experiments were lost in transit. Once again, Hooke had to summarise his findings, this time in a letter to Boyle dated 3 February 1666 after Hooke had returned to Gresham College. He described his findings as considerable, and wished he could have done more, but his account is very brief and includes most of the above topics, but not weighings at different depths. His intention to continue some of these investigations is clearly stated

> I have great hopes of having an opportunity of examining both greater depths and much greater heights, in some of our English mines, and some of the mountains of Wales, which, with some other good company, I design to visit this summer.[480]

The Royal Society Council reconvened in Gresham College in February 1666 and decided that its Wednesday meetings should re-start on 14 March, about nine months after the adjournment at the time of the Plague. At this meeting, Fellows were called upon to report on investigations they had carried out during the recess. Hooke and Wilkins described work they had done in building a chariot (now brought to London) which carried two people, one behind in the chariot and the other on a sprung saddle, apparently supported by cantilever above the horse's back, which was capable of being pulled across level ground by a weight of only 50lb over a pulley. This contraption was not exactly what the President referred to when he charged Hooke to work on chariot wheels during the recess, but Wren and Hooke were ordered to make improvements to it. Further work was done in the following months by Hooke and Wren, taking account of similar chariots in France, and of one built by Colonel Thomas Blount, FRS, but nothing more seems to have been done on the chariot after 14 November 1666.[481]

On 14 March 1666 at the Society's first meeting after the recess, Hooke spoke of his experiments on weighing and was ordered to bring in a written account of them for the next meeting. Accordingly on 21 March 1666 he presented and read a paper "Of

Gravity"[482] on the matter of the earth's gravitation. This paper sets out the purpose of his investigations into gravitational attraction and goes on to describe the experiments he made above the earth's surface at Westminster Abbey and St Pauls, and below the earth's surface at the wells near Banstead Downs in Surrey. It concludes with an innovative design for a new instrument to detect and measure very small changes in gravitational force. The paper shows that during his absence from London he had given some thought to the problem of the causes of gravitational attraction and how to measure changes in its effect on a heavy body as the distance of the body from the surface of the earth changed. This paper shows that he approached the problem as one that could be solved by mechanics and experimental investigations, including specially designed apparatus. The principle of his proposed mechanism (the counterbalancing of gravitational force against an applied force - in his case a spring - so that a small change in the former would disturb the equilibrium and produce a large measurable effect) came to be used in twentieth-century gravimeters for measuring differences in gravitational attraction. More than two hundred years of progress in mechanical engineering methods and materials were needed before it became feasible to put Hooke's idea into practice.

4.2 Hooke's Experiments for the Royal Society in the Aftermath of the Fire

In the months after the Fire, Hooke's activities for the Royal Society continued their earlier pattern. He returned to experiments and trials which, despite their apparent diversity, were relevant to understanding gravity and measuring gravitational attraction and its variation more accurately. Experiments in timing free-falling objects became in this present century the most accurate method for measurement of absolute gravitational force. Hooke was frequently engaged in improving the accuracy of measurement of time by devising mechanisms for compound and conical pendulums and for starting and stopping the mechanisms automatically. He saw that improvements in the optical and mechanical construction of telescopes were necessary in order to make more accurate astronomical observations to enable the diameter of the earth's orbit round the sun and of the earth's circumference to be measured more accurately.[483] These investigations were interspersed with related experiments on magnetic force and its variation with distance

between the magnet and the attracted object. Demonstrations of wonders, primarily for entertainment, were less frequently ordered.[484] Experiments performed at the Society's meetings were becoming less capricious and more systematic, but Hooke's duties as City Surveyor were soon to have a noticeable effect on his work for the Royal Society.

On 23 May 1667, when he was busy staking out the streets, Hooke managed to go to the meeting of the Royal Society, but did not perform the experiments that had been called for.[485] Fellows of the Royal Society were aware of Hooke's obligations to the City and their possible adverse effect on his duties as Curator. Two weeks after his failure to perform the ordered experiments the Royal Society Council decided to think about who might be appointed as another Curator. Physicians Dr Walter Needham and Dr Richard Lower were considered to be suitable candidates.[486] They were suggested as curator of anatomical experiments, not of mechanical experiments, so the proposal can be seen as an attempt by the Royal Society to free Hooke from at least some of his obligations, such as the dissection of an embryonic dog and other experiments on animals.[487] Hooke was having difficulties finding time to do all he wanted to do for the Royal Society and favoured Lower as curator of anatomical experiments.[488] The Royal Society Council on 5 November 1667, acknowledging the necessity of having another curator, asked Wilkins to speak to Lower about the matter,[489] but nothing came of the idea. Despite its best intentions the Royal Society could not afford to support Hooke in the way its Council intended and sought to realise.[490]

Hooke continued to struggle to find time to meet the demands placed on him by the Royal Society, but on 11 January 1668 the Royal Society Council added even more to his duties when he was told to design a new building for the Society's college and present it two weeks later.[491] In the following months he may have prepared and presented some rough designs, but on 11 May 1668[492] he was called on by Council to bring in his design and estimate of the cost of building. On 30 May 1668 he set out the grounds for the new college.[493] His design and estimates of costs were approved by Council on 22 June 1668 when Hooke was ordered to have a model made and consider purchase of materials and engagement of workmen.[494] After a flurry of activity by Council in the next

few weeks when Hooke was ordered to amend his design, draw the proposed south elevation, revise his estimates and provide materials,[495] the plan for a new building was dropped.[496]

Six months after the Royal Society's Council had agreed that Hooke could employ a boy to assist him, he reported to Council on 30 May 1668 that he had found a man fit to be employed in experimenting for the Society for an annual salary of twenty pounds and that he (Hooke) would then not fail to perform three experiments at every meeting. Council decided that Hooke should employ the man on trial for three months pro rata, but that the man should work not only for Hooke, but also for other Fellows in their anatomical and other experiments when called upon to do so.[497] This was not what Hooke intended. The record of the meeting of the Society five days later noted

> Mr Hooke, not being present, the experiments appointed for this meeting were referred to the next.[498]

which should have been a further incentive to the Royal Society to act as Hooke had requested. His intermittent failure to perform the ordered experiments and few absences from Society meetings continued in 1669 and 1670.[499] In particular, on 17 June 1669 Hooke received a warning

> Mr Hooke excused himself for having prepared no experiments for this meeting. He was ordered to take care, that against the next either his own new instrument for working elliptical glasses, or that of Dr. Wren for grinding hyperbolical ones, might be ready; as also that a couple of long pendulums, to be moved by the force of a pocket watch, be prepared, to see how long they would go even together.[500]

Such tasks as these needed more care and attention to complete satisfactorily than Hooke alone had time for, even without his City duties. The Royal Society's impatience with him was brought about as much by its own unrealistic expectations and failure to provide him with an assistant as by Hooke's absences. Hooke found it sometimes impossible not to spend time investigating some new phenomenon unconnected with his principal mechanical investigations, but which had taken his fancy. On 28 June 1670, more than two years after the Royal Society had failed to appoint the man Hooke had found to work

as his assistant, he was ordered again to find someone to help him in his experiments, for quarterly payments of five pounds. The Royal Society Council also decided that a curator (presumably anatomical) should be used by the Society for the quarter beginning the following Michaelmas (if one could be found).[501] Council again recognised that Hooke needed an assistant for mechanical experiments and that an additional employee was necessary to be employed as curator of anatomical experiments. Once more nothing was done to meet these needs.

On 14 November 1670 Council resolved to call Hooke to attend its next meeting to receive their rebuke for the neglect of his office.[502] This was a harsh decision, but the rebuke does not seem to have been delivered as intended. If it were, it had little effect, because ten days later

> Mr Hooke being absent from this meeting [of the Society], no experiments were provided.[503]

Hooke does not seem to have been unusually busy in the city in the four weeks prior to the Royal Society Council's decision to call him to receive their rebuke.[504] During that period he had staked out and certified at least sixteen foundations (possibly as many as thirty)[505] and taken part in (and written reports on) at least nine views of citizens' disputes about rebuilding.[506] He had also viewed and reported to the City on the important matter of rebuilding private properties belonging to Mr Barbon (or Barton) adjacent to St Magnus Church, Fish Street Hill and to ensure that Barbon's new buildings would not obstruct the view of the Monument which would later be erected in the vicinity.[507] The City accepted the report and ordered one of their Surveyors (un-named, but almost certainly Hooke who had been responsible for surveying in the area before and who would continue to do so for many years to come) to stake out the new buildings accordingly. Barbon was a wealthy speculative builder who would not readily accept any reduction in his rebuilding plans. The reason for Hooke's absence from the Royal Society's meeting on 24 November 1670 may be explained by engagements on site with Barbon, or his agents, to ensure that the City's requirement for securing an unobstructed view of the Monument was met. It would have been Hooke's decision as to what constituted an obstructed view; City records give no indication that either the City or Barbon was

dissatisfied with Hooke's recommendation.

Hooke failed to perform required experiments in early 1671,[508] but in the aftermath of the Fire the Royal Society Council issued no more rebukes to him for neglect of his office. He continued experiments to find the earth's circumference and, by measuring stellar parallax, to find the diameter of the earth's orbit around the sun, but without success. These investigations represented a significant extension of his interest in gravitational attraction from its terrestrial manifestation to the way it affected heavenly bodies.[509] As in his investigations of terrestrial gravity, he sought understanding through experiments, but again he realised that he would have to improve the resolution of his telescopes and sensitivity of mechanical devices in order to be successful. He continued to perform many other, unsystematic, experiments and to devise mechanisms for specific purposes unrelated to instrumentation for his main tasks as he had done from time to time before the Fire.

On 6 February 1672, Newton wrote from Cambridge to the Royal Society on colours and the refraction of light. Two days later the Society "desired" Seth Ward (then Bishop of Salisbury) Boyle and Hooke to study Newton's letter and report on it.[510] Hooke lost no time. He reported on Newton's letter to the Royal Society at its meeting a week later.[511] Experiments on colour and refraction then replaced those on gravity as the main theme of Hooke's curatorial work during 1672. In the early 1670s the number of meetings of the Royal Society decreased significantly.[512] This meant that Hooke was able to give more time to publishing his Cutlerian Lectures.

Through an ability to organise his business for the City, and by sheer hard work, Hooke had been able to maintain a precarious balance between satisfying the City (as Surveyor in particular, but also as Gresham Professor of Geometry) and the Royal Society (as Curator of Experiments and Cutlerian Lecturer) during the busiest time of rebuilding from 1667 to around 1672. However, the burdensome duties as City Surveyor prevented him from preparing and publishing major works. Before the Fire, his two major publications were *An Attempt for the Explication of the Phenomena* ... (or *Tract on*

Capillary Attraction) in 1661 and *Micrographia* in early 1665.

His first major publication after the Fire was *An Attempt to Prove the Motion of the Earth from Observations* (1674), the first of his published Cutlerian Lectures. It was followed later the same year by the second: *Animadversions on the First Part of the Machina Coelestis of ... Johannes Hevelius ... Together with an Explication of Some Instruments Made by Robert Hooke ....* During 1671 and 1672 he prepared these two inter-related Cutlerian Lectures for publication, but had begun work on their subjects five years earlier in 1666 and 1667, just before he began to take on surveying duties for the City. He was then unable to find enough time to develop his astronomical instrument with telescopic sights and make observations of inter-stellar distances with it. His inability to follow this scientific idea to a conclusion led to his dispute with Hevelius which lasted many years in which he found himself unable to present evidence to answer the charges laid against him by Hevelius and some Fellows of the Royal Society.[513]

Hooke was right when he asserted, contrary to Hevelius, that telescopic sights would make a significant improvement to the accuracy of astronomical observations, but that was not generally accepted at the time.[514] He had not followed his own method of careful experimenting and reporting of evidence to show that what he claimed was true. He was confident that he could have provided the evidence, but claimed that his work for the City had prevented him from doing so. He answered his critics in a manuscript (found by Richard Waller amongst Hooke's papers after his death) which included:

> As to my not returning the Observations of certain distances of Stars, which Hevelius desir'd, 'tis sufficiently known what inconveniences we lay under in this place after the Fire of London, and had I found conveniences, yet the unkind Reception those things found, which I sent him, was enough to deter me from such a Compliance; though he was sensible how I had often been ready to gratify his Curiosity in many other particulars. But when his Machina Coelestis was publish'd, I was oblig'd to write those Animadversions, in which I hope all unprejudic'd Readers will justify my proceedure, at least I am ready to prove any thing I have

> therein asserted.[515]

His special pleading here is not justified, given his insistence on scientific evidence, properly obtained, analysed and presented. He did not produce the evidence because it was impossible to do so at the time and he probably understood that fact. Only after another century or more of technological developments in metallurgy and optical engineering and growing understanding of atmospheric refraction was it possible to achieve in practice what he said could be done. His imaginative scientific and technological ambitions ranged far beyond what was feasible at that time.

4.3 Relationships Between Experimenting and Surveying

In experimenting and in surveying, Hooke's work served the same purpose: to improve the conditions under which people lived. Two characteristics of his experimenting have been identified in Section 4.1 above as important: critical observation, examination and analysis of evidence in order to make deductions which increase understanding of natural phenomena, and making known by publication what has been done; and an ability to conceive, design, test and use opto-mechanical instruments to provide new evidence (directly to the eye, or by producing numbers representing measured values) in the quest for greater understanding. When experimenting, the truths he sought were the laws of nature, determined by divine providence. Writing in 1664 he said that they could only be discovered by recovery from human error which has led to separation from the prescripts and rules of nature. The only way to do this

> seems to be, by rectifying the operations of the Sense, the Memory, and Reason, since upon the evidence, the strength, the integrity, and the right correspondence of all these, all the light, by which our actions are to be guided, is to be renewed, and all our command over things is to be establish't.

However, greater understanding of nature's laws had a higher purpose:

> we are not only able to behold the works of Nature, or barely to sustain our lives by them, but we have also the power of considering, comparing, altering assisting and improving them to various uses.[516]

It has been shown in Section 3.3 above that in performing his work as City Surveyor by investigating and reporting on a dispute about rebuilding, Hooke examined evidence from different sources. When, as was usually the case, evidence was in conflict, he sought additional information from independent sources in order to come to a conclusion about the truth in the matter and report his findings to the City. It appears that this procedure was no different from what he did in his experimenting. He took evidence from memory (his own, whether in his mind or in his survey book) and from the minds of citizens living nearby. He heard what was said and saw what was before him at the site. He referred to leases and other documents. Finally, he made reasonable deductions based on what he had discovered. He used sense, memory and reasoning in surveying and in experimenting,[517] but a fundamental difference can be identified. When he investigated a dispute on behalf of the City, the truth in the matter was determined by legislation, including the rebuilding acts which he had helped to draft.[518] In experimenting, the truth was determined by nature, or divine providence. In each case, discovery of the truth was a precursor to acts of social benefit, although in the case of surveying the act had to follow quickly upon the investigation. In experimenting the practical benefit usually was much slower in taking effect, but its possibility was often foreseen.

In looking for evidence of how his exceptional skills at devising instruments for specific measurement tasks in scientific experiments affected his methods of surveying, one particular problem must be overcome. In the absence of his survey books, no direct evidence of how Hooke performed his surveying measurements for the City has been discovered. He made no significant references in his diary to how and with which instruments or equipment he measured on site. His supreme ingenuity at instrumentation prompts the speculation that it found an outlet in the innumerable surveying tasks which he and others performed in the city in the aftermath of the Fire. Indirect evidence has been examined, analysed and presented below. It shows that he himself followed traditional site procedures which had been in use for more than a thousand years. He devised no new instrumentation for staking out streets and foundations or for measuring and certifying areas because there was no need to do so. There is also indirect evidence that he contributed to significant changes in the techniques of city mapping, but did none himself.

4.3(a) Hooke's Measured Surveys

The transcripts of Mills's and Oliver's survey books show that they recorded measured distances in feet and inches. Hooke's area certificates show that he too recorded measurements in feet and inches. It is highly probable that he conformed to the same practice in his certification of foundations. It has been shown in Section 3.2 above how measurements of linear distances in feet and inches simplified calculations in shillings and pence of the values of measured areas. Efficient management of the process of measurement, calculation and payment of compensation by the City was essential. Hooke followed accepted City Surveyors' practice because it was appropriate in that context to do so.[519] Some consideration is now given to how the City Surveyors made their measurements.

The most common equipment used by land surveyors for distance measurement in England in the seventeenth century was the chain. The two editions of William Leybourn's book which were published before the Fire[520] include descriptions of several chains, differentiated by their overall length or by the length of their individual links. He describes the chains and how they should be used for surveying and mapping in rural areas, mainly for management of estates and manors. Although he gives many examples of how to record measurements with chains he gives no examples in these pre-Fire editions of his book of any measurements in cities, nor does he describe any measuring and recording in feet and inches, even when he writes about how to measure quantities of building materials using rods and scales. If any measuring with chains and recording in feet and inches was done other than by the City Surveyors when Leybourn practised, it was very unusual.

For practical reasons, chains were most unlikely to have been used by the City Surveyors for their certification of foundations and areas. They were heavy and required two people to measure with them. Hooke would have found it unacceptably inconvenient to have to depend on an assistant in his routine duties as City Surveyor. He went hither and thither about the city, engaged on many tasks, of which surveying was only one, and

would have found it onerous to carry a chain and arrange for an assistant to be present whenever it was convenient for him to make measurements. There is no indication in Hooke's diaries or in City records that the City Surveyors worked regularly with assistants, after the streets had been staked out. The distances the Surveyors measured were usually shorter than the fifty foot chain and Gunter's sixty six foot chain. Despite the City requiring citizens to clear their foundations prior to measurement, the Surveyors often had to measure across piles of rubble and cavities and pits in old foundations where tedious step-chaining would have been necessary. In such conditions a chain would have been often caught up in broken walls, fallen rafters and general building detritus.

A light-weight wooden rod, ten feet long, graduated every foot and possibly hinged at its centre would have been a far more convenient and more accurate measuring device than a chain. The Surveyor could have held it horizontally, marking off by chalk successive ten foot lengths along the line, recording the final sub-foot part of the distance with a foot rule, divided into inches. Given the need for convenient, but appropriate measuring, it is highly unlikely when measuring for foundation certificates or area certificates that the Surveyors used a graduated circle or any other mechanical sighting device such as a cross-staff for aligning the rod along the line to be measured, or for taking measurements orthogonal to it. Alignment by eye, unaided by any artificial sighting device, would have been simple and adequate.

A statistical test has been made of the validity of the hypothesis that the City Surveyors used ten-foot wooden rods, graduated every foot and hinged at the centre for measuring distances and that they used the unaided eye for judging collinearity of boundary lines. Details of the test are given in the Appendix, where it is shown that the hypothesis should be accepted and that Hooke made no innovations, but used traditional and simple procedures in his surveying for the City.

4.3(b) Hooke's Contributions to Urban Mapping

Although it has been argued that Hooke did not introduce new methods of measurement in his own surveying for the City, it is now argued that he did make a

significant contribution to the surveying and plotting of urban maps and plans such as those produced by John Leake in December 1666 and Ogilby and Morgan in 1676. Before the Fire, almost all maps of London were pictorial, or scenographic,[521] and therefore geometrically inaccurate. After the Fire nearly all new maps were ichnographic. Methods of surveying at that time had been developed and generally used for mapping in rural areas where accuracy was not very important, even for large scale plans. In the aftermath of the Fire, neither the current methods of surveying nor the form in which the measurements were depicted were adequate for representing the detailed and important irregularities in streets and buildings of a large city and at the same time, showing the correct relative spatial relationships between widely separated parts of the city. New methods of surveying and mapping had to be devised.[522]

On 4 October 1666 the City ordered Hooke Mills and Jerman to join with the King's Commissioners to

> take an Exact & speedy survey of all Streetes Lanes Aleys houses & places distroyed by the late dismall ffire That every particular Interest may be assertained & provided for & the better Judgment made of the whole Affaire [of rebuilding the city].[523]

Within three months, six surveyors (John Leake, John Jennings, William Marr, William Leybourn, Thomas Streete and Richard Shortgrave) had produced an ichnographic plan of the burnt area of the city which was used by the King and the City to decide where new streets should be laid and which old streets should be widened and by how much. It is unlikely that any significantly new measurement techniques were used for this map.[524] It was needed as quickly as possible, so the surveyors would have used familiar methods, and it served its purpose, more as a general guide than as a detailed and accurate plan. Hooke played no part in the measured survey, but he was unlikely to have ignored the City's instruction to him to see that the survey was accurately and speedily undertaken. He was already directing Shortgrave at the Royal Society and would have been recognised by the other five surveyors as having authority in practical mathematics and in the City, even though his official appointment as Surveyor was not to be made for several months.

By the time surveying for Ogilby and Morgan's map of the rebuilt city had begun in early 1673, innovations in surveying and in the way urban streets and buildings were represented had been introduced, if not at Hooke's instigation, then with his authority.[525] Hooke and Ogilby met frequently in city coffee houses around this time,[526] usually at Garaway's, which they seemed to have used as a site office for examining map sheets and proofs and reviewing progress with some of the surveyors.[527] It is likely that out of these meetings new procedures for surveying and mapping the city were devised which appeared in the third edition of Leybourn's book.[528] Hooke would certainly have known that the magnetic needle of a circumferentor would be significantly affected throughout the city by the presence of iron in the streets and adjacent buildings. In place of a circumferentor to measure the direction of each chain line by reference to a magnetic needle, Leybourn now recommended a theodolite or semicircle. Using the semicircle relative directions were measured by sighting along lines between successive survey stations marked on the ground. At each station the semicircle was set in a horizontal plane with the centre of its diameter vertically above the station mark by making use of a tripod, a ball-and-socket joint and a plumb-bob. Sights were taken to rods or staffs held vertically by assistants at the preceding (back) and subsequent (fore) stations. The semicircle was set to read zero when sighting to the back station. The reading to the fore station was in effect the horizontal angle at the instrument station between the back and fore stations, reckoned as clockwise or anticlockwise. Plotting was carried out using protractor and scale, replicating the measurements. Checks for misclosure were carried out to test the accuracy of measurement and plotting.

The new surveying procedure necessitated new methods for recording the observations and plotting the framework of chain lines. In particular the need to plot the framework of chain lines in such a way that they close back on the starting point to check the accuracy was an important new addition in Leybourn's book. Although the lengths of chain lines running along the streets were still measured (and recorded in feet and decimals of a foot, not inches), orthogonal offsets were taken from them to building lines, junction corners and other details using rods; bevels were used to record, in angular form, departures of building lines from collinearity.

Leybourn's description of the new methods and instruments is cursory. He gives too few details for anyone intending to understand how they could be put to proper use. It seems as if when Leybourn wrote it, he had either little experience of using the new methods or little opportunity to include a more detailed description in the new edition. A greatly improved description was published a few years later by John Holwell,[529] but neither Leybourn nor Holwell gave any details about how to proceed when a significant misclosure was found on plotting the framework. It seems that re-measurement was then expected. This would not have been too onerous because checks for misclosure were normally made on each set of four chain lines along four streets around a block of buildings.[530] These new methods for measuring, recording and plotting were necessary. If they were not directly ordered by Hooke, they were very probably discussed in his presence during meetings in the city coffee houses and they certainly had his authorisation.

It has been pointed out at the end of Section 3.4 above that there is little evidence that Hooke did any land surveying, except simple measurements for certification of areas or for staking out streets and foundations. The surveying procedures described by Leybourn and Holwell cited above would have severely limited Hooke's freedom to move around the city as he did almost every day, meeting people from all social groups, talking, listening and looking for opportunities to secure new commissions. Plotting his measurements by night would have made his scientific work impossible.[531] Payments for surveying were much less than the City Surveyors' salaries. Leybourn was frequently engaged by the City for land and quantity surveying and worked on many projects supervised by Hooke. Leybourn received £20-15s-00d from the City in 1672[532] and £12-00s-00d for a year's work in 1676.[533] He also had an income from teaching mathematics and surveying, from his books and private commissions, but Hooke's City Surveyorship was clearly a superior appointment, requiring supervision, not practice, of routine land and quantity surveying.

After Ogilby and Morgan's map had been printed, there is slight evidence[534] that Hooke returned to the idea of adapting it for various purposes similar to those foreseen,

but not practicable, in the immediate aftermath of the Fire when a land information system for London was proposed (Section 2.3 above). The new 1/1200 scale map could have been a basis for a cadastre and many other purposes despite its shortcomings.[535] Maintenance of the map and associated data to take account of changes in topography, ownership, rents and uses would have been necessary, but difficult to keep up to date.

4.4 Financial Rewards Compared

In assessing the importance of Hooke's surveying it is necessary to discover how much he was paid for it and to see how financial rewards for surveying compared with those for his other employments.

4.4(a) Salaries from The Royal Society and Sir John Cutler

When Hooke's nomination as curator of experiments for the Royal Society was unanimously approved by the Fellows present at their meeting in November 1662, it was made clear that he would receive no remuneration until the Society had sufficient funds (Section 2.1). His appointment was unofficial in the sense that he was not appointed to the office of Curator. Such an office did not then exist; curators were nominated from the Fellows to take care of specific experiments and demonstrations. Gentlemen Fellows of the Society, they neither expected nor received any remuneration for their curatorial responsibilities. Without any regular source of income at this time,[536] it is not surprising to find that Hooke was unable to purchase even basic materials for his work. He was ordered[537] by the Council of the Royal Society to provide a handsome book in which to show his microscopical observations, but he received a payment of 10s-00d to purchase it.[538] No other Fellow of the Royal Society would have been ordered to provide a book nor would any have received payment for it. The first great description of natural and man-made objects seen under a microscope was made by the efforts of someone who could not afford the cost of a book in which to record what he observed.

When the Royal Society's Council in October 1663 revived plans for entertaining the King which it had considered three months earlier, various Fellows were nominated

curators of specific experiments. Hooke, despite holding no official appointment and receiving no salary, was required to play a major part in this event of importance to the Society, but which probably never took place. Council ordered the President (Sir Robert Moray) and Boyle to meet and consider proposals put forward by Wilkins and Goddard for the creation of curators by office and for paying them when money became available.[539] It was difficult for the Royal Society to see where the money might come from. Only a few Fellows were contributing their time or their money; lack of funds continued to hamper the Society in its endeavours.[540] By Michaelmas 1664, only four years after its foundation, outstanding subscriptions amounted to £343-02s-00d, or 90% of the total due.[541] Hooke was playing an increasingly important part in the Society's meetings and Council were looking for means by which his services could be properly secured, particularly for his contribution to its presentation to the King. Council had tried to arrange for Hooke to live in Gresham College[542] and had supported his application for the position of Gresham Professor of Geometry (which was to succeed later) all of which is evidence that the leading Fellows of the Royal Society were intent on providing Hooke with adequate resources and income which would allow him to fulfil his duties as curator, but with little or no cost to the Society.

When Sir John Cutler, Grocer, offered to pay Hooke £50 annually to give lectures throughout his (Hooke's) lifetime in Gresham College on the history of trades, the Royal Society seized on what it saw as the answer to its problem of funding a salaried office for its present curator of experiments, with the added convenience, through an appointment as Gresham Professor, of lodgings in Gresham College where he would be on hand to prepare experiments and instruments for the Society's meetings. On 22 June 1664 the Royal Society Council decided to investigate how it could secure Cutler's offer.[543] Cutler's intentions however had nothing to do with the duties of the Royal Society's curator of experiments; his offer was to pay Hooke to give lectures on the history of trades in Gresham College, not for performing his duties of curator of experiments. It seemed as if he were intending to add another subject to the seven already founded by Gresham's will. Through its eagerness to seize an opportunity for a regular salary to be paid to its curator, without cost to itself even though that was not the purpose of Cutler's

offer, the Royal Society set in train events which Hooke came to find increasingly wearisome throughout the next 30 years and which would eventually come to an end on his sixty-first birthday when an Order of the Court of Chancery awarded him arrears of salary from Cutler's estate, which by then amounted to several hundreds of pounds.

The manner of the Royal Society's dealings with Hooke in connection with his salary soon became devious and high-handed. Only a month after hearing of Cutler's offer, Council of the Royal Society voted that Hooke should receive £80 annually as a salaried Curator, payable from subscriptions to be collected from Fellows or otherwise.[544] Council expected that £50 of the £80 curator's salary it had just approved would come from Cutler for Hooke's lifetime, and was hoping the remainder would be provided by Fellows' special contributions, at least for the present. Just over two months later, on 5 October 1664, Council ordered the Treasurer to collect Fellows' outstanding subscriptions, including money subscribed specifically for the curator's salary, and to pay to Hooke what had already been collected of the £80 per annum owed to him.[545] At the same time, Council ordered Hooke to prepare an oration on Sir John Cutler's account (thereby inaugurating the Cutlerian Lectures) and submit for its approbation details of how he intended to proceed with his lecture programme. He had become caught in a mesh of contradictions, misunderstandings and inconsistencies tangled further by signed bonds and resolutions which were to take years to unravel. The complications of the Cutlerian Lectureship and misunderstandings between Hooke, the Royal Society and Sir John Cutler from the time of Cutler's offer in 1664 to the conclusion in 1694 of the legal process by which Hooke finally recovered from Cutler's estate the arrears of salary owing to him have recently been brought to light in great detail.[546]

When Council of the Royal Society on 5 October 1664 ordered Hooke to give his inaugural Cutlerian Lecture, he was on the same day paid a half-year's salary in advance by Sir John Cutler,[547] but he had received no salary from the Royal Society since he started his employment more than two years earlier. After more prevarication and indecision by the Royal Society, the office of Curator was established by an amendment to its Constitution and Hooke was elected Curator by Office in perpetuity on 11 January

1665 at a salary of £30 per annum pro tempore.[548] The Royal Society's Treasurer's accounts book gives no indication that Hooke was paid any salary at all until the accounting period ending 10 April 1666 by which time the Society's arrears had increased to £678-05s-00. Hooke was one of the auditors of these accounts which include two reimbursements of his expenditure on behalf of the Society totalling £6-06s-00d and an unspecified and undated payment to him of £20-00s-00d.[549] This last sum could represent the money deriving from Council's order in October 1664 to the Treasurer to pay Hooke all that had been collected so far from the Fellows and which the President in June 1665 was authorised to sign for.[550]

Hooke was paid £30 in the next accounting period which ended on 5 November 1666.[551] Having started work as unofficial curator in November 1662, followed by appointment as official Curator in January 1665, by the end of November 1666, in the immediate aftermath of the Great Fire and four years after he had started work for the Royal Society he had received salary payments from the Society amounting to no more than £50 according to the Treasurer's account books. He was by then residing in Gresham College as Professor of Geometry at an annual salary of £50 and receiving another £50 annually from Sir John Cutler. His remuneration from the Royal Society was much in arrears with little prospect of any change for the better.

The disaster of the Great Fire and the danger of civil disorder provided opportunities for Hooke to show the City how useful he could be in its efforts to rehabilitate its citizens and restore normal trade and commerce. If he received favour from the City, he could then expect financial rewards from official and private sources which would far exceed his present expectations. He had given the Gresham Astronomy lectures during Pope's absence in 1664, been appointed Gresham Professor of Geometry in March 1665 and therefore was already known to and well regarded by some of the City's Aldermen and Deputies. He lost no time in devising a layout plan for rebuilding the devastated city. He presented it to Sir John Lawrence and other members of the Court of Aldermen, receiving their approval of it before he showed it to the Royal Society. He was soon to be offered the position of City Surveyor, which he quickly accepted. By taking

on the duties of City Surveyor in addition to those of his existing appointments as Royal Society Curator of Experiments, Gresham Professor of Geometry and Cutlerian Lecturer he faced tasks that were exceedingly demanding and frequently in contention for his time. There is no indication that he ever hesitated over accepting any of these opportunities, but he was aware of the difficulties they would bring. Only someone with his extraordinary mental and physical energies and who was completely self-confident could have taken on the tasks that he had set himself.

In the months immediately following the Fire, perhaps alerted by the City's growing recognition of Hooke's abilities, the Royal Society Council decided to regularise his salary payments, but first it had to investigate its records to discover what it had ordered and executed.[552] The Royal Society's involvement with Cutler was becoming more troublesome to all parties, Council having failed to resolve the contradiction in treating the Curatorship and the Cutlerian Lectureship as if they were both part of Hooke's duties to the Royal Society, rewarded by a combined salary of £80 per annum, £50 of which was Cutler's responsibility and the remainder the Society's. The matter was further complicated by the Royal Society ignoring Hooke and negotiating a written agreement with Cutler as if the Lectureship were a matter for the Society and Cutler, not for Cutler and Hooke, while at the same time requiring Hooke to sign his agreement to comply with conditions (including an obligation to give sixteen lectures a year) that had been negotiated for him.

Four months after it was started, the Royal Society's investigation into what it had done about payments of salary to Hooke was finished. Its findings contradict some of the evidence in the Treasurer's account book and in the Council minutes described above. Council concluded that Hooke was owed salary at £80 per annum from Lady Day 1664 to 23 November 1664 and at £30 per annum from 23 November 1664 to Christmas 1666 (a total of £114-03s-04d). It also found that he had been paid £69-00s-00d to Christmas 1666 and therefore concluded that he was owed £45-03s-04d.[553] This sum was paid in the next accounting period.[554]

The muddle surrounding the Royal Society's handling of Hooke's salary was recognised by Council. It decided to consider future payments to Hooke at its next meeting, but no record that it did so then or later has been found. Nevertheless Council having settled on the rate of £30 per annum and paid what it found it owed up to Christmas 1666, ensured that payments thereafter were more regular, although at first often paid very much overdue (Table 5).[555]

Sir John Cutler's annoyance with the Royal Society in particular, and Hooke to a lesser extent, for the way they paid little heed to his original intentions in founding the Lectureship was probably the main reason why he apparently stopped paying Hooke from Midsummer 1670,[556, 557] although his well-known parsimony may have played a part.[558]

4.4(b) Salary from Gresham College

The City's records of payments to Hooke and the other Gresham Professors for whose salaries it was responsible show method and regularity in administration which are absent from the Royal Society's records of its accounting procedures. This is not surprising; they were (and are) quite different bodies. The salaries of the Gresham Professors and other costs of maintaining the College were derived almost entirely from tenants of the galleries, yards, walks and rooms of the Royal Exchange. Income and expenditure were carefully recorded.[559] Whereas the Royal Society had great difficulty in securing its income from Fellows' subscriptions, the livelihoods of the Royal Exchange tenants were at stake if they did not pay their dues to the City. Moreover the City was able to employ clerks to collect income, keep its accounts and inform its Courts of defaulters and had done so for centuries. The Royal Society had been in existence for only a few years and was attempting to define its role and procedures in the new experimental philosophy. Nevertheless, it was capricious in paying a salary to Hooke; he knew the City would not be as wayward in paying the Gresham Professors.

There is evidence that Hooke may have received payment from the City before his appointment as Gresham Professor of Geometry, when he read the Astronomy Lectures at Gresham College during the absence of Walter Pope in 1664 at the time when Hooke

had just accepted the Cutlerian lectureship.[560] Hooke was appointed Gresham Professor of Geometry on 20 March 1665 in place of Arthur Dacres. The last payment of salary to Dacres was made on 14 April 1665 when he signed for £25 as half a year's salary to Lady Day 1665.[561] Hooke received his first payment of salary on 16 October 1665: £25 for the half year ending at Michaelmas 1665.[562] The City paid Dacres up to the time of Hooke's appointment, even though by then it was known that his appointment was irregular. Hooke was paid from the date of his appointment, in arrears as was usual, but only a month or so overdue. During the absence in 1668/9 of Walter Pope, Professor of Astronomy, Hooke read Pope's lectures (as he had in late 1664 and possibly earlier) and was paid Pope's salary in addition to his own for that period.[563] He continued to receive regular and prompt half-yearly payments of his own annual salary of £50 per annum throughout the aftermath of the Great Fire and subsequently until near the end of his life when infirmity meant that he could visit Guildhall less frequently. The last recorded payment of his salary as Gresham Professor is of £50 made on 23 July 1702 for one year ending Lady Day 1701.[564] Records show that payments had been continuous from the date of his appointment more than 37 years earlier. No records of salary payments to Hooke or to his estate for the period from Lady Day 1701 to the time of his death in Gresham College on 3 March 1703 have been found.[565] Given the obvious and continuous change in his signature towards the end of his life (Figure 10 shows his last signatures for his Gresham salary and those of his successor Andrew Tooke) infirmity finally prevented him from going to Guildhall Chamber to collect his salary.

4.4(c) Salary from the City of London

Hooke's and Mills's salaries as City Surveyors were initially £100 per annum. Although Hooke was not officially appointed until 14 March 1667, he had been called upon by the City to act on its behalf nearly six months previously, within a month of the outbreak of the Fire (Section 2.3 above). His salary was however paid from the time he first began work for the City, not from the time of his official appointment. One of the City Chamberlain's Day Books includes details of payments of salary to the Surveyors from monies coming in to the Chamber from citizens at the rate of 6s-08d for each foundation to be set out.[566] The first payment to Hooke was £25 of the £50 due from

Michaelmas 1666 to Lady Day 1667 which he signed for on 9 July 1667.[567] Three weeks later he signed for the remaining £25.[568] The Surveyors' salaries were then increased to £150 per annum, payment continuing to be made from money received by the City for foundations. Salary payments were made half-yearly until Lady Day 1668 and quarterly thereafter (Figure 11) for as long as sufficient money for the foundations was coming in to the Chamber. Surveyors' signatures for receipts of salaries[569] show that payments were made regularly until Lady Day 1673 when Hooke and Oliver received only £15 each. Full arrears of £135 each were finally paid for services to Christmas 1673 on 24 December 1673 by an Order dated 10 December 1673.[570] No receipts for these arrears have been found, but Hooke records in his diary for 24 December 1673

> Receivd of chamber £135 which with £15 formerly Receivd made £150 for last years Salary ending at Xtmas.[571]

Between Michaelmas 1666 and Christmas 1673 Hooke had received £1062 10s from the City for his salary as Surveyor.

By the following year, 1674, demands on Hooke and Oliver for staking out and certifying foundations, certifying areas of ground lost, and viewing and reporting on matters in dispute during re-building had declined as private rebuilding neared completion. The number of foundations set out by Hooke had decreased from around 800 in 1668 to about 40 in 1674. The 94 area certificates he issued in 1671 had decreased to 26 and the number of reports of views he wrote had fallen from about 130 in 1671 to 27 in 1674. The most significant of these decreases was in the demand for private foundations to be set out and certified; the income to the City of 6s-8d per foundation was no longer sufficient for paying the two Surveyors' salaries at the former rate of £150 per annum. Although his regular duties in connection with legislation concerning private rebuilding had lessened significantly, he and Oliver (Mills had by now died) were increasingly engaged in work for the City's own rebuilding programme which was the responsibility of the City Lands Committee. From time to time gratuities were paid to Hooke. For example, on 2 October 1673 he was ordered to be paid eight guineas for his advice on the rebuilding Act,[572] but it is not clear whether this was for the first or second Act (or even for both). On the same day he received £25 for his work on the Monument.[573] In 1675

Hooke was paid from the Coal Money a gratuity of £100 for his work on public buildings,[574] but received no payment of salary. By the end of the following year it seems as if the City had done nothing further about paying either gratuities or salaries to Hooke and Oliver. When the City Lands Committee met in December 1676, Hooke and Oliver were expecting a decision on their payments for the past year and waited until the meeting ended at 8pm, only to discover that the Committee had forgotten the matter. Hooke and Oliver thereupon spoke to the Chamberlain and some members of the Committee who agreed informally to pay them £50 each,[575] but the official warrant was not issued until 6 April the following year. It contained instructions that this payment too was a gratuity to be paid from the Coal Money.[576] Hooke and Oliver had received no salary since the end of 1673 and by the end of 1676 each was owed arrears of £450 with little prospect of receiving either arrears or future salary now that the money for foundations had almost ceased to come in to the Chamber.

Towards the end of the following year Hooke spoke about his misgivings to Oliver and they agreed to join together in making representations to the City about their salaries.[577] The City did not re-institute regular payments of salary to the Surveyors, but continued to pay irregularly and award gratuities at a generally decreasing rate. Hooke was probably paid a gratuity of £40 for 1677,[578] and in 1678 received a salary payment of £15 [579] and a gratuity of £20.[580] Thereafter payments were irregular and by 1682 had decreased to only £5 for one year.[581] The main work for which Hooke was appointed Surveyor had been done and the City saw no reason to go beyond paying him an occasional gratuity for his work on public buildings.

4.4(d) Income from Citizens for Certificates and Reports to the City

In addition to receiving salaries from the City, the Surveyors received payments from citizens for issuing certificates and reports. Hooke's income from this source was significant, but payment was an informal arrangement between a Surveyor and his client. In the absence of a systematic record it is difficult to assess accurately how much Hooke earned from payments made directly to him for performing his duties as Surveyor. It can be done by using the estimates of the numbers of certificates and reports of views already

made (Tables 1-4) in conjunction with the average sum paid for each of the three kinds of work. His diary provides evidence of payments made to him by the citizens for certifying foundations and areas of ground taken away and reporting on views, but the evidence is not as extensive as it might be because Hooke's survey books are lost and he did not begin his diary until by far the greater part of rebuilding had taken place. Another difficulty is that when one of Hooke's terse diary entries seems to be related to his surveying, it is often impossible to decide if it refers to staking out and certification of a foundation, certification of area taken away, a view, or any other of his many activities, including those unrelated to his salaried appointment as City Surveyor. He notes places, names, sums of money and various purposes such as views and certificates, but almost never records all the information necessary in any one case to define what he did, where and for whom he did it, and what he was paid for doing it. However, by examining the City records in conjunction with his diary, additional and corroborating evidence can be found which permits reasonable estimates to be made of the average sum Hooke received from citizens for performing each of his three main duties as City Surveyor and thus it is possible also to make reasonable estimates of his total income from these sources from the time of the Fire to the end of 1674.

The amount he received from payments for his foundation certificates is the most difficult to assess because, as can be seen from Table 1, by the time he began his diary in 1672 he had set out and certified about 90% of foundations allocated to him so there is no record in his diary of any payments for these. Only a few unambiguous records of sums he received for foundation certificates have been found. For example Mr Abraham Jaggard paid 6s 8d into the Chamber on 8 September 1673 for a survey of one foundation in Fish Yard, Pudding Lane.[582] In his diary for 16 September 1673 Hooke records

> Mr. Jagger in Pudding Lane 20sh.[583]

and earlier

> from Defisher, guinny.[584]

probably refers to a foundation survey for Mr Samuel Defisher who paid 6s 8d into the Chamber for one foundation in Newgate Street.[585] These two examples suggest that the usual sum paid by a citizen to Hooke for a foundation certificate was either one pound or

one guinea. Other examples confirm this suggestion,[586, 587] but sometimes the amount was ten shillings or less.[588, 589] It is not always possible to find supplementary evidence of the kind cited in the above examples. Sometimes Hooke makes no mention in his diary of issuing a foundation certificate which the City records show was requested and assigned to him to execute. Conversely he sometimes notes in his diary a payment for a foundation certificate for which only indirect evidence can be found in the City records. For example, the City records show that John Oliver and Joseph Anis paid money into the Chamber for three foundation surveys on 8 February 1673, but the work was not allocated to any particular surveyor.[590] Hooke's diary shows that he set out and certified these foundations, but he did not make a note of how much he was paid.[591] Other examples can be found where he issued a foundation certificate (or a copy of one he had issued earlier) but does not record any payment. The amount paid to Hooke by each citizen does not seem to be related to the number of contiguous foundations set out and certified. To estimate his income from payments for foundation certificates it is necessary to use the number of clients, not the number of foundations he set out (summarised in Table 1). From Table 6,[592] it can be seen that in the eight years after the Fire 2042 applications for foundation certificates were allocated to Hooke. An estimated average payment of ten shillings is similar to the average payment for area certificates and views (discussed below) so an estimate of Hooke's income from citizens for foundation surveys to the end of 1674 is £1000.

Fees were also paid by citizens to Hooke for certification of areas of ground taken away by the City. About thirty diary entries made before the end of 1674 have been found which describe work clearly related to area certificates and which also give details of payments. The highest payment was five guineas,[593] the lowest five shillings.[594] Ten shillings was the amount he received most frequently, but the average was about £1. From Table 3 it can be seen that he issued 279 area certificates before the end of 1674. If the average payment for each of these was the same as the average for the sample found in his diary, he would have received £279 from this source by the end of 1674.

The evidence of payments received by Hooke for views is more extensive than

evidence for foundation or area certificates. Almost sixty diary entries made before the end of 1674 have been found which relate to payments for views. The average was ten shillings to each Surveyor. Sometimes Hooke collected Oliver's share (which implies that Oliver was not present at the view) and later passed it on to him.[595, 596] It is shown in Table 4 and in the accompanying text that Hooke made and reported on about 550 views before the end of 1674, so his income from this source was about £275.

4.4(e) Salary for Rebuilding the Churches

The evidence in Table 7[597] shows that from 1671 to 1693 inclusive, Hooke received £2820 in salary from the fund for rebuilding the churches. Each payment was authorised by Wren and such a large sum of money (about half the total cost of rebuilding one of the larger churches) represents a major contribution on Hooke's part, which should be subjected to detailed research, analysis and interpretation, not only in connection with the rebuilding, but also into the social, technological and philosophical aspects of the relationship between Wren and Hooke.[598] From the Fire until the end of 1674, the period studied here, Hooke earned £725 from the fund.[599]

4.4(f) Payments from Other Institutions and Citizens for Private Commissions

Private commissions had just begun by the end of the period under examination here, but they were then becoming an increasingly important source of income for Hooke. The eagerness with which he took up work once it was offered (Section 3.6) showed how important he regarded these opportunities. His alacrity in starting new work was as notable as the tardiness of his most important clients in paying him for it. The exception was the College of Physicians. Hooke received an initial payment of twenty guineas in 1670, a second payment of £20 in 1671, another of £20 in 1672, followed by twice-yearly payments of either £20 or twenty guineas.[600]

Sir William Turner paid Hooke £5 in November 1672 for his work on Bridewell,[601] but Hooke does not record the receipt of any further payment for working at Bridewell and Bedlam before the end of 1674. As late as the end of 1676 he recorded

Due from Hospital for Bedlam building and Surveying £200[602]

which implies that he expected to be paid for his work on Bedlam at the rate of £50 per annum. This is more than the £40 per annum he received from the Physicians' College, but Bedlam Hospital was very much greater than the Physicians' Theatre. By the end of 1677 Hooke had been paid £150 of the £200 owed to him at the end of the preceding year.[603]

After more than two years' work designing, building, re-designing and re-building the house for Ralph Montague, Hooke had received nothing for his pains, but he indicated at that time that he hoped to receive £100,[604] equivalent to a rate of £50 per annum. After another year attending to and approving workmen's wages and bills of quantity, Hooke began to seek payment of his own money, but Montague did not pay readily.[605] Of all Hooke's important private building work at this time, Montague's house was by far the most demanding of Hooke's time, but paid the least. Despite his repeated frustrations, Hooke made no disparaging remarks about Montague in his diary. The relationship between them seems to have been cordial; they often walked together, conversing in Montague's garden (designed and laid out by Hooke) as Montague changed his mind and the building slowly evolved.[606]

By examining *Diary* (R&A) from the start in August 1672 to the end of 1674 it is possible to estimate the amount of money Hooke received in fees from private citizens, livery companies and parishioners for his services in connection with rebuilding, but excluding payments for work which has already been identified as part of his three main duties as City Surveyor, i.e. certification of foundations and areas taken away, and views. His income from those activities has been accounted for in Section 4.4(d). Table 8[607] shows the income from other institutions and private citizens.

4.4(g) Summary of Income from All Sources

From the evidence presented, Hooke's income from different sources in the eight years' aftermath of the Fire is summarised in Table 9.[608] Of the components of this total, the least reliable is the sum of £1000 for foundation certificates. From internal statistical evidence the other estimated values are subject to about 15% error, from internal

evidence.

His average annual income in these years of around £500 placed him well within the wealthier middle classes of London, on a par with the highest paid clergy, well above teachers (although Busby was said to have earned up to £1000 a year), but below many Physicians.[609] Even if allowance is made for the exceptional circumstances in the aftermath of the Fire which boosted his income, his salaries from the Royal Society, Cutler and Gresham College (including the value of his accommodation there) were worth at least £300 per annum, enough to live comfortably in the style of a gentleman. The £30 contributed by the Royal Society to this annual income was the least significant, roughly the cost of renting accommodation equivalent to his rooms in Gresham College. The irregularity with which it was paid made it even less valuable to Hooke than his City salary which was paid from deposits made by citizens to City for registering their applications for foundations to be set out. The contrast can be explained by the unique and new position which Hooke occupied in the Royal Society.

CHAPTER 5
CONCLUSIONS

To assess the importance of Hooke's work as City Surveyor it was necessary first to find and present evidence to answer the questions: what did he do? how did he do it? how long did it take him to do it? and what was he paid for doing it? Recalling Andrade's opinion, stated nearly fifty years ago, that Hooke had not had his due because few had gone direct to his writings, it was decided that primary documents should be the main source of evidence for answering the questions. The Corporation of London Records Office contains thousands of records of Hooke's work as City Surveyor, but they are almost entirely un-indexed by individuals' names and have apparently not been used until now in a systematic study of Hooke's surveying. Primary sources at the Mercers' Company, Guildhall Library and the Royal Society have also been used. Evidence has been presented and the questions answered in Chapters 2-4 above.

In surveying Hooke has been regarded as less important than Mills and Oliver (whose survey books survived in transcript and have been published); when discussed as a scientist, or experimental philosopher, his surveying has been regarded, if at all, as inconsequential. The first viewpoint is erroneous and the second inadequate.

Given the idea commonly held since his death that Hooke was of doubtful integrity, the City archives were examined with this in mind. The aftermath of the Fire, when men of authority and stature in the City and other citizens were desperate to recover their losses, was a time when anyone of doubtful integrity had ample opportunity for serving their own interests rather than those of the community. Amongst the thousands of records consulted, not one could be read as casting doubt on Hooke's zeal, efficiency or integrity. On the contrary, compared with the behaviour of the Surveyors Mills, Oliver and Jerman who, like Hooke, all had other paid work, he displayed commendable civic virtue throughout the rebuilding period. Unlike the other Surveyors, he turned to private commissions only when the business of rebuilding the City was almost finished. More than

half the Surveyors' work in and about the streets of London from 1666 to 1674 was done by Hooke. He took the lead in surveying and worked unstintingly, with astonishing efficiency.

His reputation in science for being a difficult man, quick to take and give offence, does not extend to his dealings with the rulers and citizens of London in the aftermath of the Fire. At a time when many faced ruin and were desperate to recover their losses he worked nearly always harmoniously with the City in meeting the immediate needs of the citizens and improve their living conditions, sometimes doing more than the minimum necessary to fulfil his official obligations in order to ameliorate particular hardship.

From time to time in the early days of rebuilding the Surveyors were admonished by the City for their irregular attendance at formal meetings. It became clear later that regular attendance by the Surveyors at City meetings was not necessary for the performance of their duties. Communications between the City and the Surveyors worked well enough without it. Hooke alone was reprimanded only once, when he refused to comply with repeated orders to hand in his survey books. It has been suggested above that he used them for memoranda on matters that lay outside his City duties, so their disappearance is a great loss. By the time he began his diary in 1672, the city had been largely rebuilt. The extent of his engagement on surveying duties is only evident from City archives, which accounts in part for their long neglect by scholars. From 1667 to 1672 he spent most mornings on his surveying duties and was busiest outside the winter months.

He introduced no new methods or instruments in his three routine activities as City Surveyor (staking out streets and foundations, certifying areas of ground taken away and viewing and reporting on rebuilding disputes) because there was no need to do so. In examining his reports to the City, particularly those on views of matters in dispute, similarities in form and content between them and his reports to the Royal Society on experimental investigations (discussed in Sections 3.3 and 4.1 above) have been noticed. In both cases his manuscripts rarely show any corrections. He either wrote one or more preparatory drafts and made a final copy, or he had in mind exactly what he needed to

report and wrote it down without any amendment. The latter alternative is far more likely: he would not have wasted time on preliminary drafts. Another common feature of his reports to both his employers is the clarity with which he presented and assessed evidence and justified his conclusions and recommendations. Quite complicated disputes, often involving more than two parties, are described with economy and lucidity, excepting the formal opening and closing sentences which were conventional phrases commonly used in official City reports. The City benefited from his logical approach to taking evidence and writing about it.

He supervised surveying and plotting for Ogilby and Morgan's map of the rebuilt city and approved new procedures and the method of representation which were introduced for that purpose, but he did little surveying himself for plans and maps. He supervised and approved on behalf of the City activities which are now described as building surveying and quantity surveying. He practised property valuation and undertook work which is now carried out by local authority planners, engineers and surveyors of all kinds and their staff. On major construction sites he acted for the City as resident engineers and consultants now do. When his scientific investigations (of topics such as astronomy, the atmosphere, hydrography, and gravity) are taken into account he is seen as the first professional surveyor, engaged in almost all the activities encompassed today by members of the Royal Institution of Chartered Surveyors. He has not been seen in this way before. Neither he nor anyone else at the time proposed institutionalising such activity. Cutler's promotion of the idea of a history of trades might have led in that direction, but more than two centuries were to pass before crafts-based institutions were superseded by professional organisations as arbiters of good practice. Hooke's imagination and intellect drew him towards experimental investigations of natural phenomena. He was less concerned with the social organisation and management of the application of new knowledge for the benefit of society although he saw such benefit as a reason for seeking knowledge.

By his daily surveying he met a particularly urgent and strongly felt social need, coming into contact with hundreds of citizens at a time when each one looked to the City

for efficient and fair treatment. In his dealings with them he showed probity and efficiency in making his recommendations to the City, but in a wider context he was zealous in doing all he could to improve the living conditions for all citizens. In working amicably with Wren in all the important matters concerning rebuilding he served the City well in its relationship with the King, which was particularly important in the early days, and consequently in meeting its obligations to its citizens. Although others could have carried out Hooke's work as Surveyor (albeit with less intensity and dedication) none could also have worked with Wren in the way Hooke did. They were intellectual equals with common interests. Wren's genius in architecture and his social graces and Hooke's genius in mechanics and understanding how things worked were complementary. Another relationship of importance in rebuilding was that between Hooke and Sir John Lawrence, a respected figure in the city and in the City. The fact that Hooke had long-standing amicable relationships with Boyle, Wren and Lawrence, all men of integrity and authority although from quite different backgrounds is hard to understand if Hooke himself was of generally doubtful integrity.

Hooke made no major technical innovations in the practice of surveying in his time and did little to change the way it was practised. The importance of his surveying for the City lies almost entirely in his contribution to the rebuilding of London. Only Hooke had a significant role in all matters affecting the form and rebuilding procedures of the new city. He helped draft the rebuilding regulations and saw that they were put into effect by standing amidst the rubble settling matters that were of individual concern to thousands of citizens. Through his intense energy and probity, allied to the highest technical knowledge and administrative efficiency, he made very significant contributions to more aspects of the rebuilding than any other individual.

It is now necessary to discuss what effect his surveying had on his other employments. He admitted to Boyle that working as City Surveyor left him too little time for what he wanted to do for the Royal Society and Waller reported that his City duties hindered his work for the Royal Society. It is a measure of Hooke's exceptional energy that consideration is given to the extent to which his major contribution to rebuilding

London affected his scientific work, rather than to whether or not it enabled him to do any other significant work at all. His successful balancing of the great demands made on him by his various employments (all of which he eagerly sought) was founded on a self-disciplined organisational ability to decide on priorities and was made possible by his extraordinary energy, even when accompanied by physical hardship.

His series of experimental investigations into terrestrial gravity were interrupted by the Plague and by the Fire, but by then he had probably taken them as far as he could. Variation of gravitational attraction with height above the earth's surface is so small that to detect and measure it requires instruments and procedures that in the seventeenth century could not be realised to the degree of refinement required. About two centuries later, progress in metallurgy, optical engineering, manufacturing processes and electrical power had developed to the stage where instruments and procedures devised by Hooke could begin to be put into effect. His far-sightedness in conceiving instruments for experimentation far exceeded the contemporary knowledge and skills needed to make them work successfully. Much of the controversy surrounding him derived from his creative imagination. He knew that an instrument, no larger than a man's hand, with telescopic sights could give sixty-times the accuracy obtained by Hevelius and he almost certainly knew he could not prove it by making one. It is necessary but not sufficient in science to have imagination and understanding in order to claim priority: demonstration is also necessary. Although he was unable to perform all the work given to him by the Royal Society in the aftermath of the Fire, that work was often either inconsequential or impossible to perform.

He had time to publish his Cutlerian lectures only when his duties for the City had lessened. By 1672 he was busy preparing them for publication, the first two volumes appearing two years later. By 1678 all six volumes had been published. The Fire only delayed publication of the first two; Hooke soon made up for lost time. Although the Royal Society made intermittent attempts to reprimand him for neglect of his office in the aftermath of the Fire, they also tried several times to employ either an assistant for him or a curator of anatomical experiments to relieve him of that work, but funds were not

available. It is difficult to discover a serious effect on Hooke's experimental and philosophical work which could be directly attributed to the time he spent as City Surveyor. On the contrary, the considerable extra income which derived from his surveying gave him more freedom of action than he would have enjoyed had the Fire not occurred. He was able to engage much more freely in the social life of London and to buy the things, including books, that were necessary for his scientific and philosophical activities. His gregariousness and dealings with the thousands of people he came into contact with as City Surveyor, from the King and Privy Council to building labourers and craftsmen, enabled him to meet and exchange arguments and opinions with purveyors of news, gossip and knowledge in the new city streets and buildings which he, more than anyone, had made possible by innumerable acts which, under oath, he had sworn to do truly, impartially and according to his skill, knowledge and power. Nothing in this investigation has been found which shows that he did anything other than use extraordinary skill, knowledge and power to meet in full his sworn obligations to the City and citizens of London.

APPENDIX

The purpose of the numerical and statistical analyses in this Appendix is to use measurements made and recorded in survey books by Mills and Oliver as evidence for testing hypotheses about how those measurements might have been made. In the absence of Hooke's survey books it has been argued in Section 4.3(a) above that Hooke used the same methods as Mills and Oliver. The mathematical, statistical and algorithmic principles used in this test have been published by the present author and others.[610,611] They are now described in general terms.

In land surveying for mapping it has been common practice to measure first the distances and angles between survey stations and then to plot, or calculate the coordinates of, those stations. The framework of stations, lines and angles is a "control survey". It provides the geometrical foundation from which later measurements can be taken to features which are to be shown on the map. Modern practice is to calculate the coordinates of the stations from the measurements using a computer program based on "least squares estimation" or LSE. This process takes all measurements (angles and distances for example) together with their individual standard deviations and transforms them into the coordinates of the stations between which the measurements were made, and their standard deviations. Various statistical tests can be made to test hypotheses about the validity of the data, both measured and computed.

Measurements made by the City Surveyors when setting out foundations were not intended to be a control survey, but when surveys of contiguous foundations are brought together, the measured lines can be regarded as a control framework. By examining the transcripts of Mills's and Oliver's survey books, some contiguous foundations at Poultry have been identified, drawn and joined together in a plot (Figure 12(a)).[612] In drawing this plot it was necessary to make some assumptions because, as already stated in Section 3.2 above, measurements of only the bounding sides are insufficient to define the shape of the area within the boundary. It is also impossible, for the same reason, to compute coordinates from the measurements alone. The opportunity is now taken to test the

validity of the following assumptions about how the surveyors went about their measurements:

(a) wooden rods were used to measure the distances with standard deviations of ±0.3ft; and

(b) alignment of boundaries were estimated by eye and can be represented in LSE by pseudo-measurements of horizontal angles of 180° with standard deviations of ±1°. No assumptions about orthogonality of boundaries have been made.

Two files of input data for LSE were prepared. The "station data file" which gives the station names and their approximate two dimensional (X,Y) coordinates (necessary for an iterative solution of a linearised non-linear problem) and the "observation file" of measured horizontal distances (in feet) and pseudo-measurements (in degrees) of horizontal angles and their standard deviations (in units of thousandths of feet and seconds of arc respectively, to conform to the program requirements). At the end of this file are some additional pseudo-measurements (and their standard deviations) necessary to define an arbitrary coordinate datum and for additional boundary alignments. Computer data files are printed thus.

INPUT FILES

```
# Station data file and standard deviations
#
#  N in last column means this station Not bordered in a free adjustment.
#
# Station       X            Y            Z       Indices
#
      RO     364.3438     426.5834       0.0     -1 -1 -1
       A      10.7904      73.0300       0.0     -1 -1 -1
       B      20.7990      73.4996       0.0      0  0 -1
       C      38.8576      75.1024       0.0      0  0 -1
       D      63.9953      76.0499       0.0      0  0 -1
       E      61.8237      70.0940       0.0      0  0 -1
       F      75.5981      75.2265       0.0      0  0 -1
       G      71.9610      62.1020       0.0      0  0 -1
       H      65.5873      37.6590       0.0      0  0 -1
       I      52.4218      31.4971       0.0      0  0 -1
       J      31.8417      41.3120       0.0      0  0 -1
       K      13.7371      46.6180       0.0      0  0 -1
       L       3.9783      45.8256       0.0      0  0 -1
       M       6.5303      56.0097       0.0      0  0 -1
```

```
      N       16.9847      58.8174      0.0      0  0 -1
      O       36.2620      63.3915      0.0      0  0 -1
      P       36.8566      64.9910      0.0      0  0 -1
      Q       40.4684      64.0452      0.0      0  0 -1
      R       57.8488      59.2979      0.0      0  0 -1
```

```
# Observation data file and standard deviations
# Each of the following five blocks of data is preceded by the name of the
# person who commissioned the survey and the volume and folio numbers of
# the LTS publication The Survey of Building Sites in the City of London
# where a record of the survey may be found.
# Lewin IV.142v
-1  0  A  B  10.0  300.0
-1  0  B  N  15.0  300.0
-1  0  N  K  13.0  300.0
-1  0  K  L   9.8  300.0
-1  0  L  M  10.5  300.0
-1  0  M  A  17.5  300.0
-1  0  M  N  10.0  300.0
 2  B  N  K 180.0 3600.0
 2  A  M  L 180.0 3600.0
# Pulford IV.136v
-1  0  B  C  18.0  300.0
-1  0  C  J  35.2  300.0
-1  0  C  O  11.0  300.0
-1  0  J  K  19.1  300.0
-1  0  K  N  12.3  300.0
-1  0  N  B  15.0  300.0
 2  B  N  K 180.0 3600.0
 2  C  O  J 180.0 3600.0
# Fletcher & Jesson IV.74r
-1  0  C  D  25.0  300.0
-1  0  D  R  17.7  300.0
-1  0  R  P  26.0  300.0
-1  0  P  C  10.0  300.0
-1  0  D  E   6.3  300.0
-1  0  E  Q  22.5  300.0
-1  0  E  R  11.3  300.0
-1  0  R  Q  21.4  300.0
 2  D  E  R 180.0 3600.0
 2  C  P  O 180.0 3600.0
 2  P  Q  R 180.0 3600.0
 2  O  Q  E 180.0 3600.0
# Pulford IV.89r
-1  0  P  Q   4.0  300.0
-1  0  Q  R  21.2  300.0
-1  0  R  I  27.8  300.0
-1  0  I  J  23.0  300.0
-1  0  J  O  24.3  300.0
-1  0  O  P   3.0  300.0
-1  0  O  Q   4.3  300.0
```

```
 2  P  Q  R 180.0 3600.0
# Nutt IV.166r
-1  0  E  F  15.0  300.0
-1  0  F  G  13.5  300.0
-1  0  G  H  25.5  300.0
-1  0  H  I  14.7  300.0
-1  0  I  R  28.6  300.0
-1  0  R  E  11.9  300.0
-1  0  R  G  14.0  300.0
 2  E  R  I 180.0 3600.0
 2  F  G  H 180.0 3600.0
# Additional constraints
 2 RO  A  H  72.3002 1.0
 2  A  B  C 180.0 3600.0
 2  B  C  D 180.0 3600.0
 2  M  N  O 180.0 3600.0
 2  N  O  Q 180.0 3600.0
 2  Q  R  G 180.0 3600.0
```

The computer program used for LSE was "GAP"[613] The results are shown in the two output files below which correspond to the two input files. "Station data file and standard deviations" shows the station names, their estimated (X,Y) coordinates and the standard deviations of the estimated coordinates. The "variance factor, residuals and redundancy numbers" file shows: the amounts by which the measurements and pseudo-measurements have been adjusted in order for them to fit together in accordance with LSE (the residuals); a statistic which is an indicator of the validity of the input data in a LSE context (the variance factor); and statistics which indicate the reliability of the measurements and pseudo-measurements (redundancy numbers).

OUTPUT FILES

```
# Station data file and standard deviations
#  Results from GAP (v6.11) run on Thursday, 30/7/98 at 20:59 by M.A.R. Cooper
#  Input files:
#  Station data     : C:\My Documents\Hooke\Ltssurvey/tar.ah
#  Survey obs. data : C:\My Documents\Hooke\Ltssurvey/gobs.lts
# Station       X            Y            Z                Indices
#
      RO     364.3438     426.5834       0.0000  -1.00000  -1.00000   1.00000
# s.d.'s       Fixed        Fixed        1.00000
# Vars 0.0000e+000 0.0000e+000 1.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000
       A      10.7904      73.0300       0.0000  -1.00000  -1.00000  -1.00000
# s.d.'s       Fixed        Fixed        Fixed
# Vars 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000
```

```
      B      20.5741      74.8186       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.29197      0.20234      Fixed
# Vars 8.5247e-002 4.0941e-002 0.0000e+000 -1.7030e-003 0.0000e+000 0.0000e+000
      C      38.2626      78.1719       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.43864      0.42816      Fixed
# Vars 1.9241e-001 1.8332e-001 0.0000e+000 -4.5592e-002 0.0000e+000 0.0000e+000
      D      63.3791      82.9577       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.52994      0.63544      Fixed
# Vars 2.8084e-001 4.0379e-001 0.0000e+000 -1.3271e-001 0.0000e+000 0.0000e+000
      E      63.7605      76.8072       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.53175      0.59768      Fixed
# Vars 2.8276e-001 3.5722e-001 0.0000e+000 -1.6896e-001 0.0000e+000 0.0000e+000
      F      78.4628      76.6393       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.58104      0.71094      Fixed
# Vars 3.3761e-001 5.0544e-001 0.0000e+000 -1.7035e-001 0.0000e+000 0.0000e+000
      G      78.6398      63.1477       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.66266      0.64040      Fixed
# Vars 4.3912e-001 4.1011e-001 0.0000e+000 -3.2505e-001 0.0000e+000 0.0000e+000
      H      79.3197      37.6591       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       1.13608      0.58638      Fixed
# Vars 1.2907e+000 3.4384e-001 0.0000e+000 -6.6618e-001 0.0000e+000 0.0000e+000
      I      64.7892      37.0582       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       1.12766      0.58927      Fixed
# Vars 1.2716e+000 3.4723e-001 0.0000e+000 -4.8100e-001 0.0000e+000 0.0000e+000
      J      42.3261      42.9013       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       1.25087      0.43421      Fixed
# Vars 1.5647e+000 1.8854e-001 0.0000e+000 -1.5485e-001 0.0000e+000 0.0000e+000
      K      23.7466      47.2126       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       1.33230      0.32292      Fixed
# Vars 1.7750e+000 1.0428e-001 0.0000e+000 9.1934e-002 0.0000e+000 0.0000e+000
      L      14.1820      45.4301       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       1.31534      0.40712      Fixed
# Vars 1.7301e+000 1.6575e-001 0.0000e+000 1.7383e-001 0.0000e+000 0.0000e+000
      M      12.9171      55.8582       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.81557      0.25257      Fixed
# Vars 6.6515e-001 6.3792e-002 0.0000e+000 6.4001e-002 0.0000e+000 0.0000e+000
      N      22.2965      59.7722       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.78514      0.22801      Fixed
# Vars 6.1645e-001 5.1989e-002 0.0000e+000 -1.1851e-003 0.0000e+000 0.0000e+000
      O      39.4299      66.8090       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.60322      0.43181      Fixed
# Vars 3.6387e-001 1.8646e-001 0.0000e+000 -1.2229e-001 0.0000e+000 0.0000e+000
      P      39.2013      68.9787       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.55670      0.46748      Fixed
# Vars 3.0991e-001 2.1854e-001 0.0000e+000 -1.1857e-001 0.0000e+000 0.0000e+000
      Q      43.2285      68.3734       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.58179      0.46834      Fixed
# Vars 3.3848e-001 2.1934e-001 0.0000e+000 -1.3576e-001 0.0000e+000 0.0000e+000
      R      64.3421      65.2285       0.0000   0.00000   0.00000  -1.00000
# s.d.'s       0.61312      0.55638      Fixed
```

```
# Vars 3.7592e-001 3.0955e-001 0.0000e+000 -2.3982e-001 0.0000e+000 0.0000e+000
# RMS sd       0.83736      0.49110      1.00000
# MAX sd       1.33230      0.71094      1.00000
```

```
#  Variance factor, residuals and redundancy numbers file
#  Results from GAP (v6.11) run on Thursday, 30/7/98 at 20:59 by M.A.R. Cooper
#  Input files:
#  Station data     : C:\My Documents\Hooke\Ltssurvey/tar.ah
#  Survey obs. data : C:\My Documents\Hooke\Ltssurvey/gobs.lts
#  Degrees of freedom = 18
#  Variance factor (sigma-nought-squared) = 2.592, square root = 1.610
#  Residuals on survey observations:
#Type     From       At       To   Measured     s.e.  ht_ins  ht_tar   resid
  HD         -        A        B    10.0000  300.000  0.0000  0.0000  54.115
#  Redundancy                        0.0754
  HD         -        B        N    15.0000  300.000  0.0000  0.0000 -144.687
#  Redundancy                        0.6980
  HD         -        N        K    13.0000  300.000  0.0000  0.0000 356.967
#  Redundancy                        0.5008
  HD         -        K        L     9.8000  300.000  0.0000  0.0000  70.719
#  Redundancy                        0.2072
  HD         -        L        M    10.5000  300.000  0.0000  0.0000  -4.490
#  Redundancy                        0.0008
  HD         -        M        A    17.5000  300.000  0.0000  0.0000 196.994
#  Redundancy                        0.3637
  HD         -        M        N    10.0000  300.000  0.0000  0.0000 -163.363
#  Redundancy                        0.5124
  HA         B        N        K   180.0000 3600.000  0.0000  0.0000 199.647
#  Redundancy                        0.5230
  HA         A        M        L   180.0000 3600.000  0.0000  0.0000 -517.573
#  Redundancy                        0.0771
  HD         -        B        C    18.0000  300.000  0.0000  0.0000  -3.495
#  Redundancy                        0.0040
  HD         -        C        J    35.2000  300.000  0.0000  0.0000 -303.894
#  Redundancy                        0.4196
  HD         -        C        O    11.0000  300.000  0.0000  0.0000 -422.734
#  Redundancy                        0.6883
  HD         -        J        K    19.1000  300.000  0.0000  0.0000  26.876
#  Redundancy                        0.0089
  HD         -        K        N    12.3000  300.000  0.0000  0.0000 -343.033
#  Redundancy                        0.5008
  HD         -        N        B    15.0000  300.000  0.0000  0.0000 -144.687
#  Redundancy                        0.6980
  HA         B        N        K   180.0000 3600.000  0.0000  0.0000 199.647
#  Redundancy                        0.5230
  HA         C        O        J   180.0000 3600.000  0.0000  0.0000 3749.480
#  Redundancy                        0.1094
  HD         -        C        D    25.0000  300.000  0.0000  0.0000 -568.399
#  Redundancy                        0.3347
  HD         -        D        R    17.7000  300.000  0.0000  0.0000 -55.332
#  Redundancy                        0.4161
```

```
  HD        -       R       P     26.0000 300.000  0.0000  0.0000 581.012
#  Redundancy                      0.5793
  HD        -       P       C     10.0000 300.000  0.0000  0.0000 758.983 #
#  Redundancy                      0.5920
  HD        -       D       E      6.3000 300.000  0.0000  0.0000 137.648
#  Redundancy                      0.4404
  HD        -       E       Q     22.5000 300.000  0.0000  0.0000 303.396
#  Redundancy                      0.2104
  HD        -       E       R     11.3000 300.000  0.0000  0.0000 -293.257
#  Redundancy                      0.6136
  HD        -       R       Q     21.4000 300.000  0.0000  0.0000  53.528
#  Redundancy                      0.6750
  HA        D       E       R    180.0000 3600.000  0.0000  0.0000 -2421.819
#  Redundancy                      0.0427
  HA        C       P       O    180.0000 3600.000  0.0000  0.0000 669.285
#  Redundancy                      0.0094
  HA        P       Q       R    180.0000 3600.000  0.0000  0.0000 273.480
#  Redundancy                      0.5167
  HA        O       Q       E    180.0000 3600.000  0.0000  0.0000 -187.986
#  Redundancy                      0.2737
  HD        -       P       Q      4.0000 300.000  0.0000  0.0000 -72.519
#  Redundancy                      0.7182
  HD        -       Q       R     21.2000 300.000  0.0000  0.0000 -146.472
#  Redundancy                      0.6750
  HD        -       R       I     27.8000 300.000  0.0000  0.0000 -373.874
#  Redundancy                      0.5012
  HD        -       I       J     23.0000 300.000  0.0000  0.0000 -210.616
#  Redundancy                      0.0653
  HD        -       J       O     24.3000 300.000  0.0000  0.0000 217.560
#  Redundancy                      0.4291
  HD        -       O       P      3.0000 300.000  0.0000  0.0000 818.273 #
#  Redundancy                      0.8610
  HD        -       O       Q      4.3000 300.000  0.0000  0.0000 191.856
#  Redundancy                      0.6537
  HA        P       Q       R    180.0000 3600.000  0.0000  0.0000 273.480
#  Redundancy                      0.5167
  HD        -       E       F     15.0000 300.000  0.0000  0.0000 296.721
#  Redundancy                      0.2014
  HD        -       F       G     13.5000 300.000  0.0000  0.0000   7.281
#  Redundancy                      0.0001
  HD        -       G       H     25.5000 300.000  0.0000  0.0000   2.302
#  Redundancy                      0.0000
  HD        -       H       I     14.7000 300.000  0.0000  0.0000 156.987
#  Redundancy                      0.0564
  HD        -       I       R     28.6000 300.000  0.0000  0.0000 426.126
#  Redundancy                      0.5012
  HD        -       R       E     11.9000 300.000  0.0000  0.0000 306.743
#  Redundancy                      0.6136
  HD        -       R       G     14.0000 300.000  0.0000  0.0000 -448.380
#  Redundancy                      0.4598
```

```
  HA        E        R        I   180.0000 3600.000  0.0000  0.0000 -7078.937
#  Redundancy                        0.2703
  HA        F        G        H   180.0000 3600.000  0.0000  0.0000 2794.183
#  Redundancy                        0.1240
  HA       RO        A        H    72.3002   1.000  0.0000  0.0000   0.000
#  Redundancy                        0.0000
  HA        A        B        C   180.0000 3600.000  0.0000  0.0000 1348.438
#  Redundancy                        0.1220
  HA        B        C        D   180.0000 3600.000  0.0000  0.0000 192.307
#  Redundancy                        0.2153
  HA        M        N        O   180.0000 3600.000  0.0000  0.0000 -1159.478
#  Redundancy                        0.1337
  HA        N        O        Q   180.0000 3600.000  0.0000  0.0000 197.890
#  Redundancy                        0.2599
  HA        Q        R        G   180.0000 3600.000  0.0000  0.0000 689.791
#  Redundancy                        0.0076
#  Residuals on flexing targets:
# Target        X            Y            Z                Indices
#                         Observations                     Residuals
      RO     364.3438     426.5834       0.0000 -1.00000 -1.00000  1.00000
                                                  fixed    fixed  0.00000
#  Redundancy numbers:                                             0.00000
#  Total of redundancy numbers = 18.000000
```

The most important statistic for the present purpose is the variance factor designated "sigma-nought-squared" (σ_0^2) in the second output file above. If, on average, the measured and pseudo-measured values and their standard deviations are an appropriate stochastic model, then σ_0^2 should be equal to 1. It is equal to 2.59, but is it significantly different from 1? A statistical test is carried out to settle the question. The null hypothesis H_o: $\sigma_0^2 = 1$ is tested against the alternative hypothesis H_a: $\sigma_0^2 > 1$ at the 95% confidence level using the χ^2 statistic $r\sigma_0^2$ where r is equal to 18, the sum of the redundancy numbers ("degrees of freedom"). The χ^2 test statistic T = 46.6. The critical value $T_c = \chi^2_{18,\ 0.05} = 28.9$. Because $T > T_c$, H_o is rejected and H_a is accepted: the measured and pseudo-measured values and their standard deviations are not an appropriate stochastic model at the 95% confidence level. This means that the probability of rejecting H_o when it is true is 5% (a "Type 1 error").

This analysis is unsatisfactory for two reasons. The values of the standard deviations of the measurements and pseudo-measurements were guessed. Better values

should be found from experiments using the methods and equipment proposed as being those used by the City Surveyors. The other unsatisfactory feature of the example is the smallness of the redundancy numbers and the few degrees of freedom. It would be sufficient to increase the values of the standard deviation guesses by a factor of only 1.3 (giving ± 0.4ft and ±1.3° respectively - still reasonable values in the context) for the null hypothesis to be accepted at the 95% confidence level.

In an attempt to improve these shortcomings, research was undertaken at the suggestion of, and supervised by, the present author.[614] A new and much larger network with 50 degrees of freedom was compiled from Mills's and Oliver's survey books and analysed in a similar way. Experiments verified the earlier guesses of standard deviations were valid, so these values were used again. The variance factor σ_0^2 for the new LSE was 1.149. The value of the test statistic T was 57.45 with a critical value T_c ($\chi^2_{50, 0.05}$) of 67.4, so the null hypothesis was accepted, the alternative hypothesis rejected, and the values of the measurements and the pseudo-measurements and their standard deviations were accepted at the 95% confidence level.

These two tests led to different conclusions at the 95% confidence level, but taken together they both show that the postulated methods of measurement used by the City Surveyors could have produced the measurements recorded in the survey books by Mills and Oliver; this does not necessarily mean that the Surveyors used the postulated methods.

Figure 12(b) is a computer plot of the Poultry Survey using the X and Y coordinates estimated by least squares and listed in the computer output file "Station data file and standard deviations" above. The root-mean square standard deviations of these coordinates are ±0.83 feet for X and ±0.49 feet for Y. An arbitrary coordinate datum was used. The shapes of the tofts in Figure 12(b) differ from those in Figure 12(a) because different assumptions have been made. What these were for Figure 12(a) are unknown; the assumptions underlying Figure 12(b) are given above in this Appendix.

If Hooke had handed in his survey books and they had been transcribed by the City as Mills's and Oliver's were, it would be now be possible, but tedious, to produce a plot similar to the one in Figure 12(b) for most of the City, accurate to about a foot. Painstaking archival searches could yield information that would enable at least a partial, but computerised, land information system for the rebuilt city to be produced more than three hundred and thirty years after it was proposed.

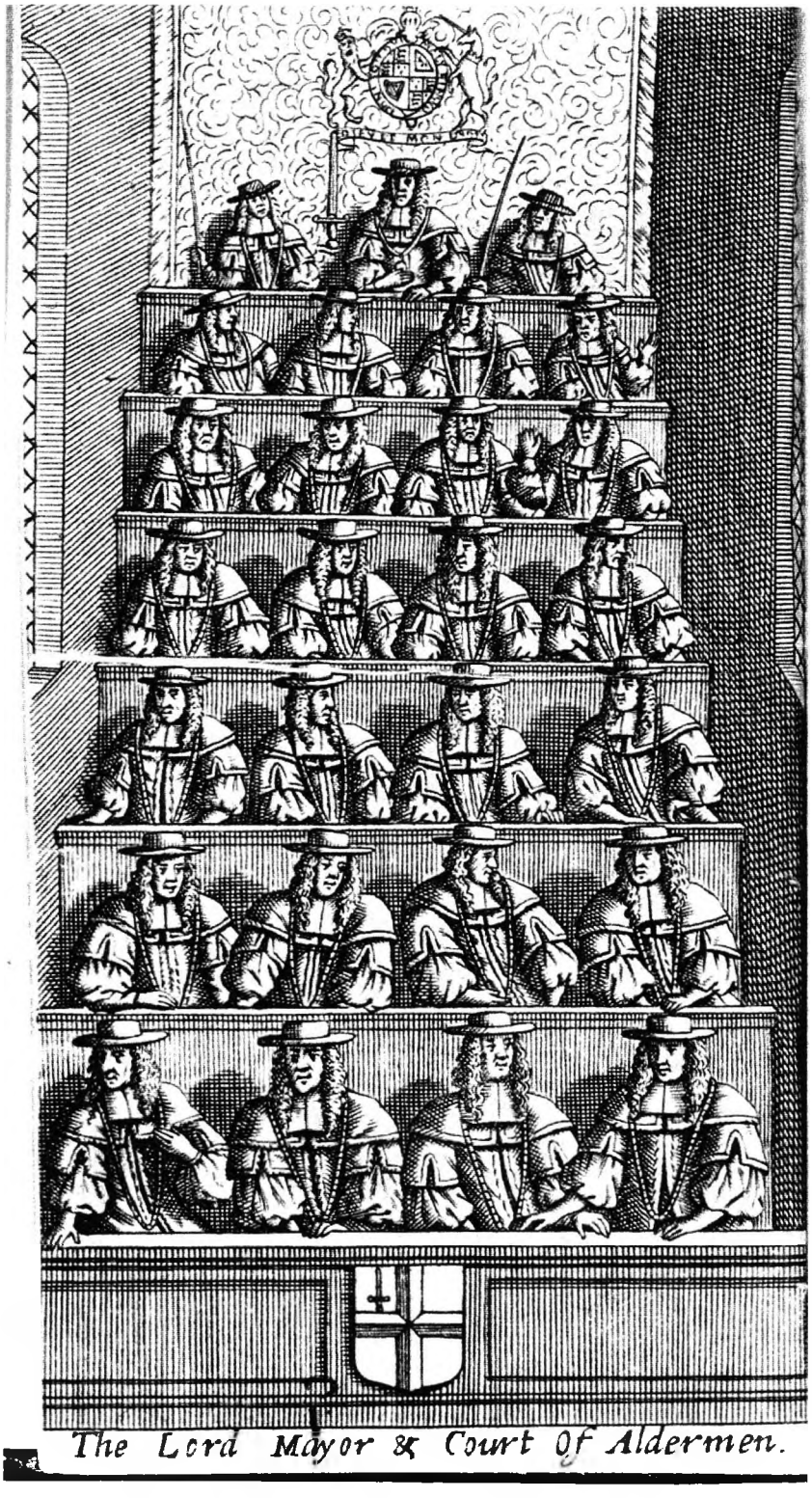


Figure 1
From de Laune, T. The Present State of London (London, 1678).
Guildhall Library, Corporation of London.

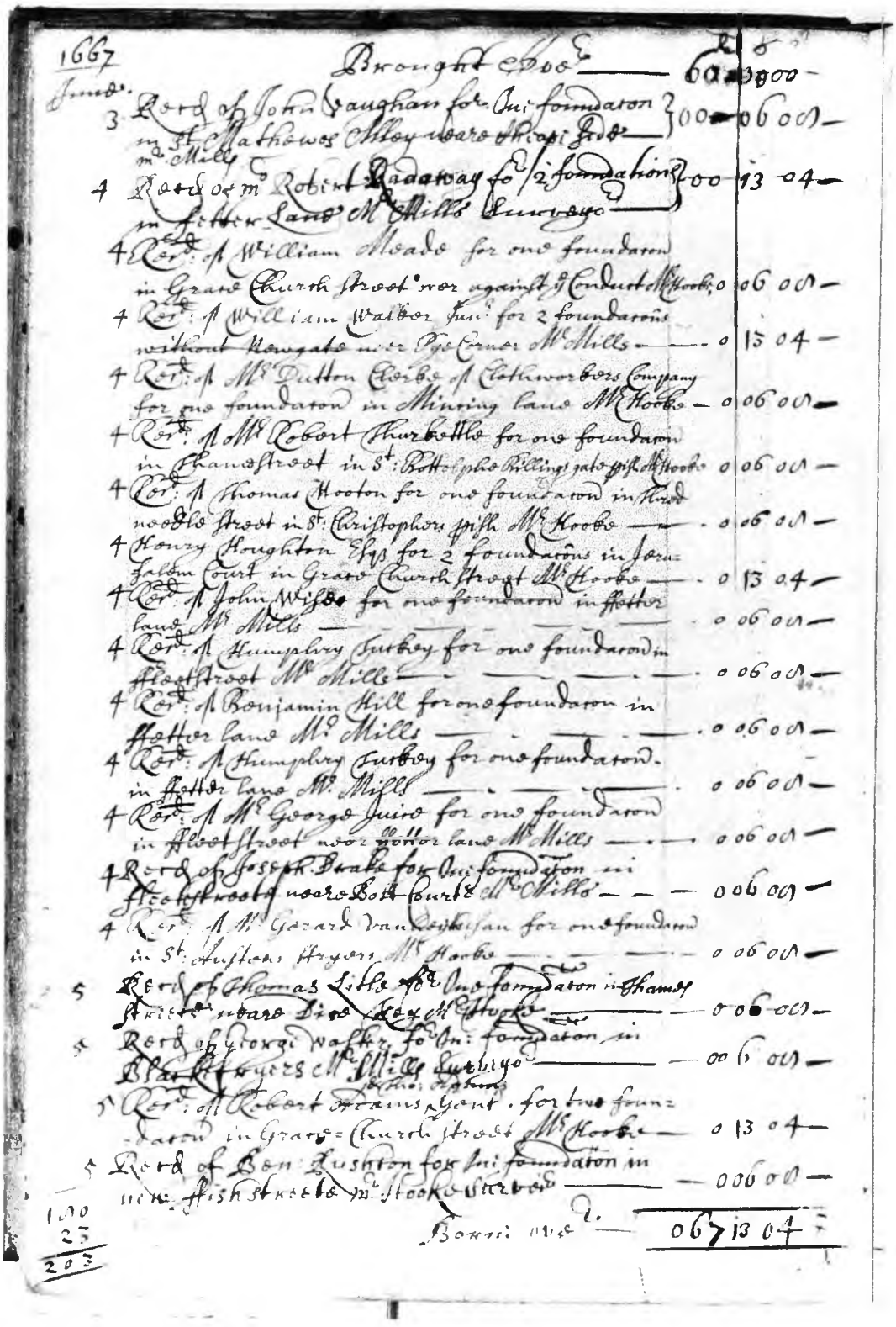
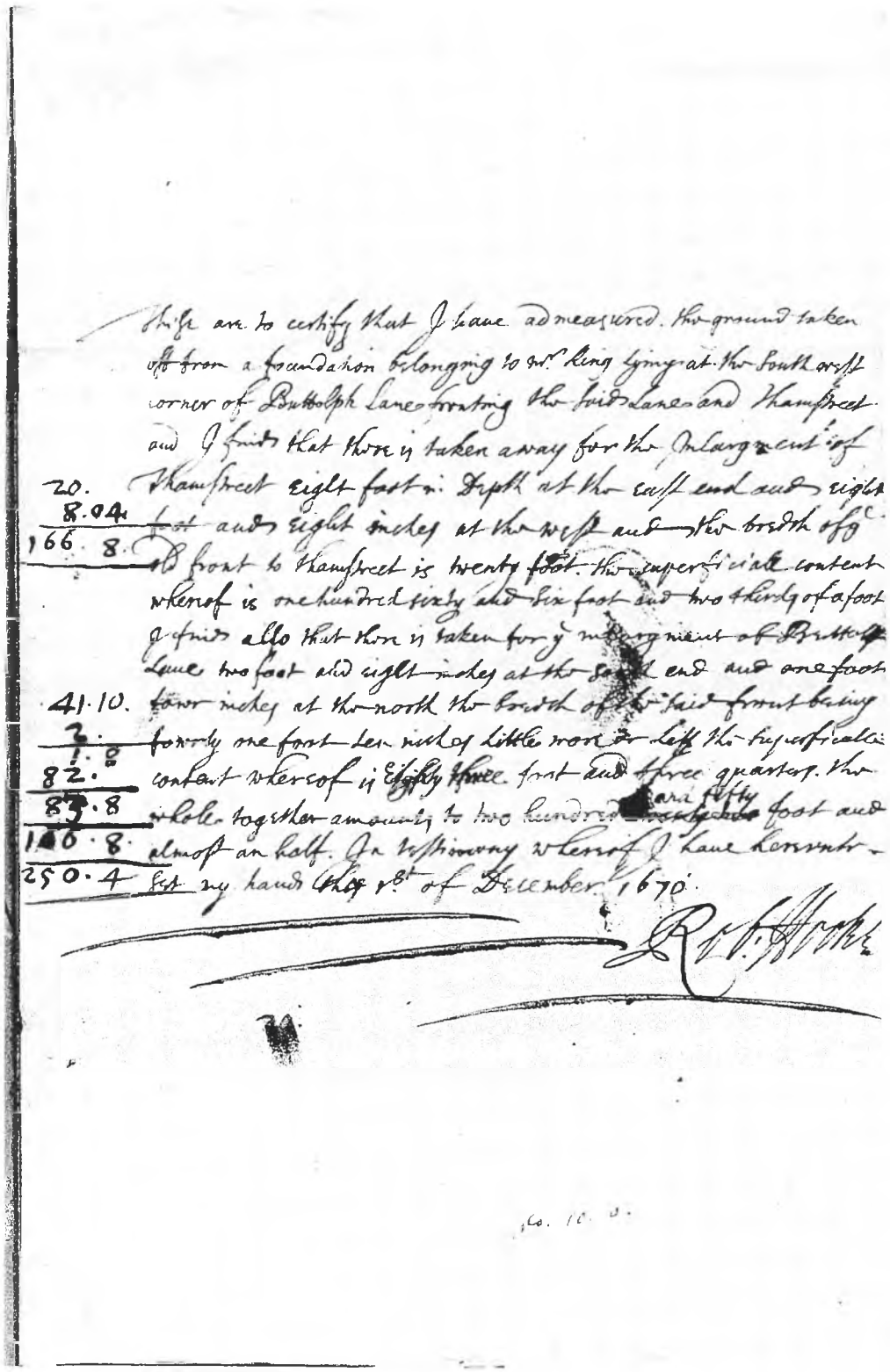


Figure 2
Ex-GL Ms.275 f.4^{v} showing receipts of payments for foundation surveys @ 06s-08d.
Corporation of London.



These are to certify that I have admeasured the ground taken off from a foundation belonging to Mr. King lying at the South west corner of Buttolph Lane fronting the said Lane and Thamstreet and I finde that there is taken away for the Inlargement of
20. Thamstreet eight foot & Depth at the east end and eight
8.04 foot and eight inches at the west and the breadth of
166. 8. the front to Thamstreet is twenty foot. the superficiall content whereof is one hundred sixty and six foot and two thirds of a foot I finde also that there is taken for y^e inlargement of Buttolph Lane two foot and eight inches at the South end and one foot
41.10. four inches at the north the breadth of the said front being
2. fourty one foot ten inches Little more or Less the superficiall
1.8 content whereof is
82. eighty three foot and three quarters the
83.8 whole together amounts to two hundred and fifty foot and
166.8 almost an half. In testimony whereof I have hereunto
250.4 set my hand this 1st of December 1670.

Robt Hooke

Figure 3
CD Box K K/6 showing Hooke's calculation of area. Corporation of London.

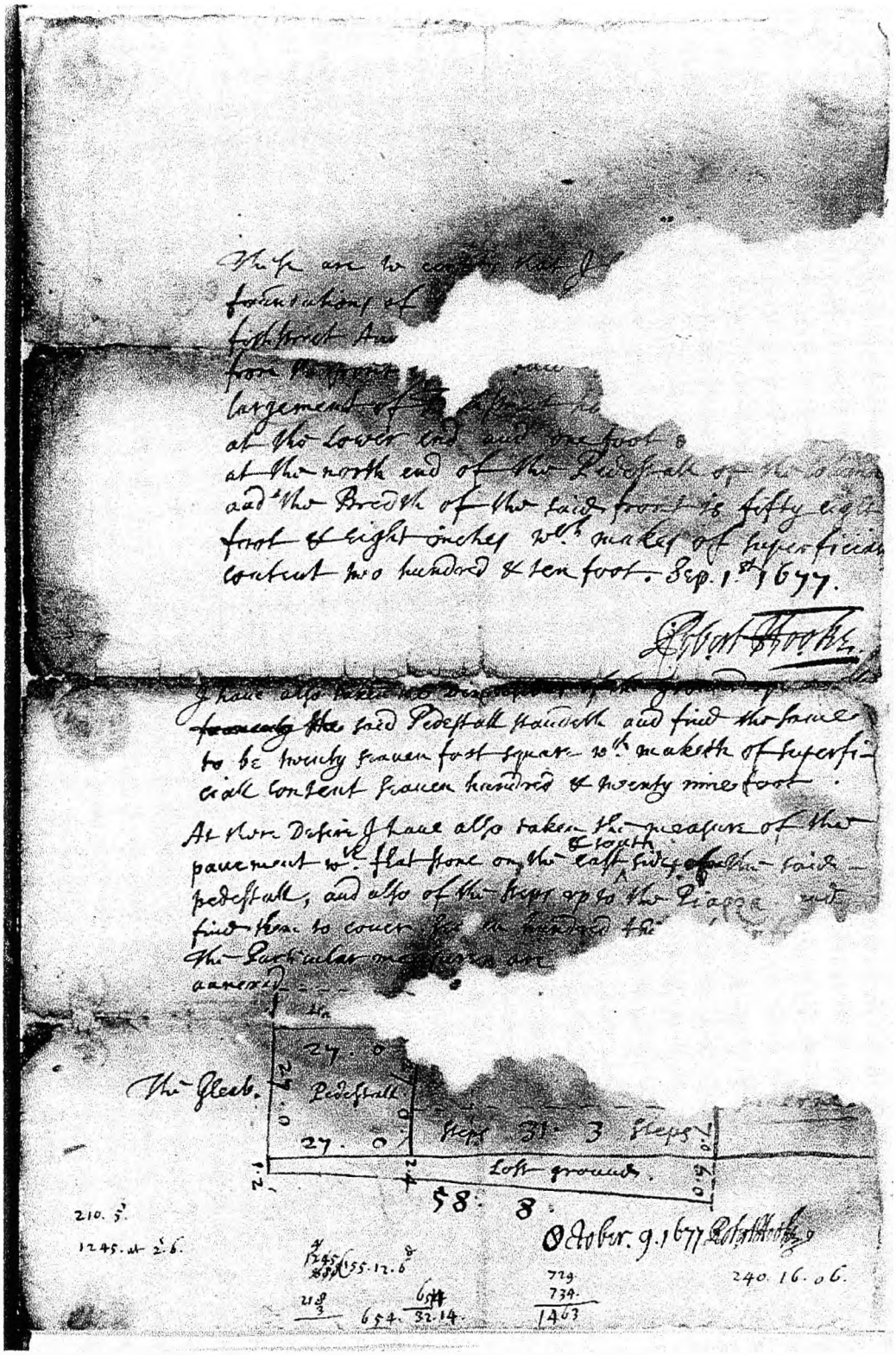


Figure 4

CLRO CD Box K M/37[A]. A rare example of Hooke's use of a sketch for an area of ground taken away. Measurements were made of ground taken by the City for building the Monument and adjacent piazza. Corporation of London.

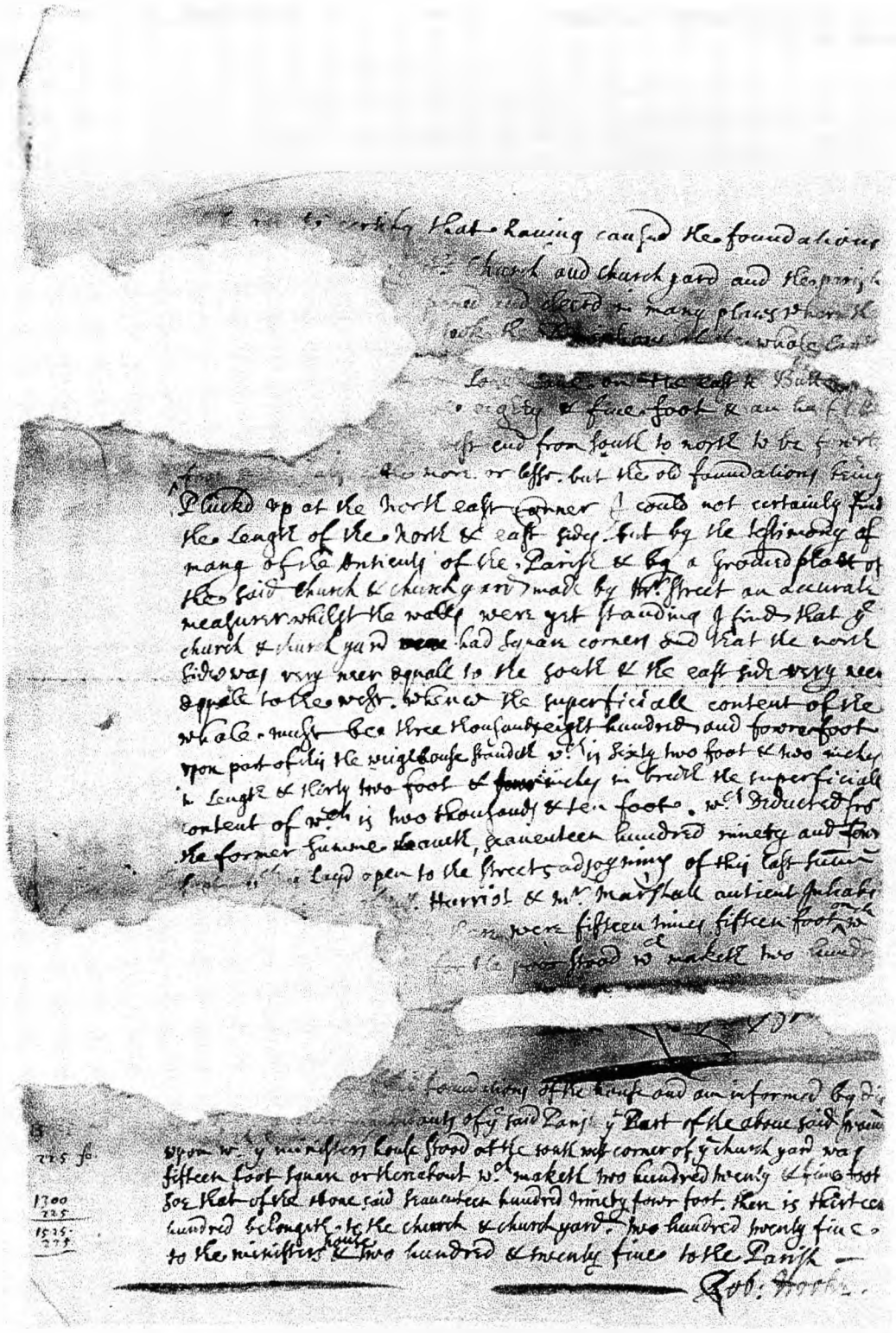
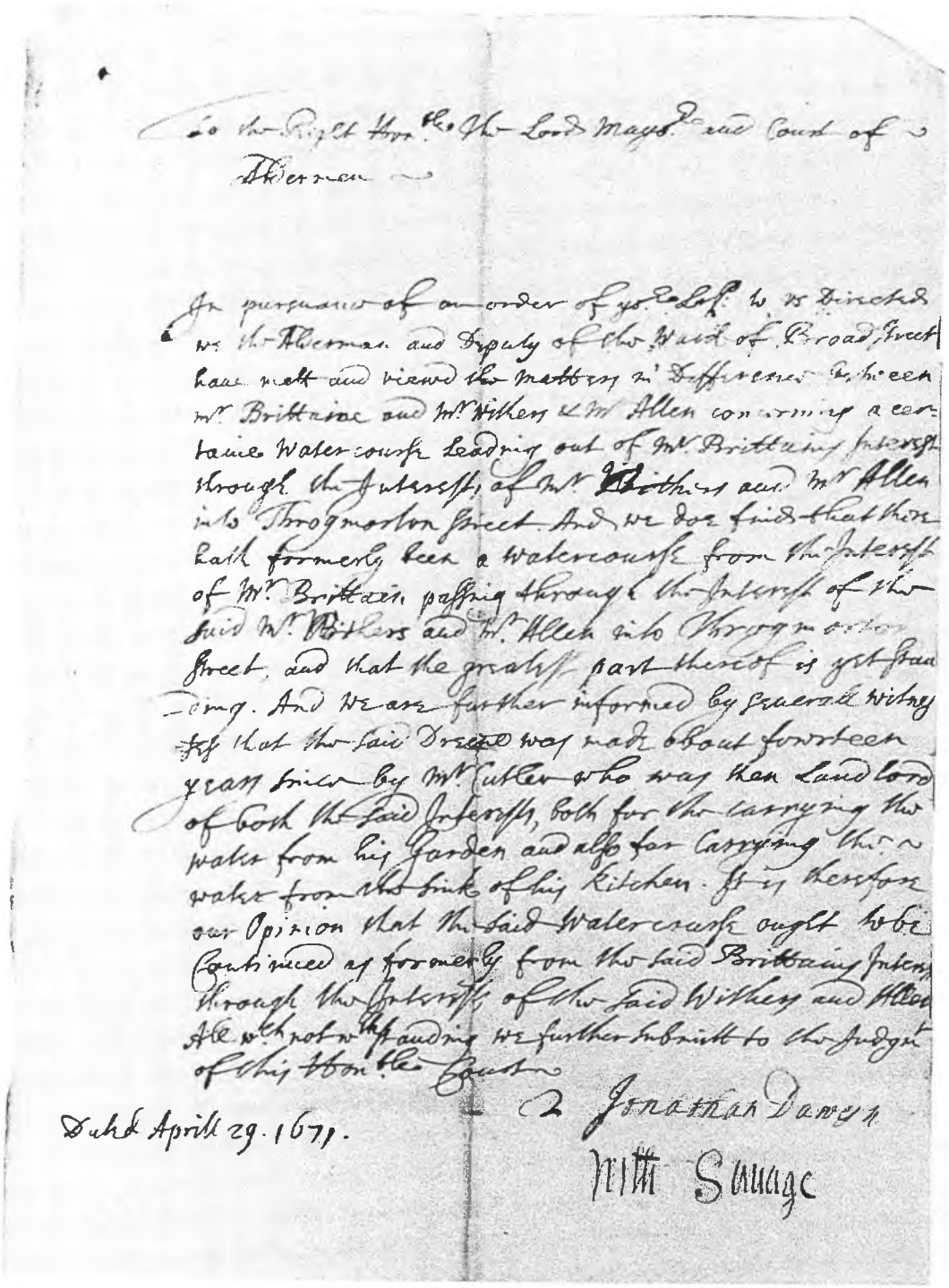


Figure 5
CD Box K H/42. Showing Hooke's use of documentary evidence when certifying ground taken away by the City (in this case from St Andrew Hubbard Church). Corporation of London.



To the Right Hon.ble the Lord Mayor and Court of Alderman

In pursuance of an order of yor Lop. to us directed we the Alderman and Deputy of the Ward of Broad Street have met and viewed the matters in Difference between Mr Brittaine and Mr Withers & Mr Allen concerning a certaine Water course Leading out of Mr Brittaines Intereſt through the Intereſts of Mr Withers and Mr Allen into Throgmorton Street And we doe find that there hath formerly been a watercourſe from the Intereſt of Mr Brittain passing through the Intereſts of the ſaid Mr Withers and Mr Allen into Throgmorton Street and that the greateſt part thereof is yet flowing. And we are further informed by Generall Witney &c that the ſaid Street was made about fourteen years ſince by Mr Cutler who was then Land Lord of both the ſaid Intereſts, both for the carrying the water from his Garden and alſo for Carrying the water from the ſink of his Kitchen. It is therefore our Opinion that the ſaid Watercourſe ought to be Continued as formerly from the ſaid Brittains Intereſt through the Intereſts of the ſaid Withers and Allen &c which notwithſtanding we further ſubmitt to the Judgt of this honble Court

Dated April 29. 1671.

Jonathan Dawes

Wm Savage

Figure 6
Misc. Ms.92.62. A report written by Hooke, but not signed by him.
Corporation of London.

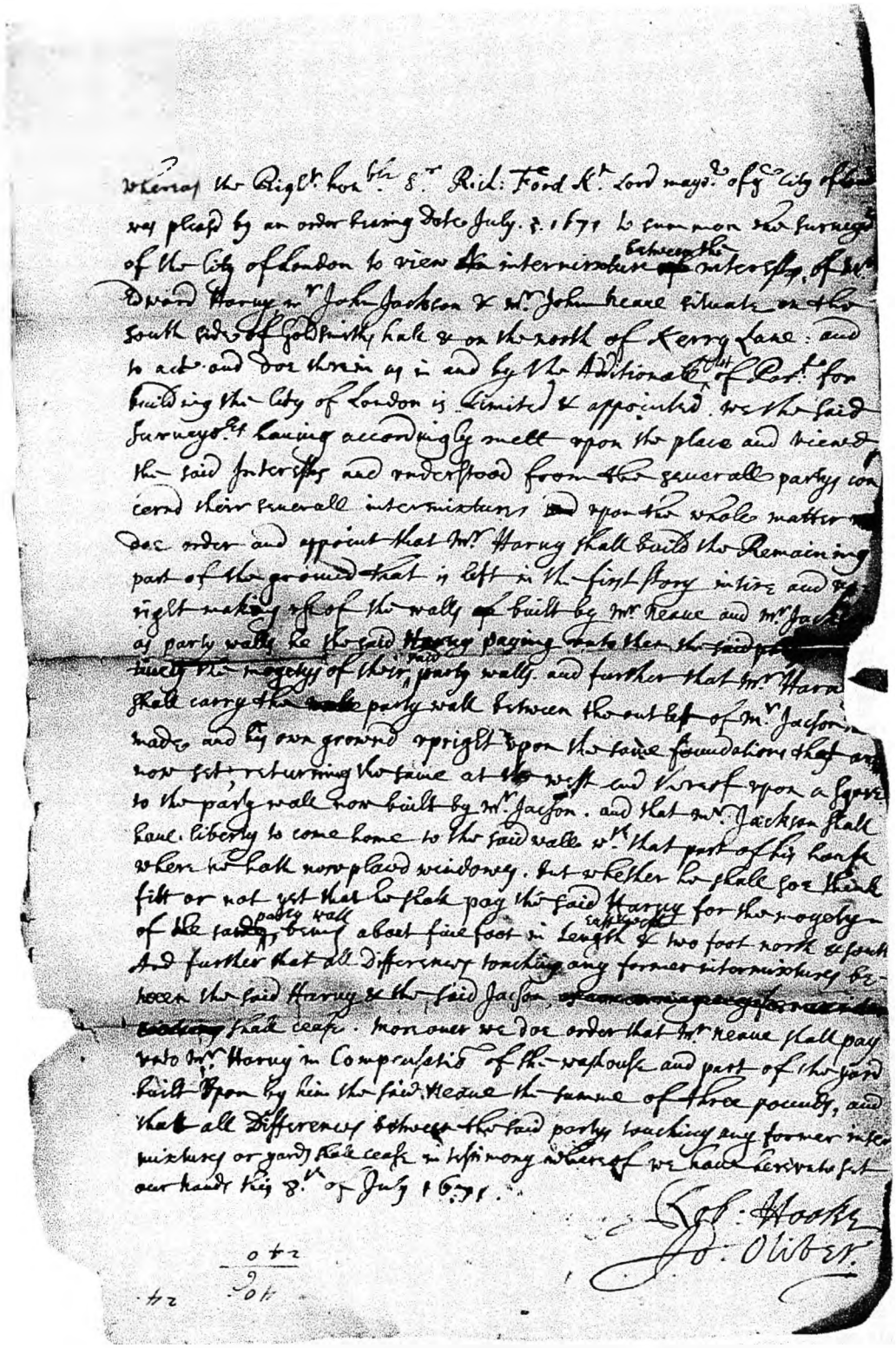
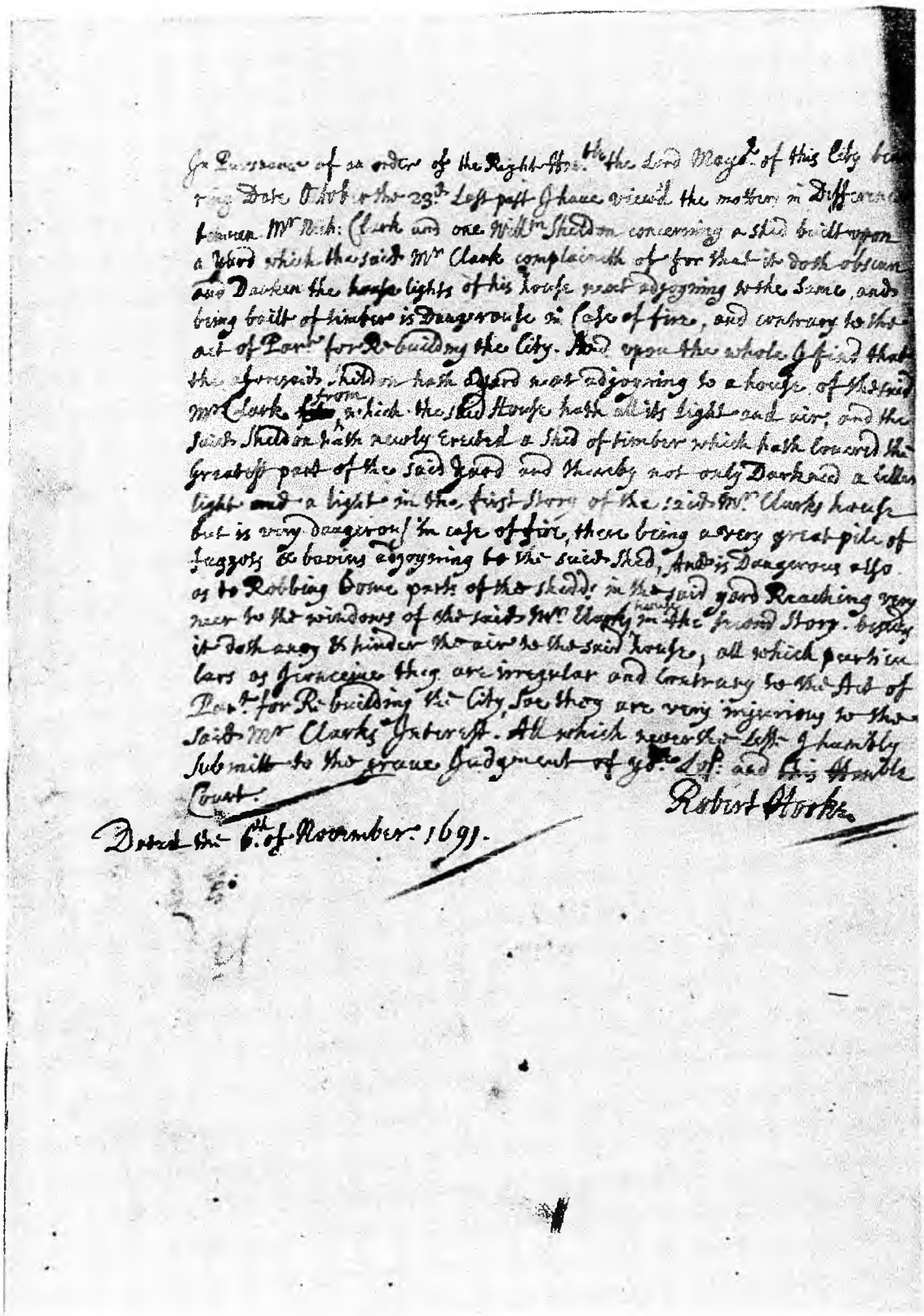


Figure 7
Misc. Ms.92.73. Hooke's report of a view of a complicated intermixture of interests between three neighbours. Corporation of London.



In Pursuance of an order of the Right Hon.ble the Lord Mayor of this City bearing Date Octob.r the 23.th Last past I have viewed the matters in Difference between Mr Rich: Clark and one Will.m Sheldon concerning a Shed built upon a Yard which the said Mr Clark complaineth of for that it doth obscure and Darken the house lights of his house great adjoyning to the same, and being built of timber is Dangerous in Case of fire, and contrary to the act of Parl.t for Re-building the City. And upon the whole I find that the aforesaid Shed or hath a yard next adjoyning to a house of the said Mr Clarks from which the said House hath all its light and air, and the said Sheldon hath newly Erected a Shed of timber which hath Covered the greatest part of the said Yard and thereby not only Darkened a Cellar light and a light in the first Story of the said Mr Clarks house but is very dangerous in case of fire, there being a very great pile of Faggots &c having adjoyning to the said Shed, and is Dangerous also as to Robbing some parts of the Sheds in the said yard Reaching very neer to the windows of the said Mr Clarks house in the second Story. besides it doth annoy & hinder the air to the said house, all which pertticulars of Grievance they are irregular and Contrary to the Act of Parl.t for Re-building the City, for they are very injurious to the said Mr Clarks Interest. All which nevertheless I humbly Submitt to the grave Judgment of yo.r Lo.ps and this Honble Court.

Robert Hooke.

Dated the 6.th of November. 1691.

Figure 8
Misc. Ms.93.129. The last manuscript report of a view by Hooke found in the archives. Corporation of London.

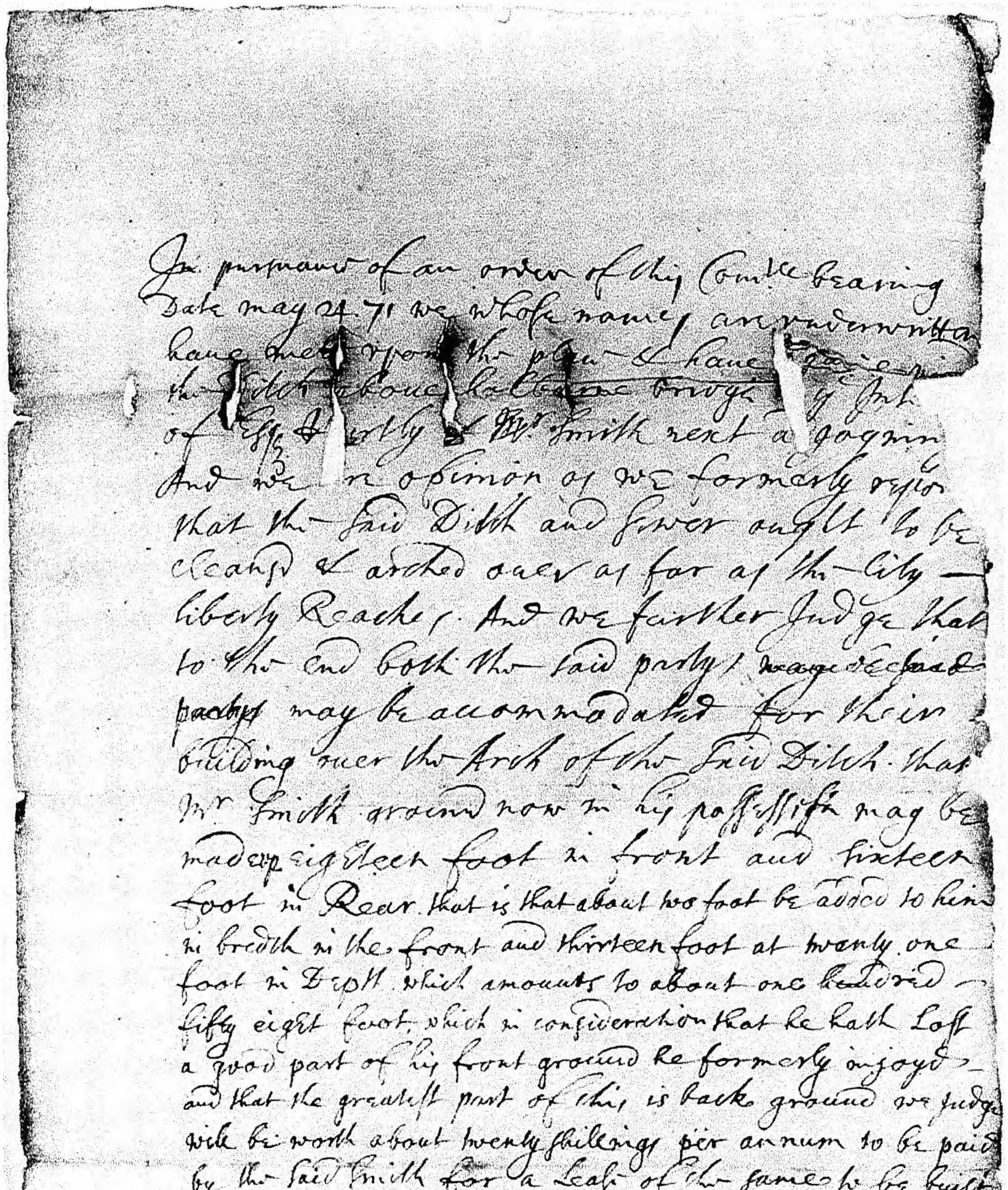
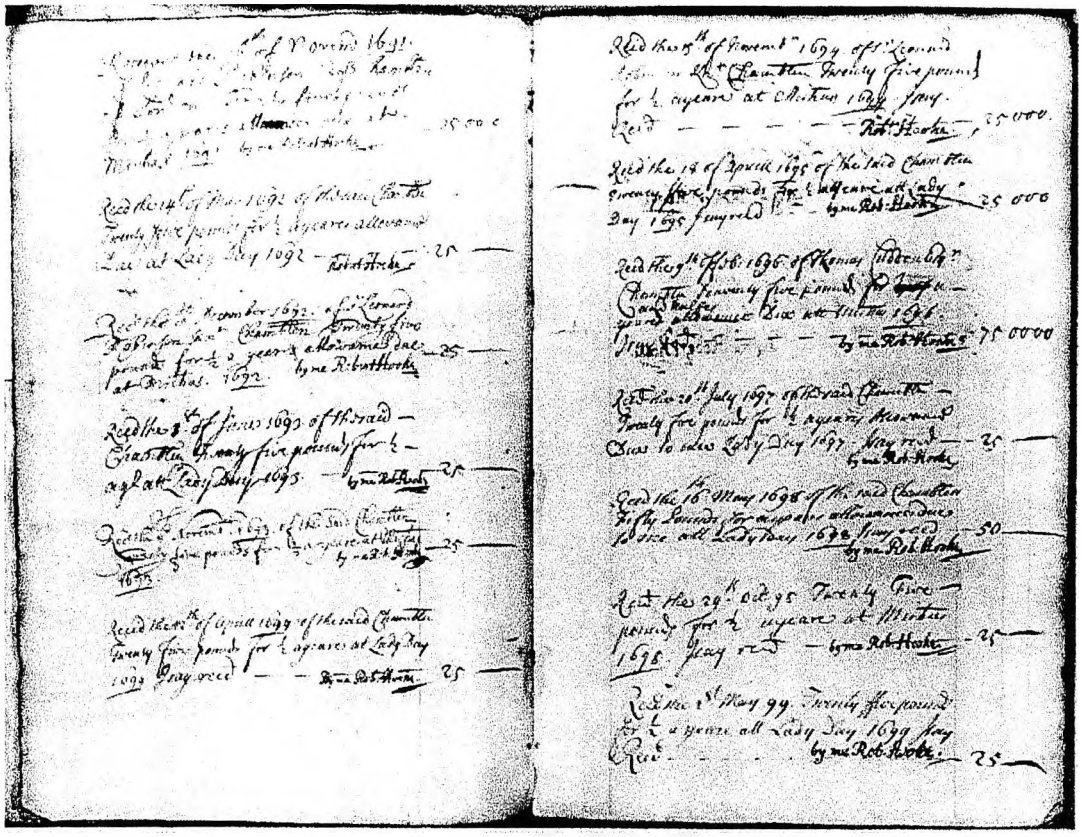

In pursuance of an order of this Comittee bearing
Date May 24. 71 we whose names are underwritten
have met upon the place & have viewed
the Ditch above Holborne Bridge & the ground
of Mr Hartly & Mr Smith next adjoyning
And we are of opinion as we formerly reported
that the said Ditch and sewer ought to be
cleansed & arched over as far as the City
liberty Reaches. And we farther Judge that
to the end both the said partys may be accommodated for their
building over the Arch of the said Ditch that
Mr Smith ground now in his possession may be
made up eighteen foot in front and sixteen
foot in Rear. that is that about two foot be added to him
in bredth in the front and thirteen foot at twenty one
foot in Depth which amounts to about one hundred
fifty eight foot, which in consideration that he hath Lost
a good part of his front ground he formerly injoyed
and that the greatest part of this is back ground we judge
will be worth about twenty shillings per annum to be paid
by the said Smith for a Lease of the same to be built
upon. We are further of opinion that Mr Hartly
may be accommodated with the Remainder to witt
about fowrteen foot in front and about five foot
in the Rear. the Greatest part of which being front
ground we judge the same to be worth about ten pounds
per annum. All which notwithstanding we humbly leave &c.
Dated May 29th 1671

Figure 9
CLCP Ms.25. A report to the City Lands Committee written by Hooke, but not signed by him. Corporation of London.



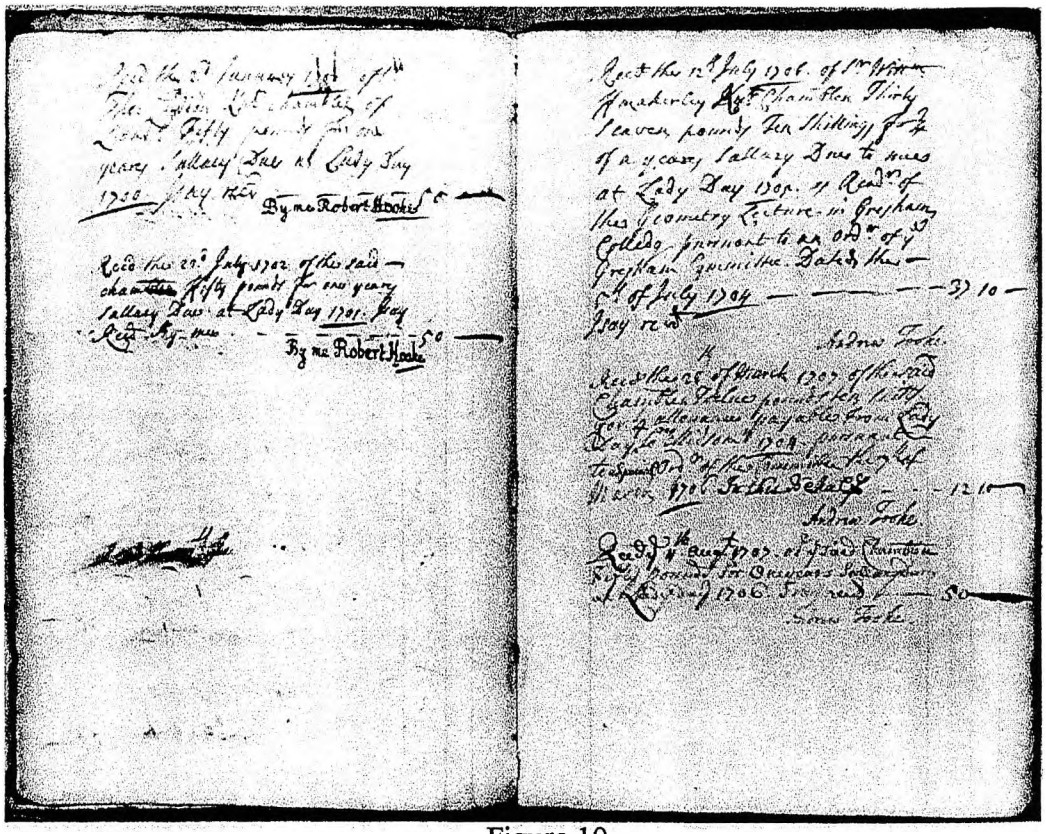


Figure 10
GCAB AB III ff.7^{v}-9^{r}. Changes in Hooke's last signatures. Corporation of London.

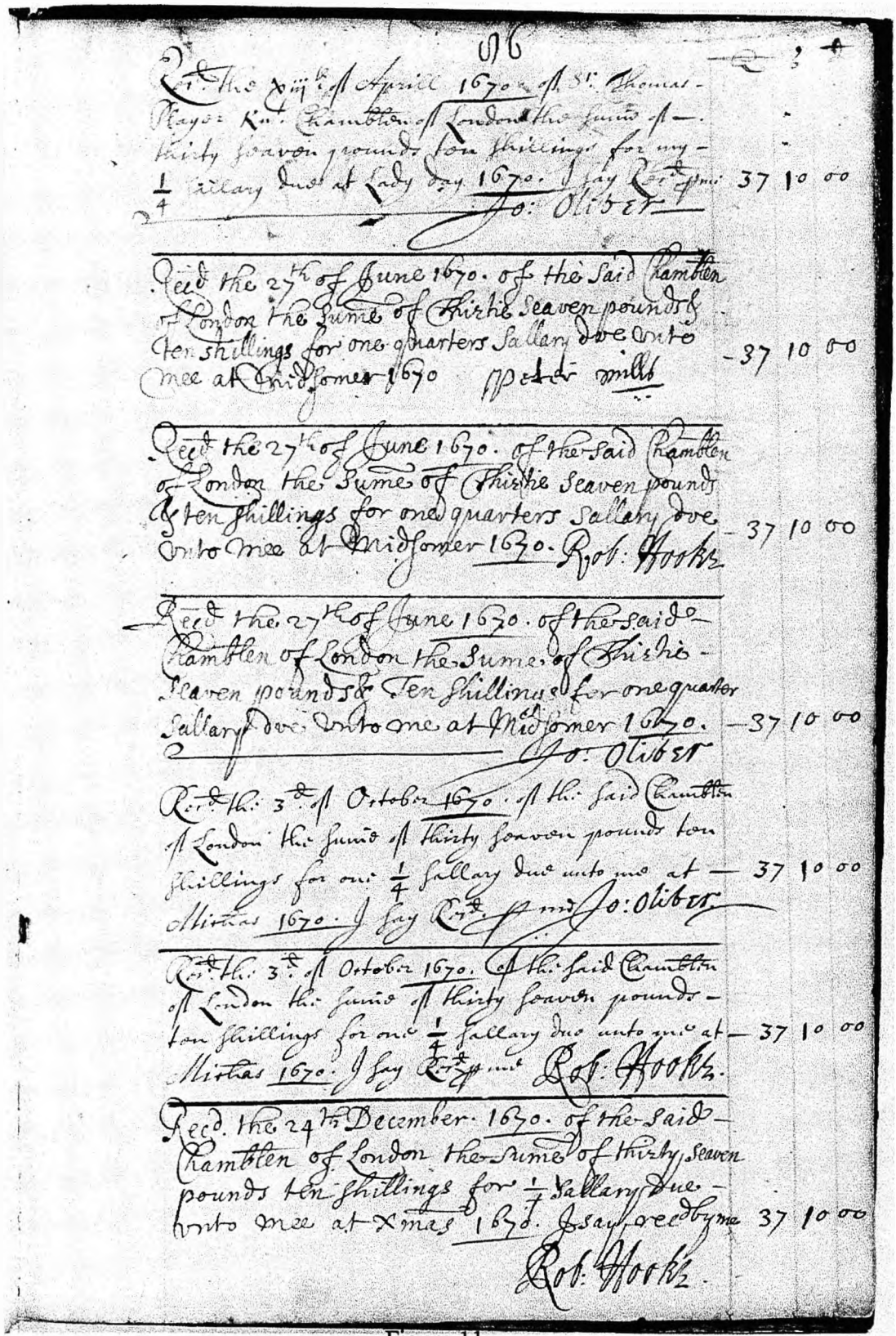
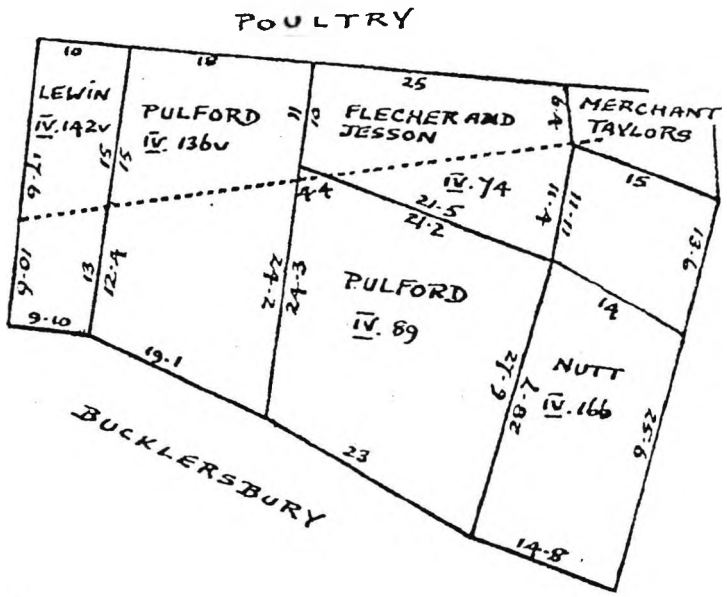
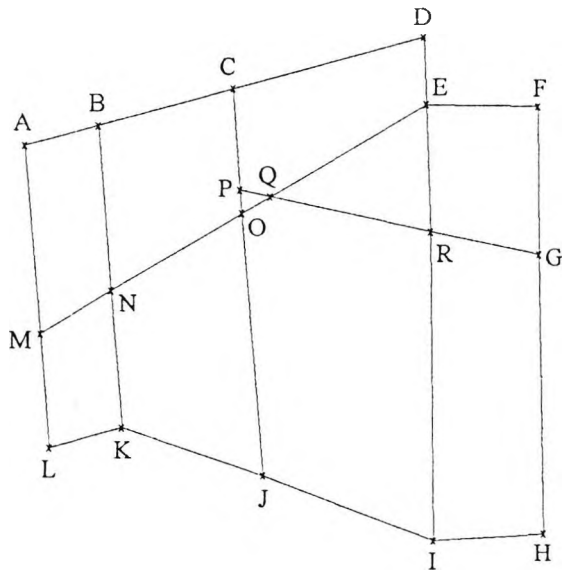


Figure 11

Ex-GL Ms.275 f.86[r] showing the signatures of Mills, Hooke and Oliver for their quarterly salaries. Corporation of London.



(a) a graphical plot from
The Survey of Building Sites in the City of London After the Great Fire of 1666 Volume I
(London, LTS, 1964) p.xxiii



(b) a plot from coordinates computed as described in Appendix A

Figure 12
The Poultry Survey

NOTES

1. 'Espinasse, M. *Robert Hooke* (London, Heinemann, 1956).

2. Reddaway, T.F. *The Rebuilding of London After the Great Fire* (London, Jonathan Cape, 1940; reprinted London, Edward Arnold, 1951 with changes to some illustrations).

3. Waller, R. "The Life of Dr Robert Hooke" in Waller, R. (ed.) *The Posthumous Works of Robert Hooke* (London, 1705) p.xiii.

4. 'Espinasse, M. *Robert Hooke* (London, Heinemann, 1956) p.87.

5. 'the City' is used in this dissertation to mean the various Courts, Committees and Officers who were responsible in the seventeenth century for directing and managing the affairs of the City of London; 'the city' should be taken to mean the geographical City and Liberties of London at the time.

6. Cooper, M.A.R. "Robert Hooke's work as Surveyor for the City of London in the aftermath of the Great Fire Parts 1, 2 & 3" *Notes and Records of the Royal Society of London* 51(2) pp.161-174 (1997); 52(1) pp.25-38 (1998); 52(2) pp.205-220 (1998).

7. 'Espinasse, M. *Robert Hooke* (London, Heinemann, 1956).

8. Waller, R. "The Life of Dr. Robert Hooke" in Waller, R. (ed.) *The Posthumous Works of Robert Hooke* (London, 1705) pp.i-xxviii.

9. Ward, J. *Lives of the Professors of Gresham College* (London, 1740) pp.169-193.

10. Stephen, L. & Lee, S. (eds.) *The Dictionary of National Biography, Volume IX* (London, Oxford University Press, 1917) pp.1176-1181. The author of the entry on Hooke was Agnes Mary Clarke.

11. Perks, S. *The History of the Mansion House* (Cambridge University Press, 1922). In Chapter 8 "The Surveys after the Fire" (pp.143-152) Perks gives particulars of and extracts from archives which record payments to Hooke and the other Surveyors Mills and Oliver. It is possible that Perks's is the first published description of such records.

12. Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930).

13. Gunther, R.T. *Early Science in Oxford Volume VII* (Oxford, 1930).

14. Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.xii & xvi.

15. Gunther, R.T. *Early Science in Oxford Volume VI* pp.xviii-xix.

16. Gunther, R.T. *Early Science in Oxford Volume VIII The Cutler Lectures of Robert Hooke* (Oxford, 1931).

17. Gunther, R.T. *Early Science in Oxford Volume X Robert Hooke's Tract on Capillary Attraction 1661 and Diary 1688-1693* (Oxford, 1935). The latter is hereafter referred to as *Diary* (G).

18. Gunther, R.T. *Early Science in Oxford Volume XIII Robert Hooke's Micrographia* (Oxford, 1938).

19. GL Ms.1758. It is a remarkable document, totally unlike Pepys's in that it contains hardly any social gossip or political comments, although the terse, abbreviated style of the entries allows the reader to make inferences about such aspects of life in late seventeenth-century London as they affected Hooke. He intended the entries in his diary to serve as memoranda, not only as a record of the weather (such regular entries soon ceased) but of the countless transactions and meetings he was engaged in for the Royal Society, Gresham College, the City, private institutions and citizens. Occasionally he could not resist the temptation to insert one-word denigratory remarks ("dog" is common) when noting the name of someone with whom he had just had unfavourable dealings. It is a rich source of information about his life during those few years, but infuriatingly ambiguous and almost worthless to anyone who does not already know something about his acquaintances and activities; the more one already knows about Hooke, the more useful it is.

20. Robinson, H.W. & Adams, W. *The Diary of Robert Hooke 1672-1680* (London, Taylor & Francis, 1935) hereafter abbreviated as *Diary* (R&A). The index is inadequate, but a full index of names and places would almost double the size of the publication. The manuscript was begun on 10 March 1672 and concluded on 16 May 1683, but the published version starts with the entry for 1 August 1672 and ends with the entry for 31 December 1680. The editors omitted details of Hooke's observations of the weather in his entries for the period August to December 1672 and omitted entries earlier than August 1672 altogether because they "are very scanty and difficult to understand". The editors claim that "the rest of the manuscript has been printed *in full*" (their italics, *Diary* (R&A) p.3). This is not true. It is later stated (ibid. p.460) that entries dated after 31 December 1680 have not been printed "as many days, weeks and months are missing altogether they are not of sufficient importance to publish." Moreover, bound-in with many blank folios are a few bearing odd notes and memoranda, some of which are important and all are interesting. One memorandum dated October 1666 lists "things" belonging to the Repository of the Royal Society which Hooke received from Jonathan Goddard. On the reverse of the folio is a list of "books and things" lent by Hooke, including two books of Dr Wallis in manuscript given to Lord Brouncker to be transcribed by Collins for Hevelius, dated 11 May 1669. Of different interest are three ribald stories which Hooke wrote down. Nothing else so far known of his writings shows such a vivid

glimpse of his humour and scorn for the intelligence of some of the worthies of the City. The folios bearing these additional notes and memoranda are of the same size and material as the diary folios and the large number of blank folios which were all bound together in 1934 to form one volume about 230mm in breadth and 360mm in height. It is likely that the editors knew of these additional manuscripts, but chose not to print them or even mention their existence.

21. An obituary notice is in *The Palmers Green and Southgate Gazette* for April 29 1960.

22. Gunther, R.T. *Early Science in Oxford Volume X* (Oxford, 1935) pp.vi-vii.

23. Anon. "Robert Hooke born July 18, 1635" in *The Times Literary Supplement* No. 1746, dated 18 July 1935, pp.453-454.

24. Andrade, E.N.da C. "Robert Hooke and his contemporaries" *Nature* 3436, 7 September 1935, pp.358-361.

25. Andrade, E.N.da C. "Hooke and his Editors" *Nature* 3462, 7 March 1936, pp.378-381.

26. Andrade, E.N.da C. "Hooke and his Editors" *Nature* 3462, 7 March 1936, p.381.

27. Andrade, E.N.da C. "Hooke and his Editors" *Nature* 3462, 7 March 1936, p.379.

28. Andrade, E.N.da C. "Hooke and his Editors" *Nature* 3462, 7 March 1936, p.379.

29. Andrade, E.N.da C. "Hooke and his Editors" *Nature* 3462, 7 March 1936, p.380.

30. Gunther, R.T. and Andrade, E.N.da C. *Nature* 3469, 25 April 1936, pp.702-703.

31. Andrade, E.N.da C. "Hooke and his Editors" *Nature* 3462, 7 March 1936, p.380. After giving examples of Gunther's inaccurate editing of the later diary, Andrade wrote

> The few examples given are to put the student on his guard against accepting this production as a transcript. He might wonder, for example, why on May 6, 1693, Hooke received one guinea for a "view", instead of the usual half-guinea; the reason is that Dr. Gunther has dropped a 2.

32. Batten, M.I. "A Partner with Wren - Discoveries in a Diary - The Unrecognised Hooke" in *The Times*, Thursday 14 February 1935 pp.13&14, with a picture on p.16 of the Church at Willen, Buckinghamshire, formerly believed to have been designed by Wren, but now attributed by Batten to Hooke. In *The Times* p.15 on the following day, a letter from J.L. Douthwaite, the Guildhall Librarian, announced

> permission has now been given to the Royal Society to arrange for the editing

and publication of the diary at an early date.

but editorial work on the diary had by then been in progress for seven years (*Diary* (R&A) p.v). Douthwaite's letter shows that Batten's newspaper article had been published before *Diary* (R&A) and was therefore based either on the manuscript in Guildhall Library, or more probably on a pre-publication version of *Diary* (R&A).

33. Batten, M.I. "The architecture of Dr Robert Hooke FRS" *Journal of the Walpole Society* 25 pp.83-113 (1936/7).

34. Stoesser-Johnston, A. *Robert Hooke and Holland: Dutch Influence on Hooke's Architecture* (3 volumes, unpublished Doctoraalscriptie Bouwkunst, Rijksuniversiteit, Utrecht, 1997).

35. Anon. "Tercentenary of Robert Hooke, 1635-1703" *Nature* 13 July 1935 pp.56-57. Although anonymous, payment for this article was made to Smith, E.B. (Izdebska, B. personal communication, 1999). The author quotes Lord Oxford

> There is a peculiar fascination in trying to pierce through the gloom which veils the life-history of some of the most famous of our race.

In the case of Hooke, such fascination shows no sign of diminishing and is no less peculiar.

36. Reddaway, T.F. *The Rebuilding of London After the Great Fire* (London, Jonathan Cape, 1940, reprinted London, Edward Arnold, 1951 with changes to some illustrations).

37. Perks, S. *The History of the Mansion House* (Cambridge University Press, 1922).

38. Reddaway, T.F. *The Rebuilding of London After the Great Fire* (London, Edward Arnold, 1951) p.16.

39. Andrade, E.N.da C. "Robert Hooke", *Proceedings of the Royal Society of London* Series A Vol 201 pp.439-473 (23 May 1950).

40. Andrade, E.N.da C. "Robert Hooke, inventive genius" *The Listener*, 8 February 1951, pp.215-216.

41. Andrade, E.N.da C. "Robert Hooke, 1635-1703" *Nature* 4348 pp.365-367 (28 February 1953).

42. Andrade, E.N.da C. "Robert Hooke, 1635-1703" *Nature* 4348 p.365 (28 February 1953).

43. 'Espinasse, M. *Robert Hooke* (London, Heinemann, 1956) p.v.

44. Bell, W.G. *The Great Fire of London in 1666* (London, Bodley Head, 1923, re-printed as *The Great Fire of London* (London, Bracken Books, 1994).

45. 'Espinasse, M. *Robert Hooke* (London, Heinemann, 1956) p.83.

46. 'Espinasse, M. *Robert Hooke* (London, Heinemann, 1956) p.86.

47. Hunter, M. & Schaffer, S. (eds.) *Robert Hooke New Studies* (Woodbridge, Boydell Press, 1989).

48. Hunter, M. & Schaffer, S. (eds.) *Robert Hooke New Studies* (Woodbridge, Boydell Press, 1989) pp.295-304.

49. Hunter, M. & Schaffer, S. (eds.) *Robert Hooke New Studies* (Woodbridge, Boydell Press, 1989) pp.1-19.

50. Shapin, S. & Schaffer, S. *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life* (Princeton University Press, 1985) stimulated discussion not only on Boyle, but on the origins of scientific authority.

51. Shapin, S. *A Social History of Truth* (Chicago & London, University of Chicago Press, 1994).

52. Shapin, S. "Who was Robert Hooke?" in Hunter, M. & Schaffer, S. (eds.) *Robert Hooke New Studies* (Woodbridge, Boydell Press, 1989) pp.253-285.

53. Shapin, S. "Who was Robert Hooke?" in Hunter, M. & Schaffer, S. (eds.) *Robert Hooke New Studies*, (Woodbridge, Boydell Press, 1989) p.256.

54. Shapin, S. "Who was Robert Hooke?" in Hunter, M. & Schaffer, S. (eds.) *Robert Hooke New Studies*, (Woodbridge, Boydell Press, 1989) p.285.

55. Shapin, S. "Who was Robert Hooke?" in Hunter, M. & Schaffer, S. (eds.) *Robert Hooke New Studies*, (Woodbridge, Boydell Press, 1989) p.253.

56. Shapin, S. "Who was Robert Hooke?" in Hunter, M. & Schaffer, S. (eds.) *Robert Hooke New Studies*, (Woodbridge, Boydell Press, 1989) p.255.

57. Iliffe, R. "Material doubts: Hooke, artisan culture and the exchange of information in 1670s London" *British Journal for the History of Science* 28 pp.285-318 (1995) is an example.

58. Pumfrey, S. "Ideas above his station: a social study of Hooke's curatorship of experiments" *History of Science* 29 pp.1-44 (1991). Pumfrey's statement

> However, while Shapin [in "Who was Robert Hooke?"] primarily investigates Hooke's relations with the Honourable Robert Boyle, mine is a parallel study of his dealings with the Royal Society.

could be taken to be applicable to the intention of this dissertation in relation to Hooke's work as Surveyor.

59. Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) pp.1-2.

60. Wallis wrote two accounts of these early meetings, one in 1678 and the other in 1697. Each in different ways implies that the meetings had been taking place before 1645, possibly before Wallis took part. For a full discussion of the origins of the Royal Society and references to contemporary accounts see McKie, D. "The origins and foundation of the Royal Society of London" in Hartley, H. (ed.) *The Royal Society its Origins and Founders* (London, Royal Society, 1960) pp.1-37.

61. Barnett, P.R. *Theodore Haak, F.R.S. (1605-1690)* ('s-Gravenhage, Mouton & Co., 1962).

62. McKie, D. "The origins and foundation of the Royal Society of London" in Hartley, H. (ed.) *The Royal Society its Origins and Founders* (London, Royal Society, 1960) p.23.

63. Waller, R. "The life of Dr Robert Hooke" in Waller, R. (ed.) *The Posthumous Works of Robert Hooke* (London, 1705) p.iii.

64. Waller, R. "The life of Dr Robert Hooke" in Waller, R. (ed.) *The Posthumous Works of Robert Hooke* (London, 1705) pp.iii-iv.

65. The common, but erroneous, belief that Hooke invented the anchor escapement, and other matters relating to his longitude timepiece, are discussed by Hall, A.R. "Robert Hooke and Horology" *Notes and Records of the Royal Society of London* 8(2) pp.167-177 (1951) and further by Wright, M. "Robert Hooke's longitude timekeeper" in Hunter, M. & Schaffer, S. (eds.) *Robert Hooke New Studies* (Woodbridge, Boydell Press, 1989) pp.63-118.

66. This was probably a wheel barometer made by Hooke when he was working for Boyle at Oxford around 1659. Boyle found that atmospheric pressure varied with time, but was unrelated to the phases of the moon (Derham, W. (ed.) *Philosophical Experiments and Observations* (London, 1726) p.1). This matter is also discussed by Bennett, J.A. *The Mathematical Science of Christopher Wren* (Cambridge, 1982) pp.83-85, who points out that Hooke's wheel device for recording small changes in the height of a column of mercury was, according to Boyle, derived from Wren's earlier use of a similar mechanism in his weather-glass.

67. Davis, E.B. "'Parcere nominibus': Boyle, Hooke and the rhetorical interpretation of Descartes" in Hunter, M. (ed.) *Robert Boyle Reconsidered* (Cambridge University Press, 1994) Chapter 10, pp.157-175.

68. Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) p.21.

69. The full title is *An Attempt for the Explication of the Phenomena Observable in an Experiment published by the Honourable Robert Boyle, Esq; in the XXXV Experiment of his Epistolical Discourse touching the Aire in Confirmation of a former Conjecture made by R.H.* (London, 1661).

70. Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) p.21.

71. Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) p.123.

72. Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) p.124. The record by Birch immediately following the one cited shows that Lord Brouncker, President of the Royal Society, did not intend to pass all responsibility for experimental demonstrations to Hooke. The President let it be known that he (Brouncker) would be curator of the experiment to find what "force" is required to raise one pound through one foot in one second.

73. RS CM(C) I p.6, dated 20 May 1663.

74. At its meeting on 3 June 1663

> Mr Hook was Elected a Fellow of the Society by the Council, and Exempted from all Charges.

RS CM(C) I p.11 and Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) p.250.

75. Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) p.125.

76. Pumfrey, S. "Ideas above his station: a social study of Hooke's curatorship of experiments" *History of Science* 29 pp.1-44 (1991).

77. See MC GR, passim. In particular MC GR III p.178 dated 8 October 1675 records that members of the Joint Committee had visited the College and found that "some persons" had built coach houses in the stable yard which denied Professors their rights of access. The Joint Committee suspected that the Professors were not meeting their obligations. Further investigations showed that only two of the seven Professors (Hooke and John Mapletoft, who succeeded Jonathan Goddard as Professor of Physic) actually lived in their rooms. The other five lived elsewhere and leased their accommodation. All except Mapletoft also leased their stabling. Hooke's stable was used by a Mr Sutton who lived in the lodgings of Henry Jenkes, Professor of Rhetoric. A Mr Crispe, the occupant of the lodgings and stables assigned to Roger Meredith, Professor of Law had gone so far as to turn the stables and hay room into a hall and kitchen with a door and steps leading down into Broad Street which he used as his private entrance. The Joint Committee ordered him to close up the entrance he had made, but gave no instructions about removing his hall and kitchen. Sir Andrew King occupied the

stables belonging to Walter Pope, Professor of Astronomy, and was found to be using some of the public rooms in the College as his own lodgings (MC GR III pp.182-3). The Joint Committee's response to this gross abuse of Gresham College was to order two of its members (Sir Nathaniel Hearne, City Side and Thomas Papillon, Mercers' Side) to inspect the rules for regulating the actions of the Professors, but nothing seems to have been done to rectify the abuses. Hearne and Papillon presented their report to the Joint Committee when it met at Gresham College on 16 July 1677 (MC GR III p199) but the report is not transcribed. The Joint Committee decided to consider the report at its next meeting, but records of the next three meetings (12 November 1677, 8 December 1677 and 19 March 1678) make no mention of it, nor is any action against the Professors recorded. Successful action under the terms of Gresham's Will was likely to be difficult to achieve and certainly time-consuming. At that time, the Joint Committee was far more concerned with collecting the arrears of rent from the Royal Exchange lessees which placed in jeopardy the future of the College itself.

78. MC GR 1626-1669 p.180.

79. In his preface to *Micrographia* (London, 1665) Hooke wrote

> By the help of [astronomical telescopes, the Ancients] have been very much outdone by the famous Galileo, Hevelius, Zulichem [Huygens]; and our own Countrymen, Mr Rook, Doctor Wren, and the great Ornament of our Church and Nation, the Lord Bishop of Exeter [Seth Ward].

80. MC GR 1626-1669 p.208.

81. MC GR 1626-1669 p.209.

82. RS CM(C)I p.44, dated 7 December 1663 records that Hooke was given the responsibility for preparing the Royal Society's experiments to be performed before the King and that he

> should be invited to lodge in Gresham College foure dayes of the Weeke, viz, Mondayes, Tuesdayes, Wednesdayes & Thursdayes; and that a Convenient Lodging should be provided for him, & he [be] allowed Twenty Shillings a Week for that time. Mr Hook was called in hereupon, and this proposition being made to him, he accepted thereof.

Hooke was then ordered to attend the Society's Council every Monday and report on the success of the experiments.

83. RS CM(C) I p.83, dated 27 July 1664 records that Hooke was ordered forthwith to provide himself with lodgings in or near Gresham College. He is unlikely to have moved there the previous December; the preparation of experiments for the King had lost its urgency and it is not certain that the King actually visited the Society in Gresham College.

84. Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) p.187 footnote1 cites a letter from Hooke to Boyle dated 6 October 1664 in which Hooke writes that he had "been full five weeks settled there."

85. Ward, J. *The Lives of the Professors of Gresham College* (London, 1740) p.169.

86. MC GR 1626-1669 p.215, dated 20 May 1664. This is the earliest found occurrence of Hooke's name in the Gresham Repertories.

87. RS CM(C) I pp. 78-79, dated 8 June 1664. Wallis, Colwall and Palmer were nominated to look into the matter, but Wilkins, not Wallis was one of the three according to Birch, T. *The History of the Royal Society of London Volume I* (London,1756) p.435.

88. MC GR 1626-1669 p.217, dated 20 March 1665.

89. CLRO Jor.45 ff.388^{v}-389^{v} (where the date of the meeting of the Court of Common Council is given as 6 May 1664, not 7 May as recorded in MC GR 1626-1669 p.217). The Court of Common Council nominated twelve of its members to be a Committee (until the first meeting of the Court of Common Council after 25 December 1664) for deciding on matters relating to Gresham College on its behalf. The twelve who were nominated were the nine whose votes were reported in MC GR 1626-1669 p.217 and three others: Alderman Sir Richard Reeves, Deputy Nodes and Arthur Ingram. The fact that not all twelve were at the meeting of the City Side on 20 May 1664 was not important because any five or more of the nominees could constitute the City Side. Sir Anthony Bateman was not amongst those nominated by the Court of Common Council.

90. MC GR 1626-1669 pp.217-218.

91. Adamson, I. *Foundation and Early History of Gresham College, London, 1596-1704* (unpublished PhD dissertation, University of Cambridge, 1975) p.220.

92. Adamson, I. "The Royal Society and Gresham College 1660-1711" *Notes and Records of the Royal Society of London* 33(1) pp.1-21 (1978).

93. Ward, J. *Lives of the Professors of Gresham College* (London, 1740) p.169.

94. Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) p.187 footnote1.

95. CLRO Rep.71 f.168$^{r\&v}$.

96. CLRO Rep.71 ff.168^{v}-169^{v}.

97. CLRO Rep.71 f.170^{r}, dated 7 September 1666. Dr Thomas Horton was Gresham Professor of Divinity from 1641 until June 1661. He married in 1651, but obtained a dispensation from Parliament to allow him to retain his Gresham Professorship. The dispensation was renewed by Cromwell and by Charles II, but

revoked by the King at the instigation of George Gifford who succeeded Horton on 7 June 1661. Horton was Vicar of the Church of St Helen Bishopsgate at the time of the Fire (Ward, J. *Lives of the Professors of Gresham College* (London, 1740) pp.65-72).

98. CLRO Rep.71 f.171^{r}, dated 8 September 1666.

99. Rasmussen, S.E. *London: The Unique City* (Cambridge Mass. & London, MIT Press, 1934, revised edition, 1982).

100. MC GR 1626-69 pp.217-218.

101. CLRO Rep.71 ff.167^{v} & 168^{r}, dated 6th September 1666. This was the first meeting of the Court of Aldermen after the Fire.

102. Birch, T. *The History of the Royal Society of London Volume II* (London,1756) pp.113-4, entry for 12 September 1666.

103. Birch, T. *The History of the Royal Society of London Volume II* (London,1756) p.115, entry for 19 September 1666. Lord Brouncker could not have known how useful to the City Hooke would be.

104. Waller, R. "The Life of Dr. Robert Hooke" in Waller, R. (ed.) *The Posthumous Works of Robert Hooke* (London, 1704) pp.xii-xiii.

105. Reddaway, T.F. *The Rebuilding of London after the Great Fire* (London, Edward Arnold, 1951) p.53.

106. A hand coloured copy of Doornick's print in Guildhall Library, London shows in its top left-hand corner a rather crude and only partial layout plan entitled "NIEW MODELL om de afgebrande Stadt LONDON te HERBOUWEN." It is unattributed. The main illustration in the print is a plan of the City of London and its environs showing the burnt area of the city. In Howgego, J.L. *Printed Maps of London circa 1553-1850, Second Edition* (Folkestone, Dawson, 1978) Doornick's print appears as No.17.

107. A copy of Venckel's print in Guildhall Library, London is No.24 in Howgego, J.L. *Printed Maps of London circa 1553-1850, Second Edition* (Folkestone, Dawson, 1978). The main illustration in the print is a plan of the City of London and its environs, showing the burnt area of the city. The layout plan is in the same position and has the same title as the one in Doornick's print published the preceding year, but Venckel's is shown in its entirety and not truncated as in Doornick's.

108. In Howgego, J.L. *Printed Maps of London circa 1553-1850, Second Edition* (Folkestone, Dawson, 1978) p.57 Venckel's layout plan is described as "Hooke's plan for rebuilding the city." No reason for or explanation of such an attribution is given. Despite the close similarity between this layout plan and the one in

Doornick's 1666 print which Howgego also lists, the former is not attributed to Hooke by Howgego. However, another print (anonymous and bearing no date) very similar to Doornick's 1666 print and with a similar layout plan, but uncoloured, appears as No. 25 in Howgego (ibid.) where the layout plan is described as Hooke's and the print dated 1670.

109. An illustration of what is probably the layout plan in Doornick's 1666 print is said to be Hooke's, but no evidence for the claim is put foward (Porter, S. *The Great Fire of London* (Stroud, Sutton,1996) pp.101-102).

110. London still has no complete land information system.

111. Reddaway, T.F. *The Rebuilding of London After the Great Fire* (London, Edward Arnold, 1951) pp.62-63.

112. Hooke, Mills and Jerman were ordered to represent the City in the survey

> Sir Thomas Adams & others of the Comittee appointed by order of this Court to Attend the Comittee of Lords touching the great Buissinesse of rebuilding the City declaring That they have thereupon attended the right honorable the Lord Chancellour & other Lords of his Majesty's most honorable privy Councell & received from their Lordships his Majesty's pleasure That for the better and more expedition of this worke he hath pleased to appoint Dr Wren Mr May & Mr Pratt to joyne with such Surveyors & Artificers as should be appointed by the City to take an Exact & speedy survey of all Streetes Lanes Aleys houses & places distroyed by the late dismall ffire That every particular Interest may be assertained & provided for & the better Judgment made of the whole Affaire This Court doth therefore Order that Mr Hooke Reader of the Mathematicks in Gresham Collidge Mr Mills and Mr Edward Jermyn do joyne with the said Dr Wren Mr May & Mr Pratt in taking the said Surveigh And that the Deputy & Common Councellmen have notice of the Surveighs when the same shall be taken in every Ward to the End they may be in readinesse to take Care for the Interest of themselves and the Inhabitants of their respective Wards.

CLRO Jor.46 f.123^{r}, dated 4 October 1666. CLRO Misc. Ms. 3.36/7 of the same date is a copy of the order.

113. Variant spellings of his surname (e.g. Jarmin, Jermyn) are found in the CLRO archives and other contemporary manuscripts.

114. These details about Mills and Jerman are given by P.E. Jones & T.F. Reddaway in their Introduction to *The Survey of Building Sites in the City of London After the Great Fire of 1666 by Peter Mills and John Oliver, Volume I, Index to Volumes I to V* (London, LTS, 1967) pp.x-xi.

115. The first of Hooke's experiments on breaking wood took place at the Royal Society on 8 June 1664. The experiments (Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) p.179) were an early example of the

engineering discipline "strength of materials" and Hooke recognised their importance. In a letter to Boyle he states

> Some experiments we made of breaking wood, which were considerable, and gave occasion to hope, that this subject will afford many useful experiments

cited by Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford) 1930, pp.183-185, who dates it 5 July 1664.

116. Hull, D. "Robert Hooke: a fractographic study of Kettering-stone" *Notes and Records of the Royal Society of London* 51(1) pp.45-55 (1997). Hooke's illustration of Kettering-stone for *Micrographia*, published in early 1665, and Wren's use of the material for Pembroke College Chapel (1663-1665) indicate the close personal and professional relationship between the two men began before the Fire.

117. RS CP.xx.29, dated 8 June 1664, which was the day when the Royal Society Council (at a meeting immediately preceding the meeting of the Society when Hooke presented his report on the thunderstorm) heard a report that Dacres's earlier election as Gresham Professor of Geometry in preference to Hooke was irregular.

118. He would later, in a similar manner but for more than scientific curiosity, stand before many ruined buildings, taking evidence from witnesses and report formally on what he heard and saw.

119. MC GR 1626-69 p.257, dated 2 November 1666.

120. The Joint Committee judged that there was some distaste for the work on the part of Mills and Jerman and ordered them to prepare their report by next week, at the same time the Committee

> Ordered that Mr. Hooke by himselfe be againe desired to prepare a Draught and an Estimate of the totall Charge of Rebuilding the Exchainge betweene this and ffryday morneing next and that hee bee made acquainted with the Comittees conception of building the pillars with a Kinde of Marble found in the West Countrey of which they Conceive Sir John ffrederick can give him an Account both of Stone and price thereof.

MC GR 1626-69 pp.258-259.

Mills and Jerman were much older than Hooke and much more experienced at working for the City. They were also in poor health. Hooke's energy, enthusiasm and need to secure an official City appointment and the salary it would bring made close cooperation between him and the other two men highly unlikely.

121. Hooke's report is transcribed

> Upon Examining the ffoundation of the Royall Exchainge and considering the former structure of itt as well as I canne Recollect itt from my memory, and by the helpe of the partes now standing, I doe finde that by makeing a particular Estimate of the severall thinges to bee done in Order to the Rebuilding of itt anew in the same forme as itt was heretofore

> (abateing onely the statues of the Kinges in the Nieches, and the Arched roofe of stone over the walke which I thinke would be better if made a plaistered seeleing whereby all the Crosse irons might be spared) to make the pillars Arches Architrave freez and Cornice, and the Borders of the Nieches and the ffower windowes, of Portland Stone, and to pave the walkes with squared Purbeck stone. That the wholle Charge will amount to betweene ffower and ffive Thousand pounds supposeing all the Matterialls weare to bee new bought but the paveing for the most parte seemes good the pedestalls of all the Pillars are very little damnifyed by the ffyre. There are more than halfe Bricks enough to Rebuild it. There is a greate Quantity of Stone which may bee made use of for makeing the Arches. The Pillars and Arches and fronts at both the Entryes are little hurt. And there is a good Quantity of Lead etc. which lying yet confused I cannot soe readily make an Estimate of.

MC GR 1626-69 pp.262-3.

The quantity of lead was later found to weigh 21 tons (MC GR 1626-69 p.273, dated 28 January 1666/7).

122. The Mercers' record states

> Ordered that a Copy of the Estimate Given in by Mr. Mills and Mr. Jerman of the Charge of rebuilding the Royall Exchainge (the prizes onely excepted) bee delivered to Mr. Hooke, Who is desired to Add prizes thereto or to so much thereof as he shall Conceive necessary for the aforesaid worke att such rates as workemen may bee found willing to agree for to do the work substantially.

MC GR 1626-69 p.269, dated 7 December 1666.

123. MC GR 1626-1669 p.285, dated 15 April 1667.

124. Another possible reason for Hooke no longer being engaged by the Joint Committee to advise on rebuilding may have been his proposal that the new Exchange be rebuilt much as before and that many of the old materials might be re-used, thereby saving on even his own estimate of £4,000 to £5,000 for rebuilding with new materials. The Joint Committee had in mind a much grander Royal Exchange, which it ended up with, but at a total cost of nearly £60,000 - more than ten times Hooke's estimate. Even allowing for increased costs of land, materials, transportation and workmen in response to demand, the final sum is astonishing; the cost of servicing its debt almost bankrupted the Mercers' Company in the following century (Saunders, A. "The Second Exchange" in Saunders, A. (ed.) *The Royal Exchange* (London, LTS, 1997) pp.121-135. Transactions and agreements with workmen extracted from CLRO Jor. (various) are reprinted in Appendices (ibid. pp.416-428).

125. MC GR 1626-1669 p.294, dated 25 April 1667. Hooke was paid £5 (MC RGA 1666-1667 p.13), the Mercers' moiety of £10, soon afterwards at a time when he and Mills were fully engaged staking out the new streets.

126. MC GR 1669-1676 p.171, dated 19 December 1674. Hooke recorded the same day

> at Mercers Committee they instructed about the Pawn that I designed to take it. Ordered I should cook [sic] after the clock and chimes.

Diary (R&A) p.137, dated 19 December 1674.
By this time Hooke's work for the City had declined and he was looking for private commissions; work at the pawn for the Joint Committee may have been one of these, but no details of what he might have done have been found.

127. Roscoe, I. "'The statues of the sovereigns of England': sculpture for the second building, 1695-1831" in Saunders, A. (ed.) *The Royal Exchange* (London, LTS, 1997) p.175. Hooke was paid £7-10s-00d for his care and direction.

128. Reddaway, T.F. *The Rebuilding of London after the Great Fire* (London, Edward Arnold, 1951) p.58.

129. However, Bennett, J.A. *The Mathematical Science of Christopher Wren* (Cambridge University Press, 1982) contains references to Hooke throughout, mainly in connection with Wren's science; he is considered only marginally in the context of Wren's architecture.

130. Reddaway, T.F. *The Rebuilding of London After the Great Fire* (London, Edward Arnold, 1951) pp.63-67.

131. John Leake's compilation dated December 1666 (BL Add. Ms.5415 E.1) from six sheets drawn from surveys by Leake, John Jennings, William Marr, William Leybourn, Thomas Streete and Richard Shortgrave. (The latter was the Royal Society's Operator with whom Hooke worked closely at Gresham College on instruments and apparatus for the Society's meetings until the time of Shortgrave's death in October 1676 (*Diary* (R&A) p.254, entry dated 24-28 October 1676); in *Diary* (R&A) p.517 Robinson and Adams give the name of the Royal Society's Operator as Tom Shortgrave, but Thomas was Richard's son (Taylor, E.G.R. *The Mathematical Practitioners of Tudor & Stuart England* (Cambridge, Institute of Navigation, 1954, p.245) and was employed at the Royal Society by Hooke from time to time after Richard Shortgrave's death). Although no evidence has been found that Hooke undertook any surveying for this map, many examples in the records of the Committee for City Lands of the way Hooke worked with Leybourn and Shortgrave - and, from *Diary* (R&A), with Leake in private practice - lead to the conclusion that Hooke had much to do with the appointment, organisation and supervision of the six surveyors.

132. An engraving by Wenceslaus Hollar based on this map was published in April 1667. It is reproduced in Fisher, J. *A Collection of Early Maps of London 1553-1667* (Lympne, Harry Margery, 1981) pp.20-21.

133. CLRO Jor.46 f.129^{r}, dated 31 October 1666.

134. Birch, T. *The History of the Royal Society of London Volume II* (London,1756) p.119, entry for 31 October 1666.

135. "An Act for the Rebuilding of the City of London" 18 & 19 Charles II, c.8.

136. CLRO Jor.46 f.146^{v}, dated 25 February 1667.

137. This map was probably a version of John Leake's manuscript compilation (BL Add. Ms.5415 E.1) from the six surveyors' original sheets. It shows the proposed widths of streets and intended new works such as King Street and the Fleet Channel. The original six manuscripts have not survived.

138. CLRO Jor.46 f.147^{v}, dated 13 March 1667.

139. CLRO Jor.46 ff.151^{r}-152^{r}, dated 29 April 1667. Two hundred copies were printed by James Flesher, the City's Printer (CLRO PD 10.54(L)).

140. CLRO Jor.46 f.148^{r}, dated 13 March 1667.

141. CLRO Jor.46 f.147^{r}, dated 27 February 1667.

142. CLRO Rep.72 f.80^{v}, dated 14 March 1667.

143. CLRO Rep.72 f.81^{v}, dated 20 March 1667. Hooke mentioned in passing to the Royal Society at its meeting on the following day (Birch, T. *The History of the Royal Society of London Volume II* (London,1756), p.160) that because the air had been for a good while so thick about London he had not been able to see the new star "in collo Ceti" or the other "in cingulo Andromedae", a typical example of his incessant interest in and observation of all things around him, whether amidst the rubble on the streets or in the heavens.

144. Peter Mills wrote in his survey book:

> Wee began to stake out the streets in ffleet street the the 27th. of March 1667.

GL Ms.84.1 f.22^{r}, reproduced in *The Survey of Building Sites in the City of London after the Great Fire of 1666 Volume II* (London, LTS, 1964).

145. CLRO Ex-GL Ms.322/3

146. CLRO Ex-GL Ms.322/9 is the latest account of the Clerk of Works for expenses incurred in staking out the streets that has been found. It is for the seven days ending Monday 26 May 1667. Only 280 feet of timber were needed and the cart was used for only two of the seven days.

147. The person responsible for the rebuilding could be for example a lessee, tenant or landowner.

148. CLRO Jor.46 ff.151^{r}-152^{r}, dated 29 April 1667. Two hundred copies were printed by James Flesher, the City's Printer (CLRO PD 10.54(L)).

149. CLRO Ex-GL Mss.275-8 are three Day Books (Mss.275-277) and one Posting Book (Ms.278). The Posting Book lists the dates, builders' names, numbers of foundations and sums paid, classified according to the locations; entries seem to have ceased in September 1679.

150. GL Ms. 84.1 ff.16-18, reproduced in *The Survey of Building Sites in the City of London after the Great Fire of 1666 Volume II* (London, LTS, 1964) show entries in Mills's survey books of surveys by Hooke and Oliver. Only transcripts of the original survey books are available, so it is not possible to see whether other entries in Mills' books are not in his hand.

151. CLRO Rep.73 f.62^{r}, dated 28 January 1668.

152. GL Ms.84.2 f.86^{v}, reproduced in *The Survey of Building Sites in the City of London after the Great Fire of 1666 Volume III* (London, LTS, 1962).

153. CLRO Ex-GL Ms.276 f.86^{v} bears the signature of one of Mills's Executors for receiving Mills's quarter salary due at Michaelmas 1670. The date of the signature is 7 October 1670.

154. GL Mss.84.1 & 84.2 are two volumes of transcripts of Mills' ten survey books and GL Mss.84.3 & 84.4 are transcripts of Oliver's. GL Ms. 84.5 is an index to the other four volumes.

155. *The Survey of Building Sites in the City of London after the Great Fire of 1666*, by Peter Mills and John Oliver was published by the London Topographical Society (LTS) in five Volumes: *Volume I, Index to Volumes I to V*, with an Introduction by Jones, P.E. and Reddaway, T.F. LTS 103 (1967); *Volume II, Mills' Survey Volume 1 of the Manuscript*, LTS 101 replacing LTS 79 & 89 (1964); *Volume III, Mills' Survey Volume 2 of the Manuscript*, LTS 97 (1962); *Volume IV, Oliver's Survey Volume 1 of the Manuscript*, LTS 98 (1962); and *Volume V, Oliver's Survey Volume 2 of the Manuscript*, LTS 99 (1962).

156. Hooke's diary entry for 7 November 1677 includes
> with committee of City Lands all the afternoon till almost 7 at night, they enquired concerning my books and concerning Certificatts, would have my books Deliverd.

Diary (R&A) p.326.

157. CLRO Ex-GL Ms.277 f.3^{r}.

158. *Diary* (R&A) p.36, dated 27 March 1673.

159. On the last folio$^{(v)}$ in the second Day Book (CLRO Ex-GL Ms.276, un-numbered folios) is a note, presumably a clerk's aide mémoire

> South side of Austens gate to the Thames Mr Oliver & so to Temple Barre the North side of Austens gate to Mr Hooke & from Thence to Temple Barre dividinge Ludgate Streete & Paules Churchyarde & Fleetstreet

which is a description of the general areas allocated to Hooke and Oliver following Mills's death.

160. *The Survey of the Building Sites in the City of London after the Great Fire of 1666 Volume I* (London, LTS, 1967) p.xviii.

161.

Table 1.
Estimated number of foundations surveyed by Hooke in each year

Year	1667	1668	1669	1670	1671	1672	1673	1674
No.	347†	778	720	440	369	136	59	43

Year	1675	1676	1677	1678	1679	1680	1681	1682/96
No.	39	15	8	3	5	8	3	22

† Beginning in May.

162.

Table 2.
The (non-zero) frequencies of Hooke's multiple foundation surveys

Number of foundations	2	3	4	5	6	7	8	9	13	20
frequency	142	29	18	11	4	1	1	1	1	1

163. Cooper, M.A.R. "Robert Hooke's work as Surveyor for the City of London in the aftermath of the Great Fire. Part 1: Robert Hooke's first surveys for the City of London" *Notes and Records of the Royal Society of London* 51(2) pp.161-174 (1997).

164. CLRO CLCO I f.1(a)^{r} & CLRO Jor.46 f.209^{r}, both dated 22 January 1668. Each of the first three folios of CLCO bears the number "1" so they are differentiated here by 1(a), 1(b) and 1(c) respectively.

165. 18 & 19 Charles II, c.8 of 8 February 1667 and 22 Charles II, c.11 of 11 April 1670.

166. The Foundation Cash was money paid into the City Chamber by those who intended to rebuild after the Fire. Before rebuilding could start, the sum of 6s 8d for each foundation had to be paid, whereupon a City Surveyor carried out a survey of the foundation and issued a certificate to the person or corporate body intending to rebuild. Surveyors' salaries were paid from the Foundation Cash. See Section 3.1.

167. CLRO Jor.46 f.209^{r}, dated 22 January 1668.

168. The Fire Court was set up by the Parliamentary Act of 8th February 1667 and started work only 19 days later. Its purpose was primarily to settle disputes between landowners, tenants, under-tenants and occupiers of buildings as a consequence of rebuilding after the Fire, for example an occupier claiming a reduction in rent as a consequence of losing living space, the owner having received compensation for loss of ground. See Reddaway, T.F. *The Rebuilding of London After the Great Fire* (London, Jonathan Cape, 1940) and Jones, P.E. *The Fire Court Volumes I & II* (London, The Corporation of London, 1966 & 1970 respectively).

169. Jones, P.E. *The Fire Court Volume I* (London, The Corporation of London, 1966) pp.42-44.

170. CLRO CD Box K contains bundles of manuscripts, mainly certificates by the City Surveyors (Peter Mills, Robert Hooke & John Oliver) stating the areas of ground taken by the City for such purposes as widening streets, enlarging Fleet Ditch and making quays along the Thames. A bundle is identified by the initial letter of the surname of the person or of the corporate body to whom the certificate was issued and who is seeking compensation for loss of ground. So, for example, a particular reference denoted by CLRO CD Box K F/37 means Ms. 37 in bundle F of Box K of the Comptroller's Deeds in the Corporation of London Record Office.

171. CLRO NGICR ff.27-39 gives a list of certificates arranged alphabetically in the same way as the bundles in CLRO CD Box K are arranged. The certificate CLRO CD Box K F/37 corresponds to the entry CLRO NGICR F/37.

172. Cooper, M.A.R. "Robert Hooke's work as Surveyor for the City of London in the aftermath of the Great Fire. Part 1: Robert Hooke's first surveys for the City of London" *Notes and Records of the Royal Society of London* 51(2) pp.1-15 (1997) and Section 3.1 above.

173. CLRO CLCO I f.1(b)^{r}, dated 4 March 1668, is an order for payment. An entry in the Coal Duty accounts (CLRO CDAB 5 f.43^{r}) shows that Hoddilow was paid £600 on 19 March 1668.

174. CLRO Jor.46 f.219^{v}, dated 18 March 1668.

175. CLRO NGICR f.36^{v} and CLRO CD Box K S/1.

176. CLRO CD Box K H/7$^{A\&B}$, dated 16 July 1668.

177. CLRO NGICR H/72, dated 11 March 1687.

178.

Table 3.
The number of area certificates issued by Hooke

Year	1668	1669	1670	1671	1672	1673	1674	1675
No.	9	26	36	94	43	45	26	9

Year	1676	1677	1678	1679	1680	1681	1682	1683-87
No.	9	10	1	3	2	4	2	4

Data compiled from CLRO NGICR ff.27-39 and Hooke's certificates in CLRO CD Box K. Some of these certificates refer to 11 others previously issued by him, but now neither listed in the NGICR nor found in the CD Box K. Evidence from *Diary* (R&A) passim and from bonds in NGICR and CD Box K that Hooke probably wrote a few more certificates than are summarised here, has not been used in compiling the table.

179. *Diary* (R&A) p.26.

180. CLRO CD Box K L/17, dated 3 February 1673.

181. CLRO CD Box K C/49, dated 3 February 1673. This certificate is incorrectly dated 1672 in the CLRO NGICR list of certificates.

182. This does not mean that no record of it exists. Searches have been made not only of the records already referred to (CLRO CD Box K and NGICR) but also of CLRO CDAB Volume 5. These books record payments made from the Coal Monies. If Hauslope had lost land, and compensation at six months was paid to him, one would expect to find a record of it in this document, but no relevant entry at or around the expected date has been found. Payment may have been delayed, or Hauslop may have assigned his warrant to another.

183. *Diary* (R&A) p.152, dated 9 March 1675. Unusually, the entry is almost verbose:
> Sent Mr. Hauslope by the hand of Mr Hammond 18sh for 1 Load of Coales. Mr. Hammond gave me his acquittance in full.

184. *Diary* (R&A) p.26, dated 1 February 1673.

185. Cooper, M.A.R. "Robert Hooke's work as Surveyor for the City of London in the aftermath of the Great Fire. Part 1: Robert Hooke's first surveys for the City of London" *Notes and Records of the Royal Society of London* 51(2) pp.161-174 (1997), where it is erroneously stated (p.170) that Hooke's annual salary from the City was £175.

186. CLRO CD Box K K/6, dated 1 December 1670.

187. CLRO CD Box K M/37[A], dated 1 September (Saturday) and 9 October 1677. Hooke, suffering badly from diarrhoea since eating three bunches of grapes at Lady Ranelagh's a week earlier, probably wrote the first part of this certificate in the Sun Tavern on his way from Fish Street Hill to Gresham College. He there worked on a mount for a telescope eyepiece and transcribed part of a letter from Leibniz before going out to Jonathan's Coffee House in Exchange Alley where he met John Aubrey and others. After measuring the ground for the second part of this certificate in the morning, Hooke was occupied for the rest of the day in various places with different groups of Fellows of the Royal Society, discussing and planning the election of a new President (*Diary* (R&A) pp.308-319).

188. CLRO CD Box K M/42[A], dated 11 November 1671.

189. *The Survey of Building Sites in the City of London after the Great Fire of 1666*, by Peter Mills and John Oliver was published by the LTS in five Volumes: *Volume I Index to Volumes I to V* Introduction by P. E. Jones and T. F. Reddaway (London, LTS, 1967); *Volume II Mills' Survey Volume 1 of the Manuscript* (London, LTS, 1964); *Volume III Mills' Survey Volume 2 of the Manuscript* (London, LTS, 1962); *Volume IV Oliver's Survey Volume 1 of the Manuscript* (London, LTS, 1962); and *Volume V Oliver's Survey Volume 2 of the Manuscript* (London, LTS, 1962).

190. CLRO CD Box K B/65. This is a copy dated 18 December 1672 of a certificate which Hooke issued to a Mr Thomas Browne because the original was lost. It is written and signed by Hooke and starts

> I doe hereby certify that I find by my survey book that I did upon the 8th of Feb: 1668/9 make a certificat

The certificate referred to was not a foundation certificate, but certified the area of land taken from a foundation for widening the street. On the day before the date of the copy certificate, Hooke noted in his diary

> from Thomas Brown 5s.

Diary (R&A) p.16.

191. GL Ms.1758. This is the manuscript used for *Diary* (R&A) which begins with the entry for 1 August 1672.

192. CLRO CD Box K F/31, dated 10 November 1675.

193. CLRO CD Box K H/28, dated 16 May 1671.

194. CLRO CD Box K F/31, dated 10 November 1675.

195. CLRO CD Box K M/22, dated 9 November 1671.

196. CLRO CD Box K D/18, dated 14 December 1671.

197. CLRO CD Box K V/5^{A}, dated 2 March 1676. CLRO CD Box K V/5^{B} is a copy, certified by the Comptroller, Joseph Lane, of the entry in Mills's survey book (published as *The Survey of Building Sites in the City of London after the Great Fire III* (London, LTS, 1962)) f.114^{v} on which Hooke based his calculation of area.

198. CLRO CD Box K S/41, dated 12 July 1672.

199. CLRO CD Box K H/26, dated 6 April 1671.

200. CLRO CD Box K W/25^{A}, dated 31 January 1671.

201. CLRO CD Box K W/46, dated 15 December 1676.

202. The linear dimensions in both certificates are: breadth north-south 20ft 9in; depths 6ft 10in at the south and 5ft at the north. The area is therefore given by 20ft 9in × 5ft 11in, which is 123.1ft superficial content, to the nearest 0.1 in duodecimal notation. In the earlier certificate (CLRO CD Box K W/25^{A}) Hooke gives the area as 121.3ft superficial content; in the later (CLRO CD Box K W/46) it is given as 122 ft superficial content. This example shows the usual slight underestimate of an area through rounding errors in arithmetic. Perhaps rounding-down was deliberate; any error arising from the assumptions about orthogonality of adjacent boundary lines would make the calculated area too large. In any case, the methods sufficed.

203. CLRO CD Box K M/5, dated 19 June 1669.

204. CLRO CD Box K W/34^{A}, dated 5 December 1671.

205. CLRO CD Box K W/34^{B}, dated 27 January 1672.

206. CLRO CD Box K P/25^{A}, dated 11 November 1673.

207. CLRO CD Box K W/45, dated 26 March 1674.

208. From a contemporary manuscript cited by Beaven, A.B. *The Aldermen of the City of London Volume II* (London, The Corporation of London, 1913) p.188.

209. CLRO CD Box K H/42, dated 17 December 1672.

210. CLRO CD Box K M/24, dated 14 November 1671.

211. CLRO CD Box K B/71, dated 4 November 1673.

212. For example, in preliminaries (p.xxiv) to Hooke's *Diary* (R&A) Robinson and Adams use "views" in connection with foundation surveys and certifications of ground lost. Even 'Espinasse departs from her usual accuracy when she describes
> personal surveys ... of hundreds of sites which were to be built on

as "views" ('Espinasse, M. *Robert Hooke* (London, Heinemann, 1956) p.86).

213. *Diary* (R&A) and *Diary* (G).

214. Loengard, J.S. *London Viewers and their Certificates, 1508-1558* (London, London Record Society, 1989).

215. Although all four were chosen, Mills and Hooke were sworn as Surveyors on 14 March 1667 and Oliver on 28 January 1668. Jerman did not accept the appointment and Mills died in 1670. Thereafter Hooke and Oliver shared the duties of City Surveyor.

216. *The Survey of Building Sites in the City of London After the Great Fire of 1666 by Peter Mills and John Oliver Volume 1, Index to Volumes 1-5*, with an Introduction by Jones, P.E. & Reddaway, T.F. (London, LTS, 1967) pp.x-xi.

217. *The Survey of Building Sites in the City of London After the Great Fire of 1666 by Peter Mills and John Oliver Volume 1, Index to Volumes 1-5*, with an Introduction by Jones, P.E. & Reddaway, T.F. (London, LTS, 1967) p.xxxi. On 23 February 1677 a John Oliver, Glazier, received £61-03s-00d from the City for 1631 foot of extraordinary work at Bow Church @ 9d per foot (GL Ms.25,539 Vol.2 f.88^{v}). This probably refers to the City Surveyor John Oliver.

218. 18 & 19 Charles II, c.8 of 8th February 1667 and 22 Charles II, c.11 of 11th April 1670.

219. Cooper, M.A.R. "Robert Hooke's work as Surveyor for the City of London in the aftermath of the Great Fire. Part 1: Robert Hooke's first surveys for the City of London", *Notes and Records of the Royal Society of London* 51(2) pp.161-174 (1997).

220. Cooper, M.A.R. "Robert Hooke's work as Surveyor for the City of London in the aftermath of the Great Fire. Part 2: certification of areas of ground taken away for streets and other new works" *Notes and Records of the Royal Society of London* 52(1) pp.25-38 (1998).

221. CLRO Rep.73 f.223^{r} dated 7 July 1668.

222. CLRO CLCO I f.1(c)^{r} dated 10 May 1668.

223. CLRO Misc. Mss. Boxes 92 and 93.

224. CLRO VR I, II and III.

225. *Diary* (R&A) & *Diary* (G).

226. CLRO VR I.1 dated 13 March 1668, copied in CLRO Rep.73 ff.97^{v}-98^{v} where it is also recorded that the Court of Aldermen accepted the Viewers' recommendations and ordered them to be carried out. Although the report of this view was the first to be transcribed in the three extant volumes of Viewers' reports in the CLRO, it was not the first to be undertaken by Hooke for the City. On 7 November 1667 Mills and Hooke were ordered to view and report on a dispute near Basing Lane between Nailor and Beane (CLRO Rep.73 ff.3^{r}). Their report was accepted by the Court of Aldermen who found against Beane (ibid. f.10$^{r\&v}$ dated 12 November 1667). Beane appealed against this decision and requested the Alderman and Deputy of the ward to arbitrate (ibid. f.12^{v} dated 12 November 1667). It was normal for the Viewers' report and recommendations to be accepted and ordered by the Court of Aldermen. From time to time (particularly in the early days of rebuilding when the Surveyors had just started to view) the losing party in the dispute would appeal against the decision of the Court of Aldermen. The Alderman and Deputy of the ward would then re-view and report, nearly always finding in accordance with the original report. As rebuilding proceeded the inhabitants generally accepted the decisions of the Court of Aldermen which in turn were based on the recommendations of Hooke and the other Surveyors.

227. CLRO VR I.264

228. CLRO Misc. Mss. 92.19.

229. *Diary* (R&A) p.23, dated 21 January 1673.

230. *Diary* (R&A) p.20 dated 8 January 1673.

231.

Table 4.
Estimated number of views by Hooke

Year	1668	1669	1670	1671	1672	1673	1674	1675
No.	47†	76	114	127‡	9¶	82#	27§	19

Year	1676	1677	1678	1679	1680	1681	1682	1683-93
No.	5	14	4	7	1	8	4	48¶

Derived from CLRO VR I, II & III, CLRO Misc. Mss. Boxes 92 & 93 and *Diary* (R&A) pp.18-78.

† Hooke's views started 13 March 1668.
‡ Annual total shown is proportional to the number of Hooke's views found in CLRO VR I for 1 January - 10 February. The actual total for the year is probably higher because the rate of rebuilding (and of complaints) increased during the summer months.
¶ No entries in CLRO VR I, II or III; meagre specific diary entries not included.
# No entries in CLRO VR I, II or III.
§ Annual total shown is proportional to the number of Hooke's views found in CLRO VR II for 6 November - 31 December. The actual total is probably higher for the reason stated at ‡ above.
[Range of the 10 annual totals: 1 to 10. No evidence has been found of a view by Hooke after the end of 1693.
The absence of adequate archival and other evidence for the year 1672 means it is necessary to find another method for estimating the number of views made by Hooke in that year. It is reasonable to assume that the demand for views was correlated with the demand for foundation certificates, but delayed by two years. In that case, it is possible to apply the temporal distribution of the number of foundation certificates in Table 1 (advanced by two years) to the data in Table 4 (except for the year 1672) and to calculate the number of views undertaken by Hooke in 1672 using simplified least squares estimation. The result of this statistical process is that 83 (±10) views were made by Hooke in 1672 so the total made before the end of 1674 is increased from the value of 482 in Table 4 to 556.

232. Jones, P. E. *The Fire Court Volume I* (London, The Corporation of London, 1966) pp.42-44.

233. CLRO CLC M(R) dated 31 March 1669. At the same meeting, Hooke was ordered to assist the Committee to set out piles and stairs at Temple Lane and measure some ground. Similar orders are found throughout the Minutes and Papers of this Committee.

234. See Reddaway, T. F. *The Rebuilding of London After the Great Fire* (London, Edward Arnold, 1951) Chapter VIII pp.200-243 for descriptions of the great problems encountered in these projects by Hooke and Wren.

235. On 9 July 1668 Robert Rawlins, Eldest (first) Clerk in the Utter (Mayor's) Court was ordered to

> attend the Surveyors of new buildings in their Views upon any differences arising between parties and draw up & enter the same as he used to do of the Views of the City's Common Viewers.

CLRO Rep.73 ff.225$^{r\&v}$.

236. See for example CLRO Misc. Mss.92.62 dated 29 April 1671, 92.170 dated 5 December 1673 and 93.14 dated 14 July 1677.

237. CLRO CLCP Ms.67 dated 6 February 1673.

238. CLRO Misc. Ms.92.73 dated 8 July 1671.

239. CLRO Misc. Ms.93.108 & VR III.37 dated 14 June 1686.

240. CLRO VR I.49 dated 30 December 1668.

241. CLRO VR I.19 dated 13June 1668.

242. CLRO Misc. Ms.92.81 dated 30 August 1671.

243. CLRO Misc. Ms.93.129 dated 6 November 1691. Hooke was unaccompanied on the view. Only two other reports have been found where Hooke alone viewed and reported: VR III.103 & 105.

244. CLRO Misc. Mss.93.77 & 93.78 dated 6 May 1693. Hooke's last manuscript report found in the CLRO is dated 14 December 1693 (CLRO Misc. Ms.93.79).

245. One golden guinea.

246. Ten shillings presumably, Oliver's share of the money paid to Hooke for the earlier of the two views reported on 6 May 1693, but carried out the previous day.

247. Jonathan's coffee house in Exchange Alley, near the Royal Exchange.

248. *Diary* (G) p.237.

249. Reddaway, T.F. *The Rebuilding of London after the Great Fire* (London, Edward Arnold, 1951) p.215.

250. Reddaway, T.F. *The Rebuilding of London after the Great Fire* (London, Edward Arnold, 1951) Chapter VIII, pp.200-243.

251. CLRO CLCO I f.47^{v}, dated 25 November 1670.

252. CLRO CLCO I f.50^{r}, dated 8 February 1671.

253. The City Lands Committee decided to meet every Wednesday afternoon, each member to be summonsed accordingly, and they

> Ordered that Mr Hook & Mr Oliver fail not to be present at every meeting of this Committee according to the summons given to them in that behalfe.

CLRO CLCO I f.50^{v}, dated 1 March 1671.

At the same meeting, Hooke was ordered to

> attend Dr Wren to obtain the King's directions and approbation for the manner of wharfing on Fleet Ditch, whether with timber brick or stone.

CLRO CLCO I f.51^{r}.

254. Birch, T. *The History of the Royal Society of London Volume III* (London, 1757) p.42.

255. CLRO CLCO I f.54[r&v], dated 22 March 1671.

256. Abundant evidence for these activities can be found in the Orders, Minutes and Papers of the City Lands Committee in the Corporation of London Records Office. Many entries in *Diary* (R&A) show that Hooke's involvement in the Thames waterfront and Fleet Channel took a significant amount of his time and effort in the early 1670s.

257. CLRO CLCP Ms.57 p.1. This report was presented to the City Lands Committee on 20 November 1672.

258. CLRO CLCM(R) for 20 November 1672.

259. *Diary* (R&A) p.125, entry for 7 October 1674. Sir John Lawrence's installation feast was attended by the King and Queen, the French Ambassador, the Lord Chancellor, the second Duke of Buckingham (George Villiers) and others in the King's circle - an unusually grand array of guests at a Lord Mayor's installation. According to John Evelyn, who was present, the feast was said to have cost one thousand pounds (Bell, W.G. *The Great Plague of London* (London, Bodley Head, 1924) p.26) which was about half of Lawrence's annual income at the time of the Fire (Woodhead, J.R. *The Rulers of London 1660-1689* (London, London & Middlesex Archaeological Society, 1965) p.106). Lawrence was a courageous and respected member of the City. When Lord Mayor in 1665 at the time of the Plague, he remained in the city throughout and urged his Aldermen to do the same. His reputation in the City can be judged from the numerous positions he held, often for more than one period. He was Master of the Haberdashers' Company and committee member of the East India Company (each three times) Governor of the Irish Society and President of St Thomas's Hospital (each twice) Father of the City in 1690 and Alderman of Queenhithe Ward from 4 February 1658 until his death on 26 January 1692, except for the period of suspension of the City's Charter. (CLRO Biographical Notes). A leading City Whig, in his friendship with Hooke he shared a common purpose of civic duty and responsibility. He was proposed by Seth Ward and elected Fellow of the Royal Society on 27 November 1673, exempt charges. He was one of four City Merchants proposed by Ward and elected that day at a time when the Royal Society's fortunes were declining, so the Society might have been looking for some support from the City. Described as "slightly active" (judged by the number of times his spoken contributions at meetings were recorded in the Society's minutes) he nonetheless was elected to the Council of the Royal Society in 1674, 1678 & 1680 (Hunter, M. *The Royal Society and its Fellows* (Chalfont St Giles, British Society for the History of Science, 1982) pp.212-213.

260. *Diary* (R&A) p.9, entries for 2 & 3 October 1672.

261. *Diary* (R&A) p.9, entries for 7, 8 & 9 October 1672.

262. *Diary* (R&A) p.10, entry for 12 October 1672.

263. CLRO CD Box K B/67 & 68 and *Diary* (R&A) p.10, entry for 16 October 1672.

264. CLRO CLCM(R) for 16 October 1672.

265. CLRO CLCM(R) for 23 October 1672. The report of the measurements, signed by Leybourn and Shortgrave, was not delivered by Hooke and Oliver to the Committee until 3 January 1673 whereupon the Comptroller was ordered to work out the amounts payable to Fitch according to the Articles of Agreement (CLCP Ms.65 dated 3 January 1673).

266. *Diary* (R&A) p.11, entries for 21, 22, 23 & 25 October 1672. However Hooke may have muddled these dates; he cites the 25 October as the day the Royal Society met, but 25 October was a Friday. Hooke had been ill around that time and often wrote his diary several days after the events took place. Further, it might be thought that Shortgrave's presence with Hooke at Gresham College was to be expected as Shortgrave was the Royal Society's Operator, but in this case it is clear that he was there with Fitch, so the matter under discussion between them and Hooke was one in which they all were engaged at the time, i.e. the Fleet Channel.

267. CLRO CLCM(R) dated 13 November 1672.

268. Author of philosophical books, and a Divine.

269. *Diary* (R&A) pp.12-13, entries for 2, 5, 9, 12 & 14 November 1672.

270. This is not generally recognised. Sir John Lawrence is not mentioned by 'Espinasse, M. *Robert Hooke* (London, Heinemann, 1956) and Reddaway, T.F. *The Rebuilding of London after the Great Fire* (London, Edward Arnold, 1951) mentions him twice only, in neither case is his friendship with Hooke mentioned.

271. Reddaway, T.F. *The Rebuilding of London after the Great Fire* (London, Edward Arnold, 1951) Chapter VIII, p.216 footnote 6 states that as far as Hooke's possible influence and guidance of Wren was concerned

> Hooke's *Diary* ... is disappointing ... its curt jottings, though they show that he was actively concerned in the work of supervision, give no indication of how much he contributed towards the planning of the scheme. The only entries which can be construed as bearing upon the latter are those of October 1st and of November 2nd, 1673, and they are too slight to build anything upon.

Although it is true that Hooke in his diary seldom writes more than a word or two (and often none) to indicate why he went to a particular place or met a particular person, and that any one diary entry is too slight to build anything upon, the accumulation of names and places he recorded in the few weeks preceding the City Lands Committee meeting on 20 November is strong circumstantial evidence of significant involvement in the Fleet Channel. Whether or not it is evidence of a contribution to "planning" depends on what is meant by

that word. If it is taken to mean the organisation and ordering of resources and estimation of costs his contribution was important. If it means the conceptual design of the navigable channel, he contributed to it through his work in determining the Rebuilding Acts. If it means structural design of such as piles, piers, wharfing, quays, and cellars, then even though this may have been entirely Wren's work initially, the enormous amount of re-design that was found to be necessary could not have been completed without significant help from Hooke. Finally, if it means talking to and persuading those in the City whose support and agreement on what had to be done was necessary for the progress of the work, he was trusted by Wren and Lawrence to take part, in their presence or not, in informal, but crucial, meetings with the City's representatives - so Wren and Lawrence regarded his contribution in this matter as important. In addition to planning, Hooke had a major role in overseeing the manner in which the work was carried out. If contributions to planning and execution are taken together, Hooke's contribution exceeded that of any other individual.

272. At the same time it was

> Ordered that Mr Hook doe treat with some good & able workman for building of a substantiall payre of stayres at the old Swan & report to this Committee his proceedings That an Agreement may bee thereupon made for the same & The same out of hand performed.

CLRO CLCO I f.55^{r}, dated 3 May 1671.

The stairs at the Old Swan were one of many pairs proposed to be built at intervals along the new quay.

273. The City Lands Committee

> ordered that the City Surveyors doe attend Dr Wren - his Majesty's Surveyor with the designe or draught of the Waterline by them prepared for his approbation That the same may be ascertained and the Wharfe to bee thereupon made according to the late Act of Parliament speedily undertaken Which worke will bee the better & more easily accomplished by imploying the soyle & rubbish to be taken up at Fleet ditch for that purpose.

CLRO CLCO I f.56^{v}, dated 24 May 1671.

At the same meeting Hooke was ordered to accompany members of a City sub-committee to Billingsgate Dock to negotiate a contract with workmen for taking down old stairs and building new ones according to a design to be determined by Hooke and the others. The plan used for the design of the new waterline was drawn and probably surveyed by Richard Shortgrave. On 18 October 1671 the City ordered him to be paid £18-10s-00d for his work on plots and draughts relating to the waterline and wharves by the Thames as far as Holborn Bridge (CLRO CCAB I (1671-1673) f.144^{v}).

274. CLRO CLCO I f.59^{v}, dated 5 July 1671.

275. The City Lands Committee

> ordered that the Surveyors of new Buildings doe forthwith attend Dr Wren Surveyor generall of his Majesty's works & find out the old stakes sett out pursuant to the Act of Parliament for the lyne of the wharfes & keyes from the Temple to London bridge & to ascertain the same to be described in a vellum draught & chiefly from Bridewell docke to Puddle docke whereby the Clearing of Bridewell dock & Fleet ditch may be speedily undertaken & carried on and the Rubbish which shall be taken out from thence be imployed towards the raysing & fitting of the intended wharfes there. And that the Timber already in preparation be forthwith imployed towards that worke. And it is further Ordered that the right honorable the Lord Maior be desired to attend his Majesty before he leaves Windsor togeather with Dr Wren & Mr Hooke with this order to the end a warrant may be obtayned under the great Seale for his Majesty's approbation of the said Waterlyne.

CLRO CLCO I f.60^{r}, dated 10 July 1671.

The "old stakes" were those set out around June 1670 (Reddaway, T.F. *The Rebuilding of London After the Great Fire* (London, Edward Arnold, 1951) p.124 footnote1.

276. Reddaway, T.F. *The Rebuilding of London after the Great Fire* (London, Edward Arnold, 1951) p.231 footnote 4.

277. *Diary* (R&A) p.12, entry for 9 November 1672.

278. *Diary* (R&A) p.44, entry for 21 May 1673.

279. *Diary* (R&A) p.45, entry for 26 May 1673.

280. *Diary* (R&A) p.45, entry for 31 May 1673.

281. *Diary* (R&A) p.45, entry for 1 June 1673.

282. Hooke noted

> At Lord Mayors. Olivers. Councell. Mans coffee house, Ogylby and divers others there. Dr. Barrow in the Councell with Lord Chancellor. Prince Rupert newly returned from Sea. Chancellor gave order about key and for attendance on the councell.

Diary (R&A) p.58, entry for 29 August 1673.

This typical entry can be interpreted in different ways. It does seem probable that Hooke was at Whitehall and if not present himself at the Council meeting, he heard about the order from Isaac Barrow (his predecessor as Gresham Professor of Geometry, and an ardent royalist) who was at the meeting, or from Prince Rupert FRS, whose device for perspective drawing Hooke had been ordered by the Royal Society in December 1663 to improve upon.

283. Hooke noted

> At ... Lord Mayors ... Councell table. The Lord Chancellor accused me

with great bitternesse and craven, but grew milder ... at Lord Mayors. Warnd the wharfingers to take downe.

Diary (R&A) p.58, entry for 3 September 1673.

Hooke's usage of "craven" might be as the verb "to render spineless through fear" given in OED (1971) where such a usage by Dryden in 1683 is cited.

284. *Diary* (R&A) p.59, entry for 4 September 1673.

285. *Diary* (R&A) p.59, entry for 5 September 1673.

286. *Diary* (R&A) p.61, entry for 24 September 1673.

287. *Diary* (R&A) p.64, entry for 8 October 1673.

288. Referring to the fact that Wren's genius resulted in many buildings that were not his being attributed to him, including, inter alia, the Monument, she goes on to say that this has resulted in

> a complicated tangle which it seems probable will now never be completely unravelled

M.I. Batten "The architecture of Dr Robert Hooke, F.R.S." *Journal of the Walpole Society* 25 pp.83-113 & Plates XXXV-XL (1936-7) p.83.

289. Stoesser-Johnston, A. *Robert Hooke and Holland: Dutch Influence on Hooke's Architecture* (Doctoraalscriptie Bouwkunst, Rijksuniversiteit Utrecht, unpublished, 1997) in her Introduction thanks Mr A. Geraghty for his

> willingness to impart his expertise on the drawings of Hooke and Wren

which indicates significant research on Hooke's and Wren's architectural drawings was in progress.

290. On 30 November 1666 the City's Court of Common Council listed 23 "heads" they thought should be included in the Rebuilding Act. Head 14 was

> That the second day of September yearly be kept as a day of public Humiliation within this City & Liberties in Memoriall of this sad Desolation by ffire And that a Columne be erected upon the place where the ffire began as a perpetuall Remembrance of it.

CLRO Jor.46 f.133^{v}.

291. On 28 January 1669 the City Surveyors were ordered to view a toft at Pudding Lane, where Thomas Farriner sought to build, and report their findings because the toft was at the site of the proposed pillar (CLRO Rep.74 f.75^{r}, dated 28 January 1669). No Surveyors' report on the view has been found, either as an individual manuscript or in the volumes of Viewers' Reports, so it is not possible to say definitely that Hooke was involved, but at this time all three Surveyors often were engaged in each view and in any case the site of the pillar was in an area of the city where Hooke took part in most of the views that were ordered.

292. CLRO Rep.74 f.189^{r} dated 10 June 1669.

293. On 3 August 1670 the churchwardens of St Magnus were given permission to take down the wall and steeple of St Margarets Church and the City Surveyors were called upon to view the building of Mr Barton (or Barbon) on the adjoining land and certify whether or not it would obstruct the proposed pillar. The City Lands Committee would then decide whether to allow Barton to rebuild or to purchase the ground from him. (CLRO CLCO I f.42r dated 3 August 1670). Some months later the committee received the Surveyors' report and allowed Barton to rebuild on foundations to be set out by the (unnamed) Surveyor (CLRO CLCO I f.46^{r}, dated 9 November 1670). Although no manuscript report has been found and no Surveyor is named in the records, it is certain that Hooke was involved in the original view (Mills by this time was dead, or very ill) and very likely that he set out Barton's ground.

294. CLRO Rep.76 f.58^{r}, dated 26 January 1671.

295. CLRO Rep.76 f.72^{v}, dated 14 February 1671.

296. On 28 July 1675, in response to a request from the City Lands Committee, Wren sent some designs for ornamenting the top of the pillar that he had earlier made and showed to the King. A copy of his letter has recently been reprinted in *The Official Guide to the Monument* (London, Corporation of London, 1994) p.11. The City wanted to be certain that its choice of ornament would not cause offence to the King; it was probably relieved to learn from Wren that the King preferred a large gilded ball to a statue. The latter would of necessity be large and therefore expensive if it were to not to appear ridiculously small when viewed from ground level, near or far.

297. On 6 June 1672 the City decided to make an ex-gratia payment to Wren, but the decision was made in the context of meetings about the Fleet River and the Thames Quay. An unnamed member of the City Lands Committee moved that they take into consideration the

> many and great Services which Christopher Wren Esq. his Majestys Surveyor hath performed for the benefit and on the behalfe of the Citty of London

They forthwith agreed, ordered and signed a warrant for the Comptroller to draw 100 guineas from the Coal Account and take them to Wren's lodgings

> as a Testimony for the present of their kind resentment† of his good inclinations and Services towards the Welfare of the said City.

CLRO CLCM(R), dated 6 June 1672.

There is no reason to think that a design for the pillar was one of the "great Services" Wren had performed.

†Resentment: "grateful appreciation or acknowledgement (of a service, kindness etc.). Obsolete, but common 1650-1750" (OED, 1933).

298. Dick O.L. (ed.) *Aubrey's Brief Lives* (London, Mandarin, 1992) p.165.

299. CLCRO CLCM(R), dated 9 October 1672. On 22 October Hooke made a visit to the site (*Diary* (R&A) p.11) when it may reasonably be assumed that he carried out the City's order.

300. CLRO CLCM(R) dated 6 November 1672.

301. *Diary* (R&A) p.54, entry for 8 August 1673.

302. *Diary* (R&A) p.59, entry for 11 September 1673.

303. *Diary* (R&A) p.66, entry for 19 October 1673.

304. *Diary* (R&A) p.93, entry for 28 March 1674.

305. *Diary* (R&A) p.106, entry for 1 June 1674.

306. *Diary* (R&A) p.116, entry for 7 August 1674.

307. *Diary* (R&A) p.120, entry for 8 September 1674.

308. Hooke recorded

> At Lord Mayors about Balcony pillars

Diary (R&A) p.129, entry for 6 November1674.

309. *Diary* (R&A) p.136, entry for 16 December 1674.

310. On 15 November 1676, members of the City Lands Committee and the City Surveyors were ordered to visit the pillar and report on several matters (CLRO CLCP Ms.158, which is anonymous and in an unrecognised hand). It seems from a later entry in Hooke's diary as if the visit was an official opening of the Monument

> At the Piller the laying it open reported with Sir Chr. Wren.

Diary (R&A) p.257, entry for 17 November 1676.

311. The audited accounts received the Surveyors' assessment of the reasonableness of the rates charged. They included a payment of £12 to William Leybourn for measuring quantities of materials for the last year (CLCRO CLCP Ms.161, dated 13 December 1676). Hooke took these accounts to the Lord Mayor Sir Francis Chaplaine and discussed them with him the same day (*Diary* (R&A) p.262, entry for 13 December 1676).

312. In response to an order by the City Lands Committee dated 15 December 1677 Hooke reports in a manuscript dated 19 December 1677 that he and Oliver found the measurements by Shortgrave (who was employed by the City to measure the quantities of stone and rubble used by Marshall for work on the foundations and pedestal of the pillar) had not been received by Marshall. Hooke also reported that because Shortgrave was now dead they could not in the time available make an exact estimate of the quantities of material and cost of the work. Instead they

took evidence on oath from Marshall, based on his own records, and sought the views of the men who worked for him to make their estimates of the quantities and costs (CLRO CLCP Ms.187). Although this manuscript is dated 19 December 1677, Hooke records that he wrote the certificate on 18 December 1677 (*Diary* (R&A) p.335). When the City issued its order, it was also concerned about other accounts, including one from Hodgkins, a Master Smith, for the cost of trees around the railings at the column (*Diary* (R&A) p.334, entry dated 15 December 1677). No record that the Surveyors were ordered to settle these other matters has been found, but it is probable that they dealt with them.

313. Gunther, R.T. *Early Science in Oxford Volume VII* (Oxford, 1930) p.526 reproduces one of Hooke's manuscripts (without stating its source) which gives the volume of faced Portland stone contained within the fabric of the pillar, based on measurements and computations made by William Leybourn under Hooke's direction and with his assistance. Hooke notes that the exercise was carried out

> together with the assistance and in the Presence of Mrs Marshalls friends & servants

and dates the manuscript 10 July 1679. Joshua Marshall had died in 1678 so it seems as if his widow was questioning the City's payments to her husband for masonry work.

314. CLRO CLCM(R) & CLRO CLCO II f.27^{v}, both dated 17 July 1672. Newgate had been patched up after the fire and continued to be used as a gaol.

315. *Diary* (R&A) 1672 p.5, dated 14 August 1672, where Hooke records

> Sir Will. Peak. Committee City Lands for the repair of Newgate

& CLRO CLCM(R) dated 14 August 1672. No explicit of implicit mention is made of Oliver's name in the minutes, so it can be assumed that he did not work on the design.

316. CLRO CLCO II f.30^{r}, dated 14 August 1672.

317. CLRO CLCM(R), dated 27 August 1672.

318. CLRO CLCM(R) dated 5 September 1672, which was a Thursday.

319. CLRO CLCM(R) & *Diary* (R&A) p.7, both dated 11 September 1672.

320. CLRO CLCM(R) dated 15 January 1673.

321. CLRO CLCM(R) dated 29 January 1673. Tanner was probably Anthony Tanner, the City's Bricklayer whose plan Hooke had used in 1671 to calculate an area of ground (CLRO CD Box K D/18, dated 14 December 1671). In the Biographical Index to *Diary* (R&A) Tanner (passim) is given as John Tanner (ibid. p.520), but he died in September 1672 (ibid. p.8).

322. CLRO CLCM(R), dated 17 July 1672.

323. CLRO CLCM(R), dated 9 October 1672.

324. CLRO CLCM(R), dated 16 October 1672.

325. *Diary* (R&A) p.47, dated 13 June 1673.

326. The City's instrument setting up the Commissioners for Sewers in accordance with the Rebuilding Act is dated 16 May 1667:

> This day one writing dated this present day authorizing my Lord Maior and Aldermen and diverse Commoners of the Common Councell in each ward to designe and sett out the Numbers of all Common Sewers Dreynes and Vaults and the order and manner of paving and pitching the streetes and Lanes within this Citty and Libertyes according to the late Act of Parliament for rebuilding the Citty and an order of Common Councell in pursuance thereof was here sealed with the Common Seale of this Citty.

CLRO Rep.72 f.108^{r}, dated 16 May 1667.

A few months later, following meetings between the City Surveyors and the Commissioners, the City printed a document prescribing the rules and directions for setting gradients of streets and lanes for better drainage (CLRO P.D.10.117 (L) dated 8 July 1667).

327. Amongst the recommendations presented to the City Lands Committee by Wren and Hooke were some specifically related to sewers

> some Ingenious Carpenters doe attend the direction of the Surveyors for making & placing of Pumps where necessary & conveyances for the land water & sewers, and a person to take Exactly the levells & direct the diggers in the orderly carrying on of the worke, which must be estimated according to the occasion.

CLRO CLCO I f.54^{v}, dated 22 March 1671.

328. On 28 June 1671 Sir Jeremy Whitchcot presented a letter to the City Lands Committee protesting that work at the Fleet Channel had not been carried out properly, resulting in damage to the cellars of his properties through flooding by sewage brought about by blocked drains. The Committee responded that they were proceeding as quickly as possible in accordance with the Rebuilding Act and had engaged workmen solely for that purpose. They ordered the City Surveyors to view and report to the Committee on any damage Whitchcot had suffered and to suggest what redress should be made to him (CLRO CLCO I f.59^{r}). The order was repeated on 15 November 1671, but with the instruction that the Surveyors should report their findings to the Commissioners for Sewers (CLRO CLCO I f.71). No record of their report has been found, but Whitchcot sent a claim for compensation (CLRO CD Box K W/40^{A}) and an area certificate (ibid. W/40^{B}) dated 20 September 1673 issued to him by Hooke in connection with ground on the east side of the Fleet Channel taken away by the City. It seems probable that the buildings on this land were those Whitchcot had earlier claimed to have been damaged. The City decided to pay Whitchcot £800 for the loss of twenty two tenements on 2508 square feet of ground (ibid. W/40^{C}).

Whitchcot paid Hooke 5 guineas for the area certificate (*Diary* (R&A) p.61, entry for 24 September 1673). This is another example of the City's equitable settlement of complaints, albeit more than two years after the matter was raised, and of Hooke's involvement in the day-to-day procedures by which those settlements were reached amicably.

329. The City Lands Committee ordered Hooke to

> forthwith take care that the Sewer from Algate to Crowne hill be fitted and made & the trench cleared And that John Fitch bricklayer shall doe the Brickworke thereof with good lyme and sand and hard burnt bricks and noe Rubbish. To bee made two bricks thick at the least and four foot broad below & seaven foote high for which he shall be paid after the Rate of six pounds per Rod to be reduced to a brick & an halfe solid measure. And Mr Shortgrave is desired to Admeasure the same Worke as it shall be performed every 14 days and give account thereof to this Committee. And in order to the said Worke that a Breach be made in the Cities wall for a cart passage to carry in earth for that purpose and Labourers imployed to digge & prepare the same who shall be paid after the Rate of 5d per yard. Agreed further that for what timber shall bee imployed there for plancks & pyles the said Fitch shall be paid after the rate of 4d per foot running measure

CLRO CLCO I f.55^{r}, dated 3 May 1671.

It is probable that Hooke had specified the materials and quantities that he was now given the responsibility for ensuring were used. At the next meeting of the Committee a week later, Hooke was authorised, with Fitch, to make a gate or postern at a convenient place in the city wall near Crutched Friars for easier transport of building materials for the sewer and fill for raising the ground to the appropriate level. The nearby tenants were also ordered to comply if any part of their ground was needed for temporary storage of construction materials (CLRO CLCO I f.56^{r}, dated 10 May 1671).

330. The order reads

> Ordered that Deputy Hall Deputy Knott Mr Withers & Mr Hook doe consider of Mr Hartlyes request for Building over parte of the ditch neere Holborne bridge contiguous to his other Building there whether the same may bee granted. And returne their Opinions together with the value. And likewise consider of Thomas Smiths desire for the same thing & report to which of them in their Judgements the same may be granted.

CLRO CLCO I f.55^{r}, dated 3 May 1671.

331. The report illustrates that the detailed attention Hooke gave to the hundreds of views he made for the Court of Aldermen (Section 3.3 above) he gave also to his views for the City Lands Committee

> In pursuance of an order of this Committee bearing Date May 24.71 we whose names are underwritten have mett upon the place & have again examined the Ditch above holburne bridge & the Interests of Esq. Hartly & Mr Smith next adjoyning and we are opinion as we formerly reported that the said Ditch and sewer ought to be cleansd & arched over as far as

> the City liberty Reaches. And we further Judge that to the end both the said partys may be accommodated for their building over the Arch of the said Ditch. that Mr Smith ground now in his possession may be made up eighteen foot in front and sixteen foot in Rear. that is about two foot be added to him in bredth in the front and thirteen foot at twenty one foot in Depth. which amounts to about one hundred fifty eight foot, which in consideration that he hath Lost a good part of his front ground he formerly injoyedand that the greatest part of this is back ground we Judge will be worth about twenty shillings per annum to be paid by the said Smith for a Lease of the same to be built upon. We are further of opinion that Mr Hartly may be accommodated with the Remainder to witt about fowrteen foot in front and about five foot in the Rear. the Greatest part of which being front ground we Judge the same to be worth about ten pounds per annum. All which notwithstanding we humbly Leave &c.
> Dated May 29th 1671. [signed] Will Withers Wm Hall
> John Knott

CLRO CLCP Ms.25, dated 29 May 1671.

332. CLRO CLCO I f.15[r], dated 30 April 1672. In a damaged and unsigned manuscript by Hooke dated 9 October 1672 (CLRO CLCP Ms.53) John Fitch's work is valued at £6-10s-00d per rod, the three-inch planking to be used is valued at five pence per square foot, nine-inch square piles four feet six inches long valued at half a crown each are specified and several other valuations, now illegible or on missing parts of the manuscript were given. Although Wren was charged by the City with Hooke and Oliver to view, it is again found that Hooke took responsibility for writing and presenting the detailed report. He probably discussed and readily agreed the valuations with Wren; neither man would wish to debate the issue for longer than was necessary. Wren and Fitch were with Hooke at Gresham College the day before Hooke wrote the report (*Diary* (R&A) p.9, entry for 8 October 1672) and Hooke was at the Holborn sewer with Fitch on the following day (ibid., entry for 9 October 1672). Oliver's part is indeterminate and probably insignificant; the City would be satisfied if Hooke and Wren were in agreement.

333. CLRO CLCO II f.29[r], dated 24 July 1672.

334. *Diary* (R&A) p.6, entry for 11 September 1672.

335. CLRO CLCM(R), dated 11 September 1672. The report recommended means for removing obstacles and rubbish thrown into the Channel and that the City Solicitor should be present to indict offenders. It was transcribed and approved by the City Lands Committee who ordered the City Solicitor to prosecute those who continued to throw rubbish into the Channel and failed to conform to the long-publicised command of the King and Parliament
CLRO CLCO II f.32[v], dated 11 September 1672.

336. CLRO CLCO I f.43[v], dated 10 August 1670.

337. CLRO CLCM(R), dated 23 October 1672. The complaint was made by Dr Whitch who was about to move with his family into the nearby parsonage where the nuisance would be unwholesome and prejudicial to his family. Hooke was at Guildhall the same day, but whether or not he examined the cause of Whitch's complaint is not clear (*Diary* (R&A) p.11, dated 23 October 1672). Two weeks later, the City Lands Committee re-ordered the removal of the nuisance (CLRO CLCM(R) dated 6 November 1672). Hooke was at Guildhall again that day and two days later, but does not give any reason for either visit (*Diary* (R&A) p.12, entries for 6 & 8 November 1672). No further orders to remove the nuisance have been found, so it can be assumed that Hooke dealt with the matter himself: no mention is made of Oliver's participation.

338. CLRO CLCO I f.66$^{r\&v}$, dated 4 October 1671.

339. Reddaway, T.F. *The Rebuilding of London after the Great Fire* (London, Edward Arnold, 1951) pp.295-296.

340. CLRO Rep.76 f.15^{v}, dated 22 November 1670.

341. On 22 June 1669 the Court of Aldermen settled on the need for a map

> And it is referred to Mr Hooke by assistance of ... Mr George [the City's Plumber] to draw a Line or plott of the severall pipes or Aqueducts by which it may readily & plainly appeare how & where the same lye for better finding & discovery thereof from time to time as Occasion shall require.

CLRO Rep.74 f.200^{r}.

Nothing appears to have been done about the map in the following few weeks, but the Court of Aldermen re-issued its former order. George was now ordered to undertake the mapping, assisted by Hooke. The specification was changed to

> makeing an exact Draught of the severall Aqueducts or Dreynes & pipes from the heads or founteynes to the Conduits of this Citty according to a former Order directed to the said Mr George

CLRO Rep.74 f.231^{r}, dated 20 July 1669.

There is no record of a map having been produced, but a re-survey of the city would have been necessary to represent accurately the plan positions of water services. It would have been an impossibly difficult undertaking for George. Hooke would have found it impossible to find time to organise such a survey. It was not until Ogilby & Morgan's map was published in 1677 that an appropriate framework for showing the routes of conduits according to the specification became available. The City Lands Committee seem to have recognised the difficulty of achieving their worthy objective. Nearly three years after the idea for a map of the water supply arose, the Committee ordered Richard Shortgrave and the City Plumber to

> make an Exact plott or map of the Pipes which convey Water from all conduits belonging to this Citty and all branches from the same with the severall places where they lye in the streets of this Citty or other places. And give an account thereof unto this Committee.

CLRO CLCO II f.10^{v}, dated 26 March 1672.
The Committee also agreed to pay Shortgrave for his pains. Nearly four months later the Committee ordered Shortgrave to deliver the map he had been ordered to make, but none was forthcoming (CLRO CLCM(R) dated 5 July 1672).

342. This cistern was intended to replace the conduit near the Royal Exchange which the City Lands Committee ordered to be taken down and replaced by stop-cocks. The Surveyors were empowered by the City Lands Committee to direct and manage the work as they thought necessary (CLRO CLCO I f.57^{r}, dated 31 May 1671). The work had been completed by March 1672 when the Surveyors were ordered to advise and direct the City Plumber, John George, in laying an underground pipe (protected by a timber casing specially treated against borers) through Bird and Hand Alley to the cistern.

343. CLRO Misc. Ms.93.52, dated 27 February 1683 is a complicated and detailed report three pages long (not in Hooke's hand) of a view made by Hooke and Oliver of the conduits from Piccadilly to The Strand.

344. CLRO CLCM(R), dated 28 April 1669.

345. CLRO CLCP Ms.7, dated 26 May 1669. This is not in Hooke's hand, but is signed by him and by six members of the City Lands Committee.

346. CLRO CLCM(R), dated 11 May 1669.

347. CLRO CLCM(R), dated 2 June 1669.

348. Masters, B.A. *The Public Markets of the City of London* (London, LTS, 1974) p.17.

349. CLRO CLCM(R), dated 1 September 1669.

350. CLRO CLCM(R), dated 6 October 1669.

351. CLRO CLCM(R), dated 10 February 1670.

352. *Diary* (R&A) p.14, entry for 20 November 1672.

353. *Diary* (R&A) p.27, entry for 7 February 1673.

354. *Diary* (R&A) p.45, entry for 29 May 1673.

355. *Diary* (R&A) p.61, entry for 23 September1673.

356. Masters, B.A. *The Public Markets of the City of London* (London, LTS, 1974) gives a description of the provenance of these maps and reproduces them at reduced scales.

357. Reddaway, T.F. *The Rebuilding of London after the Great Fire* (London, Edward Arnold, 1951) p.89 footnote 4.

358. Bennett, J.A. "Hooke and Wren and the system of the world: some points towards an historical account" *The British Journal for the History of Science* 8(28) pp.32-61 (1973).

359. Stoesser-Johnston, A. *Robert Hooke and Holland: Dutch Influence on Hooke's Architecture* (Doctoraalscriptie Bouwkunst, Rijksuniversiteit Utrecht, unpublished, 1997) p.65 argues that of three City churches clearly influenced by Dutch architecture, two were designed by Hooke: St Benet and St Edmund the King. She implies that he could have designed more, but that a recent discussion of Hooke's contribution to the architecture of the City churches by Jeffery, P. *The City Churches of Sir Christopher Wren* (London, Hambledon Press, 1996) is unsatisfactory, citing in corroboration a review of Jeffery's book by A. Geraghty, *Burlington Magazine Volume 139* (1130) pp.336-337 (May 1997). The broad outlines of Hooke's architecture were made known by M.I. Batten at the time *Diary* (R&A) was published in 1935 (seminally Batten, M. I. "A partner with Wren" in *The Times* (Thursday January 14, 1935) pp.13, 14 & 16; and subsequently Batten, M.I. "The architecture of Dr Robert Hooke, F.R.S." *Journal of the Walpole Society* 25 pp.83-113 & Plates XXXV-XL (1936-7)), but Hooke's architectural practice is only now, more than sixty years later, receiving significant attention from scholars.

360. 'Espinasse, M. *Robert Hooke* (London, Heinemann, 1956) pp.178-179 lists all the entries in *Diary* (R&A) which relate to visits to churches.

361. Gunther, R.T. *Early Science in Oxford Volume VII* (Oxford, 1930) p.vii cites the "contemporary Cash-book and annals of the College" as evidence that Hooke was appointed for his assistance in and management of the building of the College and all things concerning it in such a way as shall be agreed by a College Committee, including the President, with Hooke present. Gunther (ibid.) claims that by examining the above documents he found no evidence that Wren was engaged in the College rebuilding, although it was generally accepted at the time of Gunther's publication that Wren was the architect responsible for the new College. Batten, M.I. "The Architecture of Dr Robert Hooke" *Journal of the Walpole Society* 25:84-113 (1936-7) and earlier in an article "A partner with Wren" *The Times* Friday 15 February 1935 pp.13,14 & 16 also attributes the architecture of the College to Hooke, based mainly on the absence of any significant reference to Wren in the College archives of the time and on *Diary* (R&A). The present research does not contradict that view. Hooke's friendship with Wren however made it likely that the new College would have been a topic they discussed with one another from time to time, as they discussed many others. For example, on 2 October 1672 Hooke recorded

> Walkd to Dr Wrens, dined there etc., discoursed of theatre

(*Diary* (R&A) p.9). It is possible that Hooke is here referring to the London

stage, but this is unlikely. It would have been unusual for Hooke to record a conversation with Wren about such a frivolous topic, even though it may have taken place. The proposal for an Anatomy Theatre at Physicians' College is more likely to have been the subject of the discussion. On the day that Hooke and Wren "discoursed of theatre" Hooke had first heard that Sir John Cutler intended to pay for the theatre to be built (ibid.).

362. Gunther, R.T. *Early Science in Oxford Volume VII* (Oxford, 1930) pp.vii-viii.

363. Hooke recorded these visits to the rebuilding site in Warwick lane in *Diary* (R&A). Visits took place on: 24 August 1672 (p.5); 6 September 1672 (p.7); 30 September 1672 when he spent the afternoon there with Ent (p.8); 14 October 1672 when he took some measurements (p.10); 28 October 1672 when Joseph Lem (or Lenns) the master bricklayer took measurements (p.11); 7 & 13 February 1673 (pp.27-28); 18 March 1673 (p.34); 2 May 1673 when he and his nephew Harry took measurements for the Chemist's and Beadle's houses (p.41); 25 June 1673 when he visited with Ent (p.48); 10 July 1673 (p.50); 30 July 1673 (p.53); 15 August 1673 (p.55); 22 & 27 August 1673 (p.57); 28 & 29 August & 3 September 1673 (p.58); 13 September 1673 when he concluded the contract with Joseph Lem (p.60); 27 September 1673 (p.62); 11 October 1673 when he took a view there with one of the City Aldermen (p.64); 15 & 18 October 1673 (p.65); 5 December 1673 when he measured stonework with Abraham Story a master mason (p.73); and 27 March 1674 (p.93).

364. Hooke recorded these meetings with Sir George Ent in *Diary* (R&A). They met alone and (unless stated otherwise) dined at Ent's on the following occasions: 29 August 1672 (p.6); 11 September 1672 at Salisbury Court, a thoroughfare from St Brides in Fleet Street to the Thames; 18 September 1672 (p.7); 3 October 1672 with Caius Cibber (who would later design the sculptural west panel on the pediment of the Monument) the day after Hooke had first heard that Sir John Cutler had offered to pay the costs of building the proposed Anatomy Theatre for the College of Physicians (p.9); at the Crown on 1 November 1672 & 4 November 1672 when Hooke drank wine that disagreed with him (p.12); 25 January 1673 (p.24); 13 February 1673 (p.28); 17 February 1673 (p.29); 28 February 1673 at Goddard's with other members of the Physicians' College when Hooke again was ill after drinking wine (p.31); 20 & 24 March 1673 (p.35); 27 March 1673 (p.36); 5 April (p.37); 11 April (p.38); 24 April 1673 at Grays Inn Garden (pp.40-41); 2 May 1673 (p.41); 17 May 1673 (p.43); 31 May 1673 (p.45); 5 June 1673 when Hooke discussed Lem's bill for bricklaying (p.46); 21 June 1673 (p.48); 26 June 1673 at Goddard's with other members of the Physicians' College (p.48); 2 July 1673 at the Bulls Head with other members of the Physicians' College (p.49); 4 July 1673 at Guildhall with the Lord Mayor, some Aldermen and members of the Physicians' College (p.49); 10 July 1673 (p.50); 19 July 1673 (p.51); 8 August 1673 with other members of the Physicians' College when Hooke's head ached after drinking wine (p.54); 3 September 1673 with Boyle (p.58); 6 September 1673, again with Boyle (p.59);

20 September 1673 when Hooke presented to Ent Lem's final account for building work (p.61); 17 October 1673 when Hooke, Ent and Jenkins (who seems to have acted as treasurer's clerk for the Physicians' College) approved payment of Lem's account (p.65); 3 November 1673 with Sir Charles Scarburgh, the King's physician (p.68); 8 November 1673 with Sir William Jones, lawyer and Lord Cornbury, second Earl of Clarendon (p.69); 29 November 1673 (p.72); 17 December 1673 (p.75); 22 & 23 December 1673 (p.76); 12 January 1674 (p.80); 7 February 1674 (p.85); 25 April 1674 (p.99); and 29 April 1674 with Scarburgh (p.100).

365. Gunther, R.T. *Early Science in Oxford Volume VII* (Oxford, 1930) p.viii.

366. On Saturday 7 March 1674 at one of his frequent dinners at Sir George Ent's, Hooke recorded

> Dind at Sir G. Ents, from him 20 Guinny for Colledge house ... Sir G. Ent engaged me to make estimate of the theater.

Diary (R&A) p.90.

The former record refers to the main College building, the latter to the College's anatomy theatre which was under Cutler's patronage. The following day Hooke stayed at home, working on his estimate of the cost of the anatomy theatre (ibid.).

367. 'Espinasse, M. *Robert Hooke* (London, Heinemann, 1956) p.89 refers to Ned Ward's satirical account of Cutler's dealings with the College in *The London Spy*.

368. On 29 April 1674 Hooke recorded

> Markd out the Theater.

and on the next day he

> Drew designe for the Theater

and on the day following he

> Agreed with Lem about the Theater.

Two days later he recorded

> At the Colledge of Physitians. With Harry and Dr. Whistler. Gave him a scetch of Theater

Diary (R&A) pp.100-101.

369. On 13 May 1674 Hooke recorded

> at Sir G. Ents with Physitians

and two days later he was engaged with Wren in College matters:

> To Dr. Whistlers. To Sir G. Ents. To Sir Ch: Wrens and Sir J. Cutlers. Dind there. With Sir Christopher to Colledge by water.

Diary (R&A) pp.102-103.

He dined the next day (Saturday) at Ent's. Stoesser-Johnston, A. *Robert Hooke and Holland: Dutch Influence on Hooke's Architecture* (Doctoraalscriptie Bouwkunst, Rijksuniversiteit Utrecht, unpublished, 1997) cites the Annals of the Physicians' College (Volume 4 p.168) as recording on 13 May 1674 that the

Committee, in consultation with Wren and Hooke, had decided that "the garden of the College would be most suitable" for the position of the theatre. This record clearly relates to Hooke's diary entries above.

370. On 26 May 1674 Hooke recorded

> To Physitians Colledge. They resolved Theatre backwards

Diary (R&A) p.105.

371. On 16 June 1674 Hooke recorded

> At Sir J. Cutlers. Spoke to him. He resolved theatre before.

Diary (R&A) p.108.

372. On 19 June Hooke recorded

> To Sir J. Cutlers, Cornhill ... Sir J. Cutler desired a painter. Measured at the Colledge Sir G. Ents house. At Sir G. Ents. He would not Resolve till Dr. Whistler returned.

Diary (R&A) p.108.

373. On 14 July 1674 Hooke recorded

> At home till I went with Dr. Whistler to Sir J. Cutler. Agreed all in coffee house pallace yard. To Sir G. Ents

Diary (R&A) p.112.

374. Although the location of the theatre appeared to have been settled at the meeting in the coffee house on 14 July 1674 and on 20 July 1674 Hooke recorded

> Set out Theatre at Colledge.

he also recorded on 24 July 1674

> Theatres place confirmd from Dr Cox

implying that he was still seeking consent about its position from a number of members of the College. He now appears confident that the theatre was set out in its correct location and the excavations for the wall footings were complete, for on 31 July he records

> With Lem at the Colledge. Ordered digger money.

Diary (R&A) pp.112-115.

375. *Diary* (R&A) p.116, entry for 4 August 1674.

376. *Diary* (R&A) p.116, entry for 7 August 1674.

377. *Diary* (R&A) p.116, entry for 10 August 1674.

378. These visits and meetings in 1674 are recorded by Hooke in *Diary* (R&A) pp.116-138. However, by the middle of October their frequency decreases as the rate of building follows its seasonal variation.

379. Hooke went to the College on 13 June 1679 to examine bills which he passed a week later. On 25 June 1679 he records

> all matters ended at Colledge of Physitians about Masons, Plumber, Smith,

Paynter.
Diary (R&A) p.415.

380. Elmes, J. *Life of Sir Christopher Wren* (1823) pp.451-452, cited by Stoesser-Johnston, A. *Robert Hooke and Holland: Dutch Influence on Hooke's Architecture* (Doctoraalscriptie Bouwkunst, Rijksuniversiteit Utrecht, unpublished, 1997) p.44.

381. Richardson, A.E. "Sir Christopher Wren's Public Buildings" in: *Sir Christopher Wren* (London, Hodder & Stoughton, 1923) cited by 'Espinasse, M *Robert Hooke* (London, Heinemann, 1956) p.89.

382. *Diary* (R&A) p.5, entry for 15 August 1672.

383. *Diary* (R&A) p.6, entry for 31 August 1672.

384. *Diary* (R&A) p.7, entry for 18 September 1672.

385. *Diary* (R&A) p.8, entry for 25 September 1672.

386. *Diary* (R&A) p.14, entry for 28 November 1672.

387. *Diary* (R&A) p.33, entry for 10 March 1673.

388. *Diary* (R&A) p.34, entry for 14 March 1673.

389. *Diary* (R&A) p.34, entry for 18 March 1673.

390. *Diary* (R&A) p.37, entries for 4 & 18 April 1673.

391. *Diary* (R&A) p.66, entry for 22 October 1673.

392. *Diary* (R&A) p.109, entry for 25 June 1674.

393. *Diary* (R&A) p.124, entry for 2 October 1674.

394. Latham, R.C. & Matthews, W. (eds.) *The Diary of Samuel Pepys Volume X* (London, Bell & Hyman, 1983) p.44.

395. *Diary* (R&A) p.96, entry for 14 April 1674.

396. Dodsley, R. & J. *London and its Environs Described* (1761) cited by M. 'Espinasse *Robert Hooke* (London, Heinemann) 1956 p.90.

397. *Diary* (R&A) p.112, entry for 11 July 1674.

398. *Diary* (R&A) p.123, entry for 28 September 1674.

399. *Diary* (R&A) p.126, entry for 12 October 1674.

400. *Diary* (R&A) p.127, entry for 29 October 1674.

401. *Diary* (R&A) p.128, entries for 2 & 3 November 1674. On 2 November 1674 Hooke waited at Moorfields all morning for Wren to arrive, but in vain. Nor did Wren arrive the following day. However Hooke and Wren met the next day in Cheapside (ibid., entry for 4 November 1674) which may have been fortuitous Probably Hooke wanted to discuss his plans for Bedlam with Wren who, possibly, may not have been too pleased that the work had gone to Hooke instead of to himself.

402. *Diary* (R&A) p.130, entry for 13 November 1674.

403. *Diary* (R&A) p.131, entry for 20 November 1674.

404. *Diary* (R&A) p.133, entry for 30 November 1674.

405. *Diary* (R&A) p.135, entry for 15 December 1674.

406. *Diary* (R&A) p.248, entry for 28 August etc., 1674. Hooke did not write up his diary between 27 August 1674 and 9 September 1674.

407. On 8 January 1678 Hooke recorded

> Received letter from Chase about Bedlam chappell

He responded quickly, as the entry for the following day shows

> With Chase and Knowles at Bridewell about chappell. Drew Designe for chappell.

Diary (R&A) p.339, entries for 8&9 January 1678.

408. Ralph Montague was the second son of Lord Montague of Bourton and twice held the post of English Ambassador in Paris.

409. *Diary* (R&A) p.115, entry for 31 July 1674.

410. *Diary* (R&A) p.119, entry for 28 August 1674.

411. *Diary* (R&A) p.119, entry for 2 September 1674.

412. *Diary* (R&A) p.121, entry for 10 September 1674.

413. *Diary* (R&A) p.121, entry for 12 September 1674.

414. *Diary* (R&A) p.122, entry for 24 September 1674.

415. *Diary* (R&A) p.125, entry for 9 October 1674.

416. *Diary* (R&A) p.126, entry for 10 October 1674.

417. *Diary* (R&A) p.126, entry for 12 October 1674.

418. *Diary* (R&A) p.160, entry for 13 May 1675.

419. *Diary* (R&A) p.126, entry for 14 October 1674.

420. *Diary* (R&A) p.127, entry for 17 October 1674.

421. *Diary* (R&A) p.128, entry for 30 October 1674.

422. *Diary* (R&A) p.128, entry for 5 November 1674.

423. *Diary* (R&A) p.133, entry for 1 December 1674.

424. *Diary* (R&A) p.133, entry for 3 December 1674.

425. *Diary* (R&A) p.134, entry for 9 December 1674.

426. *Diary* (R&A) p.135, entry for 13 December 1674.

427. *Diary* (R&A) p.135, entry for 15 December 1674.

428. 'Espinasse, M. *Robert Hooke* (London, Heinemann, 1958) p.176$_{\text{footnote 33}}$.

429. *Diary* (R&A) p.114, entry for 27 July 1674.

430. *Diary* (R&A) p.123, entry for 7 October 1674.

431. *Diary* (R&A) p.7, entry for 17 September 1672.

432. *Diary* (R&A) p.13, entry for 13 November 1672.

433. *Diary* (R&A) p.15, entry for 29 November 1672.

434. *Diary* (R&A) p.23, entry for 23 January 1673 where in another footnote the Editors again give the incorrect gloss.

435. *Diary* (R&A) p.33, entry for 8 March 1673.

436. *Diary* (R&A) p.12, entry for 5 November 1672.

437. *Diary* (R&A) p.17, entry for 23 December 1672.

438. *Diary* (R&A) p.13, entry for 13 November 1672.

439. *Diary* (R&A) p.28, entry for 15 February 1673.

440. *Diary* (R&A) p.42, entry for 8 May 1673.

441. *Diary* (R&A) p.49, entry for 4 July 1673.

442. *Diary* (R&A) p.51, entry for 15 July 1673.

443. *Diary* (R&A) p.82, entry for 24 January 1674.

444. *Diary* (R&A) p.83, entry for 27 January 1674.

445. *Diary* (R&A) p.117, entry for 10 August 1674.

446. *Diary* (R&A) p.53, entry for 1 August 1673.

447. *Diary* (R&A) p.55, entry for 15 August 1673.

448. *Diary* (R&A) p.60, entry for 16 September 1673.

449. *Diary* (R&A) p.61, entry for 21 September 1673.

450. *Diary* (R&A) p.61, entry for 22 September 1673.

451. *Diary* (R&A) p.63, entry for 1 October 1673.

452. *Diary* (R&A) p.83, entry for 28 January 1674.

453. *Diary* (R&A) p.83, entry for 29 January 1674.

454. *Diary* (R&A) p.85, entry for 3 February 1674.

455. *Diary* (R&A) p.86, entry for 11 February 1674.

456. *Diary* (R&A) p.88, entry for 23 February 1674.

457. *Diary* (R&A) p.114, entry for 28 July 1674.

458. "Surveying" here is taken to mean more than the work Hooke did as City Surveyor in the aftermath of the Fire. The Royal Institution of Chartered Surveyors supports, and sets professional standards of practice for, its 100,000 members. It has seven divisions: General Practice (the business of managing and valuing property); Building Surveying; Quantity Surveying; Planning and Development; Minerals and Environmental Management; Geomatics (until recently Land and Hydrographic Surveying); and Rural Practice. In his work for the City in the aftermath of the Fire, Hooke practised in each of these divisional areas, except rural practice. In his scientific investigations and design of opto-mechanical instruments he contributed to what are now known as field astronomy, atmospheric physics, geodesy, geophysics, topographic mapping, navigation, hydrography and photogrammetry, all of which are now practised across the membership of the Geomatics Division of the Royal Institution of Chartered Surveyors.

459. In particular Pumfrey, S. "Ideas above his station: a social study of Hooke's curatorship of experiments" *History of Science* 29:1-44 (1991); Shapin, S. "Who was Robert Hooke" in Hunter, M. (ed.) *Robert Hooke: New Studies*

(Woodbridge, Boydell Press, 1990) Chapter 9, pp.253-285; and Hunter, M. *Establishing The New Science: The Experience Of The Early Royal Society* (Woodbridge, Boydell Press, 1989) have led these new studies.

460. Daston, L. & Park, K. *Wonders and the Order of Nature 1150-1750* (New York, Zone Books, 1998) discuss how in the second half of the seventeenth century, wonders could inspire curiosity which sometimes led to experimental investigations. Hooke in *Micrographia* revealed for the first time many wondrous things, about which he was curious, but they were not subjects which engaged his experimental philosophy. Predominantly living wonders, they were not as readily understood by the mechanistic approach which Hooke used to such good effect in his major studies of springs, gravity, light, etc. which appear in his published Cutlerian Lectures.

461. Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) pp.133-136.

462. Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) pp.163-165.

463. A small, but very significant, indication of Hooke's careful attention to defining and describing exactly what an experiment was intended to achieve without being influenced by any expected outcome is seen in his manuscript report to the Royal Society (RS CP.xx.7, dated 24 December 1662) the title of which, unusually for Hooke, shows that he altered what he first wrote. Although it is not possible to decide the order in which these alterations were made, the most significant is that he altered the title from

> Of the Decrease of Gravity by removnig [sic] the Heavy body below the surface of the Earth, upwards

to

> Of the difference of Gravity by removnig [sic] the Body further from the surface of the Earth, upwards

thereby admitting the possibility that the experiment could show an increase in gravity instead of the decrease that might have been expected. Such carefully stated objectivity prior to experimentation was unusual in the Royal Society at that time when, if thought were given to the outcome of an experiment, and an expected outcome was not seen, the experiment was often reported as having simply "failed", rather than having failed to demonstrate what was expected, or what had been postulated.

464. Hooke felt free in a letter to Boyle dated 15 August 1665 to make an adverse remark about Power's experiment:

> I have made trial since I came [to Durdens in Surrey, the home of Lord Berkeley], by weighing in the manner, as Dr Power pretends to have done, a brass weight both at the top, and let down to the bottom of a well about eighty foot deep, but contrary to what the doctor affirms. I find not the least part of a grain difference in a weight of half a pound between the top

and bottom.

Cited by Gunther, R.T *Early Science in Oxford Volume VI* (Oxford, 1930) pp.249-250.

This letter reveals not only Hooke's view of the worthlessness of Power's experiment, but by stating that view, also his trust in Boyle not to reveal it.

465. Hooke, R. *Micrographia* (London, 1665) was printed and ready for publication before 24 October 1664 according to a letter dated 24 November from Hooke to Boyle, cited by Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) p.219$_{\text{footnote 1}}$. The delay in the book's publication was brought about by Fellows of the Royal Society having reservations about accepting responsibility for the conjectures, hypotheses and other statements contained in it. Hooke was required to add some words to his dedication of the book to the Royal Society saying that the opinions expressed were his and not those of the Society.

466. Hull, D. "Robert Hooke: a fractographic study of Kettering-stone" *Notes and Records of the Royal Society of London* 51(1) pp.45-55 (1997).

467. Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) pp.280, 287, 297, 307, 316, 322 & 328.

468. Rather than proposing to the Royal Society that he should proceed with refinements of the mechanism and further trials, Hooke chose instead to mention to the Society his idea for a diving bell. He was accordingly charged with bringing in a description of it, and the development of the sounding device was left, incomplete (Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) p.328).

469. In a letter to Boyle dated 25 August 1664, cited by Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.190-191.

470. In a letter to Boyle dated 15 September 1664, Hooke stated

> night came so fast, that I could hardly see to get up [the steeple] again, and give order for the clearing of the lines ... We have since the last made very few experiments worth your hearing

cited by Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.197-200.

471. In a letter to Boyle dated 6 October 1664 Hooke stated

> such have been the disappointments, from winds, and rains, and divers other accidents, that we have not as yet made any further proceeding ... and indeed I fear (the winter weather coming on so fast) we shall hardly make any more trials [at St Pauls] before the next spring.

cited by Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.202-205.

472. A proposal by Huygens that a pendulum could be used to define a universal length standard was closely examined, perceptively criticised and clearly reported

to the Royal Society by Hooke on 14 December 1664.
Cited by Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.227-229.

473. In a letter dated 10 November 1664 to Boyle about the vivisection of a dog to examine its respiratory system where Hooke stated

> The ... experiment (which I shall hardly, I confess, make again, because it was cruel) was with a dog ... I shall hardly be induced to make any further trials of this kind, because of the torture of the creature: but certainly the enquiry would be very noble, if we could any way find a way so to stupefy the creature, as that it might not be sensible, which I fear there is hardly any opiate will perform

cited by Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.216-218.

474. Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.246-247.

475. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.58.

476. Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.247-249.

477. This was probably Isaac Thompson, later engine-maker to the King (*Diary* (R&A) p.521).

478. Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.249-250.

479. Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.251-253.

480. Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.253-255.

481. Gunther. R.T *Early Science in Oxford Volume VI* (Oxford, 1930) p.283.

482. RS RB(copy 2) pp.223-227, dated 21 March 1666.

483. Details of these experimental investigations which took place with decreasing frequency from the time of the Fire until the end of 1671 are given by Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) pp.63-501 and Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) pp.281-386.

484. On 30 May 1667 some entertainments, including weighing of air, were performed for the Duchess of Newcastle who had expressed a "great desire" to visit the Society (Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) pp.177-178). It is probable that the Society's success in entertaining the Duchess was as great as the consequent damage to its reputation amongst those from whom it sought patronage.

485. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.176, dated 23 May 1667.
One of the ordered experiments (with a terrella - a large spheroidal lodestone used for simulating the earth's magnetic field in experiments on magnetic declination) about which Hooke had spoken was later given to William Ball (or Balle) to perform (Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.181, dated 20 June 1667).
Another order, to proceed with the measurement in St James's Park of the earth's circumference, was a task demanding much more time than Hooke could possibly have given and more ingenuity than most of the Fellows could have provided.

486. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) pp.178-179, dated 3 June 1667.

487. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) pp.182-185, dated 27 June 1667. Hooke was not alone at this time in failing to perform the experiments ordered. At the same meeting, Dr King was absent when he had been ordered to perform an experiment on a dog's thorax - a task he repeatedly failed to complete.

488. In a letter to Boyle dated 5 September 1667 Hooke wrote
> I hope I shall prevail upon Dr Lower, and for him, so as to get him anatomical curator to the society. He has most incomparable discoveries by him on that subject, and a most dextrous hand in dissecting.

In a postscript, Hooke tells Boyle
> Many other things I long to be at, but I do extremely want time.

Cited by Gunther, R.T. *Early Science in Oxford Volume VI* (Oxford, 1930) p.318 footnote 1.

489. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.206, dated 5 November 1667.

490. Hooke continued to take part in and write reports on anatomical experiments at which Lower was present. In particular, Hooke's report on an experiment to discover whether dog foetuses live in the womb by their own or by their mother's respiration has elements of his experimental procedures and provides clear evidence of his powers of observation and description, allied to new questioning (Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) pp.232-233, dated 19 December1667). The Royal Society made several attempts to assist Hooke: Council agreed that he should find a boy who could help him in serving the Society and that fifteen pounds be paid annually to keep him (RS CM (C) I p.153, dated 5 November 1667). Council continued from time to time to try to appoint a Curator of anatomical experiments: they ordered a convenient room to be found for his experiments (RS CM(C) I p.165, dated 25 January 1668); Oldenburg was ordered to ask Lower & Dr Clark for a list of particulars necessary for making anatomical experiments (ibid. p.187, dated 29 June 1668);

and nine months later, after again agreeing that an anatomical Curator was necessary and that a salary of £50 per annum would be paid, they called for nominations - Lower's name was now one of three proposed (ibid. p.202, dated 18 March 1669). Nobody accepted the opportunity. For a Physician the salary was miserly, but more than the Society could afford, and in any case, Hooke continued to perform anatomical experiments as part of his duties.

491. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.238, dated 11 January 1668.

492. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.282, dated 11 May 1668.

493. RS CM(C)I pp.181-182, dated 30 May 1668.

494. RS CM(C)I p.185, dated 22 June 1668. Hooke was instructed by the Royal Society to undertake the modern roles of Resident Engineer and Quantity Surveyor on its behalf - roles the City Lands Committee would later instruct him to undertake.

495. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.302, dated 29 June 1668; p.304, dated 6 July 1668; p.305, dated 13 July 1668; and p.313, dated 10 August 1668.

496. Hunter, M. "A college for the Royal Society: the abortive plan" *Notes and Records of the Royal Society of London* 38(2) pp.159-186 (1984) describes reasons behind the plan. His account includes a discussion of why Hooke's design was ultimately preferred to those of Wren and Henry Howard and argues that the ambition of the Royal Society to have its own building was unrealised through internal wrangling and the Society's inability to pay for it.

497. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.289, dated 30 May 1668.

498. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.293, dated 4 June 1668.

499. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.346, dated 11 February 1669; ibid p.354, dated 11 March 1669 (when Hooke attended the meeting, but instead of carrying out the ordered experiments he reported on microscopical observations of frogs he had taken upon himself); ibid p.383, dated 17 June 1669 (when Hooke was again present, but excused himself from performing the ordered experiments); ibid p.395, dated 22 July 1669 (when at the last meeting before the recess Hooke was ordered to perform in private all the experiments already committed to his care, but not yet performed, and report on them to the Society when it reconvened); ibid p.411, dated 9 December 1669 (when Hooke excused himself, saying that avocations of a public nature had

prevented him from performing the ordered experiments); and ibid p.418, dated10 February 1670 (when Hooke was absent).

500. Birch, T. *The History of the Royal Society of London Volume II* (London,1756) p.383, entry for 17 June 1669.

501. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.441, dated 28 June 1670.

502. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.452, dated 14 November 1670.

503. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.454, dated 24 November 1670.

504. The work done in those four weeks would not have been unusual for a City Surveyor whose main employment was in that capacity; the fact that the work was not unusual for Hooke shows his great energy and skill at organising his business for the City.

505. CLRO Ex-GL Ms.276 pp.75-76.

506. CLRO VR I pp.15-16.

507. CLRO CLCO I f.46^{r}, dated 9 November 1670.

508. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.469, dated 9 February 1671.

509. Wren too was engaged with Hooke in the matter of gravity and the motion of the earth and other planets as discussed by Bennett, J.A. "Hooke and Wren and the system of the world: some points towards an historical account" *The British Journal for the History of Science* 8(28) pp.32-61.

510. Birch, T. *The History of the Royal Society of London Volume III* (London, 1757) p.9, dated 8 February 1672.

511. Birch, T. *The History of the Royal Society of London Volume III* (London, 1757) pp.10-15, dated 15 February 1672. There is no evidence that either Boyle or Ward made a contribution to Hooke's report.

512. Hunter, M. *The Royal Society and its Fellows 1660-1700* (Chalfont St Giles, British Society for the History of Science, 1982) p.113, Table 3 shows that more than fifty meetings of the Royal Society took place in each of the years 1661-1664, but by 1674 the number had fallen by more than 50%. The decline had many causes, including interruption by the Plague, deaths of very active members, retirement to the country or loss of interest by others, factionalism and lack of recruitment (ibid pp.36-39).

513. Hooke maintained that telescopic sights were more accurate than the open sights used by Hevelius and earlier astronomers for measuring inter-stellar distances for star catalogues. The resultant dispute is described by Waller, R. "The life of Dr Robert Hooke" in Waller.R. (ed.) *The Posthumous Works of Robert Hooke* (London 1705) pp.xv-xix. The dispute was revived more than a decade later when Hevelius sent to the Royal Society his *Annus Climactericus* in folio which was discussed by Wallis in *Philosophical Transactions of the Royal Society of London 175* (now Volume 15) pp.1162-1183 (1685).

514. The accuracy of observations using Hevelius's open sights was about 2-3 minutes of arc. Hooke claimed that with telescopic sights and with an instrument of but a span breadth he could make observations

> Thirty, Forty, Fifty, yea Sixty times more accurate, than could be done the other way with the most Vast Instruments

Philosophical Transactions of the Royal Society of London 175 (now Volume 15) p.1165 (1685).

It took about two and a half centuries for opto-mechanical engineering techniques and materials to develop to the stage where Hooke was proved right when the T2 Universal Theodolite was produced in Switzerland by Heinrich Wild. It measures directly to 1 second of arc (more than a hundred times more accurately than Hevelius) and can be comfortably held in one hand (Cooper, M.A.R. *Modern Theodolites and Levels Second Edition* (London, Granada (now Blackwells Scientific & Professional), 1982) passim. Hooke's far-sighted, but reckless enthusiasm and Hevelius's unimaginative intransigence were ideal for nurturing ill feeling and rash accusations on both sides of the dispute.

515. Waller, R. "The life of Dr Robert Hooke" in Waller, R. (ed.) *The Posthumous Works of Robert Hooke* (London 1705) pp.xviii-xix.

516. From the first page of the Preface to Hooke's *Micrographia* (London,1665).

517. Although views have been used to illustrate Hooke's use of sense, memory, and reason in surveying as well as in experimenting, he used them also, but with varying importance, in setting out the streets, setting out and certifying foundations and certifying areas of ground taken away.

518. However, if Hooke thought that strict application of the law would lead to unfair treatment, or undue hardship for an individual, or an institution, he would say so in his report to the City and recommend a fairer means for settling the dispute. This attention to equity is evidence of Hooke's sense of justice as superior to the law. But he could make only recommendations. The City had the power to decide what should take place. It almost always acted according to Hooke's recommendations.

519. The practice of making only linear measurements was however geometrically inappropriate (Section 3.2 above). For geometrical accuracy it would have been necessary to spend much more time measuring and calculating, but in

consequence the effects on the sums paid would have been insignificant.

520. Leybourn, W. *The Compleat Surveyor, First & Second Editions* (London, 1653 & 1657 respectively). Leybourn was an experienced mathematical practitioner and teacher before the Fire and was one of the surveyors who measured for John Leake's 1666 map of the burnt areas of the city and for Ogilby and Morgan's larger scale map of the rebuilt city.

521. Howgego, J.L. *Printed Maps of London circa 1553-1850 Second Edition* (Folkestone, Dawson, 1978) p.4. In her Foreword, Wallis, H. gives three terms used in England in the seventeenth century to differentiate between ways of representing streets and buildings: by orthogonal projection onto a horizontal plane ("ichnography") by orthogonal projection onto a vertical plane ("orthography", or "ortography") and by an approximation of perspective projection onto a plane inclined to both the horizontal and the vertical ("scenography"). Wallis states that scenography was the most common method used for city maps in the seventeenth century. Of the three forms, ichnography and orthography are geometrically correct representations of buildings and streets (unless scenography happened to be axonometric); ichnography is commonly used for large scale maps and plans and orthography (or ortography) for architectural elevations and sections.

522. The required accuracy, particularly for Ogilby and Morgan's survey, could not be achieved with equipment and procedures widely used for surveying roads and manors. In particular the circumferentor, quite adequate for taking bearings for a road survey or for an estate survey, was not suitable in city surveying because it was not sufficiently accurate, depending as it did on a magnetic needle for a reference direction. Local and generally unpredictable magnetic attraction could cause errors of several degrees. Such errors would be quite unacceptable in city surveying where streets are expected to be plotted without any mis-matches, or erroneous discontinuities. On the other hand a road survey was intended primarily to indicate features and distances along the road. Only a general indication of its direction was necessary.

523. CLRO Jor.46 f.123^{r}, dated 4 October 1666. The map, mentioned in Section 2.3 above, was intended to be the basis of a land information system for London.

524. It would be interesting to examine the relationship between Leake's plan and any of the earlier plans by digitisation, superimposition and similarity transformations. This process could reveal to what extent the earlier plans were used as a framework for the new measurements. In any case, the street widths were measured and shown in a fairly crude way with considerable generalisation.

525. Hooke was one of those nominated by the City to approve Ogilby's survey (Hyde, R. "Ogilby and Morgan's City of London map" in *The A to Z of Restoration London* (London, LTS, 1992) pp.v-xii.

526. Their frequent coffee house meetings, at which the surveyors Leybourne, Shortgrave, King and Morgan were sometimes present, are discussed by Van Eerde, K.S. *John Ogilby and the Taste of his Times* (Folkestone, Dawson, 1976) pp.125-133, and passim, where Hooke's active help and advice are shown to have been important to Ogilby in his endeavours to raise funds for his *Britannia* and for the 1676 map of London.

527. Hooke was at Garaway's with Ogilby and Shortgrave on 8 July 1673; he was given some map sheets (probably drafts) by Ogilby on 19 July 1673; he and Ogilby at Garaway's on 14 August 1673 designed the individual map sheets for printing; and on 8 December 1673 Ogilby took the first printed sheet from Hollar to Hooke

> with Ogylby at Dr. Godderds he brought mē his 1st sheet of London from Hollis.

Diary (R&A) pp.50, 51, 55, & 75-76 respectively.
At the end of January 1674 Hooke and Ogilby went to Guildhall about the map of London, so it seems as if all the map sheets had been printed by that time (*Diary* (R&A) p.83, entry for 29 January 1674).

528. Leybourn, W. *The Compleat Surveyor, Third Edition* (London, 1674) chose a new dedicatee, Sir Thomas Player, City Chamberlain, through whose offices payments were made to Leybourn for his admeasurement of the City's works. The most important addition to the contents in the third edition is a section (pp.300-301) entitled "For Streets or Lanes in Cities or Towns" which shows several significant changes in the instruments and procedures which had for decades been used in England for rural and roads surveying and which had been fully covered in previous editions. The two extra pages appear to have been hastily added to the second edition of the book.

529. Holwell, J. *A Sure Guide to the Practical Surveyor* (London, 1678) p. 190 states that he has based his description of city surveying on his experience of measuring and plotting more than two hundred acres of London for John Ogilby. His descriptions of how to use the semicircle, chain and rod and how to plot the measurements resemble Leybourn's, but are given in much more detail. The manner in which he describes the techniques clearly reveals his practical experience. He recommends use of a chain, fifty feet long made up of fifty links, and a five-foot or ten-foot rod, subdivided into feet. Bendall, S (ed.) *Dictionary of Land Surveyors and Local Map-Makers of Great Britain and Ireland 1530-1850, Second Edition, Volume 2* (London, The British Library, 1997) p.255 states that John Holwell was about twenty years younger than Leybourn and worked as his assistant on the Ogilby and Morgan plan of 1676.

530. Leybourn, W. *The Compleat Surveyor, Third Edition* (London, 1674) p.301.

531. Even if he had employed a draughtsman (and managed to retain him) to plot his surveys, Hooke would have had to spend time checking and supervising the work.

532. This sum was ordered to be paid for
admeasurements of work upon public buildings
CLRO CLCM(R), entry for 22 July 1672.
Which means quantity surveying, not land surveying.

533. On 4 October 1676 the City Surveyors were ordered by the City Lands Committee to audit the accounts of City workmen & artificers
for the reasonableness of the rates mentioned therein
CLRO CLCP Ms.161, dated 13 December 1676.
Payments were then authorised to be made, including £12 to Leybourn for measurements in the last year, including work on the Monument (ibid.).

534. Hooke, when at the Spanish Coffee House with Ogilby
Drew the uses of London map.
Diary (R&A) p.92, entry for 19 March 1674.
This implies a design for a land use map, showing information additional to delineated buildings and streets; the idea of an information system for the City was still in Hooke's mind.

535. Johns, H. "Introduction to the maps" in: Lobel, M.D. (ed.) *The British Atlas of Historic Towns* (Oxford, 1989) pp.57-58. Despite the evidence that party walls and internal courts and alleyways were not measured by the surveyors, their representation on the map could have been adequate if legislation for internal inspections had been in force and if the surveyors had taken some additional external measurements.

536. Boyle, who had been paying Hooke to assist him in his work in Oxford, may have continued to pay him an allowance. He may also have arranged lodgings for him.

537. RS CM(C) I p.21, dated 6 July 1663.

538. Hooke was paid 10s-00d by the Treasurer
for a Book for his Microscopical Pictures.
RS TAB I (unpaginated), entry dated 4 August 1663.

539. Birch, T. *History of the Royal Society of London Volume I* (London, 1756) p.309, entry for 5 October 1663.

540. Hunter, M. *The Royal Society and its Fellows 1660-1700* (Chalfont St. Giles, British Society for the History of Science, 1982) p.34 where, in letters to Boyle, Oldenburg in late 1664 is quoted as writing that
> we grow more remiss and careless ... our meetings are very thin ... [the Society could become] a mighty and important Body ... if all the members thereof could but be induced to contribute every one their part and talent.

541. RS TAB I (unpaginated).

542. On 14 October 1663 Hooke was ordered by the Royal Society to find lodgings in Gresham College "for some days" to prepare experiments for the King (Birch, T. *The History of the Royal Society of London Volume I* (London,1756) p.315). For the same reason, two months later Hooke was invited by the Royal Society Council to lodge in the College on Mondays, Tuesdays, Wednesdays and Thursdays and as a consequence be paid 20s-00d weekly. Hooke accepted the invitation (ibid. p.340), but no evidence has been found that he lodged there at that time.

543. RS CM(C) I p.80 dated 22 June 1664. At the same time Council decided that Hooke's *Micrographia* should be printed by order of the Society - provided its contents were first approved by Brouncker and others. Hooke's need for a salary and the Royal Society's intention to scrutinise what he was about to publish provide an example of the lack of trust which existed between the membership in general on the one hand and Hooke on the other, through his lack of independent means and despite his masterful descriptions in *Micrographia*.

544. RS CM(C) I pp.82-83, dated 27 July 1664. Council also decided that Hooke should provide himself with lodgings in Gresham College and that these decisions should remain secret

> till Sir John Cutler have Established Mr Hook as a Professor of the Histories of Trades.

The implication here is that Council intended to allow Cutler to set up what would be in effect be a new Gresham Professorship for Hooke (Cutler's proposed salary of £50 was the same as the salary of a Gresham Professor) but they would then use Hooke conveniently living and working Gresham College for their own purpose - an act of deceit on the part of Council.

545. RS CM(C) I pp.85-86, dated 5 October 1664.

546. Hunter, M. *Establishing the New Science* (Woodbridge, Boydell Press, 1989) Chapter 9 "Science, technology and patronage; Robert Hooke and the Cutlerian Lectureship", pp.279-338. This is the result of a detailed investigation of a lengthy and complicated series of events, expressed with clarity and soundly argued from many and varied original sources.

547. Birch, T. *The History of the Royal Society of London Volume I* (London, 1756) p.473$_{\text{footnote e}}$ is an extract from a letter from Hooke to Boyle written on 6 October 1664, the day after he had received the order to prepare his inaugural lecture. Hooke also tells Boyle that he is

> now engaged in a very great design, which I fear I shall find a very hard, difficult and tedious task; and that is the compiling a history of trades and manufactures ... and by God's assistance I shall endeavour, to the utmost of my power, to go as far in it as I am able, being resolved wholly to apply my mind and endeavours to it.

He did not find the subject in accord with his experimental philosophy, but despite this and the difficulty it would bring, his intention at this time to meet

Cutler's wishes is clear. Later events, some brought about by Hooke himself, allowed only one or two lectures on the history of trades to be delivered; most of the Cutlerian Lectures derived from his scientific investigations.

548. Birch, T. *The History of the Royal Society of London Volume II* (London, 1756) p.4.

549. RS TAB I, unpaginated. Two payments (£3-00s-00d and £3-06s-00d) are described as "paid by" Hooke; the third entry is "paid Mr Hooke £20 00s 00d".

550. RS CM(C) I p.105, dated 28 June 1665.

551. RS TAB I, unpaginated. The Treasurer was authorised by Council to make this payment (RS CM(C)I p.119, dated 4 July 1666).

552. RS CM(C) I p.124, dated 19 October 1666. The entry specifically refers to Hooke's salary as being £30 per annum.

553. RS CM(C) I pp.140-141, dated 14 February 1667. The money said to be owing to Hooke was made up as follows.

Quarter to Midsummer 1664 @ £80 p.a.	£20-00s-00d
Quarter to Michaelmas 1664 @ £80 p.a.	£20-00s-00d
Michaelmas 1664 to 23 November 1664 @ 80 p.a.	£11-13s-04d
23 November 1664 to 23 November 1665 @ £30 p.a.	£30-00s-00d
23 November 1665 to Christmas 1666 @ £30 p.a.	£32-10s-00d
Total	£114-03s-04d

The money said to have been paid to Hooke was made up as follows

Payment by Treasurer Hill @ £80 p.a.	£39-00s-00d
Payment by Treasurer Colwall	£30-00s-00d
Balance due to Hooke	£45-03s-04d
Total	£114-03s-04d

The Treasurer was ordered to pay the money owing.

554. It was paid in the period ending 11 November 1667 where it is described as the Ballance of his account as Curator.
RS TAB I, unpaginated.

555.

Table 5.
The Royal Society's salary payments to Hooke from the end of 1666 to the end of 1675

Accounting period, or date of payment	Amount paid	For period
Nov 1667 - Nov 1668	nil	

Nov 1668- Nov 1669	£60-00s-00d	Christmas 1666 - Christmas 1668
Nov 1669 - Nov 1670	£37-10s-00d	Christmas 1668 - Lady Day 1670
Nov 1670 - Nov 1671	£30-00s-00d	Lady Day 1670 - Lady Day 1671
Nov 1671 - Nov 1672	£30-00s-00d	Lady Day 1671 - Lady Day 1672
29 March 1673	£15-00s-00d	Lady Day 1672 - Michaelmas1672
Nov 1673 - Nov 1674	a/c missing	Michaelmas 1672 - Lady Day1674
15 February 1675	£15-00s-00d	Lady Day 1674 - Michaelmas 1674
29 April 1675	£15-00s-00d	Michaelmas 1674 - Lady Day 1675
28 October 1675	£15-00s-00d	Lady Day 1675 - Michaelmas 1675

From RS TAB I & II, unpaginated. The accounts were presented each November.

556. *Diary* (R&A) p.49, entry for 30 June 1673 includes

> Dind at Dr. Whistlers. Sir J. Cutler promised me payment for 3 years, Dr. Whistler witnesse at at Kings armes by the pump in threadneedle street.

Dr Daniel Whistler was a Physician and an active Fellow of the Royal Society in the 1660's and 1670's.

557. *Diary* (R&A) p.80, entry for 15 January 1674 includes

> With Sir J. Cutler. He promised to give his finall determination before the first of March, and talked of will and before Mr. Bolter sayd that he owed me for between 3 and four year.

Edmund Boulter was nephew, fellow Grocer and beneficiary of Cutler.

558. He is satirised under his own name in Alexander Pope's *Epistle III to Allen Lord Bathurst*, lines 315-334, which include the three couplets

> Cutler saw tenants break, and houses fall
> For very want; he could not build a wall.
> His only daughter in a stranger's pow'r
> For very want; he could not pay a dow'r.
> A few grey hairs his revren'd temples crowned,
> 'Twas very want that sold them for two pound.

That this was written in 1733, forty years after Cutler's death, shows his reputation for meanness went beyond the ordinary.

559. Records of payments to Hooke and the other Gresham Professors can be found in different places. CLRO GCAB MS I is a working ledger showing income and expenditure year by year in which the annual salaries paid to each of the four Gresham Professors under the aegis of the City Side of the Joint Grand Gresham Committee can be found. CLRO GCAB DS is a copy of CLRO GCAB MS, but

opening and closing dates of the series volumes do not coincide. CLRO GCAB AB I is a record of cash payments, including salaries of the four Gresham Professors, with recipients' signatures. CLRO GCAB CB I is a journal record of the transactions made in the foregoing, but entered here in date order. Misc. Mss.149/24 are abstracts, for various years, of the accounts in CLRO GCAB MS.

560. In the letter to Boyle written on 6 October 1664 (Birch, T. *History of the Royal Society of London Volume I* (London, 1756) p.473$_{\text{footnote e}}$) Hooke says that he is
> engaged to read for Dr Pope

On 15 November 1664 Abraham Hill, Merchant, and Treasurer of the Royal Society, received and signed for Pope's salary for the half-year to Michaelmas 1664 (CLRO GCAB AB I f.65^{r}). He may have passed the full amount of £25, or part of it, to Hooke who was giving at least some of Pope's lectures during that period. Hill also received and signed for instalments of Pope's salary on 26 November 1663 for the half-year to Michaelmas 1663 (ibid. f.51^{r}) and on 12 May 1664 for the half-year to Lady Day 1664 (ibid. f.51^{v}). It is possible that other Fellows of the Royal Society as well as Hooke read the Astronomy Lectures in Pope's absence and received payment from the City through Hill. Pope had returned by 26 May 1665 when he signed for his salary for the half-year to Lady Day 1665 (ibid. f.66^{r}).

561. CLRO GCAB AB I f.65^{v}, dated 14 April 1665.

562. CLRO GCAB CB I, unpaginated, dated 16 October 1665. The entry is
> 1665 October 16 Payed unto Mr Robert Hooke Reader of the Geometry Lecture at Gresham Colledge for half a yeare ending at Michaelmas 1665
> 025 00 00

There is no record in CLRO GCAB AB I of Hooke having signed for this amount.

563. CLRO GCAB AB I f.114^{r}, dated 4 June 1969 shows Hooke's signature for receipt of Pope's salary for the six months to Lady Day 1669.

564. CLRO GCAB AB III, f.8^{v}. This payment is also recorded in CLRO GCAB CB IV, where it is the last made to Hooke.

565. The next payment of salary to a Gresham Professor of Geometry following the payment to Hooke for the period ended Lady Day 1701 is to Andrew Took who received £37-10s-00d for three quarters of a year to Lady Day 1705 on 12 July 1706 (CLRO GCAB AB III f.9^{r}). No salary payment from Lady Day 1701 to the time of Hooke's death is recorded in either CLRO GCAB AB III or CLRO GCAB CB IV & V.

566. CLRO Ex-GL Ms.275 ff.77^{r}-79^{r}.

567. CLRO Ex-GL Ms.322/8.

568. CLRO Ex-GL Ms.322/17.

569. CLRO Ex-GL Ms.275 ff.83^{r}-88^{r}.

570. CLRO Ex-GL Ms.275 f.79^{r}.

571. *Diary* (R&A) p.76.

572. The following payment was ordered under the heading "Foreign Charges" for the year ending Michaelmas 1674:

> Paid unto Master Robert Hooke one of the present Surveighers Eight Guineys to advice with Councell about the Act of Parliament for rebuilding the Citie of London by order of Court.

CLRO CCAB I/15 f.59^{r}, dated 2 October 1673.
Hooke received the payment on 31 October when he noted:

> Received 8 Guinnys for Councell

Diary (R&A) p.67.

573. This payment was noted by Hooke in conjunction with his gratuity for advice about the Rebuilding Act:

> to Guildhall. Order of the court of Aldermen for seeing Councell and for the piller. ... Receivd of the chamber £25.

Diary (R&A) p.63, entry for 2 October 1673.

574. On 24 December 1675 Hooke noted in his diary

> Received Warrant from Controuler for £100.

Diary (R&A) p.203.

575. On 20 December 1676 Hooke noted in his diary

> Attended on committee till 8. They forgot us. At last Sir J. Frederick, Sir Fran Chaplaine, Sir Nath Hearne, Pilkington, Player, Sturges gave us £50.

Diary (R&A) p.263.

576. *Diary* (R&A) p.284, entry for 6 April 1677.

577. On 16 November 1677 Hooke noted

> At Jonathan's. Chocolat 3d. Talkd with Oliver about Salary etc., he said he would joyne with me.

Diary (R&A) p.328.

578. On 22 December 1677 Hooke noted

> Heard the City had ordered £40 for last year.

Diary (R&A) p.335.

579. On 26 December 1678 Hooke noted

> Councell ordered £15 for Salary to Xtmas.

Diary (R&A) p.390.

580. On 24 February 1679 Hooke noted

> I received from Mr Green an Order for £20 for the service of the last year.

Diary (R&A) p.400.

581. The Chamberlain was ordered on 18 December 1682 by the City Lands Committee to pay Hooke for his work for the Committee in 1682

> You are forthwith to pay to Robert Hooke one of the Cities Surveyors the sume of five pounds in full for his service and attendance upon and by Order of the Committee for the Cities Lands this last yeare.

CLRO Misc. Mss.157.15.

Hooke's receipt for £5 is dated 18 June 1683 (ibid.) and the payment appears in the accounts for the period ending Michaelmas 1682 under the heading of

> Guifts and Rewards

CLRO CCABI/17 f.221^{r}.

Another payment of £5 was made for the year ending Michaelmas 1683 (ibid. f.283^{r}).

582. CLRO Ex-GL Ms.277 f.5^{r}.

583. *Diary* (R&A) p. 60, entry for 16 September 1673.

584. *Diary* (R&A) p.14, dated 22 November 1672.

585. CLRO Ex-GL Ms.277 f.2^{r}, dated 15 November 1672.

586. On 30 November 1672 Hooke noted

> Lem offerd Guiney

Diary (R&A) p.15.

This entry probably refers to a foundation survey in Suffolk Lane which was assigned to Hooke following an application on 12 November 1672 to the City from Joseph Lem (CLRO Ex-GL Ms.277 f.2^{r}). Hooke's diary entry does however leave a doubt about whether Hooke accepted Lem's offer.

587. On 29 July 1674 Hooke noted

> From Dr. Good at Garaways 1 Guinny.

Diary (R&A) p.115.

This entry probably refers to a survey of two foundations in Tower Street which was assigned to Hooke following an application on 26 May 1674 to the City from Dr Good (CLRO Ex-GL Ms.277 f.6^{v}) and which was carried out by Hooke on 17 July 1674:

> Set out Dr Good.

Diary (R&A) p.113.

588. On 25 November 1672 Hooke noted

> Dr. Barbon, Mincing Lane, 10sh.

Diary (R&A) p.14.

This entry probably refers to the foundation survey in Mincing Lane requested on 18 November 1672 by Dr Nicholas "Barebone" (CLRO Ex-GL Ms.277 f.2^{v}).

589. On 13 October 1673 Hooke noted (at unusual length)
sett out Crane in Buttolph Lane, from him 6s 8d.
Diary (R&A) p.65.
This entry probably refers to a survey of two foundations in Botolph Lane requested on 11 October by John Crane (CLRO Ex-GL Ms.277 f.5^{r}).

590. CLRO Ex-GL Ms.277 f.3^{r}.

591. On 27 March 1673 Hooke noted
set out Oliver and Anis.
Diary (R&A) p.36.

592.

Table 6.
The number of citizens to whom Hooke issued foundation certificates

Year	1667	1668	1669	1670	1671	1672	1673	1674
No.	271[†]	606	514	277	216	80	47	31

Year	1675	1676	1677	1678	1679-1696
No.	27	13	7	3	32

[†]Beginning in May

593. On 24 September 1673 Hooke noted
to Sir J Whitchcots 5 guinny
Diary (R&A) p.61.
Although Hooke does not say what this fee was for, his certificate for 2508 square feet of ground belonging to "Sir J. Whichcot" and dated 23 September 1673 has been found (CLRO CD Box K W/40^{B}) together with the City's valuation of the loss of ground and 22 tenements at £800 (ibid. W/40^{C}).

594. On 19 October 1674 Hooke noted
Merrifield Certificat 5sh.
Diary (R&A) p.127.
Although Hooke does not say what the fee was for, his certificate for ground in Fleet Lane lost by Merrifield has been found (CLRO CD Box K M/35). This certificate is dated a week later than the diary entry, but Hooke probably wrote the certificate after he measured the ground, or even made a date error in his diary - he sometimes wrote it several days after the events described.

595. On 8 September 1674 Hooke noted
pd. Oliver his 10sh. for Ireland.
Diary (R&A) p.120.
On 3 September 1674 Hooke had noted a view at Ireland's (ibid. p.119).

596. On 6 May 1693 Hooke noted
I paid J. Oliv. for yesterday's view 10.
Diary (G) p.237.
The previous day Hooke had noted
View in Leaden hall street, Axe Ally 10s
(ibid.).

597.

Table 7.
Salary payments to Hooke for work on rebuilding churches

Year	1671	1672	1673	1674	1675	1676	1677	1678
No.	£250	£250	£100	£125	£100	£100	£150	£140

Year	1679	1680	1681	1682	1683	1684	1685	1686
No.	£100	£100	£150	£150	£250	£150	£150	£160

Year	1687	1688	1689	1690	1691	1692	1693	Total
No.	£120	£125	nil	nil	£50	£50	£50	£2820

Taken from GL Ms.25,548 pp.17 & 19. The title of the record is "The Accompt of Sallerys Paid unto Officers and Servants Emploid in Building Parochiall Churches". It shows also payments to Wren, Woodroofe, Oliver and Hawksmoor, inter alia.

598. In connection with the city churches, Stoesser-Johnston, A. *Robert Hooke and Holland: Dutch Influence on Hooke's Architecture* (3 volumes, unpublished Doctoraalscriptie Bouwkunst, Rijksuniversiteit, Utrecht, 1997) p.17 states:
The controversy over who designed the city churches has not yet seen the last chapter written.
and gives a summary of recent debates on the matter.

599. Independent confirmation of this sum comes from Hooke himself
To Sir Ch: Wrens. Received £25 which with former and last payment Aug.28, 1674 made £725.
Diary (R&A) p.125, entry for 7 October 1674.
Hooke recorded no further payments for churches in 1674.

600. Evidence from the Physicians' cash book and annals cited by Gunther, R.A. *Early Science in Oxford Volume VII* (Oxford, 1930) pp.vii-viii shows that Hooke was paid twenty guineas at the end of 1670 and £20 on each of the following dates to the end of 1674: 19 October 1671; 2 July 1672; 16 January 1673 (see also *Diary* (R&A) p.22, entry for 17 January 1673 where the sum is incorrectly transcribed by the Editors as twenty shillings‡); 7 November 1673 (see also *Diary* (R&A) p.69, entry for 15 November 1673); and 19 November 1674 (see also *Diary* (R&A) p.131, entry for 20 November 1673). In addition it seems as if Hooke was paid twenty guineas by Ent personally, not by the College, on 7 March 1674

> Dind at Sir G Ents, from him twenty Guinny for Colledge house

Diary (R&A) p.90, entry for 7 March 1674.

‡ In referring to the original manuscript (GL Ms.1758) to check this transcription it was found that the folio commencing 6 January 167$^{2}/_{3}$ was incorrectly bound-in following folio 20 instead of following folio 8.

601. *Diary* (R&A) p.14, entry for 28 November 1672.

602. *Diary* (R&A) p.265, entry for 31 December 1676.

603. Hooke recorded

> Receivd of Ducane [Bedlam Treasurer] £50, which with the £100 before, made £150. Due from him more £50 upon warrant for £200.

Diary (R&A) p.335, entry for 22 December 1677.

604. Hooke recorded

> Due from Mr Montacue upon promise for building his house £50, I hope £100

Diary (R&A) p.265, entry for 31 December 1676.

605. Hooke noted

> Spake to Scowen for my own money

Diary (R&A) p.309, entry for 28 August 1677.

Scowen was probably Montague's Agent. Three months later Hooke noted

> Discoursd with Mr Montacue. He seemed well satisfyed in all things. Orderd Mr Scowen to pay me £50 upon the old and £50 upon the new building ... Desired me to send him the agreements, Designes and Estimates

Diary (R&A) p.332, entry for 5 December 1677.

By the following day, Hooke had done as he had been ordered

> Mr Montacues account ended, wherein he is made Debtor to Fitch £800

Diary (R&A) p.333, entry for 6 December 1677.

A week later Hooke went to see Scowen and was promised payment of £50 the next day (*Diary* (R&A) p.333, entry for 13 December 1677) which was duly delivered to Hooke (ibid. p.334, entry for 14 December 1677) via John Scarborough, who performed tasks of the kind now undertaken by quantity surveyors for Montacue and at other building sites in the city, including parish

churches. Hooke's payments continued to be made late. Even as late as 1680, Hooke recorded

> At Mr Montacues, spake to him for money he promised me

Diary (R&A) p.448, entry for 7 July 1680.

Again, three days later

> Spake to Mr Montacue for £50 he promised

Diary (R&A) p.448, entry for 10 July 1680.

No record of any further payment to Hooke by Montacue has been found in *Diary* (R&A).

606. For example

> At Mr Montacues. Walkd with him an houre in the Garden. Spake about sashes etc.

Diary (R&A) p.381, entry for 21 October 1678.

And

> at Montacues with Tompion, viewed turrets, chimneys &c, walked long with him in the Garden

Diary (R&A) p.386, entry for 26 November 1678.

607.

Table 8.
Estimates of Hooke's income from other institutions and private citizens not already accounted for.

	1670	1671	1672	1673	1674
Physicians' College	£21	£20	£20	£40	£41
Livery Companies	#	#	nil	£8‡	£25
Bridewell/Bedlam	nil	nil	£5	nil	£50 §
Citizens & Parishes	#	#	£6	£6‡	£20
Ralph Montague	nil	nil	nil	nil	£17 †
Total	£21	£20	£31	£54	£153

No information.
‡ From August 1673.
§ Not paid until 1677.
† Proportion in 1674 of £50 per annum; not paid until 1677.

In addition, Hooke was paid £10 in 1667 for work on the Royal Exchange (Section 2.3 above).

608.

Table 9.
Estimates of Hooke's income in the eight years after the Fire.

Source	Amount	Comments
Royal Society	£240-00s-00d	Salary, Curator of Experiments
Sir John Cutler	£400-00s-00d‡	Salary, Cutlerian Lecturer
Gresham College	£425-00s-00d#	Salary, Professor of Geometry
City of London	£1062-10s-00d	Salary, City Surveyor
London's Citizens	£1000	Fees for staking out foundations
London's Citizens	£279	Fees for certification of areas
London's Citizens	£275	Fees for views
Churches Fund	£725-00s-00d	Salary for rebuilding churches
Other Institutions & Citizens	£289	Fees for private commissions
Total	£4695	Average circa £582 p.a.

‡ Only £187-10s-00d was paid in the eight-year period, the remainder was paid in 1693 after litigation by Hooke.
# Includes £25-00s-00d for giving Pope's lectures for six months in 1668-69.
The amounts given in full (£sd) are from well-documented sources; other amounts are reasonable estimates only, based on documentary evidence of varying completeness in each case.

609. Earle, P. *The Making of the English Middle Class* (London, Methuen, 1989) pp.17-81.

610. Cooper, M.A.R. *Control Surveys in Civil Engineering* (London, Collins (subsequently Oxford, Blackwells) & New York, Nicholls, 1987).

611. Cooper, M.A.R. & Cross, P.A. Statistical concepts and their application in photogrammetry and surveying *Photogrammetric Record* 12(71) pp.637-663 (1988) & 13(77) pp.645-678 (1991).

612. Jones, P.E. & Reddaway, T.F. *The Survey of Building Sites in the City of London Volume I* (London, LTS, 1967) pp.xxii-xxiii have pieced together surveys of foundations adjacent to Poultry and two other parts of the city. The Figure on p.xxiii is illustrated here as Figure 12(a).

613. "GAP" (Generalised Adjustment Program) was developed at City University by J.S. Clark under the present author's supervision and has been used for more than ten years in teaching and research.

614. Brennan, J. *As Burnt Surveys.* A project report submitted for the degree of MSc in Land Surveying, Department of Geomatic Engineering, University College London (unpublished, 1998). The report includes a description of how a network of property boundaries set out and measured by Mills and Oliver was analysed using "GAP", plotted and then fitted to the corresponding area shown on the 1/1,200 scale map of the rebuilt city published by Ogilby and Morgan in 1676. An analysis and discussion of the discrepancies are given in the report.