

The Management of the Civil Engineering
Works of Thomas Telford in the Highlands
of Scotland.

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Thesis submitted to the University of
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The Thesis concerns the management of Thomas Telford's two main civil engineering projects in the Highlands of Scotland: the Caledonian Canal and the Highlands Roads and Bridges. Special attention has been given to the involvement of central government in the financing of the projects and the methods adopted by Telford in solving the various managerial problems stemming from this involvement. The Thesis includes an examination of the responsibilities of the various civil engineers involved in the projects, the role of contractors, the supply and cost of labour and materials and the relationship between engineer and government.

A general survey of civil engineering management practice in the latter half of the eighteenth and first quarter of the nineteenth centuries form the context for the detailed discussion of Telford's work which follows.

Engineering
Management
Canal
Roads
Contractors

CONTENTS

Preface		i
Introduction		I
Chapter 1	The Organisation of Civil Engineering projects in Great Britain, 1750-1830	42
Chapter 2	Management	78
Chapter 3	Contractors	107
Chapter 4	Finance	135
Chapter 5	The Location and purchase of materials - Timber.	150
Chapter 6	Machinery	168
Chapter 7	The Supply of Stone.	185
Chapter 8	Labour and Wages.	196
Chapter 9	Land Purchase	215
Chapter 10	The relationship between Engineer and Board.	240
Conclusion		249
Appendices:	Appendix 1 Sources	289
	Appendix 2 Table of Engineers' Salaries 1750-1830.	290
	Appendix 3 Breakdown of Expenditure on the Caledonian Canal, 1805-1822.	296
	Appendix 4 Graphs showing construction costs on the Caledonian Canal, 1805-1822.	302
	Appendix 5 Table of costs for Highland Roads and Bridges, 1803-1821.	

Maps and Illustrations

Plate 1:	Thomas Telford.
Plate 2:	Proposed Highland Roads and Bridges, 1804.
Plate 3:	The Caledonian Canal, 1813.

PREFACE

In the study of the management of Telford's highland projects much invaluable information has been obtained from the large amount of material contained in the Telford Collection. This collection has been financed by Telford Development Corporation and is housed in the offices of the Ironbridge Gorge Museum Trust. I am most grateful to the Development Corporation for allowing me the time to examine the collection and include material from it in my thesis. I am also greatly indebted to Mr Neil Cossons and Mr S.B. Smith of the Ironbridge Gorge Museum Trust for their kind help and assistance in the preparation of this study. My thanks are also due to Mrs Marge Jacobs of the Ironbridge Gorge Museum Trust who read the drafts and assisted me on numerous matters.

I would also like to thank Dr Jennifer Tann without whose help and guidance this study would not have been undertaken or completed.

INTRODUCTION

The expenditure of large amounts of public money by the Government on the construction of roads, bridges, harbours and a ship canal in the Highlands during the first quarter of the nineteenth century was without parallel. In this study an attempt has been made to examine the organisational aspects of the highland project with special reference to the degree of government involvement in the management of the various schemes, the issue and control of finance, the recruitment and size of the managerial team and the failure to control costs.

The management of civil engineering projects has, rather surprisingly, received little or no attention from historians of civil engineering. Whilst we know a great deal about the technical and chronological details of our major canals we are virtually ignorant of how their construction was ^a managed, having to rely on ^{al} little scraps of information almost accidentally included in the main text. Anyone attempting to answer questions relating to finance, size and responsibilities of the managerial team and the costing of Britain's canal network, using modern secondary sources, will find that many gaps remain at the end of such a task. The comparatively short introductory chapter to the main part of this thesis is based entirely on all relevant modern sources, whilst the central section of the thesis is taken from a wide variety of sources, both primary and secondary, all of which have been detailed in Appendix 1.

The thesis is concerned with a comparative study of the managerial methods employed by Telford on the construction of the Caledonian Canal and the highland roads and bridges scheme especially with regard to overspending. No detailed account of the management of the Caledonian Canal exists although D.C. Cameron has written an excellent general history of the project covering

the period from its construction to the present day. Highland roads and bridges are better served in the form of A.R.B.Haldane's classic study of the project and it is this work, together with official reports, which provides the main source for the comparative sections. On certain occasions references have also been made to other concurrent civil engineering projects. The rapidly deteriorating state of the canal in the 1830s led to an extremely critical report by the Canal Engineer, George May, and this has been used extensively throughout the thesis.

The management of the Caledonian Canal is predominantly about one man - Thomas Telford - and it is now intended to examine briefly the principal features of his career.

The son of an Eskdale shepherd, Telford was born in August 1757 at Glendinning, in the Parish of Westerkirk near Langholm, Dumfriesshire. His father died the same year. Brought up in great hardship by his widowed mother, Telford attended the local parish school where he obtained a basic education before becoming apprenticed to a stone mason in 1770. His subsequent training as a mason provided him with the practical knowledge which was so essential in his later career. He worked with Andrew Thompson, a Langholm stone mason on Langholm 'New Town' which was part of an improvement scheme financed by the Duke of Buccleuch, and on Langholm Bridge, where his mason's mark can still be seen on the western abutment. He developed an early passion for reading and writing poetry which remained until his death in 1834.

Telford left Eskdale for the first time in 1780, gaining further practical experience as a mason in Edinburgh. Determined to improve his position he made a careful study of architectural styles and methods, hoping one day to become an architect. He left for London in 1782, gaining employment as a mason on Somerset House

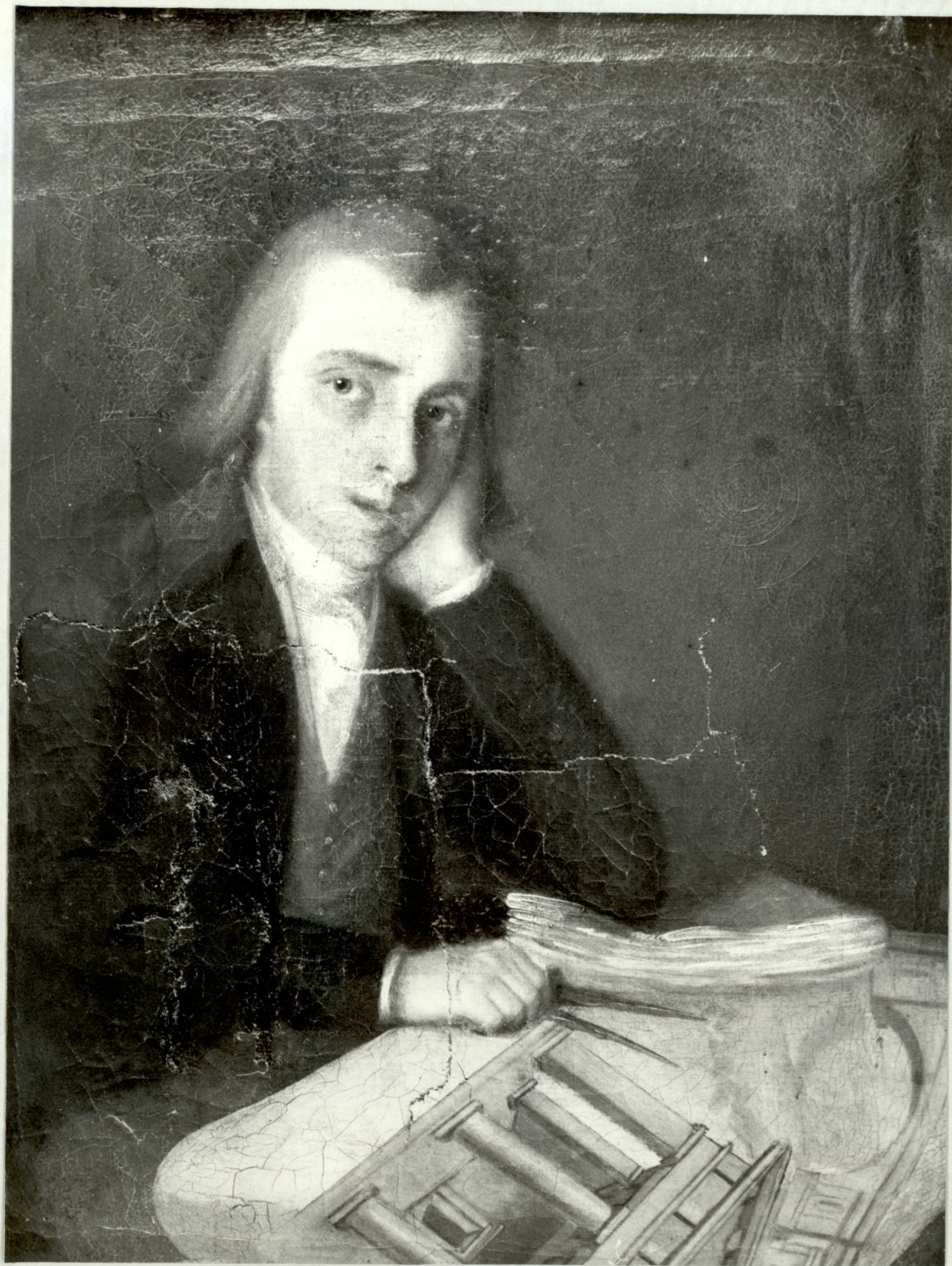


Plate 1. Thomas Telford (1757-1834)

before his first managerial appointment as Building Superintendent for the new Commissioner's House at Portsmouth Naval Dockyard in 1784. During this period Telford met William Pulteney, MP for Shrewsbury, whose friendship and patronage were to play a vital role in furthering his career. Pulteney commissioned Telford to design and supervise the restoration of Shrewsbury Castle and it was through his influence that Telford obtained the post of Surveyor of Public Works for the county of Salop in 1787 - a post he was to retain for life. It was while working as surveyor that Telford began to build up the team of assistants and contractors which was to serve him so well in later years. Still regarded primarily as an architect rather than as a civil engineer, Telford was responsible for the design and construction of public buildings and bridges in the county, including Montford and Buildwas bridges. He employed Matthew Davidson, his former colleague from Langholm, as site engineer at Montford, whilst John Simpson undertook the masonry work. In both instances it was to mark the beginning of a long association with Telford which was only severed after Simpson's death in 1815 and Davidson's in 1819.

Telford's appointment as General Agent to the Ellesmere Canal Company in 1793 marked the beginning of his long association with canals. Working under William Jessop, Telford's duties were described in some detail by the Board in the autumn of 1793; Telford in fact having to sign a form of contract:

Mr Thomas Telford of Shrewsbury, Architect ...(is) appointed the General Agent, Surveyor, Engineer, architect and overlooker of the canal and clerk to this Committee and the sub-committees. (He is)..to make reports, to superintend the cutting, forming and making the canal and taking up and seeing to the due

observance of the levels thereof, to make the drawings and to submit such drawings to the Committee.... to give instruction for contracts to attend by himself ... to pay the contractors' workmen and other persons employed in the execution of the said works and keep the accounts of the concern regularly ... His engagement to extend to all architecture and engineering business, to the drawing, forming and directing the making of bridges, aqueducts, locks, building reservoirs, wharfs and other works in and about completing the said canal.(1)

He was to be paid £500 per annum. There were several other engineers on the project and his position, at first, must have been rather ambiguous. However, his dominant personality soon made him second only to Jessop. He was responsible for the design of the major aqueducts at Chirk and Pontcysyllte, using Davidson as resident engineer and Simpson (with Wilson and Cargill) as masonry contractor. William Hazledine was given the contract for the ironwork, whilst another future Caledonian Canal contractor, William Davies, undertook the massive earthen embankment leading up to the aqueduct. John Telford was employed on the Chester section of the canal as an assistant engineer. Telford also established contact with many future Caledonian Canal suppliers at this period, principally John Fletcher of Chester and William Stanton. The Caledonian construction team^{which} began work in the summer of 1804 was thus an extremely well tested unit, having just completed one of the most ambitious canal projects to date.

The Pulteney connection had brought Telford, at a very early date, in contact with the British Fisheries Society. This in turn

led to his involvement in the Treasury Surveys of the Highlands in 1801 and 1802 and in the setting up of the two Boards of Commissioners for the Caledonian Canal and Highland Roads and Bridges in 1803. Full scale construction work on both projects ceased by the early 1820s by which time Telford had become the country's most eminent civil engineer, having accepted the Presidency of the newly formed Institution of Civil Engineers in 1820. He was involved in numerous projects which ran concurrently with the highland works, the most prominent being the Götha Canal in Sweden and the improvement of the London to Holyhead Road which commenced in 1815. This was his second government financed scheme and included the bridging of the Menai Straits by the world's first major suspension bridge. He again used many of his well tried assistants and contractors and the whole project can, with justification, be regarded as his greatest triumph, both in terms of technical brilliance and organisation. The road between Shrewsbury and Holyhead, which Telford rebuilt completely, was described at the time of its completion in the early 1830s as 'a model of the most perfect road making that has ever been attempted in any country'. His most famous work, the Menai Bridge, was completed in 1826. The links for its suspension chains had been manufactured by William Hazledine, whilst Wilson undertook the masonry contract.

Telford was employed throughout the 1820s and early 30s on numerous canal improvement schemes, including the re-alignment of the Birmingham Canal, which included the excavation of the summit level at Smethwick, and the construction of a second tunnel through Harecastle Hill. Both projects show the huge technical advances made in the practice and organisation of civil engineering in the half century since the death of Brindley, Harecastle Tunnel alone being completed in a fraction of the time taken by the builders of

the first tunnel. His last canal, the Birmingham and Liverpool Junction, which ~~shortened~~ the canal route between Birmingham and the Mersey by nearly twenty miles, was not completed until a year after his death, due mainly to technical problems at Shelmore embankment.

Throughout the 1820s Telford acted as Engineer to the Exchequer Bill Loan Commission Board; a body set up to ease the unemployment problem through the granting of financial aid to civil engineering schemes. Acting in this capacity Telford became involved with virtually all the major civil engineering projects of the period, including the Liverpool and Manchester railway and the Gloucester and Berkeley Canal.

Due to illness and old age, Telford declined taking on new commissions after 1828, concentrating on finishing those in hand and compiling his autobiography, which remained unpublished at the time of his death in September 1834. He was buried in Westminster Abbey.

Telford's achievements during the period 1803 to 1830 were astonishing. No other engineer, before or after, has ever managed successfully to bring to fruition so many huge projects. His energy, imagination and above all flair for organisation made this possible, together with the use of carefully chosen assistants and contractors. A study of the organisation of the Caledonian Canal project will hopefully shed further light on his achievements and put the project in context vis-à-vis his other major projects.

Telford's Highland Projects

The break up of the old clan system combined with the introduction of agricultural improvements caused great social distress in the Highlands. Attempts at alleviating this distress began to materialise in the latter half of the eighteenth century. In

M.A.P.

Shewing the intended
Roads & Bridges
in the
HIGHLANDS of SCOTLAND.

Engraved by J. Barrow, Blackfriars Road.

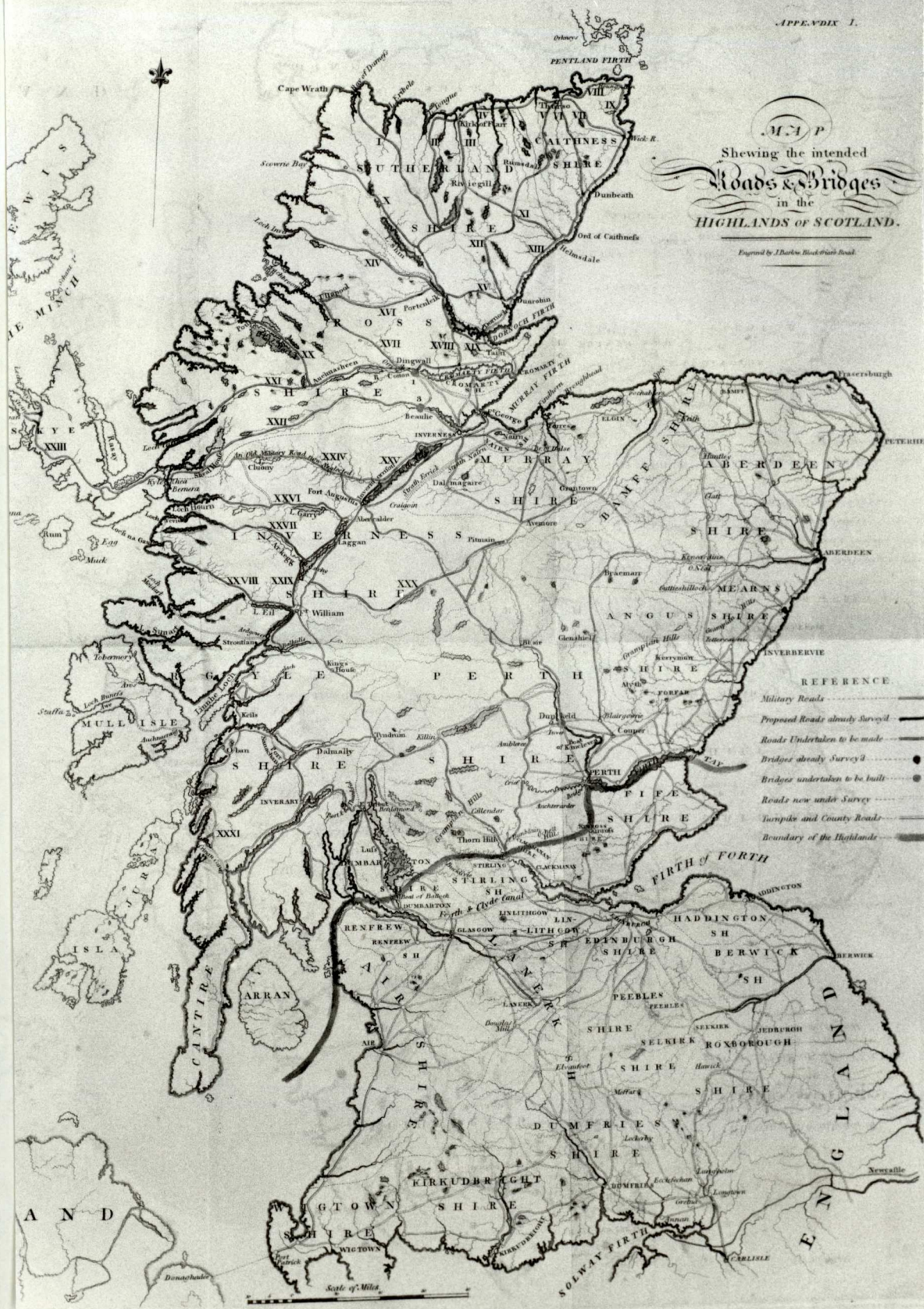


Plate 2 Map of the proposed Highland Roads and Bridges, 1804.

1786 John Knox carried out an extensive survey of the Highlands which resulted in the creation of the British Fisheries Society, whose aim was to provide employment for displaced Highlanders in purpose-built fishing villages. Settlements were proposed in Skye, Harris, Canna, Lewis, Ullapool, Lochinver, Assyut, Grumart, Torridon and Lochewe. Sir William Pulteney was a founder member of the Society and Telford was soon involved as honorary engineer, preparing surveys and reports. Public subscriptions were set up which resulted in the purchase of land at Ullapool, Tobermoray and Stein. Between 1790 and 1799 surveys of possible Highland road routes were made by George Brown of Elgin. They were financed jointly by the British Fisheries Society and the Highland Society, both of which believed that many of the Highlands' problems could be solved by improved communications.

Their ideas regarding roads were ably expressed by George Dempster of Skibo, one of the leading members of the Highland Society:

"At present a great part of this immense country is accessible only to goats and garrons. From Inverness to Cape Wrath and Johny Groats House a track of 150 miles in length and 60 miles in breadth there are neither roads through the country nor bridges over its rivers nor accommodation at its ferries. To this first step of improvements of roads, bridges and ferries the present plan should be confined When the Government have provided a fund and an organ for all applications and when these lines of roads shall be really made as well as planned it will have done its duty towards the Highlands. The rest is to be done by the proprietors in

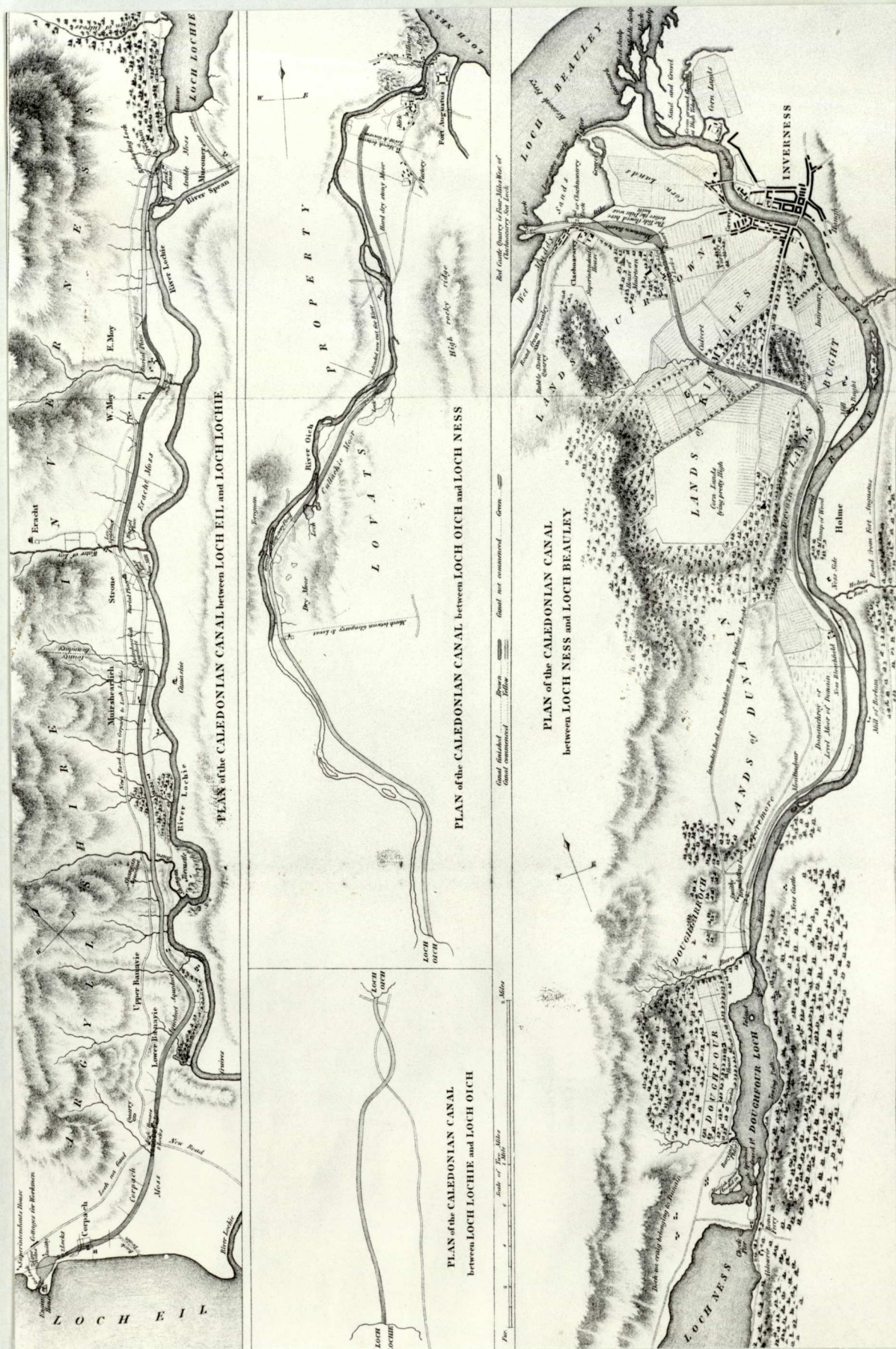


Plate 3 Map of the Caledonian Canal, 1813.

allowing the Highlanders to cultivate the waste grounds, on decent and equitable conditions."⁽²⁾ Over £1,500 was in fact raised towards building one of the lines of road proposed by Brown, although the scheme was eventually funded from Highland Road and Bridge coffers.

Proposals for constructing a canal through the Great Glen were made throughout the eighteenth century. In 1773 James Watt surveyed the line for the Commissioners of the Forfeited Estates, proposing a canal 10 feet deep at a cost of £164,000. John Knox pressed for its building in his survey of the Highlands in 1784 as did local ministers in their contributions to the 'Statistical Account of Scotland' in the 1790s. Pressure also came from the British Fisheries Society and John Rennie was commissioned to do a further survey in 1793. Continuing agitation from the Highland Society and British Fisheries Society combined with mounting anxiety over emigration caused the Treasury to send Telford on a survey of the Highlands in 1801. His involvement with Sir William Pulteney and the British Fisheries Society undoubtedly helped him in this commission. He was instructed by the Treasury to select the most suitable sites for fishing stations on the West Coast, to plan road and bridge communication on and between the mainland and islands, and examine the possibility of constructing a canal through the Great Glen. Telford reported back to Vansittart on 30th November 1801 that an improvement of communications was essential for the Highlands - and that it was also feasible:

"The whole of the objects which their lordships have in view are not only practicable but are capable of being formed into one intimately connected system which would very evidently have a striking effect upon the welfare and prosperity of the British Empire."⁽³⁾

Encouraged by his preliminary findings the Treasury ordered him back to the Highlands in the summer of 1802. His terms of reference were considerably wider, being given a five point plan of campaign: as he later stated in his report:

"In reporting upon the survey I made in Scotland...

I find the business may be most conveniently arranged under the following heads:

1. What regards rendering the intercourse of the country more perfect, by means of bridges and roads.
2. Ascertaining various circumstances relative to the Caledonian Canal, especially with regard to supplies of water on the summit level, and the best communication from this canal to the fishing lochs at the back of the Isle of Skye.
3. The means of promoting the fisheries on the East and West Coasts.
4. The causes of emigration, and the means of preventing it.
5. Improving the means of intercourse between Great Britain and the northern parts of Ireland, particularly as to the bridges and roads between Carlisle and Port Patrick, and also the harbour of Port Patrick,"(4)

In compiling his second survey Telford contacted the Highland Society as regards the best way of executing the possible improvements. He sent a seven point questionnaire to the Society's director, Henry Mackenzie, in December 1802. This more than any other factor shows Telford's involvement with, and willingness to co-operate and harness the various pressure groups then working

for highland improvement. It also shows that the creation of the two Boards in 1803 was ^{the} _A result of sustained and carefully manipulated pressure. Telford asked the Society to suggest possible lines of roads which 'would tend most effectively to open up the country and promote the public good.' He received a lengthy reply detailing many of the future road schemes. The Society was also asked to comment on Telford's proposals regarding the joint contribution of government and local proprietors towards the cost of constructing roads. He again received a favourable reply, the Society commenting that it was 'highly reasonable' that landowners should 'unite with Government in executing these plans, by contributing a certain proportional part of the expense'. Detailed questions regarding the feasibility of the Caledonian Canal were also put to the Society and again favourable answers were received. Telford's proposals that 'commercial interests' might like to contribute towards the canal received a non-committal answer, however, and the idea was completely abandoned.

Telford was thus able to prepare his second survey with the knowledge that he had the full backing of powerful pressure groups, who were not only prepared partially to finance many of the schemes but were obviously prepared to help organise and actively promote the project amongst Highland proprietors. This was of paramount importance when the matter came to be discussed by the Select Committee in 1803, which could not fail to be impressed by the uniformity of opinion about the proposed schemes and the many offers of assistance. The preparation of the case for improvement in the Highlands was brilliantly handled by Telford, with the result that virtually all his proposals were adopted by the Government. With the full support of the two most

powerful pressure groups behind him he was able to persuade government to become involved financially with Highland improvement within two years of his initial survey.

Although the Highland Roads and Bridges scheme and the Caledonian Canal shared a common history as regards their initial launching, (they were considered by the same Select Committee and both Acts of Parliament went through in July 1803), their internal organisation differed fundamentally. Many of the main problems facing Telford on the Highlands projects were not unknown on other civil engineering projects of the period and centred around four main areas namely: finance, its control and recording; the supply of materials and machinery; the control of resident engineers and contractors and the involvement of central government in the project. The essential differences with the highland projects were those of scale and Government involvement. Never before had government attempted to finance a huge civil engineering project and never before had so complete a transport infrastructure been considered.

There were, however, differences in Telford's management of the two Highland projects and this thesis is concerned with a comparison of the two schemes.

Notes

- 1 PRO Rail 827 (Telford Collection) All material referred to in the thesis has been taken from the 'Telford Collection' which consists of copies of all known Telford documents. This collection is now housed in the offices of the Iron-bridge Gorge Museum Trust. A full list of Telford Archives has been given in Appendix A. Unless specifically stated all material is from the Telford Collection.
- 2 Haldane, Op cit p64 Sir John Sinclair's letters.
- 3 Telford to Andrew Little, 30th November 1801.
- 4 Telford Report on Survey of the Highlands of Scotland in 1802. Printed June 1803.

CHAPTER I

THE ORGANISATION OF CIVIL ENGINEERING PROJECTS,

IN GREAT BRITAIN, 1750-1830

Introduction

It is generally acknowledged that a code of practice has reached maturity when it is able to maintain momentum independently of the "Great Men" who played decisive roles in its development, and when it has become strong enough to prosper without the aid of powerful outside bodies - that is the promoters, in the case of civil engineering management.

This cannot be said of civil engineering management techniques at the end of the first quarter of the nineteenth century. Progress had been great, much more rapid than in other fields, due to the huge and immediate problems faced by a rapidly expanding industrial nation and its need for improved transport and ancillary services. Continual expansion after 1830 ensured further refinement. The period 1750-1830 can be regarded as a link, albeit a very important link, in the evolutionary chain of civil engineering management.

The following brief examination of management techniques in civil engineering projects during the period 1750-1830 is intended to serve as a very basic general introduction to the principal section of the overall study and provide the contextural background necessary for a balanced assessment of the managerial developments evolved in response to the unique problems encountered on these works.

The difficulties facing established civil engineers at the beginning of the period were still present at the end and centred around four basic areas of conflict; costing and the control of finance, the relationship between engineer and sponsor, the use of contractors and sub-contractors and the effective control of projects

through deputy or resident engineers.

Numerous other problems radiated from this basic nucleus, each permutation requiring its own specific managerial solution. In this study the managerial methods of the most eminent civil engineers of the period will be examined in relationship to these individual factors.

Deputisation And The Rise Of The Resident Engineer

The rise in the number of projects requiring the services of a skilled civil engineer, either in an advisory or supervisory capacity, led to the development of a self-contained system of controls and procedural rules by which a chief engineer could, with confidence, implement his specifications and designs appertaining to one specific project through the offices of a site or resident engineer while working on any given number of civil engineering projects (1). This development was fairly well established by Smeaton's time, but the standard of resident engineer demanded by him and later chief engineers was new. By the end of the period the resident engineer was a highly paid and respected member of the civil engineering establishment (2). Through the system of deputising the chief engineer was able to reap the full advantages, both financial and status wise, of the growing demand for his services and adequately serve that demand in peak building years, as can be seen in the 1790s when chief engineers became involved in as many as half a dozen canal projects at one time (3).

A clear distinction should be made at this early stage between consulting and chief or overall engineer, a distinction which was to remain valid throughout the period. A consulting engineer was primarily concerned with assessing the feasibility of a project, drawing up the first survey and reporting back to a committee who would then decide upon the issue. He may subsequently have been approached by the committee with an offer of permanent employment as chief engineer,

but this was by no means universal (4). Although consulting engineers made use of assistants and deputies - Smeaton, Rennie and Telford (5) had virtual drawing offices - and the need for delegation was not so great, and as a result, the machinery required for the organisation of such undertakings lacked the sophistication of that evolved for the management of construction projects. The engineers included in this study (Smeaton, Rennie and Brindley) delegated routine tasks to their assistants when acting as consulting engineers; it was only with advancing years and illness that some of them allowed more flexibility in this field (6). Their attitude towards the delegation of management decisions when engaged as chief engineer on a project, was very different. Without exception they all strove to establish and encourage this development, and formalise, with varying degrees of success, the position of resident and site engineers.

Both Smeaton and Brindley had definite ideas on the use of deputy or resident engineers and the organisational machinery needed to control them. The managerial structure of their respective consultative practices was naturally less complex than that created for the supervision of actual construction work, being centred to a large extent around themselves. Their work as consulting engineers involved them personally in the preparation of detailed surveys and reports on numerous civil engineering projects ranging from river improvement schemes, mills and canals. They both travelled vast distances in the execution of survey work (7) and both used assistants and a standardised system of payment. There were, however, essential differences in layout and emphasis which arose primarily as a result of the different type of work undertaken by the two engineers. Smeaton was throughout his career principally a consulting engineer, although he did have extensive experience as a chief engineer. As a result, his consultancy practice

was able to function independently of construction projects, enabling him to develop and codify a clearly defined set of rules relating to the practice of civil engineering (8). Brindley, while personally maintaining the division between consultative and construction projects, was forced by the sheer volume of work to bypass the normal constraints, especially in relation to assistants, as will be seen later.

Like many later consulting engineers Smeaton seldom delegated the initial design work to subordinates, even at the peak of his career when he was involved in literally hundreds of projects. John Farey's description of Smeaton's office provides a very full record of the procedure evolved for the translation of original designs into finished drawings:

"Smeaton was a man of laborious habits and made all his drawings with his own hands. His earliest designs, which were executed under his own inspection, show signs of having been used as working drawings (but) After he became more established and employed a draughtsman he still continued to draw the lines of all his drawings to the proper scale in pencil lines on cartridge paper These sketches were fair copied on drawing paper by the draughtsman, Mr William Jessop at first, Mr Henry Eastburn afterwards and Mr Smeaton's Daughter frequently assisted in the shadows and finishing in indian ink." (9)

Rennie appears to have organised the design stage of his consulting practice along very similar lines nearly half a century later:

"He directed in the same manner every design whether a bridge, road, canal, dock, drainage, or harbour. It was in the first instance

sketched out by himself, then the mode of construction was specified, then estimated and then the general report explaining the whole was written by him, clerks then merely copied." (10)

Brindley's involvement between 1759-1772 in twelve canal construction projects - the Coventry, the Bridgwater, the Birmingham, the Oxford, the Staffordshire and Worcestershire, the Chesterfield, the Trent and Mersey, the Leeds and Liverpool, the Chester, the Bradford and Huddersfield (11) - resulted in his granting a very considerable amount of freedom to his assistants, including the preparation of parliamentary plans and the actual undertaking of surveys (12). His staff were involved equally in consultative and constructional projects and the distinction between 'assistant' and site engineer was less well defined. The system of deputising which Brindley evolved was, to a great extent, fashioned by his work commitments, being essentially intuitive and flexible.

Smeaton's assistants were limited in number and usually remained with him for many years. William Jessop came to Austhorpe in 1759 after the death of his father, Josia Jessop, resident engineer for the Eddystone Lighthouse. Henry Eastburn joined Jessop in 1769, four years before the latter's departure in 1773. He remained at Austhorpe until Smeaton's death in 1792 (13). They had come as general office assistants beginning with routine work and gradually progressing to more demanding tasks, although Smeaton always retained overall control over their work. In a letter to Samuel Galton he expressed a preference for such a system over self-training:

"As I have never trusted my reputation in business out of my own hand, my profession is as perfectly personal as that of a Physician or councillor at

Law: my difficulty therefore in the despatch of business is not in getting that done I have never employed anyone to do for me. One person therefore brought up in my office as my assistant, is capable of making everything false, that I am capable of producing and setting in the rough; the labouring oar, is in reality with myself. I have in my time only had two pupils both of whom were apprenticed with me for 7 years, nay I may say eventually for 8. The first continued with me for 14 years, and the second has now been with me for 14 years, is married and settled. More hands than I absolutely want would only be an encumbrance and diminish my own time. Thus you see my dear friend I have at present no opening for any fresh pupil: and this being the case I can with the same freedom tell you my thoughts of the proposition.

Any Profession that affords a genteel or decent maintenance without the necessity of a capital, is suitable to many; Go to an eminent Surgeon, Attorney, or Solicitor; an eminent Painter, carver, or Engineer; and see whether they will take a boy to intrust for his work, and pay him a salary while they are teaching him their art. O but the boy is a great genius, and likely to make a great figure: doubtless the better for him; but see how a master would turn it. The greater the genius, the sooner he gets instructed in his art, the sooner he leaves me,

sets up for himself, and becomes my rival in business. I mention this only to shew you, that in matters of business, professional men reason like other men; what am I to get by the bargain!

In the civil engineering business many are self taught; many come into it gradually, from being led to assistant business: I am one of the self taught: but what was the gain resulting from this circumstance? Why I was 30 years of age before I could ever be said to have got my head: had my father given £500 to an eminent man in business to have conducted me by the hand; and upon whose credit I would have founded myself; it would have been a rich purchase for the saving of 8 or 9 of the best years of my life. There are many operative businesses that are much bettered by a mechanical genius; if he is putt to any one he will make himself, if sober and dilligent; I heartily wish him well." (14)

Brindley's opinions on the education of assistants and the merits of the respective systems have not survived. In the 1760's (15) he utilized many of his pre-canal assistants as resident engineers and section supervisors. Although they were thoroughly grounded in the necessary technical skills they lacked specific knowledge of canal construction.

The plans were drawn up to Brindley's specification by his assistants (16), pre-eminent amongst whom were John Henshall, his son Hugh, John Varley, Samuel Simcock and Robert Whitworth. Upon his death in 1772 they were given the task of completing the unfinished sections

of the 'Grand Cross'. The description of Brindley's working methods by Samuel Smiles is extremely misleading and has contributed to the inaccurate picture of Brindley as the 'general handyman and canal builder', ignoring the mass of evidence in support of his use of assistants in construction projects.

"He seems to have settled with the farmers for their tenant-right, sold and accounted for the wood cut down and the gravel dug out along the line of the canal, paid the workmen employed, laid out the work, measured off the quantities done from time to time, planned and erected the bridges, designed the canal-boats required for conveying the earth to form the embankments, and united in himself the varied functions of land-surveyor, carpenter, mason, brickmaker, boat-builder, paymaster and engineer. We even find him descending to count bricks and sell grass". (17)

Armed with his assistants' plans, Brindley would travel to London to advise on the preparation of the canal Bill and give evidence before the Parliamentary committee (18). The latter activity whilst not directly influential to the development of new management techniques, gave the early canal engineers a useful platform to put forward their ideas and stimulate interest in canals generally. Indeed such was Brindley's standing with Parliament in the early 1770's that his services in this particular field were considered essential, even if he played no further part in the project. Smeaton regarded knowledge of parliamentary procedure as an important pre-requisite for the successful civil engineer:

"If you happen to be at a loss for a competent engineer, versed in parliamentay Business: if you apply to

Mr Joseph Nichols, Engineer, Gravel Street, Blackfriars Bridge, he is not only very competent but much used to Parliamentary applications." (19)

Smeaton did not take his assistants on all surveying trips but utilised the sponsor's employees for routine measuring work, saving time and money. In September 1782 he wrote to the Birmingham Canal Company regarding a proposed visit, specifying his time of arrival and provision of survey staff:

"I can set forward from hence for Birmingham on Monday the 7th of October and stay there one week if necessary; but that my stay may not be protracted beyond what is necessary I shall be glad that everything preparatory be done in the way of common surveying and levelling; and in case there is any thing critical in the latter, will carry my own level along with me." (20)

Presumably Rennie and Brindley incorporated this practice in their respective consultative organisations.

There were many important differences in layout and definition in the management of construction projects; Smeaton and Rennie especially endeavouring to establish clear, precise lines of responsibility between the principal and site engineers.

The resident engineer and his assistant were employed directly by the canal company although many principal engineers had a very considerable say in their appointment. Recruitment of site engineers appears to have changed very little throughout the period, being based to a great extent on personal recommendation and knowledge (21). Smeaton, like Rennie and Telford, was frequently asked to provide testimonials for fellow engineers:

"Mr Jessop (who served with me 14 years) is now in

such extensive business that the difficulty will be to get him to go deliberately over it. He lives at Newark. Mr Whitworth is certainly a very able man and of great experience; his present abode I do not know Mr Clowes I do not personally know." (22)

The main responsibilities of the resident engineer when appointed were the implementation of the principal engineer's designs, the purchase of materials, hiring of labour and the general day-to-day management of the project. With such a system in operation, Brindley, Smeaton and Rennie were able to take on concurrent civil engineering projects unprecedented in scale and complexity.

Variations in managerial procedure were most apparent at resident engineer assistant level, the position of the resident engineer by comparison remaining fairly constant throughout the period. The creation and division of managerial responsibility at this level was to some extent dependent on the availability of capital and the competence and size of contractors. Assistants were employed to supervise the construction of specific works on the project, such as locks, bridges, and ancillary buildings, or superintend the execution of specific tasks like earth moving and puddling (23). The magnitude of responsibility, especially on Brindley projects, could range from supervision of all bridges along the total length of canal, or one section of it, to a particular bridge.

The managerial problems encountered by Smeaton on the construction of the Forth and Clyde were typical of those found on early, large scale civil engineering projects, being to a large extent supervisory and sponsorial. His difficulty in establishing an adequate managerial structure stemmed from an unwillingness on the part of the canal company proprietors to provide sufficient funds at regular intervals.

Smeaton was appointed 'Head Engineer' at £500 per annum (24). He submitted a survey and estimate of the proposed canal, specifying the type of materials to be used, the number of locks, bridges and ancillary equipment, together with a possible completion date. He proposed to divide the work into three sections, with surveyors and foremen responsible for each, but this was rejected by the company on the grounds of expense. His dissatisfaction with the limitations placed upon his managerial structure occasionally erupted into fullscale disagreements with the canal committee, as in June 1771 when he complained of a shortage of 'proper officers' to deal with the routine management problems of liaison with land-owners and ordering of building materials (25). Barely twenty years later, Rennie was able to install a full site management team on the Lancaster canal capable of dealing with the many problems of canal construction.

To The Committee Of The Lancaster Canal

John Rennie, Principal Engineer

Arch. Millar, Resident Engineer on the works from
Tewitfield to Calder

Henry Eastburn, Resident Engineer, Calder to Preston
and Bark Hill to Clayton Green

Wm Cartwright, Assistant Engineer, Calder to Preston
and Bark Hill to Clayton Green

Thos. Morris, Superintendent of Masonry and work at Lune

Jas. Hamilton, Superintendent of works under Mr Eastburn

Wm. Millar, Land Surveyor

John Duncan, Superintendent of Masonry, Bark Hill to Wigan

Edmd. Baxter, Assistant Clerk to S Gregson

Fred McDonald, Overlooker of Puddling under Mr Millar

Wm. Dickinson, Carpenter

Geo.Siddle, Superintendent and Measurer of Earthworks
under Mr Millar

Geo. Joyce, Superintendent and Measurer of Earthworks
under Mr Millar

Geo. Atkinson, Superintendent of Masonry and Measurer of
Earthworks from Lancaster to Calder

John Gill, Superintendent of Masonry and Measurer of
Earthworks from Lancaster to Borwick

Geo. Germaine, Overlooker of Fencing from Lancaster to
Borwick

Wm. Smith, Overlooker of the Works and Check Keeper for the
tonnage between Bark Hill and Chorley. (26)

The most easily identifiable manifestation of managerial weakness on Brindley and Smeaton construction projects was their inability to prevent serious modifications to an agreed parliamentary plan, a plan on which the entire managerial structure (costing, materials and contracting) of the project was based.

Smeaton's original concept of the Forth and Clyde Canal was, on more than one occasion, augmented by the adoption of major policy revisions emanating from his resident engineer. In 1770 Mackell proposed a major line alteration, which obtained the backing of the committee; although he expressed grave reservations, Smeaton finally gave his approval (27).

Many of Brindley's resident engineers, at the 'request' of the canal committee, agreed to construct contour canals rather than adhere to the parliamentary routes in order to save money (28). Samuel Simcock, one of Brindley's most trusted and long-serving engineers, lengthened the Oxford Canal by nine miles as directed by the committee. He was also responsible for the implementation of similar deviations at Smethwick, on the Birmingham Canal, which were only finally rectified

after the expenditure of several hundred thousand pounds.

Brindley protested but was unable to prevent such actions occurring. Disagreement with the Coventry Canal Committee grew so heated over line deviations that he withdrew his services in 1769 (29), but this proved to be an exception. Brindley and Smeaton found themselves, along with many engineers of the period, virtually powerless in preventing canal committees from effectively destroying the managerial relationship between resident and chief engineer over this issue. They were sometimes equally powerless to prevent feuds from breaking out between their resident engineers and canal committees. It was left to a later generation of civil engineers to resolve these particular problems.

Rennie, like Smeaton, was acutely aware of the shortcomings of the deputy system and devoted a considerable amount of time and effort to their eradication. Of the many problems encountered by him on construction projects few were attributable to imprecise delegation. In a lengthy communication to the Committee of the Kennet and Avon canal company he defined the responsibilities of the various bodies and individuals involved in its construction, beginning with the principal engineer and the correct procedure relating to line deviations.

The department of the principal engineer was to furnish all designs and specifications for the work to be executed, examine the line of the canal and where deviations are prepared he should give specific directions to the resident engineer about the mode of executing all the work, who should send a monthly report of his proceedings to him and write when difficulties occur. - He should examine works before the quarterly meeting and report his opinion thereon to the said meetings. - In this way the general and sub-committees will have a full state of the business before them and where errors are committed they will be able to trace them to their source and lodge blame or approbation where it may be due. (30)

Rennie believed that 'the art of good government' consisted of delegation and in building up a system of government that enabled him to stand as it were on a pyramid, with the ranks of resident engineers, assistants, inspectors and contractors spreading out under him more widely at each stage, so that everything from the bottom up was under his control. In this way he could, while yet only 33 years old, simultaneously construct three different canals totalling 170 miles, in widely separated parts of the country, and finish them with an enhanced reputation (31). The actual content of the Kennet and Avon statement was not particularly innovatory; the basic concepts were unchanged from the 1760's, only the focus sharpened. Although the extract is very long it is worth quoting at length, for it provides the most detailed summary of civil engineering organisation before the commencement of Telford's Highland projects in 1803.

"There should be a resident engineer in each district, and under agent with assistants for superintending the masonry, and another with assistants for the earth work, who may occasionally assist as staff holders.

The business of the resident engineer is to attend to the whole of the works, to see that they are executed according to the plans furnished by the principal engineer, examine the levels, set out the canal and occasionally examine such parts as may appear to improve in any degree the line of the canal and report his opinion thereon, take the quarterly statement of the works, and in general issue all directions to the agents for the masonry and earth-work etc. For this purpose he should reside somewhere about the middle of his district, where should

be an office for sub-committee meetings, for the clerk and principal and resident engineers. In this office should be deposited all plans and contracts that refer to the works, all books in which are copies of orders given to the agents, letters wrote (sic) to the contractors or others - and also books containing copies of reports and measurements of the works, which books should lay open for the inspection of the committee. The resident agents must act under the resident engineers in whom a due confidence must be placed, and no orders and directions must be given but through such resident engineers. The agent for the masonry should attend to the state of the foundations, the materials to be used and the proper execution of the work in every stage of it agreeable to the directions and plans sent to him by the resident engineer. His assistants must attend to the particular jobs, such as making the foundations of the aqueducts (which are the most material jobs in the whole line) and see that no insufficient or bad stones are put into the work, or improper mortar used. He should also attend to the heights of the different parts of the work so that they be not too high or too low - lock foundations, gates etc are also in his department. He should likewise make statements of the work done, materials furnished, men, horses and carts employed every fortnight, or month as may be agreed on to the resident engineer. The agent for the earth work should see that the canal

is executed agreeable to the sections and directions furnished - that the linings and puddles are of proper dimensions and materials and executed at the time when the banks are in their most proper state, and see that they be sufficiently worked. He should besides put in the top and bottom level stakes where wanted, make the fortnightly or monthly measurements and in general attend to the resoiling of banks, gravelling of towing paths etc. His assistants must attend to particular and difficult jobs such as ramming of culverts and aqueducts, puddling bad ground etc, the number of men, carts and horses employed by the contractors and company, that one statement may correct another.

The contractors should be paid money on a/c once a fortnight or month, but they should be directed to give a previous notice (say a week) in writing to the Clerk of the district stating the sum they shall want.

This notice should be referred to the resident engineer who will contrast the same with his measurements and say how much or if the whole of the sum required shall be paid them. - Then partial statements will be sufficient to enable him to say what money should be advanced, and at the end of every quarter previous to the general committee an accurate statement of the whole works should be taken, with the sums of money paid on account and laid before the general committee, by which it will be easy to see how matters stand with the contractors.

Each agent should be directed to keep an exact account of his time, how he is employed and what he has done and these should be fairly copied into a book ready for the inspection of the committee at their fortnightly meetings - or perhaps monthly would be sufficient for this - which should always be held at the office of the district. The resident engineer should make the purchases of timber, ironwork etc, but this should be after he has laid all the offers he can procure before the sub-committee in cases where no advertisements are made and he should give his opinion in writing by which they may be enabled to judge for themselves. If these directions are rigidly followed I have no doubt the works will be conducted with regularity and economy and if the works are let to proper contractors at fair prices I have no doubt they will be executed in such a way as to reflect honor on all concerned, which is the sincere wish of gentlemen....

Your most obedient,

John Rennie" (32)

Although he laid great emphasis on the need for stratification and clarification in management Rennie nevertheless stressed the need for continual coöperation between all bodies concerned. "The department of surveyor and engineer be separate so that no jarring, unpleasantness or interference may take place. But although a line ought to be drawn between them yet such as understanding should exist only between the heads of each department, but between the officers and agents employed under them that the welfare and success of the whole may be effectually promoted." (33)

Demarcation between chief and resident engineer on Rennie projects

was on occasions, however, vague and uncertain. The controversy which surrounded the design and construction of the Bell Rock Lighthouse was centred around the employment of Robert Stevenson, an extremely competent and well-established civil engineer in his own right, as resident engineer on the project. (34) Claims for his involvement in the actual design of the work were championed by various groups after the death of Rennie in 1821. It can, with some justification, be argued that the Bell Rock incident was, due to the employment of Stevenson, untypical and hybrid in the general history of managerial organisation. The archival evidence suggests that Rennie organised the project along well established lines, consulting regularly with his resident engineer, possibly incorporating some of his suggestions in the final plan. It is clear, however, as indicated by Stevenson's letter of the 6 January 1807, that Rennie retained overall control of the design work:

"I shall be happy to know how soon I can receive your determination about the size of the base and curve for the lower part of the building, that I may prepare the working drawings." (35)

Charles Cunningham's statement that "the Bell Rock Lighthouse was planned by Stevenson and 'sanctioned' by Rennie" is clearly incorrect (36). In reality Stevenson supervised on-site construction, a task which he performed with great ability and efficiency.

Similar claims had been made for several of Brindley's assistants. "The Coventry Mercury" of the 28 September 1767 published a letter championing the cause of Thomas Morris:

"Your Burslem correspondent makes Mr Brindley the Sir Isaac Newton of his age, but seems not to know that the Duke of Bridgewater has another ingenious man, viz Thomas Morris, who has improved on Mr Brindley, and

is now raising a valley to the level by seven double water-locks, which enable him to carry earth and stones as if down steps" ...(37)

Boucher states that Morris was, at the time of the letter, a practical carpenter, probably acting as an assistant engineer (38).

The Relationship Between Engineer and Sponsor

The relationship between the engineering staff and the promoter reflected upon the standing of the chief and resident engineer, the general capability of the 'Engineering Profession' to maintain an independent line, and the sophistication or otherwise of the organizational machinery.

The influence of wealthy promoters, experienced in the economic exploitation of their estates (or employing Agents to do this for them) must have been very considerable on early canal projects especially. The more usual confrontation was, however, between engineer and committee who acted as watchdog for the shareholders and it is the managerial machinery developed by the engineers in response to this conflict which is of particular relevance to this study.

The main areas of conflict were primarily concerned with the appointment and accountability of personnel, adherence to the agreed parliamentary plan and the maintenance of an adequate cash supply. Wherever possible the impact of sponsorial interference has been included in the relevant section, however, some general points require an independent assessment.

The recruitment of resident and assistant engineers was a major source of irritation between the chief engineer and committee. The influence of the chief engineer regarding recruitment was very considerable. It has already been noted in the previous section that many of the engineers included in this study were actively involved in the

employment of their own assistants and trainees. James Brindley especially employed a large percentage of his pre-canal assistants as resident and assistant engineers. His monopoly of canal engineering skills presumably silenced any committee opposition (39). On construction projects the site staff were employed and paid directly by the company, hence their desire to be included in the recruitment procedure. Conflict arose when one party actively attempted to exclude the other or appointed compliant or 'interested' persons. The danger of a canal committee coming between chief and resident engineer or conflict between resident engineer and committee has already been dealt with.

William Chapman's feud with his committee over the recruitment of assistants resulted in a direct appeal to the shareholders through the publication of a pamphlet (40). In an attempt to give greater authority to his argument Chapman quoted Smeaton on the shortcomings of committees:-

"The greatest difficulty is to keep committees from doing either too little or too much - too little when cases of difficulty start, and too much when there are none." (41)

Smeaton was extremely critical of interference in technical matters and the lack of a properly organised secretariat in many organisations:-

"If, instead of making plans, I am to be employed in answering papers and queries, it will be impossible for me to get on with the business ... All the favour I desire of the proprietors is, that if I am thought capable of the undertaking, I may go on with it coolly and quietly, and whenever that to them shall appear doubtful, that I may have my dismissal." (42)

The lack of an organised secretariat and a liking for intrigue on the part of canal companies caused much delay and worry for the chief

engineer throughout the period. It was only with the passage of time, and bitter experience, that an adequate company committee management structure evolved, ensuring clearer division of responsibility.

The dangers of work being delayed by differences of opinion between committee members over canal policy were present throughout. The Forth and Clyde project was marred by such disruption when various routes were put forward. Brindley, Yeoman and Golborne* were called in to report on Smeaton's official line. The latter regarded the incident as a personal insult, but was basically powerless to stop it (43). William Jessop was involved in similar difficulties on the Ellesmere Canal in the 1790's. It could still be said with some justification in 1830 that the recommendations of the most eminent engineers could be disregarded by sufficiently powerful pressure groups within companies on non-technical grounds. Success in ensuring the implementation of his designs was due to the chief engineer's strength of character rather than any reverence for the standing of engineers on the part of the employers.

The minutes of many canal companies record that the principal engineer agreed to devote so much time to their specific project. Many engineers appear to have had great difficulty in persuading committees that they had equally important business elsewhere. Rennie's original terms for himself on the Lancaster Canal in 1792 were £600 to cover five months' residence and subsequent visits whenever his presence was considered necessary. Because of his heavy commitments he was forced by the committee to reduce his fee to two hundred and fifty guineas in 1797. (44)

Hostility between engineer and sponsor also occurred on consultancy projects. Although this had no adverse effect on the management of

* Future members of the Smeatonian Society

such schemes it did reflect upon the standing of civil engineers. Smeaton took a strong line when defending his assistant against complaints from a client that a design for a waterwheel was simply a copy of an earlier design:

"I was therefore not a little surprised that you disapproved of Mr Eastburn's plan; because it was like Mr Waterhouses's old wheel of 12 feet diam built for him by my directions give me leave to say that what I then did I cannot now improve upon so long as the object remains the same, that is, to get the most power possible out of a given quantity of water in dry seasons. The construction of mills, as to their power, is not with me a matter of opinion it is a matter of calculation and I should draw the same result from the data this year that I did twenty years ago.

..... After 34 years of experience I don't think it necessary to give any further proof that my theory of power is a right one than to say, that in that space I have directed the building of no less than 50 new mills no one of which ever failed of doing its expected duty, when brought to a full and fair examination: and in this method I have very fully instructed Mr Eastburn." (45)

He was equally severe regarding the provision of his professional opinion on an architect's design for a project in which he was not personally involved:

"It is contrary to the usual practice of professional men to give their opinions upon each other's work unless regularly called upon in the way of their profession;

and upon reflection you will readily see the want of confidence in the persons employed, and confusion, that in many cases a proceeding of this kind would naturally create." (46)

His actions in this matter cannot be regarded as typical.

The effect of sponsors on the management and organisation of civil engineering projects was to some extent fluid and variable, depending very much on the individuals concerned. The attitude of sponsors was, however, radically affected by two major developments, the determination on the part of civil engineers to define managerial responsibility and the increased status of engineers as a result of the general recognition of civil engineering as a profession (47). A table of engineering fees from 1760-1830 has been included at the end of this study. (Appendix 2)

The Use Of Contracting Firms In Civil Engineering Projects, 1750-1830

The use of contractors was of primary importance to the overall study of managerial organisation in civil engineering projects. The widespread adoption of the contracting system contributed more than any other single factor to the development of a successful managerial structure by demanding immediate solutions to the unique problems it posed. The scale of works undertaken, involving more than one sponsor and large amounts of capital, the sudden demand for such works and the consequent need for engineers to delegate responsibility, were all essential pre-requisites to the development of this structure; but it was the contracting system which tested it to the full, forcing the pace and necessitating the introduction of standardised codes of practice. The period 1750 to 1830 saw the gradual eclipse of small contracting concerns and their replacement by large 'Master Builders' and nationally based contracting firms employing many hundreds of men with large reserves of material, equipment and, above all, capital (48). It must

be stressed, however, that this was by no means universal and small contracting firms continued to play a very vital role in civil engineering projects well into the latter half of the nineteenth century (49). This was paralleled by the development of complex, legally binding contracts which ensured ultimate control for the chief engineer over a project through close adherence to his specifications as laid down in the contract, and strict supervision from his deputy on the work site (50).

The actual management of contractors remained basically constant throughout the period. Specifications and contracts were drawn up or approved by the chief engineer after the initial survey, the construction work being supervised by the resident engineer and his assistants who ensured adherence to the contract. Measurement of work and calculation of payment were also undertaken by site staff, although the chief engineer usually fixed the contract price. Variations in management technique depended to a large extent on the size and efficiency of contracting firms and their own internal management structure.

The career of James Brindley was of great importance in the development of managerial organisation specifically evolved to deal with small contractors. The problems which arose from the employment of such firms required a system of management distinct from that evolved for larger organisations, especially in the field of supervision and measurement. The small contractor was virtually dependent on the managerial machinery of the engineer and company while the larger firm was capable of assuming more responsibility and of creating its own managerial structure. The relationship between small labour contractor and employer was much more akin to the direct labour situation, where a proprietor employed his own estate workers or recruited labour direct (51). Many of the small firms were no more than loose associations of workmen, with self-appointed spokesmen to negotiate terms (52). There was seldom any conflict between such groups with regard to division and

responsibility of labour, they had no pretensions of managerial skill and were quite prepared to accept the authority of the resident engineer and his staff. They were there simply to offer their services as labourers (53) and took no part in managerial decisions. Brindley employed numerous small contractors on the construction of the earth-works for the Bridgwater Canal, the Duke providing all planks, barrows and ancillary equipment (54). Other undertakings including boat-building, carpentry, manufacture of machinery, centering and brick and masonry work were carried out by direct labour, utilising estate employees or specially recruited labourers from areas as widespread as York and Birmingham (55). The practise of advertising for skilled masons and craftsmen was used frequently by Bridgewater and Brindley and became the accepted norm for later projects. Although many of the contractors or sub-contractors employed on Brindley projects were little more than labouring gangs, many more enjoyed a slightly more elevated position, undertaking masonry and puddling work.

Did the size and number of contractors have any direct bearing on the number of assistants employed?

It is unlikely that each contractor or contract was assigned an assistant, although without a detailed investigation it is difficult to comment on the contractor-assistant ratio (56). It has already been established that both the size of contracts and number of assistants increased towards the end of the eighteenth century.

The presence of direct labour necessitated supervision. Boucher states that on late eighteenth century projects direct labour was employed on difficult work (usually underwater foundations) because the contractors of that period were not sufficiently competent to perform such tasks (57). Presumably the situation in the 1760's was even more serious and necessitated the more frequent employment of direct labour. The situation was further complicated by the widespread use of sub-

contractors which continued well into the nineteenth century and beyond. The dangers of using sub-contractors in construction work were essentially managerial and centred around the question of adequate control both of quality and finance. Pollard states that the eighteenth century building firm was usually very small, consisting of one skilled craftsman and his assistants; the accepted method of contracting was for a single craftsman to be made responsible for the complete project, sub-contracting the various specialist jobs out to others (58). Was this system employed on early canal projects? Evidence of Brindley's working methods and of the inadequacy in the managerial sense of the early contractors would suggest that this was not the case. Contracts were drawn up directly with numerous firms rather than one individual. The minutes of the Oxford Canal Company for the 13 September 1769 record that the committee agreed to sanction the acceptance of several tenders including those of John Watt for making three miles of canal from Hawkesbury stop lock at £350 per mile; additional payments were to be made for cuttings deeper than 4' 4" or embankments higher than 3'. Bridges were extra at £210 each. John Robinson and Thomas Jackson contracted to make the 12 miles of canal from Stretton Fields to Hillmorton (59). In both instances a time limit was included, exactly what form, (if any) of the final payment appears to have been developed by a later generation of civil engineers. On the Coventry Canal Piercy and Hogg contracted for the cutting of Gritt Hollow at 20 p per cubic yard, puddling at 4 $\frac{1}{2}$ p per yard, the company providing planks and barrows (60).

Brindley employed contractors from a widespread geographical area. It is not known if he established any permanent contractual links with any of them as later generations of civil engineers did. Like Brindley, Rennie used small contractors on his early canal projects. There were separate contracts for earthworks, masonry and carpentry on

the Kennet and Avon. He was very wary of trusting contractors with more work than they could properly undertake, letting out no more than three or four miles of earthwork to one man (61). The bridges were built by masonry contractors but, as has already been stated in a previous section, it was 'exceptional to find one of these who could undertake any work of real difficulty such as underwater foundations; this had to be done by direct labour' (62). The building of the foundations for the Lune, Limpley Stoke, and Avoncliff aqueducts were all executed by direct labour under the supervision of the resident engineer and his assistants. Similar difficulties were experienced at London Docks in 1800 where the difficult work of constructing the entrance locks was carried out under direct labour. On the Kennet and Avon, stone was supplied by quarry owners under contract with the company and not with masonry contractors. Lock gates were made under one contract, but the 'timber was obtained for them after tender by another contract with a selected timber merchant' (63).

To conclude briefly on Brindley's use of contractors. It would appear that he created an adequate managerial system to cope with numerous small contractors, most of whom seem to have entered into a full contractual agreement with the canal company. As in other aspects of his management, weakness resulted from lack of definition and experience, (especially amongst the contractors themselves), and makes his achievements all the more remarkable.

The transition from the use of small, dependent contracting firms to large organisations capable of undertaking all aspects of the work was slow and painful. The division of responsibility between the small contractor and resident engineer was to remain relatively clear, it was impossible for such a body to evolve a self-sufficient managerial structure, even if the incentive to do so had been there. As it was, they were more than satisfied to attach themselves to the site management

organisation. Unfortunately this attitude was not adopted by the newly emerging 'Master Builders'. They made no attempt to solve their internal management problems which naturally arose from the employment of many hundreds of men and assumption of responsibility for the construction of complete projects. They were, as a result, just as dependent on the site management as the smaller firms. Large contractors were disliked by engineers for their lack of internal management and reluctance to accept authority of site staff even though they were entirely dependent upon them (64). Disputes also arose over the larger firms' insistence that they be involved in policy decisions and matters traditionally reserved for site engineers. Companies and engineers consequently preferred to engage smaller concerns. The failure of such an organisation would not seriously impede the progress of construction; the failure of a large firm usually had catastrophic consequences on the project, bringing work to a halt and wrecking the estimated cost. The situation regarding the early use of large contractors is perhaps best demonstrated by the unhappy experiences of the Birmingham Canal Company with John Pinkerton, who can be regarded as the somewhat inefficient prototype of later large organisations.

Although the following account of Pinkerton's affairs is fairly lengthy, it forms an essential link between immediate post-Brindley management methods and those employed by later generations of engineers.

Pinkerton had been employed on numerous civil engineering projects before he came to Birmingham. With his brother he had worked on the Driffeld Navigation (1768), Bishop's Soil Sluices (1770), Market Weighton Navigation and Drainage (1772), the Hedon Navigation (1774), the Selby Canal (1775), parts of the Aire and Calder (1775-8), the Calder and Hebble (1776-80). Alone he contracted for the Erewash Canal, (1778-80), the Birmingham and Fazeley Canal (1783-9), the Dudley Canal Tunnel (1785), the Basingstoke Canal (1788), the Gloucester

and Berkely^e Canal (1795), the Lancaster (1794) and the Barnsley Canal (1793-99) (65). The amount of experience gained was very considerable for the period and clearly shows the degree of mobility among early contractors.

Pinkerton seldom contracted for the whole of a canal, unless it was of limited size, because he lacked the financial and managerial stability necessary for such an undertaking (66). The scale of his operations was, however, considerably larger than normal for the period. He clashed head on with the managerial establishment which had evolved around small contractors and lost. Pinkerton had no permanent nucleus of labour and relied almost entirely on local manpower. He had no equipment and used that provided by the company, being 'totally dependent upon the advances of money made to him, weekly or monthly, by his employers'. As a result he was 'never able to take the whole responsibility for construction upon himself; he was always subject to supervision, even in minor details' (67). As in many early canal projects, lack of capital prevented the development of an efficient management body. Friction resulted. Pinkerton was constantly arguing with Bough, Superintendent of the Birmingham Broadwater extension, about the type and quality of materials to be used. One disagreement regarding cement was finally settled by the Canal Company Committee in his favour. Later he argued that:-

"After the foundations were set out by the company's Agent, they had, properly speaking done with him, and ought not to have further interferenced with Him." (68)

Bough continued, however, to inspect his work at regular intervals, finding much shoddy work. The actual contract between Pinkerton and the Birmingham Canal Company was not drawn up until after work had started; which was according to Broadbridge, not unusual at the time (69).

The Company reserved the right to take over construction work under direct labour if it was thought necessary; a completion date and arrangements for payment were also included in the contract. Perhaps the most important clause was the one which stated that £500 was to be retained for three years after the completion of the work, during which period the contractor was liable for full repairs. The innovatory nature of the contract however proved of little use against Pinkerton who soon got into financial difficulties. All goods and materials in his possession were taken over by the company who presumably finished the work by direct labour, at his expense. The unfortunate contractor finally paid his way out of the agreement, after sustaining heavy losses. The enforcement of such a contract required a highly developed managerial structure. This was not present on the Birmingham Canal in the 1780s. An assistant engineer was dismissed by the committee for not carrying out proper checks on Pinkerton's work, he was told that:-

"Your past conduct clearly shows you can but have little if any regard for the interests of your employers, let not the undertaker any more make you believe that sand is lime or clay unburned can be bricks." (70)

The resident engineer's assistants on the Dudley tunnel were told to pay particular attention to Pinkerton's activities under threat of dismissal but they failed to cope with his internal management problems and work ground to a halt. The company complained that he had left the supervision of the project to a nephew "who was a fine gentleman and neglected (it)" and added that they "never wished to employ Mr Pinkerton again, having a very low opinion of him." (71) Pinkerton was also unsuccessfully employed by Rennie on the Lancaster Canal, one of his earliest major civil engineering projects (72). The involvement of engineers in contract work was to be maintained throughout the period,

Brindley and Rennie being very active in the manufacture of mill and pumping machinery, while many of their assistants followed successful careers as construction and labour contractors (73).

Rennie was one of the first civil engineers to use large contracting firms successfully. His most celebrated contractors, Joliffe and Banks, shared a similar, if slightly more elevated position, to Thomas Telford's 'team' of hand-picked contractors, having the full confidence of their employer in all technical and managerial matters. Banks began as a comparatively small contractor for Brindley's pupil Robert Whitworth on the Leeds and Liverpool Canal (74). In 1793 he began his long association with Rennie when he became a contractor for the Lancaster and Ulvaston Canals. From 1795 to 1800 Banks was involved in various canal projects, including the Huddersfield and Cromford Canals. The partnership was formed in the 1800s and they contracted for Rennie's West India Dock and Waterloo Bridge in 1810-11, sub-contracting the bridge approaches to Grey. In 1813 they built Sheerness Dockyard to Rennie's design, Southwark Bridge (1816) and later took part in the extensive Fen Drainage Schemes directed by Rennie and his sons together with Telford. The family connection continued after the death of Rennie senior with London and Staines Bridges. Rennie made Joliffe and Banks responsible for all the contracted work, they drew up their own contracts with any sub-contractors, for whom they were entirely responsible (75). The problem of managerial responsibility was overcome by improved organisation among the contractors themselves.

Boucher states that in Rennie's later contracts:

"Sub-letting was arranged with his permission, not upon his instructions, and sub-contractors were entirely a matter for the general contractor, the Engineer's only concern being to see that the work was properly executed according to plan and

specifications." (76)

This reflected not so much a fundamental innovation on the part of the engineers, but rather a 'catching-up' on behalf of contracting internal management.

Contracts from a comparatively early date (1780s) contained a clause providing for arbitration in the event of dispute. On one occasion Rennie claimed the right to act as arbiter himself:

"I have retained in the hands of the Company's Engineer a power of explaining his own meaning of discharging the Contractor and valuing the work himself. These may appear arbitrary and improper powers to be lodged in the hands of any man; granted, but necessity requires it. Without such a power being lodged somewhere there is no probability of doing a work of this kind properly. Suppose for instance a mason was to contract of a single Lock, Culvert or Bridge and was not proceeding properly, either in the way of executing his work, or in the time of doing it. He might by this means delay the opening of the Canal by many months after all the other works were finished and by going into the Court of Session there is no saying when the business would be settled. The settling of the work by arbitration is little better, the time lost is often great and arbitrators lean usually universally to the side of the Contractor (hence?) it ~~to~~ a certain degree takes the controlling power out of the hands of the Engineer where it ought to lay so that after many years experience I have found it

necessary to adopt the Rule stated in the Specification.

I hold it as a principle that every contract should be materially beneficial to the Parties, unless it is so, no Contractor can be bound to perform it, and the only way to have work to proceed with expedition and be well executed is to let the contractors have a reasonable profit and the director of the work a full compulsory power over them which he may have by letting them have a reasonable price for their work and retaining the power in his own hands, which the specifications I have made fully give him and I find no difficulty in getting good contractors to enter into these terms." (77)

Boucher states that much of this is 'unexceptional' except the passage which refers to the engineer 'valuing the work himself'; no court would have accepted this, preferring the usual practise of bringing in an outside engineer. His proposals were never adopted and he resumed the use of more normal methods of arbitration (78).

The contribution of Smeaton towards the efficient use of contractors is extremely difficult to assess due to the shortage of relevant archival material. Hopefully a study of his attitude towards contracting will be made in the near future.

Accounts And Costing

The one aspect of civil engineering management which appeared to have progressed very little over the period was that of costing. From Brindley to Rennie the same appalling inaccuracies relating to costing and the keeping of accounts persisted. The increase in the scale and complexity of many projects accentuated this weakness (79). The effects of weak managerial control in relation to sponsors, contractors

X and deputies on costing has already been noted in previous sections. Discrepancies between the estimated and actual cost of a project were attributed to external factors. Shortage of raw materials and labour prices were the most common scape-goats. There was no apparent realisation that any one of the managerial problems dealt with in this study was also capable of affecting an estimate. Many of the failures in costing were due to the lack of monetary control and an inability to keep accurate accounts of expenditure. Even on later projects it was impossible to ascertain from the accounts exactly where the money was going. Separate accounts for repairs and revenue were rare (80). This concealed mistakes in construction management and ensured their survival. When a canal committee ordered a resident engineer to construct a contour canal they did not take into account the higher maintenance costs and loss of revenue which resulted from longer routes. Deficiencies in accounting methods guaranteed the continuance of such practices.

The actual estimate was made by the chief or consulting engineer and included in his initial survey and report. Many projects were disabled before their commencement because of inaccurate initial estimates. As Pollard states, there was a basic inability to see that:-

"a large sudden local demand for labour would in the circumstances in rural areas at least, be likely to drive up wages, and in the case of land and materials, was to a large measure responsible for the ludicrous way in which the costs of the great civil engineering enterprises were underestimated by the engineers.

The confusion and lack of accuracy carried over into the railway age." (81)

Failures in costing continued to occur, however, even after the partial eradication of many management problems. The effects of wage rises and raw materials have already been mentioned. The Napoleonic Wars, which

caused higher wage rates, a shortage of manpower and materials, must have distorted many estimates. One of the few recorded examples of Smeaton's experiences with such difficulties is entered in the minute books of the Forth and Clyde Canal. In 1772 he reported to the committee that the estimate had been exceeded because 'of massive and substantial way' in which the work had been executed (82). Rennie's estimate of £79,002 for the Kennet and Avon Canal in 1791 was hopelessly inaccurate. When asked to explain why the half-completed canal had lost over £141,724 in 1801, he replied that it was due to increased wages and construction difficulties (83). His estimate for the Caledonian Canal in 1803, although more accurate than Telford's, was still £300,000 short of the final cost (84).

The introduction of 'standardisation' in civil engineering projects ensured a degree of accuracy in the costing of certain features. Smeaton and Brindley drew up standardised designs for mill machinery, canal and river locks, accommodation bridges and ancillary buildings and equipment. However there was no attempt at establishing a stock-pile of parts and many of the designs, although duplicated on a specific project, were unique to that project. Brindley's standardised bridges on the Bridgewater Canal were quite different from those on the Trent and Mersey (85). True standardisation did not occur until the very end of the eighteenth century when Rennie and his contemporaries began to incorporate standardised, easily-reproducible ancillary features in their designs. This did little, however, to alleviate the most serious deficiencies prevalent in costing, which continued well into the nineteenth century.

Progress in the evolution of efficient management techniques in civil engineering was considerable between 1750 to 1850. With the exception of specialised factors like contracts, however, this progress was essentially one of definition and consolidation, and not innovation.

This short study has attempted to identify some of the major managerial problems and describe how the most eminent engineers of the age approached them. It will hopefully provide a basis for comparison in the following study of - Thomas Telford's managerial methods in the Highlands of Scotland, 1803-1830.

Notes.

- 1 S Pollard, Genesis of Modern Management (1965), 134
- 2 C T G Boucher, John Rennie (1963), 72. Many of Rennie's engineers attained high rank in their profession, at least three of them held the office of President of the Institution of Civil Engineers.
- 3 Pollard, op cit, 86
- 4 Boucher, op cit, 75
- 5 Pollard, op cit, 88
- 6 For a detailed description of Civil Engineering Consultancy Practices see the following:-

C T G Boucher, John Rennie (1963)
C T G Boucher, James Brindley (1968)
Denis Smith, The Professional Correspondence of John Smeaton. An eighteenth century consulting practice. Newcomen Society vol 77, 1975-76.
- 7 Smith, op cit, 1
- 8 H J Hopkins, A Span of Bridges (1965), 71. Smeaton became the 'Father of Civil Engineering' in Britain and was acknowledged by his contemporaries^{as} as the greatest philosopher in our profession that this country had yet produced - indeed a great man possessing a truly Baconian mind'. Compare this with a contemporary description of Brindley: S Smiles (1863)...."When any extraordinary difficulty occurred to Mr Brindley in the execution of his works, having little or no assistance from books or the

- labours of other men, his resources lay within himself."
- 9 Smith, op cit, 2
- 10 Sir James Rennie, Life of John Rennie (1850-70), Manuscript in
the Institution of Civil Engineers.
- 11 Boucher (Brindley), op cit, 56-57
- 12 ibid, 12. Hugh Oldham drew the parliamentary plan for the
Bridgewater Canal.
- ibid, 68. The survey work on the Leeds and Liverpool Canal
was undertaken by Robert Whitworth ... '21 guineas
to Mr James Brindley for Mr Whitworth's trouble,
21 days in taking a survey and 10 guineas to
Mr Whitworth himself for his extraordinary diligence
in taking the survey'...
- ibid, 105. Parliamentary plan of the Oxford Canal prepared by
Robert Whitworth.
- 13 Smith, op cit, 3
- 14 ibid, 3-4. Smeaton-Samuel Galton, January 1783.
- 15 Boucher, (Brindley) op cit, 70, entry in Brindley's diary for
31 December 1759 concerning Samuel Simcock who assisted at
Congleton Silk Mills.
- 16 Boucher, op cit, 122-125, for a full list of drawings by
Brindley and his assistants, Manchester Public Library.
- 17 Boucher, op cit, 62 (Rennie). S Smiles, Lives of the Engineers,
vol 2 (1862).
- 18 Boucher, op cit, 50, Brindley spent 46 days at Worsley preparing
plans, left in July 1760 to give evidence before Parliamentary
committee.
- ibid 67. At a meeting of the Droitwich canal navigation on
2 September it was ordered that 'Mr Brindley's
demand for attending and soliciting the Act be paid

by the Treasurer.' There is also evidence that
Brindley's assistants were employed in this capacity
by several canal companies.

19 Smith, op cit, 4

20 ibid 7

21 Boucher, op cit, 72

22 Smith, op cit, 5-6

23 A Burton, The Canal Builders, (1972) op cit, 126-127

24 J Lindsay, The Canals of Scotland, (1968) op cit, 20

25 ibid 23

26 Boucher, (Rennie) op cit, 73-74

27 Lindsay, op cit, 22

28 Boucher, op cit, 75. The construction engineer "had authority
to make deviations if practical consideration
required it and details and negotiations with the
landowners were often left until after construction
had commenced.

ibid 80 There was trouble over the changes on the Birmingham Canal
even in Brindley's time. He and Simcock were induced
to attend a meeting on 11 January 1771 'at which they
made a signed declaration that they had never
received any instructions to make the canal indirect,
or had never done this intentionally but that the
course had been chosen by them entirely in their
capacity as engineers.'

29 Boucher (Rennie), op cit, 76

30 ibid 63

31 ibid 62

32 ibid 63-65

33 ibid

- 34 ibid 52
- 35 ibid 55 This would appear to be in line with Rennie's standard procedure on such matters. Writing to the Southwark Bridge Company in 1814, he stated that the preparation of working drawings was not the 'business' of the principal but of the resident engineer.
- 36 ibid 58-59 Charles Cunningham, Secretary to the Northern Lights commissioners to Alan Stevenson 29 May 1849.
- 37 Boucher (Brindley) op cit, 55
- 38 ibid 55 The first reference to Morris occurs in Brindley's diary for November 1763.
- 39 ibid 75-76 There was considerable friction between Brindley and the Oxford Canal Committee; on 12 September 1770 he resigned. The committee wrote to him expressing 'their very humble apologies if they have offended him' and 'begged' him to return.
- 40 Burton op cit, 101. William Chapman, Address to the Subscribers of the canal from Carlisle to Fishers Cross. (1823)
- 41 ibid 101
- 42 ibid 102 Smeaton to the Forth and Clyde Canal Committee. October 1768.
- 43 Lindsay, op cit, 21 T Yeoman, J Brindley and J Golborne. Reports relative to a navigable communication betwixt the Firths of Forth and Clyde, (1768); J Smeaton, Review of Several Matters Relative to the Forth and Clyde Navigation, (1768).
- 44 Boucher (Rennie) op cit, 74
- 45 Smith op cit, 4
- 46 ibid 5
- 47 Pollard op cit, 86-89

48 ibid 85

49 ibid 86

50 ibid 85

51 Burton, op cit, 172-173

52 Boucher (Brindley), op cit, 63

53 Burton, op cit, 173

54 Boucher (Brindley), op cit, 60-63

55 ibid

56 Ideally the employment of small contractors should have necessitated the employment of numerous assistants. The lack of managerial skills among such groups would tend to preclude their involvement in any supervisory tasks. It would appear that Telford's contractors on the Caledonian Canal formed an integral part of the management team.

57 Boucher (Rennie), op cit, 67

58 Pollard, op cit, 85-86

59 Boucher (Brindley), op cit, 78-79

60 ibid 79

61 Boucher (Rennie), op cit, 67

62 ibid 67

63 ibid 67

64 Burton, op cit, 135

65 S R Broadbridge, John Pinkerton and the Birmingham Canals (1971), Transport History, Vol 4, No 1, op cit, 33

66 Broadbridge, op cit, 33

67 ibid 33

68 ibid 34

69 ibid 35

70 ibid 42 BTHR, Letter-book of the Birmingham Canal, BCN 4/311A

71 ibid 37

- 72 Boucher (Rennie), op cit, 71. Pinkerton's tender was almost identical with that of John Murray and they agreed to join forces. Undertook sixteen miles of canal from Tewitfield for £52,000, excluding only the Lune Aqueduct. They also obtained the contract for the Ellet Grange to Roy Lane section at £19,481. In these contracts they did all the work themselves. They eventually 'came to grief' and lost the contracts.
- 73 ibid 70. In 1792 Alexander Stevens of Glasgow was recommended by Rennie for the post of Masonry Inspector on the Lancaster Canal. Arrangements fell through and Stevens turned up soon afterwards as contractor for the Lune Aqueduct. By reverse process John Murray was given the post of Resident Engineer at London Docks by Rennie after he failed on the Lancaster Canal.
- 74 H W Dickinson, Joliffe and Banks, contractors, (1931-32) Newcomen Society, Vol XII, op cit, 1.
- 75 ibid 3
- 76 Boucher (Rennie), op cit, 68
- 77 ibid 69
- 78 ibid 69-70
- 79 See details of the construction of the Caledonian Canal.
- 80 Pollard, op cit,
- 81 ibid
- 82 Lindsay, op cit, 24. FCCMB, 13 September 1771.
- 83 Boucher (Rennie), op cit, 75
- 84 ibid 76
- 85 Boucher (Brindley), op cit, 47 and 92

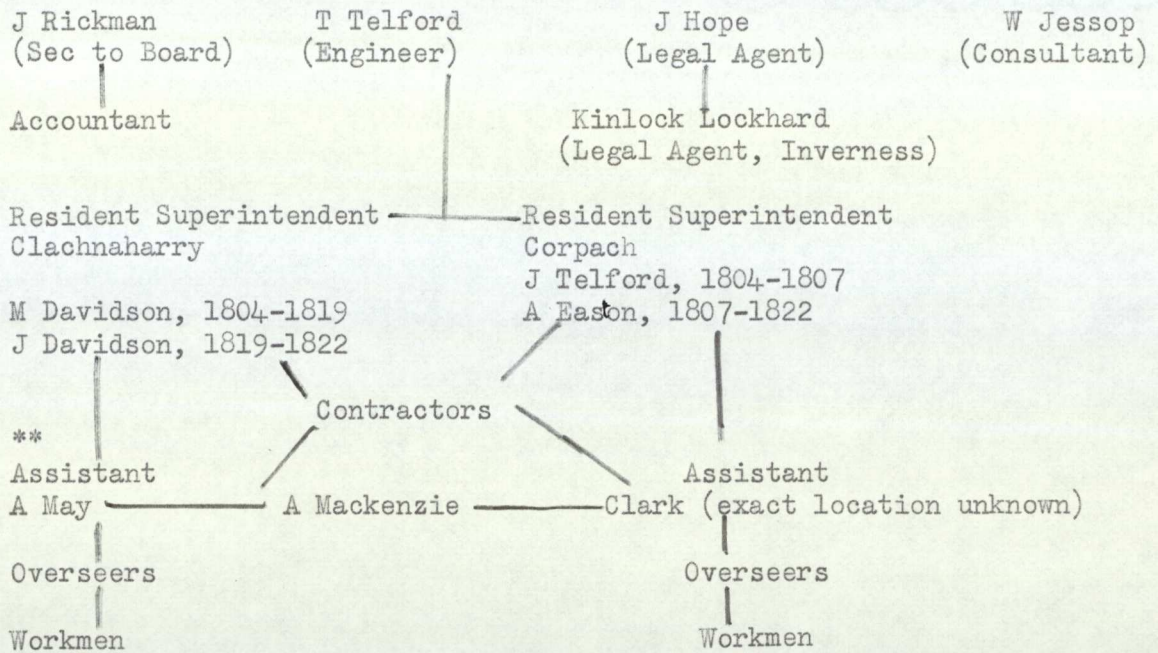
CHAPTER 2

MANAGEMENT

Problems of managerial control were increased on the Caledonian Canal and Highland Roads and Bridges by distance, supply of raw materials and the unprecedented scales of the projects. Although the two projects shared many common features, they were fundamentally different in managerial organisation and procedure. This difference was centred, to a large extent, around the existence, on Highland Roads and Bridges, of detailed contracts and specifications and a dual system of finance from local proprietors and the government. This chapter will attempt to describe the managerial structures developed by Telford in response to these problems, with special reference to the division of responsibility between Telford, Jessop, Road Inspectors, site engineers and contractors.

The managerial team employed on the construction of the canal remained essentially unaltered throughout much of the construction period, both with regard to structure and personnel. To ensure clarity, a brief outline of the structure will be given before dealing with the individual points raised in the opening paragraph. This is best shown diagrammatically:

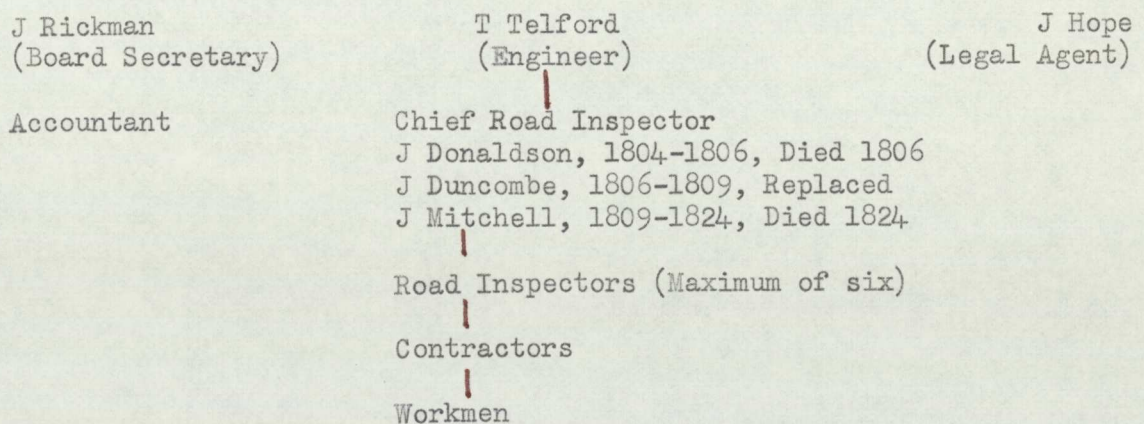
The Board of Commissioners (Canal)



** Indicates an element of doubt in the structure which will be discussed in text.

The managerial team on the Highland Roads and Bridges project. was far more precisely defined. Its structure is again best shown diagrammatically:

The Board of Commissioners (Roads and Bridges)



The two Boards of Commissioners shared a common Chairman, Secretary, Legal Agent and Engineer, however, there was no intermixing of managerial personnel below the level of engineer. The relationship between Telford, Hope, Rickman and the two Boards of Commissioners will be dealt with in a separate chapter. Before proceeding to describe the various managerial levels employed on the two projects it is intended

to examine in some detail the relationship between Telford and Jessop. This relates exclusively to the Caledonian Canal project. Jessop was not involved in the Road and Bridges project in any capacity, except for an extremely brief period in 1805 when he received a small sum for advising Telford on bridge matters.

Telford and Jessop

The purpose of this section is to examine the contribution of Telford and Jessop in the setting up and running of the managerial team and their role in the project as a whole. In assessing these factors it will be necessary to answer the following points: who was responsible for the recruitment and, therefore, size of the managerial team; who decided their responsibilities; who assessed wage and contract rates; who decided what materials should be used; who appointed the contractors and who implemented changes in design and line? A brief chronological outline of Jessop's involvement in the project will be given before examining the above points.

Jessop, together with Rennie, gave evidence before the select committee on the various Highland improvement schemes in June 1803, prior to the creation of the Board of Commissioners (1). When asked to comment on Telford's proposals for the canal, he stated that he could not give 'an accurate judgement, not having seen the country' (2). However, he did provide an estimated cost of the whole project (3). As in the London Bridge enquiry, he was called upon by the Government to give his general opinion on the feasibility of the project as one of the country's leading civil engineers. On the 4 August 1803, the newly-appointed Board of Commissioners took measures;

"for obtaining the opinion and assistance of

Mr William Jessop, another eminent and experienced
engineer". (4)

He was ordered to inspect the proposed line of canal with Telford (5),

which he did in October 1803, reporting back to the Board in February 1804 (6). A revised estimate was also submitted by him at this date. After 1804 he made a joint inspection with Telford in October or November of every year up to his retirement in 1812. He died in 1814.

Recruitment of managerial staff began in the early autumn of 1803 when Telford appointed John Wilson as Resident Engineer or Superintendent at Corpach, and A. May and W. Mackenzie as Superintendent/Pay Clerk at Clachnaharry (7). These appointments were made before Jessop had become involved with the project (8). It is probable that John Wilson was the same Wilson who had worked with Telford on Pontcysyllte Aqueduct as a contractor. Nothing is known about the background of Andrew May or William Mackenzie except that the latter was a land surveyor from Inverness. J Smith was employed at Corpach to negotiate the purchase of country timber and arrange for its cutting and delivery (9). A Mr Mason was employed to investigate the location of quarries. He was also involved in the preparation of a report on the entrances to the canal with Murdoch Downie (10). A considerable number of surveying assistants was also taken on, (11) so that by the time of Jessop's visit in October 1803 a full-scale survey team was in operation. Construction work commenced on a very limited scale in December 1803, but it was not until the passing of the Second Canal Act in June 1804 that moves were made to appoint permanent supervisory construction staff. Jessop was again excluded from the major decision-making over recruitment, simply endorsing Telford's appointments. Evidence for this belief comes from the Second Caledonian Canal Report which contains extracts from Telford and Jessop's correspondence over the new posts. The Commissioners reported that after having:

"taken into consideration a representation made to us by Mr Telford respecting the propriety of providing a constant superintendence on the spot, we appointed

Mr Mathew Davidson ... (Clachnaharry District) ...

and Mr John Telford ... (Corpach District) ...

These persons were recommended to us by

Mr Thomas Telford, with the entire approbation

and concurrence of Mr Jessop, as men of tried

ability and long experience." (12)

Telford received authorisation from the Board to appoint them (13). He had written to Jessop on the 18 June 1804 suggesting John Telford and Davidson:

"The works being upon a scale of uncommon magnitude, and in a district of country unaccustomed to operations of this nature, I propose that such persons only shall be instructed with the chief superintendence and the execution of the principal works, as have to my own and your knowledge, for ten years past, been employed upon works of a similar nature whose abilities may be relied on and who are likely to enter with zeal into the spirit of the undertaking ..." (14)

Telford had known Davidson virtually all his life, working with him as a stonemason in his native Eskdale before leaving for London in 1782. He had employed Davidson as site engineer on several bridge projects in Salop before appointing him Resident Engineer for Pontcysyllte Aqueduct. Jessop had been Principal Engineer on the project and had become acquainted with Davidson (15). Similarly, John Telford was an ex-Telford Ellesmere Canal employee who had been fully versed in his working methods, acting as his personal assistant for some time (16). Telford concluded his letter of 8 June by proposing that Davidson be provided with "such assistants for counting the men and measuring the works as may from time-to-time appear necessary." (17) For the middle district he proposed to employ "persons of an inferior description" because

"the works there can be occasionally examined and checked by Mathew Davidson and John Telford." (18) Jessop replied to Telford's proposals on the 9 June, agreeing to all the appointments. (19) He made no amendments to the managerial team as suggested by Telford. Wilson, May and Mackenzie were relieved of their supervisory posts during the ensuing months, Wilson re-emerging as one of the principal contractors, and May as assistant and pay clerk to Mathew Davidson (20). Mackenzie appears to have left the employment of the Commissioners altogether. Wilson's assistant continued to serve him in his new capacity (21). It is not known how much Telford was involved in these re-appointments, and details of Telford and Jessop's involvement in the appointment of managerial staff below the level of superintendent are extremely scarce. Jessop requested that Telford deal with the appointment of all assistants in June 1804.

"What Assistants they may want cannot at present be specified, they must from time to time be appointed as circumstances may call for them and this should be left to your discretion." (22)

Telford and Hope decided upon the appointment of Kinlock Lockhart as the Commissioners' legal representative in Inverness in 1805 (23). Jessop does not appear to have been consulted. John Telford died suddenly in 1807 and was replaced by Alexander Easton, a former stone mason and Telford road inspector in Argyll (24). Again Jessop does not appear to have been involved. No further managerial appointments appear to have been made before Jessop's retirement in 1812. Telford made Mathew Davidson the senior superintendent, appointing him as his deputy when he left for Sweden in 1808 (25).

It is clear, therefore, that Telford, rather than Jessop, was responsible for managerial recruitment. He was more in touch with the day-to-day running of the canal and therefore better able to devise and

appoint a managerial team for its supervision. In this instance at least, Jessop merely rubber-stamped his decision.

It was Telford, rather than Jessop, who decided upon the responsibilities of the managerial team. In his letter to Jessop of June 1804 Telford proposed that the superintendents fix contract rates in "particular places" with the proviso that the "state of such rates to be always immediately communicated to me and to be subject to my determination." (26) Through such a system he undoubtedly hoped to control from a distance by financial manipulation. Telford requested that Jessop comment on the "above proposal" and hoped that it gave "a reasonable prospect of the works being carried on with the economy, fidelity and success." (27) No records survive of Jessop either opposing Telford's managerial team or suggesting improvements. It was, therefore, Telford's set of instructions which was adopted by the Board and used on all subsequent occasions for the control of site construction staff.

Jessop's participation in the fixing of contract and wage rates was considerable as he accompanied Telford on the inspection tours when these matters were considered. He was not involved, however, in deciding the wage rates for the excavation of Corpach and Clachnaharry Basins, which had been determined by Telford in 1803 (28). This work had presumably been performed by direct labour, as no contractors were appointed until June 1804 when Telford and Jessop received instructions to "determine the rates of expense of the sundry works upon the line of canal ... (and the price of) labour for the different sorts of work." (29) Telford had contacted the Board of Commissioners in June 1804 requesting Jessop's assistance on the above points:

"It would be a great satisfaction to my mind, to have the assistance and advice of Mr Jessop in Scotland." (30)

Immediately after, Telford contacted Jessop, giving him a full break-

down of his proposals:

"Every part of the works which can be so managed to be executed by measure of rates or prices, to be determined by you or myself after having maturely weighed every circumstance relative to the different works. All the cutting, puddlings and embankments to be let in small lots to different persons, ... the general rules for prices to be determined by you or myself." (31)

The various rates were fixed in August 1804 after a joint inspection. Telford and Jessop had previously been instructed to take careful consideration of local wage rates in deciding upon those for the canal (32). This would suggest that those members of the managerial team who had been in the Highlands longest and therefore had a greater local knowledge (ie Telford) played the decisive role in the fixing of wages. This has to be counter-balanced, however, by the fact that Jessop had a far greater knowledge of wage rates throughout the country. Any substantial increase in the contract price was subject to Telford and Jessop's approval(33). This policy was adhered to throughout Jessop's involvement in the project and beyond. Jessop's contribution to the fixing of prices would thus appear to have been considerable both in 1804 and after. It is not known how much he was influenced by Telford's fixing of wage rates in the Autumn of 1803 or by his superior local knowledge.

In the location, purchase and transport of materials it would appear again that Telford provided the driving force. The survey team was fully involved in this department before Jessop set foot in the Highlands, Telford opening negotiations with Cameron of Lochiel for the purchase of country timber in late September 1803 (34). In the joint instructions of 1803 and 1804, Telford and Jessop were requested to pay

special attention to the location of materials.(35) As in previous instances, however, the person with the most local knowledge had the greater say in deciding such matters. By the summer of 1804 Telford had completed his third "period of duty" in the Highlands. Jessop was just arriving for his second. Decisions regarding the purchase of timber may have been taken jointly but it was Telford who handled all the initial enquiries and correspondence, as has already been seen above. Jessop was probably influential in the purchase of iron-work, although here again it was Telford who handled the correspondence, shipping and erection. Contracts for iron-work were put out to tender, the offers made by Outram and Co (Jessop's partner) and Hazledine being accepted. Hazledine had for some time been associated with Telford projects, providing the iron-work for the Pontcysyllte Aqueduct. (36) Machinery requirements were decided on at the joint inspection of August 1804 and orders were placed almost immediately afterwards, for three Boulton and Watt pumping engines and a large amount of plateway.(37) The canal's first dredging machine appears to have been designed entirely by Jessop,(38) who was probably instrumental in the adoption of a steam dredger. Telford did not involve himself in the development of dredging machines after Jessop's departure, preferring to import specialised knowledge on the matter, in the person of Bryan Donkin.(39)

The choice of construction contractors was made by Telford in June 1804. In that month he wrote to Jessop suggesting Simpson, Wilson and Cargill as the masonry contractors.

"In all matters relative to the execution of building I mean to employ John Simpson with whose abilities and character you have also been acquainted for upwards of ten years past. John Wilson and James Cargill are with him ..."(40)

Jessop "heartily concluded [with Telford] in appointing the contractors straight away rather than open the contract to competition (and) run the risque of getting very inferior men".(41) He also agreed to Telford's proposals for letting the earth-work in small lots to different persons, although he thought that "the size of such lots (ought) to be proportioned to the ability of the undertakers" in the hope of finding some who "may be able to manage a large contract, or a number of small lots".(42) Simpson, Wilson and Cargill had all been employed on the Ellesmere Canal, undertaking the masonry contract on the Pontcysyllte Aqueduct. Simpson had also been employed on virtually all of Telford's bridge contracts from 1790 onwards. The decision to bar competition on the masonry contract was thus understandable, given the wealth of experience offered by the successful contractors. Jessop's proposals over letting earth contracts in multiple units appears to have become standard practice, only half a dozen "firms" being involved in the main excavation work between 1804 and 1822.(43)

Alterations in Canal Design

Telford examined the line of the canal in 1801(44) and again in 1802, using James Watt's survey as a guide.(45) The second survey was comparatively detailed, listing the number of locks, bridges, aqueducts and culverts. This plan was accepted by the Parliamentary Select Committee and was included in the application to Parliament for obtaining the initial grant of £20,000.(46) In the autumn of 1803 Telford was ordered to draw up a detailed plan of the canal suitable for re-application to Parliament for a second more permanent Canal Act.(47) Jessop received instructions in September to examine the line of canal. (48) In December 1803 he was ordered to prepare a report and estimate on the canal, using

information supplied by Telford and his team of surveyors.(49) His report was submitted to the Board in February 1804, having first been endorsed by Telford. (50) It was then included in the papers used in obtaining the second Canal Act.(51) The estimate which was included in the report was considerably more than Telford's 1802 figure, mainly on account of the adoption of more expensive lock designs. (52) The number of locks had been reduced by two to twenty-three, and aqueducts reduced from twelve to seven, although bridges had been increased from twelve to twenty-three.(53) As in other aspects of decision-making, it is difficult to assess how much Jessop was influenced by Telford and his surveyors. Line changes had been decided upon before he even arrived in the Highlands; the position of the sea locks being altered after a joint report by Murdoch Downie and Mason.(54) General survey work proceeded well into 1804 and it was not until June of that year that Telford and Jessop received instructions to mark the exact position of the locks, bridges, weirs and culverts.(55) Many of the canal features were positioned during August 1804 although weirs and culverts were not definitely fixed, as their position depended on the raising of the fresh-water locks, a task which was not to be performed until the completion of the project. (56) The siting of locks and bridges in the middle district was also left open, as it was not intended to commence operations in that area until the two outer districts had been completed. Jessop was not involved in the detailed surveying of the middle district which did not start until the year of his departure in 1812.(57)

Jessop appears to have been very much involved in the major design changes relating to lock construction and in the adoption of cast-iron as a suitable material for bridge and lock gate construction. Telford had submitted turf walled lock designs in his original 1801 survey. He argued that the slowness of operation would be counter-

balanced by the cheapness of construction, and the accompanying estimate was based on the use of turf locks.(58) Jessop budgeted for more conventional masonry locks in his February 1804 estimate, which increased the overall cost of the project by £56,000.(59) Telford, after considering the revised designs, gave his approval. (60) It is not known who was responsible for the design of the locks as built, although Telford does include drawings of the locks in the Atlas of plates to his autobiography (61). Telford and Jessop decided to increase the size of the locks after a joint investigation into the type of vessel most likely to use a canal. They were assisted in this task by Sir William Rule, who supplied information on the size of Navy frigates and warships (62). The decision to use cast-iron for the lock gates appears to have been taken jointly, for Telford states in the 1814 Report that "the high price of oak led Mr Jessop and myself to adopt cast iron." (63) The use of cast-iron for accommodation bridges was also a joint decision, the basic design being based on swing bridges constructed in the West India Docks, a project which had strong Jessop connections (64).

To conclude, Jessop's role in the project was essentially that of a monitor, rather than decision-maker. It was Telford who organised and carried out the initial survey work, it was Telford who recruited the managerial and contractual team and devised the procedure for their guidance and control, and it was Telford who handled all problems of land purchase and finance. He was also responsible for the ordering and transportation of materials. Jessop was sent in by the Government to add weight to the project at a time when its future was uncertain; once the 1804 Canal Act had been obtained, his involvement in the project was limited to an annual joint inspection with Telford and in putting his signature to the latter's report to the Board of Commissioners. Telford continued to visit the construction site twice a year

throughout the period of Jessop's association with the scheme (65). Jessop's experience was undoubtedly a great help to Telford, who was by comparison inexperienced in canal building, having been involved in the construction of only two canals before his appointment as Engineer in 1803 (66). Apart from changing the design of locks and introducing cast-iron, however, Jessop appears to have simply endorsed Telford's actions. He was also paid for his services, at least in the early years of the project, from Telford's own budget, which perhaps tells us much about his status vis-à-vis Telford and the canal (67).

Resident Engineers and Inspectors

It was through this link in the managerial chain that Telford attempted to solve one of the major problems of the project - namely, adequate control from a distance. The differences in the organisation of the canal and roads projects was no more clearly marked than at this level.

As has already been noted, the evolution of the canal management structure was divided into two sections, the termination of survey work and the passing of the June 1804 Act marking the dividing point. Developments prior to June 1804 were concerned with controlling what was essentially a survey rather than a construction team. This did not occur on the Road and Bridge scheme.

Roads

The Board of Commissioners for Highland Roads and Bridges was set up in July 1803 with Thomas Telford as Chief Engineer, the commissioners considering him to 'be the fittest person for this trust.' (68) He received instructions to re-survey some of the proposed roads and determine the best position of bridges. He was to be responsible for receiving proposals for contracts and for transmitting them, with his comments to the Board (69). Upon his arrival in the Highlands Telford appointed a team of surveyors to examine possible new lines of road (70).

The continuing nature of the roads and bridges scheme ensured that this provisional survey team effectively remained in existence until the deadline for new road construction in 1816 (71). The surveyors were not however employed by the Commissioners on a permanent basis, undertaking each survey as a separate commission (72). The large influx of road applications between 1804 and 1809, however, must have provided full-time employment for them. Their responsibilities remained unchanged throughout the period of construction. Upon receiving an application for a new road from local proprietors Telford ordered the surveyors to prepare a survey and estimate of the total cost (73). The entire future of the road rested on this survey, for it formed the basis of Telford's report to the Commissioners on the general feasibility of the project. If the report was favourable, the local proprietors were instructed to deposit half the estimated cost of the scheme in the Bank of Scotland (74). Telford was then ordered to lay out the precise line of the road and prepare the specifications, using the surveyors' report as his principal guide (75). The specifications formed the basis for inviting tenders of contract. The accuracy or otherwise of the original survey was thus critical to the whole operation. Telford personally performed some of the initial road surveys, having previously carried out extensive surveys of the Highlands in 1801 and 1802 (76). The number of surveys performed by Telford, however, formed only a small portion of the total figure. It should be noted that the Chief Road Inspector, a post created after the commencement of construction in 1804, was also involved in survey work (77). There is no evidence to suggest that any of the surveyors were ever involved in general road inspection work. The number of surveyors employed in the year ending July 1807 appears to have been no more than eight (78). This number appears to have remained constant throughout the main period of construction. The responsibilities of the survey

team were thus clearly defined from the start of the project. This was due to the inclusion of local proprietors in the financing of the project, which forced Telford to introduce a well defined management team immediately after the passing of the 1803 Act. Unlike the Caledonian there was no attempt at any construction work until the summer of 1804.

Caledonian Canal

As has already been noted, Telford divided the project roughly in two, appointing Superintendents at each end, together with sundry assistants and surveyors. Provision was made for limited construction work in the two end Basins which were marked out in the autumn of 1803. Fortunately, records of Telford's initial instructions to A May, his Superintendent at Clachnaharry, have survived. They were written on 27 September 1803 and ordered May to engage men for the excavation of Muirtown Basin and line of canal which extended from there to Clachnaharry (79). This line had previously been marked out by Telford and was to be excavated exactly to his directions (80). May was to ensure, if at all possible, that work was to be "performed by the cubic yard, each man's work to be measured up monthly." (81) Records of all expenditure were to be recorded in monthly paybills, which were to be dispatched, at regular intervals, to Telford, together with a journal of all that had occurred. Wages were to be fixed at 18d or 16d, according to quality of workmen (82). Telford thus ensured full control over expenditure, accounts, type of labour to be used and line of canal to be excavated. Similar instructions were sent to May's assistant, William Mackenzie, who was, when not engaged in recording the paybills, to visit the works and "assist if necessary in measuring the work and in making agreements." (83) A Mr Mason who was "to manage the business about the quarries" appears to have had similar powers to May and Wilson, for Mackenzie was instructed "to do the

same with regard to Mr Mason." (84) John Wilson employed an assistant who dealt with the purchase and cutting of country timber (85). The early years of the project were thus very similar to other projects of the period, having a mixture of basic supervisory staff plus people allocated to one specific task, although on other projects this always appears to have been geared to the construction of one specific object or section, rather than to matters like timber, wood and finance, as appears to have been the case on the Caledonian. This degree of specialisation does not appear to have been carried over into the post-1804 structure, as will be seen below. During the months after September 1803, the individual members of the team were busily engaged on survey work, W Hughes accompanying Jessop over the line at the end of October (86) and Mackenzie performing land valuations in the Corpach area (87). The small number of workmen employed on excavation work was controlled by permanent overseers who presumably remained with the workmen on one particular site. The earliest reference to overseers is found in a Telford letter of February 1804.

"As well as engaging workmen and overseers it will be necessary to set them to work." (88)

The essential elements of the managerial structure were all present before the passing of the Canal Act in June 1804. The appointment of the two permanent Superintendents heralded the commencement of full-scale construction work. Telford was again responsible for drawing up their instructions, after receiving authorisation from the Board for their appointment (89). As before, the canal was divided into two districts, each half having its own Superintendent, Mathew Davidson at Clachnaharry and John Telford at Corpach. No appointment was to be made for the middle district until the commencement of operations there. Taken in conjunction with the earlier set of instructions, Telford's June 1804 directive provided the basic framework for the management of

construction work up to the opening of the Canal in 1822.

As has been noted already, many of the elements in the Road and Bridge management team remained unchanged after the commencement of construction, unlike the Caledonian which underwent fairly basic changes after that date. Road and Bridge construction supervisors were appointed in the summer of 1804. The system of management was drawn up in response to the need for adequate supervision and enforcement of contracts and specifications, as can be seen from the 1805 Report:

'It has become necessary to appoint some competent person resident in Scotland, who might from time to time, as the installments become due, survey and make a report of the work and, on the recommendation of our Engineer, we have appointed for this purpose

Mr James Donaldson, now resident at Fort William.' (90)

By the following year a full team of road inspectors had been appointed, leaving Donaldson, who was now referred to as 'Chief Road Inspector', more time to supervise all the projects:

'The increasing number of roads distant from each other, and now in progress, necessarily restricts his attention to a general superintendence, whereas the due execution of specifications, the most essential of which relate to the foundations of masonry, and the depth of gravel, cannot be ensured by any precaution short of actual inspection of the work during its performance ... under this persuasion Mr Telford (is) to appoint Mr Alexander Martin, an intelligent Mason, to be inspector ... and Mr Charles Gower.' (91)

The team of Inspectors was soon afterwards made up to six and remained at this number until the termination of construction work, many of them

later transferring to the Road Repair Inspectorate team which continued until 1863 (92).

The main duty of the Road Inspector was detailed in the standardised form of road contract, which was drawn up by James Hope in June 1804, with Telford's assistance:

'And it is expressly agreed, that the said commissioners shall have power from time to time to appoint a surveyor or overseer upon the said road, and an engineer or overseer for the said Bridges and Quays, to whose satisfaction the work upon the said Road, Quays and Bridges must be executed on all points, agreeably to the terms generally and particularly before specified, and, specified in the said report and specifications.' (93)

Closely connected with enforcing specifications and contracts was that of issuing interim payments to road contractors. These payments were dependent on satisfactory progress reports from the road inspectors on work performed. The inspectors dispatched their reports every two months to James Hope in Edinburgh who administered all Road money transactions (94). Full details of this procedure have been given in the chapter on finance.

The Chief Road Inspector was also often responsible for the final payment due to the contractor (95). The Road Inspectors thus had very considerable power over how the work was executed, through their close involvement in the system of contracts and interim payments, the one being dependent on the other. No such power was enjoyed by their opposite number on the Caledonian, due to the absence of written legally enforceable contracts and specifications.

The Road and Bridge Commissioners saw the system of Road Inspectors

as a safeguard against the contractor 'protecting himself from loss by an imperfect performance of his undertaking' (96) which was unfortunately a perfect summary of what happened on the Caledonian.

In addition to the points mentioned above the Road Inspectors were to offer advice to the contractors, acting as general go-between, paymaster and contract enforcer:

'These Inspectors are instructed to assist the road contractors with advice, as well as to watch their proceedings and to authorise them to draw for money, when due under their respective contracts.' (97)

They had no say in the fixing or changing of contract prices, responsibilities reserved solely for Telford and very occasionally his Chief Road Inspector. They were not involved in the choosing of contractors which was dependent on open tender.

The system of letting 'contracts' and fixing prices on the Caledonian and the Superintendents' involvement in this procedure appeared to be much less organised and well defined. It is now intended to examine this aspect of Canal management vis-à-vis Superintendents and assistants, together with their other managerial responsibilities.

As has been seen already, the superintendents were to let the cutting, puddling and embankments in small lots and 'where circumstances admit, a preference (was) to be given to letting several contracts to the same persons.' (98) They were also let~~the~~ the masonry by contract. Telford was ordered by the Board to ensure that in 'no case whatever (was he) to allow the resident Superintendents upon the line of the canal to exceed the prices to be paid for labour, as previously settled by Mr Jessop and himself, without specially reporting the same, and receiving the sanction of the Board thereof.' (99) The Superintendents were also to ensure that the contractors kept in good repair

any of the tools lent to them by the Commissioners (100). No mention was made of the recording of expenditure and procedure for the payment of workmen, which would suggest that they remained as before. The instructions relating to the letting of masonry and general contracts appear to have been partially overruled by Telford and Jessop, as the line of the canal and 'the mode in which the works are to be let' were decided in August 1804 (101). The Superintendents were allowed to fix rates 'applicable to particular places ... according to the soil, situation and other circumstances,' and Telford's approval (102). In the event of the ground proving ...

'more difficult to work than the general appearance and trials already made had led us to conclude, a proportional allowance is to be made, but if any variation shall increase the expense above the rate of 6d per yard on an average, every case of this kind is to be reported to Mr Telford, and the agreement is only to be conditional until he has approved of the same.' (103)

As in the earlier 1803 instructions, Telford ensured rigid adherence to the prices fixed by him through the introduction of a clause giving him the right to reserve judgement on any increase. This feature was made more explicit in the June 1804 instructions (104). Instances of increases in the contract prices were regularly recorded in Telford's annual reports which would suggest that the above-mentioned safeguard worked efficiently (105). Adherence to Telford's 'arrangements' by the Superintendents was given as one of the main reasons for the project's steady progress up to 1808 (106). No evidence exists to suggest that the Superintendents were not responsible for appointing general contractors. A very small number of individual firms was taken on, however, which would suggest that Telford and Jessop's desire that multiple units be let to single contractors was adhered to by Davidson

and J Telford. (107)

On the occasions when design or line changes were implemented, as at Clachnaharry Sea Lock and Fort Augustus, (108) Telford and Jessop made all the major decisions, although much of the information must have been supplied by the Superintendents. Telford and Jessop also instructed the Superintendents as to where work should be concentrated; as in 1809 when they ordered Davidson to complete the section between Doughfour and Moullindour.(109) In addition to the 1804 provisions, the Superintendents played a vital role in the issue, transference and recording of finance and expenditure: From a comparatively early date, they were ordered to keep an exact record of all monies spent, in the form of a monthly paybill, which was sent to Telford together with all vouchers.(110) It is also probable that the system of advanced monthly estimates was calculated by the Superintendents, as Telford made only two visits to the Highlands a year, although there is no documentary evidence for this assumption. The Superintendents received money direct from Telford rather than the Board.(111) It is not known if they handled all of the monthly allowance, although they did have control of the wages money, which was distributed by their subordinates. It is conceivable that Telford paid the larger machinery and material suppliers directly from his account.

The Road Inspectors were to a large extent free from the financial responsibilities imposed on their opposite numbers on the Caledonian. This was due to a shift in emphasis away from the semi 'direct labour' situation found on the canal to the strict contractual arrangements on the Roads and Bridges, where to a large extent financial responsibility rested with the contractor. As has already been noted, the Inspectors were involved in the distribution of interim payments, but the actual recording of such payments was undertaken by James

Hope.

To conclude, it would appear that the Superintendents on the canal were kept in check by an elaborate system of monetary control and recording. Control of the money supply hopefully ensured control of contract price, wages and the amount of materials consumed. The contract system performed much the same operation on Highland Roads and Bridges. However, the Canal Superintendents were responsible for the day-to-day running of the construction programme, receiving periodic visits from Telford and Jessop, who decided any major issues on the spot. Their role in the management structure was second only to Telford. Like the Road Inspectors they do not appear to have had any say in what that role should be, the majority of decisions appertaining to this being taken before their appointment. Their very considerable achievement was marred by financial worries and inadequate supervision below Superintendent level, which resulted in structural failure and rebuilding in the 1840s. The chief road Inspector acted as Telford's immediate deputy in the Highlands. His responsibilities were essentially those of a co-ordinator, supervising his team of Inspectors who in turn supervised the Road and Bridge contractors. Their responsibilities were already defined by the system of contracting. As a result they were able to concentrate far more than canal officials, on the actual process of checking what the Contractors built, to the ultimate enhancement of the project.

There were no construction supervisors below the level of Road Inspector on the Roads and Bridges scheme, with the possible exception of Andrew May who acted as Telford's clerk when the latter made his periodic trips to the Highlands.(112)

Lower Management

Details of the lower managerial structure employed on the canal project are extremely scarce and vague, making it difficult

to distinguish between those employed by the Commissioners and those by the contractors. Immediately below the level of Superintendent came the post of General Assistant/Pay Clerk which appears to have been occupied in the Clachnaharry district by Andrew May from 1804-1822. (113) He had previously been employed as temporary Superintendent before the appointment of Mathew Davidson. His main duties were the keeping of accounts and 'measuring the contents of the last work.' (114) The names of two general assistants have been recorded, (115) although their exact place of work is unknown. Presumably they were assigned to the Western and Middle districts. In pressing for a salary increase for the Assistants in 1813, Telford stated that they were paid £1.50 a week. He requested that this be increased to £100 per annum, (116) which gives some indication of the importance of the position.

The measurement of task or measure work, the main unit of labour on the canal, was a duty traditionally performed by assistant engineers. It is not known if May and his colleagues worked on the actual line, measuring all the work as it was performed, or if they were based in site offices, receiving work records from overseers and possibly even Davidson and Easton. The large number of concurrent construction sites would tend to suggest that there were either more assistants/pay clerks whose existence was never recorded or, more probably, that it was the overseers who recorded the work performed on site. The small number of references to their being present on the construction site would suggest that they were concerned primarily with office work and that it was the overseers who controlled the project on the numerous construction sites. The number of overseers employed on the project varied from five to ten according to season, and was not affected by the number of workmen or sites. (117) May's knowledge of construction work was clearly very considerable, as he assumed the title of Super-

intendent for the Clachnaharry district after 1817. (118) It should be noted, however, that the main construction programme had moved to Fort Augustus by this period. (119) It is not known if May continued in this capacity after the completion of the work at Fort Augustus. Reference is also made at this period to Clarke being employed at Fort Augustus as Superintendent. (120) Mathew Davidson had died earlier that year and had been replaced by his son, James, and Clarke's activities at Fort Augustus could possibly have been connected with these events. (121) The position of May and his colleagues was thus extremely ambiguous, appearing to require the qualities of engineer and accountant. There appears to have been considerable overlap between the roles of Superintendent, Assistant and Overseer, especially with regard to the measuring and recording of labour. There is even a remote possibility that the references to 'overseers and counters' recorded in the monthly employment figures includes May and his colleagues, as no other record of their existence was kept, unless they were included under 'Mr Telford's Clerks' in the annual management accounts. The remaining section of this chapter will attempt to clarify the position of overseers in the managerial structure by showing that they were employed by the contractors rather than the Commissioners. Overseers were included in the general employed figures, which recorded the number of carpenters, blacksmiths, masons and labourers. Presumably some of these workmen were hired directly by the Commissioners, but it would seem clear that the majority were technically employed by the contractors. Evidence of overseers coming within this second group is limited to isolated wage certificates and receipts. However, there is nothing to suggest that they were employed by the Commissioners. The names of at least two of the overseers are known, John Mackferson, Foreman of the Masons (122) and Thomas Smith, (123) who had previously been employed by Telford prior to June 1804. The inclusion of

overseers' signatures on all wage receipts would suggest that they kept records of work performed. It would also imply the formal handing over of money from one body to another. The implications of this hypothesis are extremely serious as it would imply that the contractors had more agents on the construction site than the Commissioners and that the whole managerial team was dependent on co-operation between two groups whose interests sometimes conflicted, especially in the fields of finance and quality control. Detailed control of the project was left to the contractors (through their overseers), the Commissioners' agents providing overall supervision. There were possibly as few as five government engineers/assistants on the project, (124) if the above assumptions are correct. The duties of the overseers appear to correspond fairly closely to those of assistant engineers employed on contemporary civil engineering projects. They appear to have been responsible for one specific site, rather than large areas.

The importance of the contractors' overseers in the managerial structure would suggest that the contractors themselves played a key role. As has already been noted, the masonry contractors were well acquainted with Telford's working methods and the high standards demanded by him. Their permanent presence in the Highlands was virtually guaranteed by their heavy commitment to the Highland Road and Bridge Scheme. They were provided with temporary accommodation at the commencement of the project but soon built themselves permanent dwellings at Inverness and later Fort Augustus. (125) One of them, John Wilson, had, as has already been noted, acted as Telford's temporary Superintendent prior to June 1804. Telford appears to have been regularly accompanied by at least one of the masonry contractors on his annual tours of inspection. They were also involved in preparatory survey work, as can be seen from Telford and Wilson's investigation of Loch Oich in 1813. (126) They even acted as unofficial pay clerks

as Mathew Davidson reported in 1816:

'All is going well on the canal, I am in daily expectation of Mr Telford here, Mr Cargill and my son, James, are gone to pay the workmen at Fort Augustus.' (127)

Allegations of malpractise by Alexander Easton in 1813 resulted in memoranda being sent out to Superintendents and contractors, instructing them to sack anyone who caused trouble. (128)

To conclude, it would appear that the mysterious lack of information regarding government supervisory staff under the level of assistant/pay clerk was due to the fact that there was none. The rest of the managerial team was made up of the contractors and their overseers. As a result of this, the contractors enjoyed a very considerable amount of freedom which resulted in shoddy workmanship and transgression from what was required. This was most apparent in the Western and Middle divisions, which contained a large proportion of the masonry works. Banavie locks especially were not provided with adequate foundations or side walls, which resulted in rapid deterioration. (129) Had the managerial structure been balanced in favour of the Commissioners, rather than the contractors, these shortcomings would have been corrected. The trust and freedom placed on the contractors counted for nothing at a time of high inflation. Ironically, the rigid system of price controls forced them to take the only way out, namely bad workmanship. Such action was aided by the lack of supervision. It will never be known if Telford and his assistants were aware of the shortcomings of the contractors and therefore the whole project. Did his Superintendents deliberately try to conceal them from him, as May suggested in his 1837 report, (130) or was the whole project written off as a result of lack of capital, a conspiracy of silence whose members included Telford, his Superintendents, the Contractors and



perhaps even the Board of Commissioners?

In addition to the permanent staff already mentioned, Telford employed specialists on particular topics, to advise on specific areas , usually relating to geographical features of the Highlands or machinery. In this first capacity, he employed Murdoch Downie, and Aberdeen sea captain, to survey the sea locks and canal entrances. (131) He was assisted by Mason.(132) Land valuation was carried out by George Brown of Elgin, probably the most experienced land valuer in the Highlands. (133) A Langlands, another land surveyor and valuer, was employed for the area around Fort William. (134) Numerous assistants and surveyors were employed temporarily to carry out trial borings and to produce maps of the line of canal.(135) Telford employed the Fyfe brothers to look after the pumping engines and at least one of the dredgers. (136) The Rhodes brothers of Hull were employed on the design and construction of lock gates, (137) and Bryan Donkin was consulted on an improved dredging machine. (138)

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- 1 Third Report from the Committee on the Survey of the Coasts, etc of Scotland. Caledonian Canal, June 1803. App 4.
 - 2 Ibid
 - 3 Ibid. 'Under the favourable circumstances of ground tolerably even, and the soil moderately good, I should suppose it might cost about £22,000 a mile, in making no allowances for any extra works.'
 - 4 1st Caledonian Canal Report, 1804.
 - 5 Minutes of the 2nd Caledonian Canal Meeting, 4 August 1803.
 - 6 Minutes of the 11 Caledonian Canal Meeting, 6 February 1804.
 - 7 See 1st Caledonian Canal Report: Accounts (Management) and Telford's instructions to May and Mackenzie, 27 September 1803.
 - 8 Jessop was Mayor of Newark at the time of Telford's departure

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for the Highlands in August 1803. He was unable to attend any canal business until October, requesting that instructions be sent direct to him. (W Jessop-Rickman, Newark, 29 September 1803).

- 9 S R O MT1/1. Telford-Cameron of Lochiel. 3 October 1803.
- 10 1st Caledonian Canal Report, 1804. Ap F "Report on the intended entrance from the Western Sea, at Corpach to Loch Eil by Messrs Downie and Mason, Fort William 2 September 1803".
- 11 See Management and Survey Accounts in 1st Caledonian Canal Report, 1804.
- 12 2nd Caledonian Canal Report, 1805.
- 13 Minutes of 19th Caledonian Canal Meeting, 11 June 1804.
- 14 2nd Caledonian Canal Report, 1805, Ap C.
- 14 Telford-Jessop, 8 June 1804.
- 15 For general details of association between Jessop, Davidson and Telford see Rolt, L T C, Thomas Telford, London, 1958.
- 16 Ibid. John Telford appears to have acted as Telford's personal draughtsman, preparing the plans for Bridgnorth Church in the 1790's, which are now preserved in the Ap'ley Park Estate Office, Bridgnorth.
- 17 Telford-Jessop, 8 June 1804.
- 18 Ibid. This proposal does not appear to have been implemented, Mathew Davidson assuming responsibility for the centre district.
- 19 2nd Caledonian Canal Report, 1805. Ap.D.Jessop-Telford, 9 June 1804.
- 20 See 2nd Caledonian Canal Accounts (Management)
- | | |
|--|-------|
| "John Wilson on account of Salary to June 1804 | £130 |
| William Mackenzie on account of Salary to | |
| 14 September 1804 | £145" |
- No reference is made to Andrew May.

- 21 His name appears on wage certificates after 1804.
- 22 Jessop-Telford, 9 June 1804.
- 23 2nd Caledonian Canal Report, 1805.
- 24 4th Caledonian Canal Report, 1807. See also Cameron, AD,
The Caledonian Canal, p67.
- 25 Davidson was given the responsibility of handling all financial
matters relating to the canal.
- 26 Telford-Jessop, 8 June 1804.
- 27 Ibid.
- 28 S R O MTL/1. Telford-A May, 27 September 1803.
"The day wages are to be 18d a day for the best
hands and 16d for the inferior ones."
- 29 2nd Caledonian Canal Report, 1805.
- 30 S R O MTL/1 Telford-Rickman, 6 June 1804.
- 31 2nd Caledonian Canal Report, 1805. Ap C. Telford-Jessop
8 June 1804.
- 32 Ibid. Main Report.
- 33 Ibid. Ap K. Report of Telford and Jessop, Autumn 1804
- 34 S R O MTL/1. Telford-Cameron of Lochiel, 2 September 1803.
- 35 2nd Caledonian Canal Report, 1805, Ap B.
- 36 Hazledine provided the ironwork for Telford's larger
iron bridges, including Menai, Tewkesbury, Bonar and Craigellachie.
- 37 2nd Caledonian Canal Report, 1805. Main report and Machinery
Accounts.
- 38 See Skempton, A W "A History of the Steam Dredger," 1793-1830.
Trans-Newcomen Society, Vol 47, 1974, p103.
- 39 See Donkin, S B "Bryan Donkin, F R S, M I C E 1768-1855.
Trans-Newcomen Society, Vol 27, 1949-51.
- 40 Telford-Jessop, 8 June 1804.
- 41 Jessop-Telford, 9 June 1804.

- 42 Ibid.
- 43 Records of contractors are not numerous, only the names of Meak, Gillies, Ross, Davies and Hughes being recorded amongst the general contractors.
- 44 Third Report from the Committee on the Survey of the Coasts, etc of Scotland. Caledonian Canal. Ap I.
- 45 Ibid. "In the year 1773, the Trustees for the forfeited Estates, employed Mr Watt to make a survey of this track, which he did, and furnished them with a Report and Estimate of the expense working a canal of ten feet water ... I have followed him whenever the circumstances would permit."
- 46 Ibid. Main Report.
"Your Committee, from a full consideration of all the evidence laid before them ... submit to the House their opinion, that the excavation of the inland navigation, proposed in Mr Telford's survey ..."
- 47 1st Caledonian Canal Report, 1804. Instructions to Mr Telford,
"A plan of the line of canal ... is to be completed as soon as possible, and all the necessary measures to be taken thereto, which are required by the standing orders of the House of Commons, in order to the making an application for a regular canal act in the next session."
- 48 Ibid. Main Report.
- 49 Minutes of 7th Caledonian Canal Meeting, 25 November 1803.
- 50 1st Caledonian Canal Report, 1804 and Minutes of 11th Caledonian Canal Meeting, February 1804.
- 51 S R O MTL/1. Telford-Rickman, 15 February 1804.
- 52 Telford's 1802 estimate was £349,617, Jessop's £474,531.
- 53 1st Caledonian Canal Report, 1804, Jessop's report and estimate.

- 54 Ibid. Downie and Mason presented their report on 2 September
1803. Jessop did not leave for the Highlands until October.
- 55 2nd Caledonian Canal Report, 1805. Main Report.
- 56 Many of the weirs, included on the original plans, were not
built until the 1840's.
- 57 Some isolated work had been carried out before this, although
it was not until the 1811-12 season that serious survey work
started.
- 58 Third report on the survey of the coasts, etc of Scotland
Ap 1. Telford's 1801 Report.
- 59 Telford's Turf locks were to cost £5,000 each, [REDACTED]
- 60 Telford stated that he would not have accepted the revised
plans if the cost of individual locks had exceeded £10,000.
- 61 Atlas to the Life of Thomas Telford, London, 1838, plate.
- 62 2nd Caledonian Canal Report, May 1805. Main Report.
Jessop's knowledge of Baltic shipping was non-existent as
he had told the June 1803 Select Committee.
- 63 11th Caledonian Canal Report, 1814, Ap C.
- 64 3rd Caledonian Canal Report, 1806.
It had originally been intended to construct timber bridges,
similar to those on the Forth and Clyde, but after consultations
with Jessop, Telford decided to use cast-iron.
- 65 His visits to the canal site were reduced to once a year after
Jessop's departure.
- 66 He was appointed 'General Agent' to the Ellesmere Canal in
1793. Jessop was principal engineer. In 1795 he became
Engineer to the Shrewsbury Canal.
- 67 SRO MT1/1. Telford-Rickman, 24 March 1804.
- 68 H R & B 1st Report, 1804.
- 69 Ibid.

- 70 Ibid.
- 71 op cit, Haldane p134.
- 72 Ibid. p74
- 73 Ibid. p46
- 74 Ibid.
- 75 Ibid.
- 76 See introduction pVI-X
- Telford later surveyed many of the larger Highland Bridges,
including Dunkeld, Canon, Craigellachie and Bonar.
H R & B 9th Report 1821.
- 77 Joseph Mitchell and James Duncombe carried out survey work on
the Laggan, Loch Carrog and Creech Roads.
- 78 H R & B 3rd Report, 1807. Accounts.
- 79 SRO MT1/1. A May, 27 September 1803.
- 80 Ibid.
- 81 Ibid.
- 82 Ibid. The wage rates were listed only for day work.
- 83 SRO MT1/1. Telford-W Mackenzie, 27 September 1803.
- 84 Ibid. Reference was made in the 1805 Accounts to Mackenzie
as 'Superintendent' for the Clachnaharry district, although
Telford's 1803 instructions made it clear that it was May who
was given more responsibility. Mackenzie received £145 up to
September 1804, including fees for land valuation.
- 85 T Smith.
- 86 SRO MT1/1. Telford-Rickmen, 31 October 1803.
- 87 SRO MT1/1. Telford-Lochiel, 22 December 1803
- 88 SRO MT1/1. Telford-Rickman, 18 February 1804.
- 89 Minutes of 19 Caledonian Canal Meeting, 11 June 1804.
- 90 H R & B 2nd Report, 1805.
- 91 H R & B 3rd Report, 1807.

- 92 Haldane. op cit, pl60-161.
Robert Garrow and Martin continued after 1816 as Road Repair
Inspectors.
- 93 H R & B 2nd Report, 1805. Ap D.
- 94 Haldane. op cit, pl13.
- 95 See Mitchell, J: Reminiscences of my Life in the Highlands.
- 96 H R & B 4th Report.
- 97 H R & B 3rd Report.
- 98 Jessop-Telford, 9 June 1804.
- 99 2nd Caledonian Canal Report, June 1805, Ap E.
- 100 Ibid.
- 101 Ibid. Main Report.
- 102 Ibid. Ap M. Prices of labour and workmanship, as determined
by Messrs Jessop and Telford.
- 103 Ibid.
- 104 In Telford's letter to Jessop of 8 June 1804 constant reference
was made to 'subject to my determination' and 'to be determined
by you or myself,' with regard to the fixing of prices.
- 105 For example, Telford and Jessop agreed to price changes in the
contract for masonry in October 1806. (4th Caledonian Canal
Report, 1807), and general excavation work performed by Meek in
1813. (11th Caledonian Canal Report, 1814).
- 106 6th Caledonian Canal Report, 1809.
- 107 It is not known if any of the general contractors worked on
previous Telford/Jessop projects.
- 108 6th Caledonian Canal Report, 1809.
'Considerable' design changes were made at Clachnaharry sea lock
during Telford and Jessop's 1807 autumn visit. The proposed
coffer dam was scrapped and replaced by a solid embankment.
- 109 Ibid.

- 110 Details of this procedure have already been covered in the section on Finance.
- 111 Ibid. Money was paid into Telford's special bank account and then drawn out to pay for construction work.
- 112 Haldane. op cit, pl60. May received £40 per annum for his services.
- 113 May was also responsible for handling early steamship business on the canal. See A R B Haldane, New Ways Through the Glen.
- 114 Minutes of 63rd Caledonian Canal Meeting, 1813.
- 115 Alexander Clark "for writing and keeping accounts at Corpach" in 1805. Evidence only of May staying in the Commissioners' employment all through the construction period remains.
- 116 Minutes of 63 Meeting.
- 117 Even during the peak employment years the number of supervisors or overseers did not increase, the ratio between overseer-workmen always being considerably higher in the Corpach district.
- 118 HLRO. Paybill, September-October 1819.
- 119 Construction work at Fort Augustus was at its peak, when Southy^e visited the site in 1819.
- 120 HLRO. Paybill, September-October 1819. Clark received £7 15s 10d a month, as did May at Clachnaharry.
- 121 James Davidson was appointed Superintendent for the whole of the Eastern District, which included Fort Augustus. Clark could possibly have been a "person of Inferior description" as envisaged by Telford in 1804, for the superintendence of the Centre district, although it is strange that no reference should be made to him until the height of the construction work.
- 122 J Mitchell. Reminiscences of My Life in the Highlands, Vol 1 p68.

- 123 HLRO. Wage certificates. 1807-8.
- 124 The two Superintendents and three Assistants/Pay Clerks.
- 125 Cameron, p55 Op Cit. Simpson and Cargill built houses in
Telford Street, Inverness. Southey refers to Cargill having
built himself a stonehouse at Fort Augustus.
- 126 Cameron, Op Cit p78.
- 127 HLRO. Mathew Davidson-Hope. 12th September 1816.
- 128 Minutes of 61st Caledonian Canal Meeting, 27th March 1813.
- 129 Cameron, Op Cit p130. May had pointed out the masonry in
the Banavie flight as particularly bad.
- 130 May's 1937 Report.
- "I have reason to believe that the contractor for these locks,
while engaged in the actual execution of the works, was fully
under the conviction (which was shared by many others at the
time) that the navigation was a thing which was never to take
effect and that his locks would consequently never require
to come into actual operation".
- "..That so imperfect a description of workmanship should
have satisfied, or rather escaped the severe reprehension
of Mr Telford on his occasional visitations to the canal,
is surprising, and can only be accounted for on the supposi-
tion, which I believe to be the correct one, that the utmost
pains were taken by the contractor to conceal, by a variety
of arts, the true nature of his proceedings."
- 131 1st Caledonian Canal Report, 1804.
- 132 Ibid.
- 133 2nd Caledonian Canal Report, 1805. Main Report.
- 134 Ibid.
- 135 John Howell and Barlow and Arrowsmith were employed in survey-
ing and map making, together with numerous un-named assistants.

- 136 Mitchell, p68.
137 Ibid.
138 14th Caledonian Canal Report, 1817, Ap E.

N.B.

Since the the completion of this Thesis a detailed study of the life and works of William Jessop has been published by David and Charles (William Jessop,"C.Hadfield and A.W.Skempton,1979).The Caledonian canal is examined in some detail,especially with regard to the division of responsibility between Telford and Jessop.There are no fundamental differences between the conclusions drawn in this study and the Jessop biography.I would like,however,to include a small number of additional points drawn from the book which should be considered in conjunction with the main section of this chapter on Telford and Jessop.

Hadfield and Skempton argue that Jessop was appointed to the post of 'advisory' engineer as a result of his experience with the Shannon improvement scheme which included the utilisation of inland lakes.No other prominent civil engineer of the period had similar experience.(1) The authors also quote from the Edinburgh Encyclopaedia of 1817 which perhaps provides the best summary of the working relationship between Telford and Jessop: 'For several years previous to his death,he (Jessop) acted jointly with Mr Telford in conducting the great caledonian canal.....and that engineer embraced every opportunity of acknowledging,in the warmest manner the advantages.....he derived from the able and upright and liberal conduct of his enlightened colleague and friend'. (2)

1)."William Jessop,"C.Hadfield and A.W.Skempton,1979.op.cit.;p.156

2).ibid.p.166.

CHAPTER 3

CONTRACTORS

The organisation of contractors was, as has been noted in the introductory chapter, one of the touchstones in assessing the success or otherwise of the managerial organisation of a civil engineering project. This chapter will examine the contractual arrangements on the Caledonian Canal and Highland Roads and Bridges and the system of controls introduced, making comparisons with other contemporary projects. Many of the differences in the management of the two projects stemmed from the use and control of contractors and a study of this particular aspect of the project demonstrates more dramatically than any other feature the fundamental differences between the two projects. A short chronological account of the contractors' involvement in the projects will be given.

No action regarding the letting of canal contracts appears to have been taken until the summer of 1804, (1) when Telford and Jessop received orders to decide upon the mode of letting the works 'in lots to the workmen, or otherwise executed in the best and safest manner.' (2) Telford contacted Jessop in June 1804 suggesting John Simpson (died 1815), John Wilson and James Cargill as masonry contractors. (3) All ex-Ellesmere Canal contractors, (4) they began work in the autumn of 1804 and remained on the project until the official opening in 1822. The general earth contractors were also appointed at this time and included Meek, Gilles and Ross, Hughes and Davies. Records of their having been involved throughout the whole period of construction have not survived, except in the case of Williams Hughes who remained until 1824. (5)

No road contracts were let until the summer of 1804. Many of the more successful road contractors took on successive contracts after the

completion of their initial projects and remained in the Highlands until the 1820s.(6) This trend was more pronounced in Bridge projects where good contractors were extremely difficult to find. A small handful of individuals including George Burnett, W Minto and Simpson, Wilson and Cargill (the latter three of canal fame) erected all the major bridges in the Highlands between 1803-1821. (7) Although the introduction of open competition for road and bridge contracts theoretically reduced the chances of firms being involved throughout the whole of the construction period, practical considerations such as expertise and experience led to their re-employment on numerous occasions. (8) In this at least the two projects shared some common ground.

Details of contractual arrangements on the Caledonian Canal are extremely scarce, as has previously been mentioned. This lack of contractual evidence would suggest that there were certain fundamental elements, common on other contemporary projects, which were missing on the Caledonian Canal and that the system operated on the project was not strictly contractual.

Contractual Procedure

The practice of opening contracts to tender was well established by the beginning of the nineteenth century, having been employed on many of the early canal projects. Telford used the procedure on his Highland Road and Bridge project which commenced in 1803.

The road and bridge contracts were advertised in Scottish newspapers by James Hope after the Board's approval of the survey and estimate. (9) A copy of the survey was deposited locally for inspection by the possible contractors. (10) Offers of contracts came from all over Scotland from a great variety of sources, including architects, masons, gardeners, nurserymen, vintners, farmers and labourers together with general builders. (11) So many made the trip north to tender for contracts that the Commissioners employed guides to show them over the

area. Payments of £3 to £5 were made to each successful offeror by way of compensation, but this was stopped after abuse. (12) Offers nearest to Telford's estimate (or lower) were usually accepted by the Board and local proprietors. Initially this led to many problems, acceptance of the cheapest often taking precedence over experience, with sometimes disastrous consequences. Many of the cheaper offers were based on inadequate knowledge of the area, and Telford's high standard of workmanship, resulted in the financial ruin of the contractor, for which the Commissioners were not responsible. All intending contractors had to provide security. (13) This at least weeded out some of the unsuitable candidates, although many still managed to slip through the net. Responsibility for checking on contractors' security fell to James Hope and Telford. (14) A great variety of contractors was employed in the early years of the project, many with little success. Telford expressed concern over this matter to Rickman in 1808:

'In works of this kind, widespread, executed by contractors indiscriminately employed and amongst a people just emerging from barbarism, misunderstandings and interruptions must be expected.' (15)

This was to a large extent rectified in later years when only experienced contractors were employed, and not simply the cheapest. This was acknowledged by the Commissioners in their report of 1812, and by Rickman:

'That affair I think has proved sufficiently that the personal character of our contractors is of much more importance than the small differences upon which the contributors expect preference to be given.' (16)

The letting of contracts on Roads and Bridges was thus only completely open in the initial years of the project. Even in its later form, however, when only experienced contractors were used, there was still

considerably more freedom than had ever operated on the Caledonian with regard to the choice of contractors.

It was decided from the beginning of the canal project that the masonry contracts would not be open to tender but would be given to Simpson, Wilson and Cargill, who were all well acquainted with Telford and Jessop, having worked on the Ellesmere Canal. It was hoped to eliminate 'the risk of getting very inferior men' by such actions. (17) The same procedure was presumably followed in the appointment of general earth contractors as no reference to throwing jobs out to tender has survived. At least one of the earth contractors from the Ellesmere Canal, M Davies, was employed on the Caledonian. (18) The decisions to use established contracting firms fully conversant with large-scale canal construction schemes resulted in the adoption of a comparatively small supervisory team. This would not have occurred if the contracts had been opened to general competition at the beginning of the project. (19)

The most unusual feature of the whole contractual set-up on the Caledonian Canal is the lack of any form of written contract. Nothing which remotely resembles a contract has survived. (20) Telford and Jessop fixed the line of canal and prices at which the work was to be performed in August 1804, (21) nearly two months after the appointment of the main masonry contractors. Details of prices were given to the Superintendents and presumably the contractors. There is no surviving evidence to suggest that the contractors had any say in the fixing of prices or that they were obliged to sign any document agreeing to terms. The issue was settled and presented to them in very much the same way as would have occurred on a direct labour project. (22) Any subsequent increase in price was subject to Telford's examination and approval. (23) The fixing of prices after the award of the main contract, however, would suggest that the contractors had at least some idea of what the

figures were likely to be, even if they did not participate in the actual pricing. John Wilson was in an ideal position as regards what was wanted on the canal, having served as temporary Superintendent at Corpach from 1803 to 1804. (24) The absence of any written contract meant that there was no time clause or system of fining contractors for delay. Estimates of seven years were made by Telford in 1802, which were subsequently revised throughout the construction period. (25) At no time do the contractors appear to have had any say in deciding upon the completion date, all such decisions being taken by Telford and his Superintendents. (25) Penalty clauses for delay had been introduced on the Birmingham Canal, and Telford incorporated them in his Highland Road and Bridge standardised contracts which were drawn up for all roads and major bridges built. Any delay resulted in retention of final payment. (27)

It is now intended to examine in some detail the form of road and bridge contract and the procedure surrounding its drawing up and enforcement. The contract for constructing a road or bridge was only drawn up after the approval by the Commissioners of the survey and estimate. The form of contract which remained standard throughout the period of construction had originally been 'approved of by our engineer Mr Telford' (28) in the summer of 1804. The Commissioners had ordered Hope 'to execute it on our behalf, having previously obtained the opinion of the Lord Advocate of Scotland that such execution of a contract was sufficient, under the authority of a general power and commission from us to that effect.' (29)

The price of the work was included in the contract. Any change in price was to be made by Telford alone, and the contract duly amended. (30) Throughout the period of construction there were comparatively few amendments, unforeseen technical difficulties, usually associated with bridge foundations, being the main cause. (31) The contract price

was always a matter for the Commissioners' engineer and does not appear to have involved the contractor at any stage.

The contract included provision for interim payments at two-monthly intervals which were to be made:

'Progressively and by instalments, at the intervals of two months, as the work proceeds ... no money will be advanced to the said contractors until they shall have collected their tools and workmen, and horses and carriages, and are in readiness to commence the work; and the amount of the said instalments or progressive payments shall be regulated by the reports and certificates transmitted by the surveyor named by the Board.' (32)

A very responsive form of control was thus immediately established over the contractors. Payment by result was unfortunately not adopted on the canal. A quarter of the total contract price was retained until the completion of the contract and only released upon satisfactory final inspection. (33) This particular aspect of the contract will be dealt with in a later section. Interim payments were used by the contractors for the purchase of labour and materials, although very little has survived on this matter. It is doubtful if any of the contractors could have undertaken contracts without some form of interim payment.

The provision of interim payments to the contractors does appear to have been practised on the Caledonian Canal, although in an unusual form. No record exists of any advance payments being made to any of the canal contractors, although this was a common enough feature on the Highland Roads and Bridges project. (34) This would imply that the contractors were sufficiently well organised financially to be able to buy in tools, materials and pay for labour at the very beginning of the

project.(35) Interim payments were made monthly, being detailed in paybills, and in the annual printed accounts under "Masonry", "Labour by Day" and "Labour by Measure". Virtually all the money paid out for "masonry" was consumed on the payment of wages, which may or may not have included the contractors' profits.(36) Only the monthly paybills recorded direct payment to the contractors' overseers and the contractors themselves played a key role in the recording and distribution of wages. The need for monthly payment on the canal was obvious as no contracting firm at this date could have undertaken so large an undertaking without frequent payments. The deployment of all Telford's supervisory staff on the recording and issuing of interim payments does appear to have been a most unusual feature for the time.(37)

The absence of contractors also precluded the use of maintenance clauses, a common feature on earlier contracts and the main protection against bad workmanship. Telford made ample provision for maintenance in his Highland Road and Bridge contract.(38) A quarter of the contract price was retained by the commissioners

"until the whole of the work, both on the Road and Bridges shall be finished and finally inspected and surveyed and approved of by the said commissioners and contributors or a person or persons employed by them for that purpose."

A far more elaborate clause was inserted for bridge contractors, which actually bound the contractor to maintain the structure for a given number of years. They were to:

"support, maintain and uphold all and such of the said bridges against all damage or destruction of whatever kind arising from floods, or any other causes for the space of three years."(40)

Haldane states that the maintenance period was as long as five years on some early contracts.(41) In practice even three years was impracticable, for it effectively prevented contractors from undertaking new projects until the expiry of the maintenance clause, making it extremely difficult for the Commissioners to find good bridge builders.(42) Many of the road contractors had considerable difficulty in building even small bridges and many were ruined through inadequacies in this department.(43) The Commissioners report in 1809 that one bridge on the Strathur Road had collapsed no less than four times and had finally been abandoned.(44) Separate contracts were entered into for larger bridges. Simpson and Wilson undertook many of the large bridge contracts, and were probably the only contractors who could with confidence guarantee the safety of a bridge within the specified period of maintenance.(45)

There are no records of the canal contractors being called upon to carry out repair work after the canal's opening in 1822. All but one of them appears to have left the construction area by 1823-4 to take on new contracts,(46) even though there were signs of very defective workmanship at a comparatively early date,(47) actual structural failure occurring in 1826.(48) Repairs to the canal before 1822 do not appear to have been recorded, although all works were inspected for damage at regular intervals.(49) The leakage which occurred in several sections of the canal was rectified at the Commissioners' expense, not the contractors', as very little puddling had been specified in Telford's original plan of the canal. (50) Given the appalling condition of the works almost immediately after its opening, it is perhaps fortunate for the contractors that they were not responsible for maintenance.

The final feature missing from the contractual arrangements on the canal are detailed specifications.(51) No detailed specifi-

cations relating to individual features survive apart from a small number of ink wash drawings in one of Telford's pocket notebooks.

(52) It contains five transverse sections of the canal signed by William Jessop in the autumn of 1804 which are accompanied by a set of instructions to John Telford for marking out the canal. It is extremely unlikely that they were ever intended for anything but educational use.(53) The book also contains a plan of bridge walls and section of Loy Aqueduct, neither of which is sufficiently detailed for construction purposes.

Telford and Jessop's report relating to the fixing of prices gave only the most basic description of what was required. No details were given of lock construction, and the report was concerned primarily with specifying the type of materials to be used rather than actual construction methods.(54) In no way does the 1804 document compare with the detailed specifications annexed to all Highland Road and Bridge contracts(55)

Extremely detailed specifications for all roads and bridges were drawn up by Telford and included as part of the overall contract signed by the contractor and the commissioners. The specifications were thus legally enforceable and the contractor liable to litigation if the commissioners felt that the work had not been executed in a satisfactory manner.

"The said contractors bind and oblige them and their foresaids, to ... build in a sufficient manner to the satisfaction of the Engineer employed by the Commissioners.

(55)

All bridges were to conform 'in every respect' to the drawings annexed to the specifications as were all cross drains, culverts and retaining walls.(57) All interim payments depended on the satisfactory execution of the specifications. They were thus central

to the whole management of the project, and probably did more to ensure the project's ultimate and permanent success than any other single factor. A clause was inserted in the standardised contract for minor alterations to be carried out (with official approval) without the need for changing the contract.(58) Machinery for settling disputes over enforcement of contracts and specifications was also contained in the contract, but was seldom used.(59)

To conclude on the use of contractors on Highland Roads and Bridges, Telford appears to have defined more clearly than any previous civil engineer what was expected of the contractor with regard to quality of work, responsibilities for repair and the role of site engineer vis-à-vis the contractor. The formalisation of interim payments, which had always been carried out in a haphazard fashion before 1803 added stability to the project even if it did not always prevent disaster. The combination of the above mentioned factors ensured the ultimate success of the project.

It must be concluded from the above points that the contractual arrangements on the Caledonian Canal were most unusual. The absence of open tenders, contracts, detailed specifications and maintenance obligations suggests a non-contractual relationship, one that was much more akin to the direct labour situation. The integral role of certain contractors in the managerial team would also tend to suggest such a situation. Reasons for the evolution of a hybrid form of contractual agreement are best found in the unprecedented scale of the project, and the difficulty of dividing the masonry work up into small contractual sections whilst ensuring consistency. As will be seen later, this last aim was not achieved. In the remaining part of this section the managerial structure of the various contracting concerns and their responsibilities will be examined and contrasted with those of the Commissioners' [redacted]

managerial team, with reference to the main period of construction between 1804 and 1822. Details of the managerial structure of both road and canal contractors are rather vague. The next section of this chapter will attempt to examine contractual management on both projects. Particular emphasis will be placed on the managerial responsibilities of the road and bridge contractors. The responsibilities of canal contractors have been examined in the chapter on Management.

The road contractor was responsible for recruiting his labourers, paying them, and for the purchase and location of materials, all features apparently missing on the Caledonian. They were not, however, actually involved in the design of the road or bridge or in the measuring and inspection of work, which was left entirely to the Road Inspectors who were, in the administrative sense, a free-standing body, unlike their counterparts on the Caledonian. Very few of the road and bridge contractors had any form of developed managerial structure, relying to a great degree on personal attendance of the work in hand. This appears to have been a common factor amongst good and bad contractors alike, although the very worst contractors sub-let, as will be seen in a later section. Many of the contractors worked with their men, as Southey noted in his diary of a tour of Scotland in 1819.

"Davidson was the contractor, an honest, plain, contented man, who works with his workmen, places all his pride and pleasure in performing his work well and has lost by several of his contracts!"(60)

The Road and Bridge commissioners were most anxious that Contractors gave adequate supervision to their contracts and the early reports are full of references to the problem of adequate supervision from contractors. They reported in 1807 that J Readdie the Loch Na Gaul

road contractor had previously agreed to supervise the work personally;

"His presence, however, has not been so efficacious as was expected, and we have reason to believe that he much under-rated the difficulty of forming a road through a very rugged tract of country".(61)

Matters did not improve on the road and the commissioners finally decided in 1810 to take the contract away from Readdie, the final payment being settled by arbitration.(62) Many of the road contracts were undertaken by partnerships, each partner making himself responsible for a section of the road. There is no evidence of any further managerial devolution.

Canal Contractors

It is not possible to establish the exact relationship between Simpson, Wilson and Cargill at the commencement of the canal project. Wilson and Cargill were employed by Simpson as principal foremen on the Ellesmere Canal, more particularly Pontcysyllte Aqueduct, which was not completed until November 1805.(63) It seems unlikely that they would have been partners and foremen on concurrent projects. It would appear likely that they entered into partnership in the ensuing years before assuming full control of the masonry contract after Simpson's death in 1815.(64) Simpson appears to have worked in both canal sections, leaving Wilson at Corpach and Cargill at Clachnaharry.(65) It is not known at what date Wilson and Cargill severed the partnership; they were certainly operating as two separate units by 1817 when Wilson assumed responsibility for the Western half of the middle district and Cargill the east.(66) Cargill appears to have concentrated solely on masonry work while Wilson undertook both excavation and masonry work.(67) Telford's policy of beginning at the two ends and gradually working into the middle would tend to

preclude any exchange of contractual staff. No evidence survives for the period immediately after Simpson's death when the partnership apparently dissolved. It would also appear that the general earth contractors operated in one of the two end sections before moving to the middle and never alternated from one end section to another,(68) presumably because of difficulties in moving men and machinery. Thomas Davies and William Hughes were responsible for most of the cutting in the ~~E~~astern district,(69) whilst Meek and Gillies and Ross undertook the Western section.(70) Hughes appears to have specialised in undertaking dredging contracts after 1814(71) and no further reference is made to Davies after this date. Hughes assumed responsibility for the excavation of the eastern half of the Middle section.(72) Meek worked continually on the deep cuttings in the Western section.(73)

No records of the managerial structure of the smaller general contractors survive. It is not known if they were recorded in the employment figures as overseers or whether they were able to employ assistants.(74) None of the contractors appears to have employed full-time clerks or any distinct form of secretariat, being reliant on their own overseers and the Commissioners' clerks for the measurement of work and calculation of work performed. The close managerial involvement of the contractors in the overall managerial structure of the project and the lack of formal contracts probably prevented the sub-letting of contracts,(75) one of the most serious problems in early canal projects, as has been noted in the opening chapter.

Sub-Contracting

One of the major problems on the Roads and Bridges project was that of sub-contracting. The contractors were pledged to give 'due personal attention' to the works in the standard form of contract,(76) but Haldane states that sub-contracting was not infrequent, as on the Moidart Road where the contractor, Halkett, sublet and failed to keep

adequate supervision of the works.(77) He was eventually warned by Hope for inadequate work and control:

'I cannot blame our surveyor for declining to be whipper-in of a number of different sub-contractors.'(78)

The sub-letting of contracts, however, did not release the original contractor from his responsibilities and all contracts were eventually completed. The practice did cause delay on some projects but such was the strength of the inspectorate system that the quality of work performed did not fall unduly, as occurred on earlier civil engineering projects where sub-contracting took place.

It is not known if the policy of employing well tried contractors/supervisors on the Caledonian Canal was evolved specifically with the aim of overcoming the sub-contractor problems, and all the relevant difficulties of inconsistent work. If so, the experiment was a failure for the contractors failed to respect Telford's trust and produced extremely variable work, as George May pointed out in his 1837 Report.(79)

Labour and Contractors

It now remains to examine the Canal contractors' role in the hiring of labour. This aspect of the project will be examined in some detail as it lies at the very centre of the controversy surrounding the organisation of the project. As has been noted Road contractors were ~~entirely~~ responsible for labour and much of the remainder of this chapter will be devoted to canal matters.

The canal contractor's role in the hiring, payment and dismissal of labour is extremely difficult to distinguish from that of the Commissioners. In trying to unravel the problem it will be necessary to examine labour figures and the few surviving paybills.

A small number of men were employed before the summer of 1804.

to excavate the Basins. They were employed directly by the Commissioners and appear to have been paid mainly by the day.(80) The main masonry contractors brought with them a small number of highly skilled masons and craftsmen, notably Thomas Jones who appears to have been an early overseer.(81) The majority of labourers and masons appear to have been recruited locally however, as shown by a survey of the origins of workmen, carried out in 1817-18.(82) Most masons appear to have come from Nairnshire and Moray, being employed on a seasonal basis.(83) The majority of common labourers came from the surrounding Highland counties, and were also employed on a seasonal basis.(84) A very considerable number of workmen travelled up from Glasgow in times of economic depression but this was the exception rather than the rule.(85) There is no surviving evidence of either the Commissioners or the contractors advertising or actively recruiting for labour.(86) This would suggest that the unemployment problem was so great in the canal area that active recruitment was unnecessary. Delay in commencing the Middle district caused the local inhabitants to draw up a petition requesting work to alleviate social distress.(87) This view has to be balanced by the demand for labour from the local Militia and Highland Road and Bridge contractors, both very active at the main period of canal construction. The problem of trying to apportion responsibility for labour recruitment is closely allied to the much larger one of overall responsibility for labour. The unusual contractual agreements between contractors and Commissioners showed many of the features associated with the direct labour situation. It is now intended to ascertain who was responsible for actually employing the labourers and paying their wages, both of which have a direct bearing on the type and size of managerial structure deployed.

Telford gave strict instructions in 1804 that no labourer was to be paid over a certain rate and that wages in general should be

compatible with those of the surrounding areas.(88) These instructions were sent primarily to the Superintendents who were presumably responsible for supervising direct labour operations.(89) Did they apply to contractors? Judging from Telford and Jessop's 1804 Report, it would appear not, for it implies that the instructions related to labour 'under the immediate direction of the officers of the Board.'(90) The contractors were apparently given a free hand:

"In work let to contractors by measure, their own interest must determine between them and the men they employ; but as canal work is very labourious, they must, whether they re-let it by measure, or by the day, give such wages in advance (if by measure) or in payment (if by the day) as will be the means of procuring and calling forth the utmost exertions of able workmen, so that although the wages paid by the contractors may be higher than those for common workmen in the adjoining country, yet when compared with the quality of work performed, it is much the cheaper labour."(91)

Before proceeding further it is vital to ascertain the size of the labour forces, for it is only when this matter is settled that the true impact on managerial organisation can be fully appreciated. A large direct labour force and a small contractual contingent would have required a large body of 'official' assistant and supervisory engineers to control it. This was obviously not the case as only five supervisors were employed by the Commissioners on the site. It is extremely unlikely that the contractors themselves would have played so prominent a role in the managerial organisation had they not had their own large labour forces at their command. It is also extremely unlikely that contractors would have been involved in the supervision of direct labour,

which, because of the small number of official supervisors, would have taken place on the Caledonian. Arguments against the existence of a large semi-independent contractual workforce are centred around the evolution of administrative machinery designed to control prices and wages, which would suggest a large direct labour workforce. However, by insisting on official approval of all contractual price rises, the Commissioners could keep in check the rate which contractors paid their workmen. The machinery was thus equally successful or unsuccessful for both direct and contractual labour arrangements. It would thus appear likely that the small government contingent of supervisory engineers was responsible for control of a comparatively small direct labour force and that they left the contractors to organise their own managerial structure. This would explain much of the poor workmanship and apparent inability to control overspending. Labour records do not distinguish between those employed by the Commissioners and those by the contractors, being calculated from official labour returns submitted by both parties. The table of work 'performed under the immediate direction of the engineer or Superintendents' which was published annually in the printed reports does not give a true representation of the employment situation on the canal. Expenditure on masonry, labour by day and labour by measure all correspond to the amounts recorded in the main accounts, which would imply that the contractors employed no labourers at all. The table presumably referred to all works performed on the canal site as a whole, under the Superintendents' control. Evidence of actual numbers employed by the contractors and of monthly payments being handed over, are recorded in the few surviving paybills. The paybill for 25 December 1819-25 January 1820 shows payment of £205 to John Wilson for the excavation of 1500 cubic yards of earth at Laggan at 5d a cubic yard.(92) At this time 80 labourers were employed at Laggan (93) which means that each labourer excavated 51 sq yards of earth, a

probable figure given the time of year. There is thus an exact correlation between the number of labourers employed, the work performed and the amount paid to the contractor. Contractors appear to have employed both day and measure labourers although the former made up only a very small percentage of the total labour force. The procedure for the actual payment of labourers has been described in previous chapters.

It is clear that the contractors were the major employers on the project and that they enjoyed considerable managerial freedom. It is also clear however, that the Commissioners had the ultimate say in how many men were employed as they had control of the rate of monthly payments. It is unlikely that any of the contractors had sufficient reserves to carry on without these payments.(94) Frequent references were made by Telford to contractors exceeding the monthly allowances and the need to cut down the number of men employed.(95) It is unlikely that the direct labour force was sufficiently large to affect the ratio between available funds and number of men employed.

It now remains to examine the supply and preparation of materials and the contractors' involvement in this department.

As in other aspects of road and bridge contracts, the contractor was completely responsible for the supply and preparation of materials. They were however, given some assistance in this field by the inclusion of a special clause in the Road and Bridge Act which enabled them to obtain materials free of charge if they were in close proximity to the work in hand. This concession was mentioned in the standard form of contract, together with related material on payment of damages.

'and it is also agreed that the contractors should have the full benefit of the Act of Parliament for obtaining materials for construction work, any damages to owners of land from which

he obtained materials to be paid for

by him.'(96)

On Telford's iron bridges the contractors appear to have had overall responsibility for the work, although the ironfounder provided skilled workmen to erect the main spans. It is not known if this ^{formed} ~~proved~~ part of a sub-contractual arrangement.(97) Responsibility for choosing the iron supplier and paying him appears to have been handled by the Road Commissioners.(98)

The Canal Commissioners were responsible for preparing and opening up the quarries needed for the supply of stone and for general maintenance.(99) The contractors appear to have been responsible for actually quarrying the stone and preparing it for use in the locks. They were also partially responsible for transport costs of stone,(100) full details of which have been given in the relevant section. The Commissioners appear to have assumed full responsibility for the legal ownership of quarries, for all disputes were between landowners on whose ground the quarry stood and the Commissioners - never the contractors. The plateways used to transport stone to the construction sites were purchased by the Commissioners and maintained by the contractors,(101) who appear to have hired their own horses, for which they received regular monthly payments from the Commissioners.(102) The provision of timber was also a partial responsibility of the contractors, Wilson receiving payment for oak and fir timber in 1819, (103) although it is clear that Telford and his Superintendents retained overall control of this department.

The initial purchase of iron and timber followed conventional procedure, for Telford invited firms to quote their prices before placing a firm order. It is not known if this procedure was carried on in later years.

All re-routing of canal-side roads was performed by contractors

according to the procedure laid down by the Highland Road and Bridge Commissioners, which included detailed specifications, contracts and maintenance obligations. The canal Commissioners acted as the main contractor, sub-letting to an experienced contractor, (Simpson and Wilson on the Lochy side road).(104)

To conclude, the use of contractors on the Caledonian Canal was most unusual. Seldom can contractors have employed such a vast number of men with so few legal and contractual obligations. Reasons for the absence of normal contractual arrangements centred around three main points; the unprecedented size of the project and the dangers of committing oneself to what was virtually an unknown quantity; the specialised knowledge of most of the contractors in the working methods of the principal engineer, and the assimilation of the principal contractors into the managerial team. This freedom was checked by the Commissioners through the control of monthly payments, which had a direct bearing on the number of men employed and therefore on the amount of work capable of being performed by the contractors. As has been noted in previous sections, this control was inadequate and did not prevent bad workmanship and overspending, the two main factors which eventually destroyed the canal's viability. The type of contractual arrangement used on the Caledonian had a profound effect on the structure of the managerial team which resulted in inadequate official supervision. This was not counterbalanced by the contractors' internal organisation.

The provision of written contracts and specifications of Roads and Bridges gave Telford a firm foundation on which to assemble his managerial team, this was entirely lacking on the Caledonian Canal. All matters relating to roads and bridges were clearly defined, a very considerable achievement given the complexity of the project.

- 1 Men had been employed on the excavation of the two end basins
since the October of 1803, being employed directly by the
Commissioners.
- 2 2nd Caledonian Canal Report: Main Committee Report.
- 3 Ibid. Telford-Jessop, 8 June 1804.
- 4 See Report on the Ellesmere Canal, November 1805, which contains
details of Simpson and Co's involvement in the project.
- 5 See Telford-Rickman, 7 November 1823. Outstanding debts had to
be paid to Cargill and Wilson who were planning to leave the
area as soon as possible. Hughes appears to have remained at
least until 1824.
- 6 See H L & B 9th Report, 1821. Ap 3 List of Road and Bridge
contracts.
- 7 Ibid. Simpson, Wilson and Cargill undertook Dunkeld, Craigellachie,
Bonar and Ballater. George Burn contracted for ~~Wide~~ Lovat,
Helmsdale and Fairness Bridges. The few remaining large bridges
were built by individual contractors.
- 8 Haldane, op cit, p54.
- 9 Ibid. p53.
- 10 Ibid.
- 11 Ibid.
- 12 Ibid. p54, see also H R & B 2nd and 3rd Reports, Accounts.
- 13 Ibid. p56.
- 14 Ibid.
- 15 Ibid. p95, Telford to Rickman, 30 November 1808.
- 16 Ibid. p55, Rickman to Hope, 23 September 1809.
- 17 2nd Caledonian Canal Report, 1805. Jessop-Telford, 9 June 1804.
- 18 See Report on the Ellesmere Canal, November 1805.
- 19 Had standard procedure been followed, it is probable that a more
varied group of contractors would have got the job. The degree of

supervision would, as a result, have had to have been ^{at} a more detailed level.

- 20 The absence of any form of contract on so large a government project seems extremely difficult to believe, especially when one remembers the Commissioners' obsession with points of detail, as described in the chapter on accounts. No references have been found to the drawing up of contracts in the annual printed reports, the private and official correspondence relating to the project or in the official minutes of the Board of Commissioners. This is ~~indirect~~ contrast to the Highland Roads and Bridges project which recorded not only the contracts themselves, but details of their drawing up and signing. Details of the form of contract and dates at which they were signed were given in the annual printed reports. The official correspondence abounds with detailed references to contracts, as do the surviving Board Minutes. A search has been made amongst the papers housed in the House of Lords Records Office and the Scottish Record Office, the two main centres for canal material. It is a very outside possibility that canal contracts survive amongst the huge collection of unsorted papers belonging to James Hope, Legal Agent to the Canal Commissioners. It is highly improbable that they ever existed, as no reference was ever made to them by any of the officials connected with the canal.
- 21 2nd Caledonian Canal Report, 1805.
- 22 Presumably work was able to start as soon as the prices were fixed.
- 23 2nd Caledonian Canal Report, 1805. Ap M.
- 24 Ibid. Main Accounts, Management.
- 25 See Telford's Survey of the Highlands, 1802 and subsequent estimates of 1808, 1813, 1816 etc.

- 26 No written evidence survives of any contractors giving an opinion
as to the overall completion date, although they were presumably
involved in estimating completion dates for individual features
on the canal.
- 27 2nd Highland Road and Bridge Report, 1806. Ap P. 'Form of
Contract for Making a Road, and Building the Bridge Thereupon.'
- 28 H R & B 2nd Report, 1805.
- 29 Ibid.
- 30 Haldane, op cit, pl08.
- 31 Ibid. pl31. Bonar Bridge design was changed very considerably
after difficulties with the foundations.
- 32 H R & B 2nd Report, 1805.
- 33 Haldane, op cit, pl01.
- 34 Many of the Road and Bridge contractors had insufficient funds to
begin work, without advanced payment. See A R B Haldane: New
Ways Through the Glens.
- 35 It should be noted that the Commissioners provided some of the
tools and had overall responsibility for providing all pumping
equipment.
- 36 See the small tables printed at the end of every annual account,
detailing percentage of labour costs.
- 37 The two Superintendents and their three assistants all appear
to have been heavily involved in the measuring of work and
distribution of payment - see section on Management.
- 38 2nd Highland Road and Bridge Report, Ap P.
A proportion of the final payment was retained until the work
had been inspected and further maintenance obligations imposed
for a stipulated period.
- 39 H R & B 2nd Report, 1805. Standard form of contract.
- 40 Haldane, op cit, pl22-23.

- 41 Ibid.
- 42 Ibid.
- 43 Haldane, *op cit*, pl20. Dick and Readdie lost two bridges in their Road contract. The Commissioners tried letting separate bridge contracts, but this failed as the road and bridge contractors were constantly arguing over damage to partly built roads. All but the largest bridge ~~were~~ included after this date in the general road contracts.
- 44 H R & B 4th Report, 1809.
- 45 There are no instances of failure occurring on any Simpson, Wilson and Cargill Bridges.
- 46 See Telford-Rickman, 6 January 1824.
- 47 May notes in his 1837 Report that the water was let into the locks at Fort Augustus before the mortar dried, a fault which must have been apparent from an early date.
- 48 The lock gates at Clachnaharry broke in that year and sections of a wing wall at Fort Augustus also collapsed.
- 49 See HLRO. 1819 Paybill which states that A Ross received £4.20 a month for superintending the construction and maintenance of the banks. Telford also inspected all finished works carefully.
- 50 See 2nd Caledonian Canal Report, Ap M. Fixing ~~prices~~.
Telford stated that the Commissioners would be responsible for working the puddle into the banks where it was needed.
- 51 The absence of detailed contracts would tend to suggest an absence also of specifications as the latter usually formed an integral part of the contract, as can be seen on Telford's Highland Road and Bridge contracts.
- 52 Institution of Civil Engineers Library.
- 53 Cameron., The Caledonian Canal, op cit.
- 54 This contrasts sharply with Telford's Highland Road and Bridge

- specifications where the individual features of a work were described in great detail.
- 55 A system of road inspectors was used by Telford to ensure that work was being performed according to specification.
- 56 H R & B 2nd Report, 1805.
- 57 Ibid.
- 58 Ibid. 'It shall be in the power of the said Commissioners at any time during the progress of the work, to cause any deviation or alteration to be made in the form, construction, dimensions or line of the said Road, or the said Bridge....'
- 59 Ibid. Any dispute about the execution of the contract was to be referred to 'two neutral persons,' one to be named by the contractor, the other by the Commissioners. There was to be an 'overman' who in the event of deadlock was to decide upon the issue.
- 60 Robert Southey: A Tour in Scotland in 1819. Edinburgh 1972.
- 61 H R & B 3rd Report, 1807.
- 62 H R & B 5th Report, 1811. 'It became so manifest that no vigorous exertion was to be expected from Mr Readdie, and that his interest as well as that of his cautioners would be best consulted by our having recourse to some prompt remedy, that we directed Mr Telford to inspect the road ... and from his detailed Report it appeared that ... he and Mr Telford disagreed on what needed to be done ...'
- Wilson was accepted as arbiter.
- 63 Ellesmere Canal Report, November 1805.
- 64 Simpson and Cargill especially, partnered one another on bridge contracts, including Bonmar (1811) and Craigellachie (1813-14).
- 65 Frequent references are made to the location of contractors in the annual printed reports.
- 66 Details of contractual zones are given in the paybills for this

- period. Southey also recorded in 1819 that Wilson had the contract for the Laggan area whilst Cargill undertook the locks at Fort Augustus.
- 67 See Paybill for December 1819-January 1820 which records that Wilson was contracting Laggan and cutting.
- 68 The difficulties involved in the excavation and lining of the two outer sections meant that work continued on them at least until 1818, which made sectional alternation unnecessary.
- 69 2nd Caledonian Canal Report, 1805. Labour Figures. Davies was first partnered by Lowrie, who does not appear to have remained on the project for very long, no further record of him being found.
- 70 Ibid.
- 71 11th Caledonian Canal Report, 1814, and subsequent reports. Hughes was also involved in the development of improved dredging machines.
- 72 Telford-Rickman, 1819.
- 73 He was also responsible for undertaking the Muirshearlich Cutting.
- 74 References to the smaller earth contractors are scarce, apart from Hughes and Meek. It is possible that other contractors could have been used during the period for which no paybills survive.
- 75 This is difficult to prove without the existence of formal contracts, however, no reference to any form of subcontracting has been found. The small number of masonry contractors would tend to preclude the practice, although lack of details relating to general contractors make it difficult to decide upon the matter. It had originally been intended to let the general cutting in small lots but this does not appear to have taken place.

- 76 H R & B 2nd Report, 1805.
- 77 Haldane, op cit, p108. Hope to Halkett, 6 November 1805.
- 78 Ibid.
- 79 May was extremely critical of the contractors and questioned the whole policy of letting such work to outside contractors: "I may be permitted to remark incidentally, however, upon what I consider another objectionable arrangement adopted in the execution of the canal works, namely that of letting out almost every portion of them to contractors. Although this is a course very generally pursued in similar cases with a view to the attainment of the greatest practicable economy, yet in a work of this peculiar kind, and which was destined to bear a national character, it was decidedly impolite to entrust the execution of its more important details to persons whose interests could in any sense be rendered inconsistent with bestowing on them the requisite degree of durability and efficiency ...
- ... I believe general experience will bear me out in saying that the contracts on this canal, and on all similar undertakings should be confined to mere earth-cutting and embankments which is the proper province of contract work, and to which it is in allextensive cases most prudently and wisely applicable."
- 80 1st Caledonian Canal Report, 1804.
- 81 See James and John Davidson-Thomas Davidson, 3 June 1809. Thomas Jones mentioned with Hughes as not 'going to Wales this summer,' which implies some connection with the Ellesmere Canal.
- 82 16th Caledonian Canal Report, 1819. Ap D. 'Statement of the number and proportion of labourers employed on the works of the Caledonian Canal, other natives of the Highlands.' Clachnaharry District. J Davidson.

Years	English	Welsh	Irish	Average of Whole Summer	Proportion of Strangers-natives
1804-1808	1	4	1	415	1-70
1809	2	1	-	560	1-186
1811-12	3	1	1	400	1-80
1813	2	2	8 for 4 months	320	1-46
1815-17	3	1	1	320	1-64
1818	3	1	1	350	1-70
1819	3	1	1	240	1-48

Similar figures were given by Easton for the Western District.

83 Joseph Mitchell, *Reminiscences of My Life in the Highlands*,
Vol 1, p35.

84 Ibid.

85 The height of the depression appears to have been August 1811
when 366 masons and 536 measure labourers were employed in the
Corpach area alone.

86 The Commissioners nearly always printed any advertisements in
their annual report or kept some record of it in their papers.
It should be stated that no detailed search has been made in
Highland newspapers for contractors' advertisements.

87 6th Caledonian Canal Report, 1808.

88 2nd Caledonian Canal Report, 1805.

89 The practice of employing labour direct, under the supervision
of the engineer, was traditionally reserved for difficult,
usually underwater work. This does not appear to have been
always followed on the Caledonian, for J Wilson received payment
for work below water level in 1819. It would appear that much
of Clachnaharry Lock was performed by direct labour as it was a

- work of unusual difficulty.
- 90 2nd Caledonian Canal Report, 1805. Ap K.
- 91 Ibid.
- 92 HLRO Papers relating to Highland Roads and Bridges and the
Caledonian Canal.
- 93 Employment figures ending January 1820.
- 94 Especially when one considers the huge number of men employed by
the contractors in the summer months.
- 95 See section on Accounts for full details.
- 96 H R & B 2nd Report, 1805.
- 97 The ironwork was provided by William Hazledine of Salop who sent
his foreman, W Stuttle to supervise the erection of Bonar Bridge.
- 98 See Telford to Rickman, 18 July 1811.
- Telford states that neither Simpson and Cargill, or Hazledine was
happy about undertaking Bonar Bridge at a fixed rate, which would
indicate that he handled all arrangements regarding ironwork for
bridges. The Bridge was actually built without a fixed contract
price as there were too many 'contingencies' (mainly difficult
pumping and foundation work).
- 99 2nd Caledonian Canal Report, 1805. Ap M.
- 100 Ibid.
- 101 Ibid.
- 102 Payment for the hire of horses was recorded in the annual Account.
At one stage Meek tried oxen with limited success.
- 103 HLRO Paybill ending January 1820.
- 104 Road contracts were let for the Torvaine Road diversion and for
the Loch Lochy Road.

CHAPTER 4

FINANCE

The methods of financing the Caledonian Canal and Highland Roads and Bridges differed considerably due to the financial involvement of local proprietors in the Roads and Bridges project. The Caledonian Canal was built with government money only, no outside bodies being involved with its finance. This chapter will examine the various features involved in the issue and recording of grants and the principal differences in the financial organisation of the two projects, beginning with the Caledonian Canal.

The issue of the annual parliamentary grant for the canal and the procedure governing the recording of its expenditure was, in comparison with other managerial aspects of the project, well developed. However, once the basic problems of distance and poor communications had been overcome, the procedure governing the money supply especially, remained uniform and to some extent inflexible. As a result little advantage could be taken of labour surpluses or periods of fine weather. Finance was not geared to the construction programme and whilst it proved adequate for most of the period, there were occasions when it seriously interfered with work, to the detriment of the whole project.

The machinery for obtaining money from the Treasury, converting into Exchequer Bills, paying these into a bank account, and then selling the bills to cover Telford's expenditure was extremely clumsy at the beginning of the project. A chronological account of the issue of money for the years 1803 to 1805 will show the weakness of the system and the gradual evolution of a more streamlined mode of operation.

Under the terms of the 1803 Act £20,000 was granted to the Commissioners for preparatory work. The money was to be invested in Exchequer Bills.(1) In August 1803, Rickman was ordered by the Board

to arrange 'for the Commissioners to attend at the Exchequer and receive Exchequer Bills and lodge them in the Bank of England'.(2) This was to take place as soon as the order for £20,000 had 'been procured at the Exchequer.'(3) The money was to be paid into the Bank of England after Rickman had obtained the signatures of two Commissioners 'to a proper form of acquittal at the Exchequer.'(4) The relevant papers were dispatched to the Exchequer on the 15 September, whereupon the Rolls Office demanded a duty of 6d in the pound.(5) The claim was not dropped until the 11 October and the papers were finally accepted on this date. The 14 October was settled upon the day of issue, but before that date it was discovered that a new stamp duty had been imposed and a new acquittal became necessary.(6) There were further delays until the 20 October when Rickman and Sir William Pulteney finally received £10,000 in Bonds at the Exchequer, £8,000 being placed in the deposit box at the Bank of England, the remaining £2,000 being converted to meet expenditure.(7)

The delay in obtaining the initial Parliamentary grant resulted in severe difficulties for Telford in the Highlands. In order to maintain the creditworthiness of the Commissioners he had been forced to draw a Bill for £1,000 at an earlier date than that prescribed by the Commissioners in their August Instructions from Mr Frazer, Agent to the Bank of Scotland in Inverness.(8)

Before leaving London Telford had stressed to the Board 'the necessity there would be for an immediate supply of money' and he had departed believing that he could draw (money) 'for the use of the works' after the lapse of one month.(9)

The Board demanded an explanation of his action, Rickman informing him 'that they felt more displeasure than they thought fit to express at the great irregularity of drawing your bills in direct violation of your instructions and without any previous or even

accompanying explanation of your doing so.'(10) All of Telford's Bills were refused by Rickman 'the Board having not directed that sufficient money to discharge these Bills should be put to their credit account with the Bank of England.'(11) Rickman informed Telford that he had 'no discretion to exercise in this case, as I have no means put in my hands for paying them.'(12) He concluded with a personal attack on Telford.

"If you wish to maintain the credit of the Board uninjured by your own imprudence I suppose you have assets enough in Scotland."(13)

Telford attempted to justify his actions in a letter of 18 October 1803. He had drawn on Bills at thirty instead of forty days as he had previously been informed that he would have money with discount.(14) The irregular payments had resulted from his desire that people in the Highlands be fully convinced:

"that they would regularly (be) paid for everything they did or furnished to the Commissioners, which I considered of the first importance for the credit and future of the works; but at the same time, I gave every person to understand, that in future the payments would be made monthly, by persons I shall appoint for that purpose ..."(15)

The Board met again on the 28 October 1803 and approved of Telford's action, although they required notification of any future deviation from their instructions.(16) Rickman was ordered to convert £1,000 worth of Exchequer Bills to cover Telford but was refused access to the Bank of England Deposit Box without the signed authorisation of at least three Commissioners.(17) Telford's Bills continued to be refused and he again warned the Board of the consequences of an inadequate money supply.

"a failure of credit is fatal to tradesmen, and Bills upon London only will do, I must therefore remit other bills upon London for the Bills as they are returned, this will be extremely inconvenient to me unless the Commissioners enable me to do so without delay."(18)

He requested the immediate payment of all outstanding Bills; if no Board meeting was planned for that month, the Chairman was to be informed of the situation.(19) Rickman eventually managed to obtain the signatures of three Commissioners and Telford at last received his money. The ludicrous situation of a national civil engineering project being entirely dependent on the occasional meeting of a Board of Commissioners five hundred miles from the construction site to approve every single item of expenditure before releasing the money for payment resulted in a request from Telford for a Board meeting to clarify and improve certain aspects of the money supply and accountancy methods.(20)

Steps had already been taken to improve the money flow in November 1803 when the Commissioners' current account at the Bank of England was transferred to Messrs Hoare of Fleet Street.(21) Telford attended the Board Meeting on 16 December 1803. He argued for the provision of his own current account to meet everyday expenses on the canal(22) and £1,800 was paid into the Shrewsbury branch of Messrs Robarts as a result.(23) The delay in payment was to a great extent alleviated with the creation of an independent money supply outside London. The first stage in an efficient method of money supply was thus established although further improvements were to follow.

The new procedure was in full operation by February 1804. In that month Telford requested £2,000 to meet payments. Rickman was ordered by the Board to take from 'the Deposit at the Bank of England

Exchequer Bills issued for that sum, and having deposited the proceeds thereof with the hands of Messrs Hoare, that he prepare a proper cheque for the signature of the Commissioners in favour of Mr Telford.(24) The money was soon after paid into Telford's account.(25) The procedure established at the end of 1803 was broken by Telford in March 1804 when he requested that Rickman obtain £2,000 direct from the Treasury before the Easter recess. He was to go to the Bank of England if this was not possible.(26) Rickman took the latter course. The reasons for Telford's request are not known. It may simply have reflected the low state of the Commissioners' funds at the Bank or simply a desire to shorten the procedure by going direct to the Treasury.

It is not known if the Roads and Bridges scheme suffered from the same fate at the hands of the Treasury in the early months of the project. Haldane states that a Deposit account was opened with the Bank of Scotland in Hope and Rickman's name, money actually being transferred from the Bank agents in London, Messrs Coutts.(27) The granting of government money however, represented only half the expenditure for Highland Roads, the remainder coming from local proprietors. The machinery governing the collection and recording of money from private sources was set up during the autumn of 1803. No construction work commenced until the following year and all expenditure on survey work was met from the initial government grant, so providing adequate time for an efficient system to evolve. The main responsibility for the gathering and control of proprietors' road payments fell on James Hope, mainly as a result of the complex legal issues surrounding the matter.(28) Haldane states that Hope faced two alternatives in the autumn of 1803 with regard to private contributions - either proprietors paid their money direct into the Bank of Scotland or made arrangements regarding security for its ultimate payment.(29) It was apparent from the first that very few land owners were willing to

pay immediately.(30) The other alternative was a system of mortgage or heritable bond. This would have been extremely difficult to operate due to the entailing of estates, which was common amongst Highland landowners at this date.(31) In December 1803 Hope contacted the Bank of Scotland and arranged that the Bank would advance local landowners the amount of the contributions against promissory notes or bills granted by them.(32) The method of controlling payments was thus clearly established before the commencement of construction.

A system of obtaining money for roads and bridges from Highland counties was developed parallel with the private contributions scheme. A county levy was imposed on all landowners for the provision of funds for roads and bridges. It was first introduced in Inverness-shire in 1804 and later in Ross-shire, Sutherland and Caithness.(33) The annual amounts raised by such levies were sometimes as little as £3,600 (34) but on the whole they provided as invaluable boost to road funds.

The practice of regular monthly payments from London for the canal became firmly established during 1804. In his monthly report Telford enclosed an estimate of expected expenditure for the coming month.(35) By this method he was able to cope with the ever increasing payments being made on the construction site quickly and efficiently,(36) although there were shortcomings in the system as will be seen later. The monthly estimate system was apparently evolved from a more general forecasting procedure as can be seen from the 1805 Report:

"In continuing his monthly report to the Board (Mr Telford) is to specify the probable rate of expenditure for the succeeding months, as far as he can determine it with sufficient accuracy to regulate the money transactions of the Board."(37)

The later system was certainly in operation in June 1804.(38) The procedure whereby money was paid into a Bank account from the Treasury

was improved in the summer of 1805. On the 5 July

'the Commissioners were informed that by a clause in the Appropriation Act (now) before Parliament, it is probable that they will henceforth be freed from the necessity of depositing their Exchequer Bills at the Bank of England which is found very inconvenient, the Directors of the Bank not suffering any account thereof to be taken by their officers - upon this information, the Commissioners signed an authority and order to the Secretary that he "having procured one of the Commissioners to accompany him to the Bank of England, to take from thence the Deposit made in the name of the Commissioners and that he then proceed to place the Deposit at Messrs Hoares, in the same manner as before at the Bank of England."' (39)

The system was further streamlined in August 1805 when Telford's Robart Account was transferred to Hoares.(40) All money operations were now controlled from the same banking house, thus eliminating the lengthy procedure of transferring Bonds. The deposit box at Hoares was scrapped in 1806, presumably eliminating the need for Rickman to obtain written authorisation from the Board every time he wanted to convert Exchequer Bonds, although Board approval was still required at general meetings. No changes took place in the procedure after this date as can be seen from the 1809 Report. Rickman received the monthly account from Telford,

"Containing an estimate of the next monthly payment as compared with his monthly balance in hand, whereupon an adequate sum is written over to the credit of his account at Messrs Hoares on whom he draws Bills at 30 days after

date, that being the usual premium allowed in
Inverness for Bills payable in London."(41)

The system of advanced and interim payments for Highland Roads was basically similar, although it operated on a smaller scale. As has already been noted advanced payments were made to road contractors for the provision of tools and supplies for their workmen from the beginning of construction work. Interim payments at two-monthly intervals were made after that date. These payments were made from James Hope's office in Edinburgh.(42) They were dependant on satisfactory reports from the Road Inspectors on the work performed by contractors. They were closely geared to construction, each payment relating to a precise amount of work performed. Drafts were drawn by the contractors on the Commissioners' account with the Bank of Scotland. (43) These drafts were periodically signed in advance by Rickman and sent to Hope in order that he might complete them as and when required. (44) Details of this procedure have not been given by Haldane, but it does appear to have been a little slow in operation in peak construction years for Hope was forced on several occasions to go into the red. This aspect, however, will be dealt with in greater detail in a later section. Money for these payments was drawn from the Commissioners' account, which contained payments from local contributors and government grants. Great care was taken to ensure that payments were kept in line with construction, as shown in a letter from Hope to Rickman in August 1811:

'My payments are conducted as
cautiously as possible. It is certain
that the contractors have a
ruinous bargain and that his cautioners
must suffer for it; and they are not
so able as others; so that I am aware

of the importance of the advance being as little beyond the work as possible.'(45)

Closely allied to the procedure for conveying the Parliamentary grant to the construction site was that of applying for the annual grant. The difficulty experienced by Rickman in obtaining part of the initial canal grant has already been noted. Application was made by Rickman on behalf of the Board for the issue of the remaining part of the grant in November 1803(46) which was subsequently paid into the Bank of England without mishap. £50,000 was granted for the 1804-1805 season, half being paid out in July 1804, the remainder in December 1804.(47) Much the same procedure was adopted over estimating the annual financial requirement as that evolved for calculating the monthly figures. In February 1805 Telford was ordered to prepare a prospective estimate for the next year's spending.(48) An estimate for £50,000 was sent to Rickman who forwarded it, after Board approval, to the Treasury. The wording of the estimate and the annual sum asked for remained constant for much of the construction period.

"I am directed by the Commissioners for the Caledonian Canal to transmit to you for the consideration of the Lords Commissioners of HM Treasury, the enclosed:

'Estimate of the sum desired as requisite to be granted in the present session of Parliament towards carrying on the works of the Caledonian Canal'(49)

£50,000."

After Parliamentary approval of the estimate a standardised application was made by Rickman for the issue of the grant from the Treasury.

I am directed by the Commissioners appointed for the purposes of an Act entitled "An Act (43 Geo III c102) and also for the purposes of an Act (44 Geo III c62) to request that you will move the Lords Commissioners

of HM Treasury to cause a letter to be written to the Auditor of the Exchequer directing the (remaining moiety of the*) £50,000 granted by the Act of the last session of Parliament may be forthwith issued: (the service for which the grant was made having nearly exhausted the £25,000 received by the Commissioners of the Caledonian Canal in August last.)*(50)

The machinery worked efficiently throughout the period of construction. External factors were to blame on the two occasions when it did break down. In 1809 the Treasury was responsible for the delay of over a month between the exhaustion of the initial grant and the issue of the remaining amount.(51) The following year the July issue was delayed until 18 March 1811 by the illness of George III(52) and the general 'uncertainty of the times'.(53) The remaining 1810 payment was issued in July 1811(54) and adversely affected the next year's grant when only £40,000 was issued. Construction does not appear to have been hit(55) although the Commissioners' reserves were drained and Telford was forced to overdraw by £3,500 by March 1811.(56)

Details of the issue of parliamentary grants for Roads and Bridges are not given by Haldane, although it would appear that there were no serious hold-ups in its issue. The initial annual amount of money granted by parliament had been based on an estimate for over one thousand miles of roads made by George Brown in the 1790's, totalling some £150,000.(57) The cost of bridges at Dunkeld, Fochabers, Lovat and Conon was additional.(58) After the creation of the Board of Commissioners in 1803 it was calculated that with the money from local

* Bracketed passages inserted for issue of remaining part of the grant.

proprietors £20,000 for each of the first three years and £12,000 for a further three years would be sufficient to cover the cost.(59) This timetable was not adhered to and annual grants varied considerably over the seventeen year construction period, from ten to twenty thousand pounds. Delays in the payment of grants occurred in the private rather than public sector. This was due in many cases to the various contributors becoming embroiled in local disputes over the line of road to be taken. This led to the total abandonment of certain projects, notably Orin Bridge,(60) although it should be noted that no project suffered from inadequate finance once construction work started. Haldane states that many of the local proprietors were dilatory in the payment of their contributions, causing James Hope much worry and extra work.(61) It is clear however, that the issue of funds was sufficiently flexible to cover the needs of construction. This, as will now be seen, was in direct contrast to the Caledonian Canal.

The chaotic start to the financial transactions of the canal project, previously described, did not inflict any permanent damage. The first year was spent in survey work, and after January 1804, the acquisition of machinery and timber.(62) Proportionally very little was expended on labour, only a small number of workmen being employed on excavation work on each of the two basins at Corpach and Clachnaharry. (63) Labour recruitment began to build up only after the financial improvements mentioned earlier, suggesting that the previous arrangements were inadequate for a large work-force. Ending May 1805, £15,032 had been expended on labour. The figure continued to rise until 1807 after which it remained static for some time before rising to an all-time high in 1812.(64) The allocation of money, however, remained constant throughout (at £50,000 per annum) except for the special circumstances of 1811 when the grant was reduced to £40,000.

Throughout the early years of this period there were constant

calls for a reduction in expenditure. Rickman expressed concern over the matter in November 1805.

"I am apprehensive that the work on the canal must soon be slackened, least the last year's grant should not hold but till August, before which time no money can probably be received on the next expected grant: however some good will result from a temporary interruption of part of the spade work. The best workmen will be retained at the usual price of labour and those who may be dismissed from the canal will be eager to take moderate wages from the contractors from the Glengarry and Lockna Gaul Roads. This is a convenient resource for the men and for the public and the price of labour will not be augmented in the neighbourhood of the canal."(65)

It is not known if the temporary embarrassment experienced by John Telford at Corpach in August 1805, when he ran out of money, was an indication of the general financial shortage or simply a breakdown in the cash flow.(66) Telford reported in the same month that over 1150 men were employed, .. "which is more than the funds will support, but I am very anxious to proceed when the days are long."(67) Similar opinions were expressed the following month(68) although he still intended to draw on a further £6,000 the next week.(69) The pattern was repeated throughout 1806 and 1807. Telford-Rickman, May 1806:

"This fine weather is so tempting, there is no preventing the contractors from doing more than we can pay for."(70)

Shortly after this date Telford talked of reducing the number of workmen in order to cut expenditure down to £3,500, an action which he regretted but "it will leave more workmen for the roads."(71)

Overspending by John Telford resulted in a request for information on the availability of funds for the next season.(72) At the height of the 1807 season Telford was again forced to justify high expenditure.

"The season being favourable, the day long and the workmen disengaged from the potatoe fields and fishing renders our contractors very desirous of proceeding to as great an extent as is admissable."

The rate of annual expenditure had been detailed in the early surveys at £50,000 for seven years, making a total of £350,000.(72) This figure was soon replaced by Jessop's 1804 estimate, yet no attempt was made to increase the yearly grant. Telford had ample opportunity, through the machinery surrounding the issue of finance, to influence the amount of the monthly and yearly grant. At no stage during the first ten years of construction did he argue for an increased annual allowance although great strain was placed on the project's finances during these years. The slowness of communication over long distances resulted in great inflexibility with regard to monthly estimates. Once the estimate had been dispatched very little could be done to increase the figure until the next month. No record has been found of two estimates being sent to the Board within the space of one month. Prolonged periods of favourable working conditions could, as a result, only be accommodated ~~for~~ after the elapse of one financial month and were often not taken full advantage of in order to preserve the annual allowance.

The method of monthly and annual estimates and the machinery surrounding money transference was the best system available given the complexities of the situation.

Undoubtedly the project would have been completed sooner had Telford and his subordinates been issued with the whole of the annual

grant at the beginning of each financial year. The reasons why this did not occur are covered in the section on the relationship between Engineer and Board.

Full details of cash flow problems have not survived for Roads and Bridges, but it would appear from an examination of the machinery surrounding the initial acceptance of a project - namely that no scheme could begin until the local contributors' money had been paid into the bank - was sufficient protection against funds running out. Peak construction years do appear to have placed some strain on the finances; however, the smaller scale of road operations resulted in the adoption of a less-sophisticated money transference system than that employed on the canal, with greater reliance being placed on the Bank of Scotland to assist in times of financial hardship. This resulted in few improvements to the system, reliance on the toleration of the Bank still being a regular feature as late as 1816; as can be seen from a letter from Hope to Rickman of that year:

"You need put yourself to no inconvenience
in regard to a supply of cash, as the Bank
of Scotland will cheerfully allow us to
draw whatever is wanted."(73)

An accurate accounting system was essential for the success of both the Canal and Road and Bridge project as large amounts of public money were received. As in the issue of finance, the recording and accounting methods employed on the Roads and Bridges project appear to have been less sophisticated than those used on the Canal. Haldane does not give full details of the accounting procedure; however, it would appear that Hope kept detailed accounts of every road and bridge contractor, detailing each payment and advance.(74) This was an extremely necessary step as at least part of the advance payment was calculated as a percentage of the total contract price. All interim

payments were based on the amount of work performed, which must have necessitated the keeping of some form of account by the Road Inspector. This would presumably relate to the measurement of work at a set rate rather than payment of wages or purchase of materials, for which the contractor was solely responsible.

Like the Canal, an accountant (probably the same one) was employed by the Commissioners after 1805(75) to keep a check on all payments. His duties have not been described by Haldane but were presumably similar to those performed on the Canal, which will be described shortly. It is also probable that the Roads and Bridges accounts were examined by the Treasury after 1807, as occurred on the Canal.

It is now intended to examine in some detail the accounting system employed on the Canal, which although more complex than that used on Roads and Bridges, failed to prevent massive overspending on the project.

An accurate accountancy system was essential for the success of the project as large amounts of public money were received. Accurate accounts also had a direct bearing on the procedure for transferring money from London to the construction site, as has already been noted, for the monthly and annual estimates could only be drawn up after a close examination of the accounts. It was therefore vital that a workable standardised form of accounting be established in London and Scotland.

In their 1803 instructions to Telford the Board ordered him to keep a careful record of all expenditure:

"Mr Telford is to transmit to the Secretary of the Board a journal and report of his proceedings or in his absence of the proceedings (of) those, who under his direction superintend the work, and also a statement of his receipt and dis-

bursements, every four weeks, for the information of the Board."

Telford was severely criticised by the Board for not keeping to these instructions at the outset of the project.(76) They also commented on his having drawn a bill for £180, 'when in fact it was £187, an inaccuracy which the Commissioners hope they shall not have occasion again to observe upon.'(77) He did, however, make provision for expenditure to be recorded in September 1803.

"You (will) receive the pay bills monthly from Andrew May who will attend direct and keep an account of the men to be employed between Muirtown and Kessock Ferry. In order to enable you to make the monthly payments you are authorised to draw from John Frazer, Agent for the Bank of Scotland a sum not exceeding £300 at the end of every four weeks from the 23rd inst ... You are to keep an account of the money you receive from Mr Frazer, also an abstract of the pay bills, immediately after the Bills have been paid you are to send me a copy of each Bill ... all Bills contracted with tradesmen are to be displayed in the monthly paybills".(78)

An accurate record of incoming and outgoing expenditure was thus kept from a very early date. Many of the improvements which were introduced at a later date were concerned with procedure for transmitting information about accounts and checking their accuracy. Telford gave the Board reasons for his failure to keep detailed accounts in October 1803.

"I did not make out regular returns (because) in the outset of the business I was unwilling to appoint permanent clerks hastily and did not think it advisable

to let strangers know the purport of my correspondence with you or the Gentlement of the Country - so that I must have taken time to have made duplicates of the whole and this would have interfered very seriously (?) with the various operations, consultations and applications, I was obliged to attend to - I had not for a moment lost sight of the general plan."(79)

Details of expenditure although recorded in Scotland were not expected to be ready for transmission to London for some time, ..."perhaps not till the Spring of the year when I have Head Agents fixed at each end, that I shall be able to bring the journals and payments into one (?) form, and one period of time, at present, I conceive it of importance to have the business set agoing and performed in a faithful manner."(80)

A special meeting was called in December 1803 to discuss financial affairs. It resulted primarily in changes regarding the issue of money rather than accountancy improvements, although one of the Commissioners, Charles Grant, was given special responsibility for accounts.

The recording of money transactions in London was performed by Rickman. It is not known what form his early accounts took, presumably a record was made of all payments to Telford, all money from the Treasury and all money spent by Telford, details of which were transmitted in Telford's monthly journals. In July 1804 Rickman was ordered by the Board to keep a 'Cash Book' and inform

"Mr Telford that the Board consider him as charged with all money issued to himself or his Agents, and have therefore directed the Secretary to omit entering any money as advanced by him on account that being esteemed a matter of account between Mr Telford and the persons employed, and by no means to enter into the accounts of the Board."(81)

The increasing scale of works in 1804 and therefore of expenditure prompted the Commissioners to order Telford and Jessop to devise a satisfactory method of superintendence over Accounts.(82) Charles Grant was again involved.(83) Their findings were included in the 1805 Report.(84) Expenditure on the construction site was to be broken down into headings. John Telford and Mathew Davidson were to settle accounts in regular monthly payments, every voucher being examined before any payment was made. The monthly payments were regulated by the prices previously settled and explained in the written instructions under which they operated "and from which they are not permitted to deviate on any occasion."(85) Telford was to examine the accounts and vouchers every ~~s~~pring and ~~a~~utumn on the construction site, in addition to submitting a monthly report and statement of receipts.(86) The Commissioners believed that this gave them reasonable security.

"Trusting besides that any exorbitant payment would hardly be expected to be concealed from us since the inhabitants of that part of the kingdom are so materially interested to direct their attention to any augmentation or diminution in the price both of materials and labour."(87)

The appointment of an accountant in London ensured that the new system worked properly, the Commissioners being unable to think of any further safeguards.(88)

In addition to the records maintained by Telford and Rickman the Commissioners published an abstract of the accounts subdivided under headings in their Annual Report to Parliament.(89) It was at first envisaged that Edwards the Accountant should perform this task in addition to checking the accounts,(90) but he refused and was employed only in the latter capacity after 1806. He was to examine all accounts and vouchers, costing each separate item of charge including day and

measure work and each item in tool and machinery bills. Telford's accounts were also to be checked by him.(91) Rickman was ordered to enter all of Telford's monthly accounts in a ledger, leaving out only the amount of each article.(92) After numbering every voucher with red ink he was to number the account book in a similar fashion before handing all vouchers and accounts to Edwards. After his examination they were returned and corrected prices of each item were written in before being filed in the Speakers Gallery.(93) Abstracted accounts were still to be kept by Rickman as a double safeguard.(94) Copies of Edwards' observations on Telford's accounts were sent to the latter for his comments(95) after which the accounts were signed and certified by Telford, Rickman and Edwards, before going into the Ledger.

Mathew Davidson and John Telford were ordered to certify at the foot of their monthly accounts 'in words of length, that the amount of such paybill was paid by him, or in his presence to the men mentioned in the said paybill for the number of days and rate of pay specified therein.'(96) Andrew May and two assistants were employed by Telford to supervise the finances on the construction site, May taking up his duties shortly after the commencement of the project.

The system of transmitting information about the project's financial operations and ensuring that it was correct and properly recorded was thus established by the end of 1806. The main developments had taken place after the commencement of large-scale construction, the elaborate system of checks being unnecessary before that date. It is interesting to note that the procedure surrounding the issue of money gradually became simpler and more direct whilst that of recording expenditure became progressively more complex.

The introduction of the 1806 improvements put Telford's accounts in 'a proper train for periodical examination.'(97) Details of his expenditure naturally formed the largest portion of the Accounts

between the Commissioners and the Treasury,

"and for this reason the Commissioners enquired into the form of the Treasury warrant for issuing the Parliamentary Grants, and a Treasury letter was subsequently procured (10 July 1807) requiring the accounts and vouchers for examination."(98)

All of Telford's and the Commissioners' accounts were sent, but upon examination of the Caledonian Canal Act by Treasury officials it was found that a cash account between the Commissioners and the Treasury was sufficient, and that Telford's accounts need not be examined after Edwards' inspection.(99) A record of Telford's expenditure was still, of course, examined by the Treasury, having previously been transferred into the Commissioners' main accounts;(100) as can be seen from the events of 1810 when Telford forgot to sign one of the 1809 vouchers. The Board was unable to transmit their accounts to the Treasury until this had been performed.(101)

The final stage in the development of an adequate accountancy system was thus complete. Control by the Commissioners and their construction supervisors was ensured by the keeping of accurate accounts in Scotland and London, and an elaborate three tier system of checks, beginning with the Highland Accounts clerks and ending with the Treasury. Telford's involvement in the project was minimal after completion in 1822 and the section of the accounts dealing with repair has, as a result, not been included in this study.

To conclude, it would appear that the system of finance on the Roads and Bridges scheme, although less sophisticated than that employed on the Canal, was better geared to actual construction work, due to the payment in advance of the contributors' share of cost. This, together with the smaller scale of operations on the Roads and Bridges scheme, prevented any major breakdown in the flow of money to the project.

It is unlikely however, that matters would have prospered had the Roads project been on a similar scale to the Canal. Such a vast project required an extremely elaborate system of accounting and control. The system introduced by Telford and the Commissioners was successful in many ways, except in the critical area of matching finance with construction needs. This is where the Canal failed and ironically the Roads and Bridges project succeeded.

- 1 2nd Caledonian Canal Report, May 1805. App A. Title Heads
for 1803 Act (43 Goe III cl02).
- 2 Minutes of 3rd Caledonian Canal Board Meeting, 6 August 1803.
- 3 Ibid.
- 4 Ibid.
- 5 Minutes of 5th Caledonian Canal Board Meeting, 4 October 1803.
- 6 Ibid.
- 7 Ibid.
- 8 MTL/1 SRO Rickman-Telford, 12 October 1803.
- 9 MTL/1 SRO Telford-Rickman, 18 October 1803.
- 10 MTL/1 SRO Rickman-Telford, 12 October 1803.
- 11 Minutes of 5th Caledonian Canal Board Meeting, 4 October 1803.
- 12 MTL/1 SRO Rickman-Telford, 12 October 1803.
- 13 Ibid.
- 14 MTL/1 SRO Telford-Rickman, 18 October 1803.
- 15 Ibid.
- 16 Minutes of 6th Caledonian Canal Board Meeting, 28 October 1803.
- 17 Ibid.
- 18 MTL/1 SRO Telford-Rickman, 27 October 1803.
- 19 Ibid. The Chairman of the Board was Charles Abbot, later
Lord Colchester.
- 20 Minutes of 9th Caledonian Canal Board Meeting, 14 December 1803.

- 21 Ibid.
- 22 Minutes of 10th Caledonian Canal Board Meeting, 16 December 1803.
- 23 Ibid.
- 24 Minutes of 12th Caledonian Canal Board Meeting, 9 February 1804.
- 25 Ibid.
- 26 Minutes of 15th Caledonian Canal Board Meeting, 26 March 1804.
- 27 Haldane, op cit, p45.
- 28 Ibid. p47.
- 29 Ibid. p47-48.
- 30 Ibid.
- 31 Ibid.
- 32 Ibid.
- 33 Ibid. p51.
- 34 Ibid.
- 35 Minutes of 22nd Caledonian Canal Board Meeting, 20 July 1804.
- 36 Ibid.
- 37 2nd Caledonian Canal Report, 1805.
- 38 MT1/1 SRO Telford-Rickman.
- ... "It may be right to state, as a sort of general guide to the Board in providing money, but I mean if possible to average the works so as to require about £4,000 a month, but I cannot be very correct, at this late period of the year, until I have been in the North and considered every matter upon the spot"...
- 39 Minutes of 30th Caledonian Canal Board Meeting, 5 July 1805.
- 40 Ibid proceedings.
- 41 Minutes of 8th Caledonian Canal Board Meeting, 28 November 1803.
- 42 Haldane op cit, p113.
- 43 Ibid, p111.
- 44 Ibid, p113.
- 45 Ibid, p111. Hope to Rickman, 27 August 1811.

46 Minutes of 8th Caledonian Canal Board Meeting, 28 November 1803.
 47 Minutes of 22nd Caledonian Canal Board Meeting, 20 July 1804.
 48 Minutes of 25th Caledonian Canal Board Meeting, 12 February 1805.
 49 Repeated in all Caledonian Canal Minutes at time of application
 of grant.
 50 As above.
 51 Minutes of 48th Caledonian Canal Board Meeting, 19 June 1809,
 proceedings.
 52 Minutes of 52 Caledonian Canal Board Meeting, 19 June 1810.
 53 Minutes of 53 Caledonian Canal Board Meeting, 28 March 1811.
 54 8th Caledonian Canal Report, 1811. Accounts
 55 See general graph, App A.
 56 Minutes of 52 Caledonian Canal Board Meeting, 19 June 1810.
 In June 1810 the Commissioners had a reserve of £12,000 at
 Messrs Hoares & Co.
 57 Haldane op cit, pl34.
 58 Ibid.
 59 Ibid.
 60 Ibid. pl21.
 61 Ibid. pl13.
 62 2nd Caledonian Canal Report. Accounts.
 63 Ibid. Labour Figures.
 64 9th Caledonian Canal Report, 1812. Labour figures and Accounts.
 See also 10th Report.
 65 MTL/1 SRO Rickman-Hope, 12 November 1805.
 66 Cameron, DC The Caledonian Canal, 1972, op cit p64.
 67 SRO Telford-Rickman, 27 August 1805.
 68 SRO Telford-Rickman, 15 September 1805.
 69 SRO Telford-Rickman, 6 May 1806.
 70 SRO Telford-Rickman, 29 December 1806.

- 71 SRO Telford-Rickman, 11 July 1807.
- 72 Survey and Report on the Highlands, T Telford, 1802.
- 73 Haldane, op cit, pll3.
- 74 Ibid. pll4.
- 75 See H R & B Reports, Accounts: Management.
- 76 Minutes of 5 Caledonian Canal Board Meeting, 4 October 1803.
- 77 Ibid.
- 78 MTL/1 SRO Telford-William Mckenzie, 27 September 1803.
- 79 MTL/1 SRO Telford-Rickman, 18 October 1803.
- 80 MTL/1 SRO Telford-Rickman, 31 October 1803.
- 81 Minutes of the 25 Caledonian Canal Board Meeting, 20 July 1804.
- 82 Ibid.
- 83 Ibid.
- 84 Ibid.
- 85 2nd Caledonian Canal Report, 1805.
- 86 Ibid.
- 87 Ibid.
- 88 Ibid. An Accountant was appointed to examine all the vouchers with Rickman this "being the only remaining mode in which it has occurred to us that this Expenditure could be checked or controlled."
- 89 Caledonian Canal Report. App D.
General Account of all the monies Received or Disbursed by the Commissioners for the Caledonian Canal - "for or upon account of, or relative to the said undertaking."
- D In Account Current, from 20 October 1803 - 1 May 1811
- 1803 To cash received at H M Exchequer, being moiety
20 Oct of Grant for the purposes of the Act 43 Geo III c102. £10,000
- 1804 To cash received at H M Exchequer, being re-
7 May maining moiety of the above grant. £10,000

1 Sept	To Exchequer Bills received as cash from the Exchequer moiety of grant.	£25,000
<u>1805</u>	To Exchequer Bills received as cash from the	
16 Feb	Exchequer being remaining moiety of above grant. (Format remains constant throughout.)	£25,000
<u>1811</u>	To cash received at the Exchequer, being part of	
18 Mar	Grant of Session, 1810.	£25,000
1 May	To rent of Houses at Clachnaharry and Corpach received at sundry times to this date, Smiths work for contractors, etc.	£413 15 3
	To cash received at sundry times to this date, being interest on Exchequer Bills.	£4,678 10 3
	To cash advanced by Mr Thomas Telford, and appearing to now be due to him.	£641 7 3½
	By cash paid to several persons on Account of sundry Heads of Expenditure hereinafter stated; viz.	
1	MANAGEMENT, and TRAVELLING Expenses:	
	Thomas Telford, for general superintendence and management, 1803-1811.	2,031 15 0
	William Jessop, for attendance on the business of the Caledonian Canal, 1803-1810.	1,363 19 0
	Murdoch Dowie, for surveying lochs etc. 1803	110 11 3
	Wm Mckenzie, late Supt. at Clachnaharry. Salary 1803-4.	159 16 11
	M Davidson, Supt. at Clachnaharry, salary from 16 July 1804 to 31 March 1811.	1,613 13 6
	John Wilson, late Supt. at Corpach, salary and expenses to 21 June 1804.	193 0 3
	John Telford, late Supt. at Corpach, 3 years'	

salary to 3 May 1807	600	0	0
Gratuity to the widow of the said John Telford for moving expenses back to Chester.	50	0	0
Alex Easton, Supt at Corpach, $3\frac{1}{2}$ years' salary to 3 February, 1811.	700	0	0
John Howell, making survey of the line of canal and copying and reducing maps, 1803-4.	186	0	5
Mr Barlow for engraving a large map.	87	13	0
Secretary to the Board, salary for 7 years.	1,400	0	0
Accountant, for examination of Accounts and vouchers to May 1810.	315	0	0
Messenger to the Board - to July 1810.	315	0	0
Mr Telford's clerks, and others, copying.	269	19	0
Mr Mundell and others, for fees and expenses in obtaining the Caledonian Canal Act.	470	8	7
Mr James Hope, W S for conveyancing and other law charges.	421	9	10
Mr Geo Brown for attendance on Juries, and plan and valuation of lands between Clachnaharry and Loch Ness.	106	16	9
Mr A Langlands, for plan and valuation of land purchased of Col Cameron of Lochiel and for the line of canal from Lochiel to Loch Lochie.	62	3	6
Mr Arrowsmith for reducing the drawing maps for 3rd & 4th reports, for colouring, paper etc.	53	3	0
D McPherson, keeping accounts at Corpach, to March 1805.	81	17	0
Capt Mark Gwyn, for keeping register of winds and weather at Fort Augustus for six years.	30	9	0
Sundry assistants in surveying etc.	73	7	$11\frac{1}{2}$

Travelling charges and sundry expenses incurred by
the above persons, and others, in the business of
the Caledonian Canal, to 27 April 1811.

1,805 17 3

TOTAL MANAGEMENT

£12,220 5 2

There are similar detailed accounts for the
following headings:

- II Timber and Carriage thereof.
- III Machinery, cast-iron work, tools and materials
- IV Quarries and Masonry
- V Shipping
- VI Houses and temporary buildings
- VII Labour and workmanship (day work)
- VIII Labour and workmanship (Measure work)
- IX Purchase of land and payment on account of damages
- X Purchase and hire of horses and provender
- XI Incidentals

together with a recapitulation of the annual account and cumulative
total for each heading. The layout of the printed accounts remained
standard after 1805.

- 90 Minutes of 32 Caledonian Canal Board Meeting, 1 March 1806.
- 91 Minutes of 36 Caledonian Canal Board Meeting, July 1806.
- 92 Ibid.
- 93 Ibid.
- 94 Ibid.
- 95 Ibid. Telford's accounts appear to have been very accurate, many
of Edward's corrections totalling two or three pounds in large
seasonal accounts. Of the £46,003 7 1 spent in 1819 the
account was only out by 8/-. In September 1806 Edwards corrected
an account from £2703 13 3 to £2702 13 3. Both are examples
from the House of Lords papers.

- 96 Minutes of the 37 Caledonian Canal Board Meeting, 7 March 1807.
- 97 Ibid.
- 98 Preface to Telford's Discharge Book, contained in the Caledonian
Canal minute books.
- 99 Ibid.
- 100 Ibid.
- 101 Minutes of 52 Caledonian Canal Board Meeting, 19 June 1810.

CHAPTER 5

THE LOCATION AND PURCHASE OF MATERIALS

Decisions regarding the use of materials and machinery occupied much of Telford and his assistants' time on the Caledonian Canal. Telford particularly spent much of his time when on the construction site dealing with matters relating to the costing, location and ordering of timber, machinery and occasionally stone.(1) It is therefore quite reasonable to devote some time to a discussion of the subject. Particularly since the price of materials rose dramatically over the period 1803 to 1822, placing a severe strain on the project's finances, and therefore, on overall management.(2) Discussion centres on an examination of the supply and cost of materials on the Caledonian Canal not because it is necessarily more important than roads and bridges but because references to them on the latter project are practically non-existent. No accounts were kept by the Road Commissioners of expenditure on labour or materials as these were the sole responsibility of the contractor. A small number of references were made in the official reports to difficulties over materials affecting the contract price, usually connected with bridge projects. In 1809 the Commissioners reported that the contributors towards Ballater Bridge had undertaken the contract themselves and that due to difficulties in transporting tools, men and materials from Aberdeen, had demanded a substantial increase in the estimated contract price. This was rejected and the contract given to Simpson at the original price. The Commissioners reported that:

"Difficulties of this sort had caused Mr Telford in his Estimate to add 30% to the prices of masonry on the Caledonian Canal: but the offerers of contract for Ballater Bridge required double that allowance."

As has already been noted the standard form of contract contained a clause allowing contractors to obtain materials within the immediate vicinity of the construction site. This presumably referred only to stone and gravel for roads and small rubble stone bridges. Timber for centring and piling was presumably purchased locally by contractors and the substantial rise in this commodity must have adversely affected the cost of individual projects. It is important to remember, however, that on the majority of road and bridge projects the effects of rising prices were not as serious as on the canal because the time lapse between the drawing up of the estimate and the actual completion date was, in comparison, with the canal comparatively short. Costs did rise substantially on road projects which suffered from undue delay, as on the Loch Na Gaul Road which took over ten years to complete, its overall cost rising by 18% in that period. () A full list of estimated and actual road and bridge costs has been given in the notes to this chapter, together with construction periods, in order that this trend may be seen more clearly. ()

This is as far as any examination of roads and bridges *vis-à-vis* materials can be taken, as no further information is available. This lack of evidence stems from the fact that the contractors and contributors, not the road Commissioners, bore the full brunt of rising prices. It is clear, however, that costs did not escalate to the same extent as on the Caledonian and the remainder of this chapter will be given over to an examination of the cost and supply of materials on that project.

Timber Purchasers for the Caledonian Canal, 1803-1822

Three basic types of timber were used on the Caledonian; country timber for general construction work, Baltic fir for more specialised tasks and oak for lock gates. (3) The prices of these basic timbers used varied considerably throughout the period of construction and this

chapter will attempt to describe Telford's actions with regard to the rising price of timber vis-à-vis the introduction of new materials. Over £68,000 had been spent on timber ending May 1822.

In his original survey and estimate Telford envisaged using local country timber for lock gates, swing bridges, piling, sheeting and defenders.(4) It was to be cut from Glen Morrisón, Glengarry and Loch Arbek at between 12d to 18d per foot.(5) Arrangements were made with Cameron of Lochiel to purchase 20,000 ft of country timber(6) at 10d to 14d a cubic foot,(7) in September 1803. The purchase did not include birch and ash as they were not of the required dimensions.(8) The decision to use imported timber for lock gates and other major features on the canal appears to have been made soon after this date. Jessop stated in his estimate of February 1804 that the lock gates were to be made of American pitch pine rather than oak,(9) (itself a replacement of Telford's country timber of 1802). Local timber was to be used for all other purposes.(10) This policy was operated throughout the 1804 season when a large amount of local fir and birch was purchased, being used mainly for wheelbarrows, wheeling planks and 'other common purposes'.(11) By the autumn of 1804 however, it was decided that imported timber was to be used for coffer dams and all major canal works.(12)

Country timber was still purchased in very considerable quantities after this date. By 1822 £27,577 or 40% had been expended on this commodity out of a total timber bill of £68,013.(13) Over £1,700 was consumed in 1810-11 on local timber for 'general use'(14) and a high proportion of the £4,677 spent on timber in 1812 went towards purchasing local material.(15) Local timber prices together with labour costs were directly affected by the huge construction programme of roads, bridges and the canal.(16) Telford reported that country timber was between 10d and 1/2d per cubic foot in 1804 and 3/6d per cubic foot in

1812.(17) Prices fell very slightly after that date although Hugh Maclean received 3/- per cubic foot in 1816.(18) This three-fold increase in the price of an essential basic material had a direct bearing on construction costs. Had all the country timber been purchased in 1804 there would have been an effective saving of £18,000.(19)

The decision to use foreign timber was discussed at Board level.(20) Telford was ordered to send a public notice of the quality and dimensions of the timber required 'to all ports within a reasonable distance of Inverness and Fort William'.(21) He received eleven proposals from various merchants at Leith, Aberdeen, Peterhead, Greenock and Oban, accepting the supplying 650 tons of Memel Grown timber of specified dimensions delivered at Inverness at 2/4d per cubic foot,(23) and with Mr Baine of Greenock for 370 tons at Fort William at 2/6½d per cubic foot,(24) A further consignment of memel was sent to Corpach by H Stevenson of Greenock in 1805, at 2/6½ per cubic foot.(25) 4,732 cubic feet of pine at 3/11d was delivered at Corpach in 1808 and 1,241 cubic foot at 6/-d in 1811.(26) No more Baltic timber was purchased until 1816-17 when Messrs Catto received £2,011 for an unspecified amount of memel fir.(27) James McAlpin received £5,047 between 1817 and 1821 for general imported timber,(28) and 'sundry persons' received £2,907 for 'foreign timber' over the period 1803 to 1822.(29)

As can be seen from the above information, the price of memel timber rose from 2/4d a cubic foot in 1804 to 6/-d in 1811. Telford believed that rises in the price of materials and labour were the main cause of the canal's financial difficulties. He used a large table of comparative prices drawn up for the years 1803 and 1813 to support his argument.(30) No reference was made however, to prices after that date, although construction was to continue for another nine years. Memel

timber fell in price to pre-1803 levels after 1813,(31) although it was subject to high duties after 1808, due to 'the hostility of the northern nations of Europe' and preferential treatment on behalf of Canadian timber.(32) In 1819 James McAlpin was paid 3/4d per cubic foot for Memel Crown timber delivered at Corpach.(33)

Out of the £19,570 expended on the purchase of non-country and oak timber between 1805 and 1822, only £1,298 or 6.6% was consumed during the years of high prices, (between 1808-1812).(34) £8,296 worth or 42% was purchased in 1804-1805.(35) It was stored at Clachnaharry(36) and lasted, with occasional small additions, until late 1816.(37) Telford's policy of bulk buying in the early years of the project thus cushioned the project against the worst excesses of the blockade system as the Commissioners noted in their 1810 Report.

"The precaution of providing a large quantity of foreign timber in the first instance, has enabled us since that time to avoid any large purchase, which from the obstruction of the Baltic Trade would have been highly disadvantageous".(38)

A further £7,058 (36%) was spent between 1816 and 1822 (again a low price period) on Memel and fir timber.(39) The remaining 15% of the 1822 total was used on the purchase of 'foreign timber' from 'sundry persons'.(40)

The price of Memel timber did not have any direct bearing on overspending on the project, prices remaining fairly constant at the time of bulk purchases in 1804-5 and 1815-20. The rise in prices of country timber and oak were of ar greater significance, for country timber was consumed at a far greater rate than memel and had to be constantly restocked,(41) thus precluding bulk buying at cheaper prices, whilst delay in purchasing oak after 1810 was not rewarded with cheaper prices as happened with Memel.(42)

The high price of oak and the development of new ideas in response to this factor will now be examined. Telford stated that the price of oak for lock gates rose from 5/- to 8/- in 1803 to 10/- to 12/- per cubic foot in 1812.(43) This was to have a direct bearing on general costs for no oak was purchased before 1812 and the Commissioners were forced to buy at a time of peak prices and general unavailability of the material. As a result of this development Telford and Jessop decided to introduce cast-iron framed lock gates.

Jessop stated in his estimate of February 1804 that the lock gates were to be constructed of American Pitch Pine rather than oak,(44) which was itself a replacement of Telford's country timber.(45) By 1808 progress on lock chambers at Corpach and Clachnaharry necessitated enquiries for the purchasing of American Pitch Pine.(46) Prices for this commodity had been rising steadily since 1804 and Telford recommended to the Board that it would be advisable to postpone any decision regarding its purchase, in the hope that the price would fall.(47) It continued to rise however, reaching £15 per load in 1809 before disappearing from the market between the autumn of 1809 and 1810 and then again between 1812 and 1819.(48) It was decided to revert back to oak for the lock gates in 1809.(49) Estimates for the cost of lock gates had been detailed in 1807 when it was expected that they could cost £1,500 per lock.(50) In 1809 this was revised to £1,600 per lock with the re-adoption of oak.(51) Telford cited the problem of lock gates as one of the main causes of overspending:

'The article of lock gates alone, by considering them to be made of oak and iron at the present value, instead of US Pitch Pine, the difference is £15,000, or about double the original estimate.'(52)

The cost of gates for each lock was raised by over £2,000.(53)

The 1811-12 season saw the purchase of the first load of oak for

the lock gates at Clachnaharry. 2,636 ft was obtained from W Hazeldine at a cost of £1,318.(54) This was sufficient timber to construct one pair of gates only.(55) In 1813 the Commissioners reported that:

'The necessity of beginning to prepare lock gates of dimensions adequate to the large scale of the canal has caused considerable purchase of timber and ironwork to the amount of £12,000'.(56)

Included in the above purchase was material for two pairs of lock gates which were to be hung at Muirtown. In the autumn of 1813 Telford and Jessop decided to abandon oak gates and introduce iron ones in their place. His decision was recorded in the 1814 Parliamentary Report.

'Ten bridges as well as the lock gates and other bridges throughout the whole course of the canal were to have been made of wood, but the price of large oak timber is become so high as to render such intention unadvisable upon motives of economy while the most extensive enquiries have led to a doubt whether such timber is procurable on any terms. Recourse therefore must be made to iron which has already been used to some extent in similar works, and except the outside planking and edges of the lock gates and bridges, the whole may be formed of that material' ... (56)

It was predicted that no additional cost would be incurred, the cost of two pairs of iron lock gates being estimated in 1813 at £2,200.(57) Hazeldine and the Butterley Company lost no time in 'employing skillful persons in forming models of this new application of what may be thought a British material'.(58) By 1816 a large number of iron gates were ready for installation.(59) Payment for this task and for the gates

themselves was expected to be so great that application was made to the Treasury for an increased annual grant.(60) Large scale redundancies were threatened if no more than the usual grant of £50,000 was issued.(61) The Treasury relented and the Commissioners received £75,000. Although the gates were to have iron frames they still required oak planking in large quantities, over £17,619 being spent on oak ending May 1822.(62)

Telford employed highly skilled foremen to supervise their installation, William Rhodes, the most senior amongst them, receiving three shillings a day.(63) Telford's expectation that the iron gates would prove less expensive than conventional designs was short lived, probably because of the continuing high price of oak planking and transport costs.(64) It is not known why the use of oak planking was continued.

In 1818 Telford was asked by the Board to explain why the project had cost so much more than had been anticipated in 1803. In his reply of May 1818 he stated that:

'The substitution of cast iron gates, instead of those constructed with oak timber, has in the first instance nearly doubled the expense, although, ultimately the greater durability of iron framed gates will render them the most economical.'(65)

In the 1819 Estimate to the Treasury, the price of gates per lock was £3,500,(66) more than double the 1808 total, representing an additional £58,000.(67)

The difficulties experienced by Telford in obtaining suitable oak timbers for the main framing of the lock gates, had forced him to introduce a new material. Although the new gates cost twice as much as conventional designs (when the timber was available) they were desperately needed for the completion of the two end sections of the canal.

It was only after this had taken place that full-scale operations commenced in the middle district.(68) Any delay in the end sections of the canal was reflected by rising costs in the middle. The unstable price of foreign timber failed to affect costs on the canal. It was primarily the prices of country timber and oak which wrecked Telford's estimates and forced him to introduce new features on the project.(69)

1 Telford T. The Life of Thomas Telford, written by himself.
London, 1838, p64. Telford believed that the main cause of overspending was:

.. 'the unprecedented warfare in which all Europe was involved during the time the works were in progress, the value of materials and labour rising from 30% to 50%, so that the sum annually granted remaining the same, only one half of the quality of work could be annually performed.'

2 Report to the Commissioners of the Caledonian Canal. George May, November 1837.

3 Ibid.

4 Estimates of the Expense of the Caledonian Canal. T Telford, 1802.
'All the timber (a few pieces excepted) for bridges, locks, piling, sheeting, defenders, etc is proposed to be of the country timber.'

5 Ibid.

6 SRO Telford to Col Cameron of Lochiel, 2 September 1803.

7 Caledonian Canal Report, 1804, p2.

8 SRO Telford to Col Cameron of Lochiel, 2 September 1803.

9 1st Caledonian Canal Report, 1804. Estimate W Jessop, February 1804.

10 Ibid.

11 1st Caledonian Canal Report, May 1804. Accounts (Timber):-

.. 'Alexander Fraser of Inverness, Fir and Birch Timber £158

- Col Cameron of Lochiel for timber and floating. £1,529'
- John Stevenson of Oban received £323 for 'Deals and Balks etc'... presumably for part of lock gates.
- 12 2nd Caledonian Canal Report, May 1805. Report of Messrs. Telford and Jessop, Autumn 1804.
- 13 19th Caledonian Canal Report, 1822. Accounts (Timber).
- 14 8th Caledonian Canal Report, 1811. Accounts (Timber).
- 15 9th Caledonian Canal Report, 1812. Accounts (Timber). £2,054 was paid to 'sundry persons for country timber' in that year alone.
- 16 Concurrent with the construction of the Caledonian Canal was that of Highland roads and bridges. The scheme which reached its peak after 1808 was virtually completed in 1821 when well over nine hundred miles of roads were built together with 1023 bridges. It was controlled by a Board of Commissioners from London, sharing many of the same officials as the canal scheme, including Telford, Rickman and Hope.
- 18 House of Lords Record Office. 'Observations' on the Caledonian Canal Accounts by Mr G Edwards, Accountant to the Caledonian Canal Commissioners, 12 August 1815 to 30 November 1816. In 1811 Dugald McLachlan received 3/6d per cubic foot for country timber.
- 19 Taking the higher 1804 figure, the 1812 price was exactly X5 that of 1804.
- 20 The Board did not appear to instigate any changes of materials, merely accepting their Engineers' recommendations.
- 21 2nd Caledonian Canal Report, 1805.
- 22 Ibid.
- 23 Ibid.
- 24 Ibid. The price was higher for Corpach due to the longer journey from the Baltic to Greenock rather than Greenock to Corpach.
- 25 3rd Caledonian Canal Report. Accounts (Timber).

- 26 19th Caledonian Canal Report. 1822 (Accounts (Timber)). Each printed account contained details of all previous expenditure, including prices per cubic foot (for Memel only) and date of purchase.
- 27 Ibid.
- 28 Ibid.
- 29 Ibid.
- 30 Telford, T. The Life of Thomas Telford, written by himself, London, 1838.
- 31 A Hinriches and M L Merac. 'Tables of Prices', London, April 1838. p416, 'Price of Timber - Memel Fir'.
See also, 'The Carpenters and Joiners Assistant', London 1854. p117.
- ... 'Memel timber was supplied in three qualities viz:
Crown, in baulk, 13 x 13 inches, and from 28 to 50 feet long.
Best middling and second middling or brack'... Only the crown appear to have been used on the canal.
- 32 Life of Telford, London, 1838.
- 33 House of Lords Record Office. 'Observations' on the Caledonian Canal Accounts by G Edwards, Accountant to the Caledonian Canal Commissioners, 25 December 1819 to 22 January 1820.
- 34 Ibid.
- 35 Ibid.
- 36 The Caledonian Canal Report, 1810.
- 37 19th Caledonian Canal Report, 1822. All accounts up to this date have also been examined for annual timber purchases.
- 38 7th Caledonian Canal Report, 1810.
- 39 19th Caledonian Canal Report, 1810.
- 40 Ibid.
- 41 No year passed without the purchase of country timber, from

- 1803-1822. See Caledonia^d Canal Report, 1804-1823, Accounts (Timber)
- 42 No oak appears to have been purchased before this date; if it was,
it was not specified in accounts, as after 1812.
- 43 Life of Thomas Telford, London 1838.
- 44 1st Caledonian Canal Report, 1804. Estimate of W Jessop,
February 1804.
- 45 Estimate of the Expense of the Caledonian Canal. T Telford, 1802.
- 46 6th Caledonian Canal Report, 1809.
- 47 Ibid.
- 48 A Hinriches and M L Merac, 'Tables of Prices' April 1838.
Prices of Timber - Quebec Yellow Pine.
1803 - £5 4s 0d; 1804 - £4 6s 0d; 1805 - £4 9s 0d; 1806 - £5 7s 0d;
1807 - £6 3s 0d; 1808 - £10 5s 0d; 1809 - £13 5s 0d; 1810 - not
available; 1811 - £9 5s 0d; 1820 - £3 3s 0d.
'Quebec Yellow Pine' is not listed in the Carpenters and Joiners
Assistant, presumably it was a form of Pitch Pine. No other
figures for North American timber have been included in Hinriches
and Merac's tables. Non-availability was presumably due to the
blockade system and general disruption of trade after the 1812
War.
- 49 The Caledonian Canal Report, 1810.
... 'to be made of oak and iron'...
- 50 4th Caledonian Canal Report, 1807. 'Comparative expense of the
locks finished at Corpach and Clachnaharry, showing the cost of
the masonry on each particular work'.
'Expense of lock gates, per lock ...£1,5000'.
- 51 The Caledonian Canal Report, 1810. AP C Telford and Jessop's
estimate, October 1809.
- 52 Ibid. Report of Telford and Jessop.
- 53 10th Caledonia^d Canal Report, 1813.

- 54 9th Caledonian Canal Report, 1812. Accounts (Timber).
- 55 See ⁺Atlas to the Life of Thomas Telford, London, 1838, plate 10
which gives dimensions of lock gates on the Caledonian Canal.
No more information on the price of oak was given by Telford in
his table of prices. In 1824 the average cost of oak common
scantling in small quantities, including sawing and carriage, was
6/- per cubic foot. (Taken from Account of the prime costs of
materials etc ..' H M Office of Works, 1824.)
- 56 11th Caledonian Canal Report, 1814.
- 57 Ibid. Estimate by Telford, Autumn 1814.
- 58 13th Caledonian Canal Report, 1816.
- 59 Ibid.
- 60 This was the first time an application for an increased annual
grant had been made since the beginning of construction. The
Commissioners reported in 1816 that the labour and time necessary
for planking and hanging the gates:

'Makes it desirable to us, for the regular progress and uniform
completion of all the canal works, that a sum of £18,000 should be
appropriated to this expenditure on iron castings in the next
twelve months.'
- 61 A select committee had been appointed to investigate the matter
in June 1816. Telford was called before it and stated that in

'his opinion the Commissioners had rather underrated the in-
convenience which may result from dismissing a great number of
the workmen now employed by them, and the extra expense which
could not fail to result from withholding any part of the
£75,000 proposed to be granted in the present session of
Parliament.'
- 62 19th Caledonian Canal Report, 1822, Accounts (Timber).
- 63 'Observations' on the Caledonian Canal Accounts, 12 August 1815-

30 November 1816.

See also, Mitchell, Joseph. Reminiscences of My Life in the Highlands, Vol I 1883, for a full description of William Rhodes.

64 High transport costs coincided with deliveries of iron and timber, the years 1810-1812 being particularly heavy. Over £881 being expended in 1812. (Average £400). Memel timber does not appear to have been used on some locks towards the end of the project. James McAlpin delivered Memel Crown timber 'for the lock gates at Laggan' in 1819, although no further references have been found to this specific use of Memel.

65 15th Caledonian Canal Report, 1818 Ap C.

66 17th Caledonian Canal Report, 1820. Estimate prepared by J Davidson and A Easton, November 1819.

67 1807: (number of locks) $29 \times £1,500 = £43,500$.

1813: $29 \times £2,200 = £63,800$.

1819: $29 \times £3,500 = £101,500$.

The last figure is only ^avery rough estimate as some of the locks had been completed some years before, especially at Corpach and Clachnaharry. However, not more than £10,000 had been expended on this.

68 Navigation to R. Augustus was essential as much of the masonry and timber etc had to be bought in from a distance; transport costs would have been prohibitive by any other means but canal.

69 The evolution of cast-iron swing bridges on the canal followed a very similar pattern to that of lock gates. It was originally intended to construct them out of country timber, then American Pitch Pine, then oak and finally iron. The estimated costs were as follows:

Telford's 1802 Estimate: Masonry £345, wood £404 - total £750

1807 Estimate: £1,300 (US Pitch Pine)

1813 Estimate: £1,687 (Cast-Iron)

1819 Estimate: £1,738 (The iron span to cost £600)

CHAPTER 6

MACHINERY

Over £117,336 or 18.8% of the total amount spent on the construction of the canal ending May 1822 was consumed on the purchase of machinery.(see App 4).

It was at first envisaged that all tools and equipment should be provided by the Commissioners but this idea was abandoned in June 1804 when Telford argued that workmen would not take proper care of the Commissioners' property.(1) Under his revised plan the workmen were to provide their own spades, picks and shovels, and where the Commissioners were to provide tools the contractor was to be responsible for keeping them in repair and paying replacement costs.(2) This policy had been operated on a limited scale since the autumn of 1803 when Andrew May had been ordered by Telford to .. 'take an account of all the tools and deliver what are necessary to the workmen, (who are) to pay the prime cost of the picks and spades, but the planks and barrows are to be found by the Commissioners and kept in repair at their expense'.(3)

The first year of construction saw the expenditure of £541 on tools and utensils 'made in the country viz: wheelbarrows, windlasses, picks, crowbars and sundry ironwork'.(4) £210 was spent on material from London, including surveying instruments.(5) It is not known if the people engaged in the manufacture of local tools were in the employment of the Commissioners at this date or whether they simply acted as sub-contractors. The considerable number of carpenters and smiths employed after 1804 would suggest that they were responsible for the manufacture of much of the Commissioners' tool and machinery requirements including cranes, piling engines, manually and horse-operated pumps and barrows.(6) This argument is given further credence

by the existence of a small sketch book containing ink wash drawings of many of the tools used on the project.(7) Detailed specifications of many of these items, including an ash wheelbarrow costing £1 5s 7d are also to be found.

The resale of spades to workmen at 'prime cost' brought in only £342 out of a total expenditure of £2,685 in 1807, the last year in which the sales were recorded.(9)

By May 1822, £9,073 had been spent on the purchase of ready-made tools,(10) £5,918 on tools made or repaired by day work and £21,338(11) on measure work, making a total of £36,329.(12) Much of the country timber purchased throughout the construction period was consumed in the manufacture of tools.(13) The trebling in price of this basic material must have had a detrimental effect on tool manufacture, although no instance of complaint over shortage of this commodity survives. The cost of basic tools was not detailed in the estimates, being included as a constituent part of the completed cost.

It was decided from a very early date that the Commissioners were to be responsible for keeping the various construction sites dry.(14) In the autumn of 1803, Telford was ordered 'to determine the number and size of the steam engines' and where they were needed. He estimated that £20,000 would be required for steam engines and coffer dams in the first year of construction.(15)

Boulton and Watt were contacted, as they were 'makers of the highest reputation for experience and reliability'.(16) An initial order for two pumping engines of 36 and 20 HP for the Clacknaharry district was placed in August 1804, Telford explaining that matters had been 'unavoidably delayed', due to probably difficulties in obtaining the Act of Parliament.(17) The beams were to be of cast-iron and the engine house of local rubble stone.(18) A local smith was to assemble the boilers under supervision from a Boulton and Watt agent,

who was to have overall responsibility for the erection of the engines.

(19) A further order for a 6 HP engine was placed at the end of the month.(20) Telford subsequently resited the engines, requesting that the 6 HP and 36 HP units be taken via Hull to Clachnaharry, whilst the 20 HP engine was to be erected at Corpach.(21) Priority was to be given to the delivery of the Corpach engine.(22) Arrangements were again changed when Telford requested that the 20 HP unit be dispatched via Liverpool as soon as possible.(23) He evidently believed at this period that little excavation work could be carried out without the aid of steam pumping engines, for in October 1804 he reminded Boulton and Watt of the urgency of the matter.

"I hope I need not press you to hasten the completion of the engines."(24)

Costs in transportation were to be reduced by taking advantage of the maiden voyage of the Commissioners' sloop 'Corpach' from Chester, which was expected to take place in March 1805.(25) This was delayed however as a result of difficulties over registration.(26)

A large number of spare parts including duplicate boilers for each engine were ordered, 'so as the works may not be stopped'.(27) A skilled bricklayer was to be sent by Boulton and Watt to the Highlands, who was to be 'experienced' in building boilers, ~~as~~ as Telford reported that there was no-one capable of undertaking such a task in the area.(28) It was also envisaged that a smith remain in Scotland to look after the engines, or perform general work when not employed in this task, as there was 'none here that can be relied on'.(29) It is not known if the expenses involved in employing the engine erector and bricklayer were included in Boulton and Watts estimates.

The 20 HP engine was dispatched to Chester in the middle of March 1805. The boat was unfortunately involved in an accident at Preston Brook and sank, causing further delay and frustration.(30)

Taylor, of Boulton and Watt, was ordered to examine all parts for damage before accompanying the consignment to Fort William where he would be met by Telford.(31) Plans were again changed and Taylor, accompanied by an assistant, arrived at Inverness with the Clachnaharry engines in June 1805.(32) The Corpach engine reached its destination in July, devoid of boilers which had been sent to Clachnaharry by mistake.(33)

Taylor finished erecting the Corpach engine in March 1806, after which time it was ready for operation.(34) The estimated and actual costs of the engines were as follows:

	<u>Estimated</u>	<u>Actual</u>
No One	£2,241	£2,329
No Two	£1,609	£1,675
No Three	£851	£898
TOTAL	£4,701	£4,902
(+ additional £693 for spare parts).		

Over £1,163 was spent on fitting up the Corpach unit, which presumably included wages.(36) £1,637 was consumed on freight and carriage of machinery ending May 1806, a large proportion of which must have gone towards the payment of shipping the engines to Scotland.(37) Jessop had estimated in February 1804 that £12,000 would be needed for steam engines and pumping.(38)

The urgency with which Telford requested the manufacture and dispatch of the engines contrasts sharply with their deployment on the construction site before 1810. Corpach stood idle for four years whilst Clachnaharry engines remained in their packing cases at Inverness until the middle of 1810.(39) The planned use of pumping engines for the excavation of every lock chamber did not materialise and the engines were used on four sites only, hand and horse pumps proving adequate for the remaining locks.(400

The sketch book of ink wash drawings shows plans of manually

and horse driven pumping equipment employed on the majority of locks.(41)
The cost of this equipment was included in the general machinery bills.

Excavation work on the sea locks did not begin until 1810, although Telford's original construction timetable was geared to completing the two end sections before the middle. It is curious that masonry work at Corpach and Clachnaharry was not commenced until so late a date.(42) In May 1810 Telford asked Boulton and Watt to send a 'skilled person to set the engine (at Corpach) to work'. Pumping commenced in July of that year without mishap.(43)

The reluctance to use steam on the part of Telford and the Commissioners was presumably based on grounds of economy and can best be seen in their actions at Clachnaharry. In 1810 the Commissioners reported that they had been 'so fortunate as to discover means to avoid the employment of this powerful but expensive machinery for pumping water out of the lock pits'.(44) It was hoped that the sea lock could be excavated to its full depth without the aid of the steam engine. However, by 1811:

'the increased (amount) of water became gradually too great for ordinary means of clearance. Hand pumping therefore succeeded by a large chain pump worked by six horses, and this continued till the end of August last, (1810) when the lock pit had been sunk to a depth of 15 ft under high water mark, but below 12 ft the pumping had been exceedingly laborious, and at last the horses were no longer able to overcome the water.'(45)

A six month delay followed whilst the 6 HP engine was installed in a newly built engine house.(46) The men previously engaged on the lock appear to have been transferred to other sites for there is no appreciable drop in labour figures once seasonal variations have been

taken into consideration.(47) The high price of horses was given as one of the main reasons for going over to steam by Telford.(48) The installation of the 6 HP engine was followed by the rapid completion of the lock.(49) It is impossible to estimate how much time would have been saved had steam pumps been used at the commencement of the project, rather than half way through. Hesitation over using steam engines at Fort Augustus was not repeated, perhaps as a result of the lessons learned at Clachnaharry.

In 1814 the small 6 HP engine was moved to the middle district in order that trial pits might be sunk.(50) Telford had stated the previous year that he planned to move the larger engines to Fort Augustus once the masons could be released from the Clachnaharry area.(51) By 1815 the Commissioners were able to report that the 36 HP had been shipped to the Fort and was awaiting erection.(52) The engine commenced pumping out the lower lock chamber at Fort Augustus (which was situated in loose gravel twenty four feet below the level of Loch Ness) in August 1816, under the superintendence of James Fyfe.(53) Construction proved extremely difficult and the remaining engines were brought in to assist, as the Commissioners reported in 1818:

'The most formidable difficulty which we have had to encounter, has occurred in sinking the lock pit in the bed of the River Oich near Fort Augustus and in keeping it dry while the masonry and the foundations of the walls were in progress. The whole force of our steam engines belonging to the Clachnaharry district, three in number, (equal to 62 HP) was found necessary for this purpose during the summer and autumn of 1817'.(54)

The reference to a combined output of 62 HP would suggest that the three original engines were used, although one of them, (20 HP) as has already

been noted, was installed at Corpach and not Clachnaharry. A number of smaller engines were purchased for the dredging machines and will be dealt with in the relevant section. The Corpach engine was later used for the excavation of Laggan Locks after 1818.(55)

Hesitation over using the engines may possibly have stemmed from concern over running costs and wages for skilled operations. Telford's request for a Boulton and Watt Agent to start the Corpach engine had not been met and the work had been performed by a canal employee, probably James Fyfe who took charge of all subsequent installations and operational work.(56) The cost of building engine houses at Clachnaharry and Fort Augustus was £1,527.(57) A table of expenditure on coal has been given in the notes.(58)

Jessop's estimate of £12,000 for pumping work appears to have been fairly accurate, although it is not known how much was spent on non-steam pumps and labour. However the cost of delay which resulted from Telford's reluctance to use steam must have been very considerable.

The decision to use steam dredging machinery was made by Telford and Jessop in June 1804 in response to a request by the Commissioners for an investigation into the best method of deepening Loch Oich and Loch Doughfour.(59) They thought it 'advisable to construct a machine similar to those used at Hull and Yarmouth except that instead of working it by horses, which from the scarcity of provender in the country would be expensive (we) think it much better to work it by means of a small steam engine'.(60) Preparations for its construction went ahead, and by the end of 1804 Jessop had completed the drawings. (61) The Butterley Company finished the engine and machinery in October 1805 (62) and the machine was delivered in January 1806 for erection.(63) William Bourne, the Butterley engine erector, spent over six months fitting the vessel out.(64) The cost was £430 for the engine, £670 for machinery and £108 for erection.(65) The keel was built locally using

canal carpenters.(66) By October 1806 the new dredger was ready for service and was taken to Loch Oich where it unfortunately sank.(67) The event was witnessed by Telford, Jessop and a member of the Board, who was accompanying the engineers on their annual tour of inspection. (68) This, together with the expense of the experiment resulted in its indefinite postponement.(69) The following year Telford stated that he did not intend to raise the vessel, which was in twenty five feet of water, until the commencement of the middle section; so avoiding the expense of maintaining the project at a time when finances were short.(70) In 1807 the Commissioners reported that 'another less expensive mode of deepening Loch Oich .. has since appeared to be practicable, by which the necessity of employing the dredging will be in a great degree superseded.(71) It was planned to drain the water from Loch Oich into the newly excavated cutting sufficiently to allow excavation by hand, the dredger to be used only for deep work. The scheme was eventually abandoned after objections from Glengarry.(72)

The second dredging experiment took place after initial work on the middle section had commenced in 1813-14. Considerable difficulty was experienced in obtaining oak timber for the keel.(73) In 1813 the Commissioners reported that 'a dredging machine, to be worked by a small steam engine, is prepared, for deepening where necessary, Doughfour lock and the passage from it into Loch Ness'. Work on the keel started in 1814 and the machine commenced operations in December 1814.(74) The Butterley Company had again provided the machinery. The success of the project was keenly anticipated as the Commissioners reported in 1815.

'The issue of this experiment was of no small importance to the future operations of deepening Loch Oich as well as Loch Doughfour, and we have much satisfaction in stating that the machinery succeeds beyond expectations,

having removed in all 40,000 tons, and for the last two months nearly 400 tons per day, at an expense not exceeding 9d per cubic yard' (excluding the cost of machine).(75)

Another improved dredging machine commenced operations in 1817 under the supervision of Bryan Donkin, who received £3,372 for its design and construction in 1816.(76) A further £2,771 was paid out to him in 1817-18 for a second machine. The total cost of the dredging machinery up to 1818 was at least £10,351, exclusive of labour and timber.

The price of 9d(79) a cubic yard charged by W Hughes, the contractor, compared very favourably with Telford's estimated 6d a cubic yard in 1802 and Jessop's 1/- a cubic yard of 1804 (80) (Doughfour only). Extreme caution should be used when assessing these figures however, as they related to very specific lengths of ground and were not representative of actual charges which varied according to difficulty or ease of excavation. The presence of submerged logs in Loch Oich, for instance, must have increased costs considerably.(81) The early failure on Loch Oich and the high initial cost of the operation made Telford somewhat sceptical of the ⁿnovation and he listed dredging as one of the main causes of overspending in 1818; as the Commissioners reported:

'The operation of dredging, heretofore untried on so large a scale, proves vastly more expensive than was expected, and this partly from the situation of the canal, remote from the makers of dredging machinery, and from the fuel proper for working it by means of steam.'(82)

Repair and operational costs were not detailed in the accounts and it is impossible to ascertain how much of the annual budget was consumed by them. The machines were owned by the Commissioners but operated by a contractor who was presumably responsible for the crew's wages, but

not, it seems, repair. Skilled mechanics had charge of the machines, Alexander Fyfe being responsible for the Loch Oich vessel.(83)

The supposed extra cost of the machines was rather academic as it is extremely doubtful if any means other than those eventually adopted could have performed the vital task of dredging in the short time available. The delayed start of the middle section made their adoption a certainty and the failure to obtain maximum depth by 1822 was due to the political and economic climate rather than any failings on the part of the dredgers.

A very considerable network of plateways was established linking the quarries with the lock sites, various sections of the canal, and landing quays with construction sites. Parallel with this development was the design and construction of custom-built wagons for the conveyance of stone, and later, earth and gravel.

No mention was made of plateways in Telford's original 1802 estimate or Jessop's of February 1804, which would suggest that site transportation was included in the overall construction cost.

The establishment of a plateway sytem was vital for the efficient transportation of heavy materials. By linking lochs Eil, Lochy, Oich and Ness by plateway it was possible to eliminate the need for expensive and difficult road transportation.(84) The Commissioners realised this from a very early date:

'The Commissioners are to lay down railways from the quarries and along the canal banks where necessary, and to maintain them for one month. Messrs Simpson and Cargill to keep them in repair afterwards as long as they may have use for the same.'(85)

After the passage of the 1804 Act, Telford was instructed to investigate the prices of plateway, putting the order out to tender to ensure 'the cheapest price for the public'.(86) Foundries were con-

tacted in Denb^{igh}shire, Derbyshire and Aberdeenshire.(87) A considerable amount (over 1500 yards) had been delivered to Clachnaharry by June 1805.(88) By that date 1000 yards had been ordered from Bersham at £14 per ton and two miles from Messrs Outram and Co at £11 guineas per ton,(89) The usual arrangement of ordering machinery from suppliers in the East and West of England to serve the corresponding sections of the canal appears to have been followed in the initial purchase of plateways. A further 880 yards was purchased from Messrs Ley & Co of Aberdeen at £13 a ton.(90) The purchase of plateways consumed a large proportion of the early machinery budgets.(91) New suppliers were found at Perth and Inverness itself after 1808 which reduced the cost of transportation considerably.(92) The high initial cost was offset by the immediate success of the system and low maintenance costs, for which the contractor and not the Commissioners, was responsible.(93) The cost of laying the tracks is uncertain, although Telford does give an estimate of 12/- per yard in one of his pocket notebooks.(94) It is not known if this price was calculated with a specific area in mind or simply as a general average price for the whole line of canal.

The buying of plateways was closely geared to construction and gradually extended over the whole field of operation, as the project grew. By 1810 over £15,000 had been spent on plateways and the associated hardware.(95)

The rolling stock for the plateways appears to have been built by canal labour, using local timber and imported iron work.(96) It was designed to carry specific weights to ease measurement of work performed. The use of wagons was especially valuable in sections which involved cutting and embanking, for earth could easily be transported from one to form the other, as happened at Laggan, Muirsherlich and Moy.(97)

The standard general purpose/gravel wagon was built of local ash

timber and cost £11 17s 11½d, which included £9 for iron wheels and axles.(98) It was designed, like the earth wagon, to carry exactly one cubic yard, the basic unit in assessing labour by measure.(99) The stone wagon was of similar basic dimensions but with a more substantial base and no sides. They were designed to carry three tons of cut stone and cost £11.12s.11¾d each.(100)

Notes

- 1 2nd Caledonian Canal Report, 1805. Telford-Jessop, June 1804.
- 2 Ibid.
- 3 Instructions to Andrew May, 27th September 1803.
- 4 2nd Caledonian Canal Report, 1805, Accounts.
- 5 Ibid.
- 6 See Employment figures. An average of 30 carpenters and smiths were employed during the construction season of the early years.
- 7 Institution of Civil Engineers Library, Telford Bequest.
- 8 Ibid.
- 9 4th Caledonian Canal Report, 1807. Accounts.
- 10 19th Caledonian Canal Report, 1822. Accounts.
- 11 Ibid.
- 12 Ibid.
- 13 2nd Caledonian Canal Report, 1805. Main Report of the Commissioners.
- 14 2nd Caledonian Canal Report, 1805. Ap M.
- 15 Ibid. Telford required a total of £75,000 for the first years ^e_A operation. He received £50,000.
- 16 2nd Caledonian Canal Report, 1805. Main Report.
- 17 Birmingham Reference Library. Boulton and Watt Collection. Telford-James Watt, August 1804.
- 18 Boulton and Watt Collection. Telford-James Watt. August 1804.
- 19 Boulton and Watt Collection. Telford-Watt, 25th August 1804.
- 20 Boulton and Watt Collection. *ibid.*
- 21 Boulton and Watt Collection. Telford-Watt, 24th September 1804.
- 22 Boulton and Watt Collection. *ibid.*
- 23 Boulton and Watt Collection. *ibid.*

- 24 Boulton and Watt Collection.Telford-Watt,4th October 1804.
 - 25 Boulton and Watt Collection. Telford-Watt,21st January 1805.
 - 26 Boulton and Watt Collection.Telford-Watt,May 1805.
 - 27 Boulton and Watt Collection .Telford-Watt,25th February 1805.
 - 28 Boulton and Watt Collection. *ibid.*
 - 29 Boulton and Watt Collection*ibid*
 - 30 Boulton and Watt Collection. Telford-Watt,10th April 1805.
 - 31 Boulton and Watt Collection. *ibid.*
 - 32 Boulton and Watt Collection. Telford-Watt,10th June 1805.
 - 33 Boulton and Watt Collection.Telford-Watt,9th July 1805.
 - 34 Boulton and Watt Collection,John Telford-Watt,25th March 1806.
 - 35 The estimates were taken from a letter from Telford to James Watt and the remaining figures from the 4th Caledonian Canal Report, 1807. Accounts.
 - 36 3rd Caledonian Canal Report, 1806. Accounts.
 - 37 *Ibid.*
 - 38 1st Caledonian Canal Report, 1804. Jessop's Report and Estimate. February 1804.
 - 39 8th Caledonian Canal Report, 1811. Main Report.
 - 40 The four sites were Clachnaharry Sea Lock, Fort Augustus lower locks, Laggan Locks and Corpach Sea Lock.
 - 41 Institution of Civil Engineers Library.
 - 42 The delay at Clachnaharry was due to the technical difficulties of carrying the canal entrance some distance into the Beaufort Firth. Work had been further delayed in 1808-9 due to the sea settling to such an extent "as to require an additional quantity of earth to restore them to (their) former level."
- Telford and Jessop decided that a coffer dam would be too dangerous under these conditions and planned to tip spoil

from Clachnaharry Quarry on the lock site to give stability.
This operation commenced in 1808 and was in a sufficiently
completed state to allow pumping to begin in 1811.

- 43 8th Caledonian Canal Report, 1811.
- 44 7th Caledonian Canal Report, 1810.
- 45 8th Caledonian Canal Report, 1811.
- 46 Ibid.
- 47 Employment Figures: August 1810, 393; September 398;
October 388; November 372; December 325; January 307;
February 301; March 386;
- 48 8th Caledonian Canal Report, 1811. In the table of prices
reproduced in his autobiography, Telford stated that the
price of horses rose from £25.30 to £42.50p each. Expend-
iture on horses ending May 1822 was £2,956.
- 49 9th Caledonian Canal Report, 1812. The lock was completely
finished by 1814 when the lock gates were hung.
- 50 11th Caledonian Canal, 1814.
- 51 Ibid.
- 52 12th Caledonian Canal Report, 1815.
- 53 14th Caledonian Canal Report, 1817. Mitchell states that
Fyfe had 'charge of the two great Cornish pumping engines'.
(p 69, Vol 1).
- 54 15th Caledonian Canal Report, 1818.
- 55 17th Caledonian Canal Report, 1820.
- 56 See Mitchell p 69. Taylor's drawings were used after 1815
in erecting the 36 HP engine.
- 57 Caledonian Canal Accounts 1822.
- 58 Expenditure on coal was as follows, (data from annual printed
Accounts);

Ending May

1804

£

-

1805	-
1806	69
1807	80
1808	25
1809	9
1810	15
1811	599
1812	781
1813	-
1814	911
1815	116
1816	1218
1817	296
1818	795
1819	676
1820	640
1821	462
1822	201

NB The lime kilns at Corpach continued to use small amounts of coal throughout construction.

- 59 2nd Caledonian Canal Report, 1805. Ap B Instruction to Telford and Jessop, June 1804.
- 60 Ibid. Ap K Report of Telford and Jessop, 1804.
- 61 Skempton, A W 'A History of the Steam Dredger', 1793-1830. Trns. Newcomen Society, Vol 47, 1974-76, p 103.
- 62 Ibid.
- 63 Ibid.
- 64 Ibid.
- 65 Ibid.
- 66 4th Caledonian Canal Report, 1807. Accounts. The cost of the keel was £456.
- 67 Telford-Rickman, 15th October 1806.
- 68 Ibid.
- 69 Ibid. Telford was very anxious to describe in detail the events on Loch Oich, no doubt before the Board Member reported on the matter. He wrote to Rickman from Dunkeld: "I mention these circumstances more particularly at present because persons who are not aware of the

- general scheme consider this a misfortune."
- 70 4th Caledonian Canal Report, 1807.
 - 71 Ibid.
 - 72 Glengarry objected to the presence of canal workmen and machinery on Loch Oich. He would never have allowed the partial draining of the Loch. (See Land Purchase section.)
 - 73 11th Caledonian Canal Report, 1814; Ap C. Telford's 1813 Autumn Report.
 - 74 12th Caledonian Canal Report, 1815.
 - 75 Ibid.
 - 76 13th Caledonian Canal Report, 1816. Accounts.
 - 77 15th Caledonian Canal Report, 1818. Accounts.
The Commissioners reported in 1820 (17th Caledonian Canal Report.) that two dredgers were working in Loch Oich and one at Fort Augustus (formerly at Doughfour).
 - 78 15th Caledonian Canal Report, 1818. Accounts.
 - 79 12th Caledonian Canal Report, 1815.
 - 80 Telford's 1802 survey and estimate and Jessop's Estimate of February 1804.
 - 81 Op Cit. Cameron, AD. The Caledonian Canal p84.
 - 82 15th Caledonian Canal Report, 1818.
 - 83 Mitchell, p 69.
 - 84 Road transport before the Commissioners for Highland roads and bridges (1803) was very limited in the Great Glen area, relying on badly constructed military roads, unsuitable for the movement of heavy bulk materials.
 - 85 2nd Caledonian Canal Report, 1805. Ap M.
 - 86 2nd Caledonian Canal Report, 1805. Main Report.
 - 87 Ibid.
 - 88 Ibid.

- 89 Ibid.
- 90 Ibid. Accounts.
- 91 Exclusive of steam engines most of the budget was spent on rails, axles and sundry tools up to 1810.
- 92 The Commissioners reported in 1810 that two foundries had been set up in Inverness. Details of the price but not the quantity purchased from this source are recorded in the Annual Reports.
- 93 2nd Caledonian Canal Report. Ap M.
- 94 Institution of Civil Engineers Library. Telford Bequest.
- Expense of Railway
- | | |
|---|--------|
| Rails per yard - $\frac{3}{4}$ cwt. 12/-d | 9s 0d |
| Two stone sleepers | 2s 6d |
| Nails and Wooden Pegs | 6d |
| | 12s 0d |
| | 12s 0d |
- 95 Caledonian Canal Accounts, 1810.
- 96 The annual printed accounts record payments to the Butterley Company and others, for iron wheels and axles.
- 97 The earth contractor for Laggan was Mr Meek, who used oxen to pull the wagons at one stage.
- 98 Telford sketchbook: specifications. Institution of Civil Engineers.
- 99 Ibid.
- 100 Ibid. Telford calculated that one horse could draw 4 loaded wagons, carrying six tons and travel 20 miles a day.

CHAPTER 7

THE SUPPLY OF STONE

Over £204,000 or 21% of total canal construction expenditure ending May 1822 was consumed on the purchase, preparation and transport of stone for the Caledonian Canal. Reference to Appendices three and four will show that expenditure on masonry and transport regularly consumed over 30% of expenditure, the peak year occurring in 1809, when masonry expenditure topped 36%.(see Ap 4) The Commissioners not only paid out considerable sums indirectly to the masonry contractors who actually quarried and prepared the stone, but also bore the cost of locating and opening up quarries, and in certain cases, the cost of transporting it to the construction site. The location, preparation and cost of masonry was therefore of very considerable importance to the success or otherwise of the canal project. This chapter will examine the procedure governing the use of quarries and the various difficulties encountered in the location of suitable building stone, especially in the western district which unfortunately contained the majority of locks and aqueducts. It is probable that much of the cost for masonry was consumed in labour charges and this factor will be examined in the chapter on labour and wages. This chapter will concentrate especially on the effects of delay in the western district, due to the failure of Telford to locate adequate stone supplies, and the effects of the introduction of inferior building materials, which were closely connected with the reasons mentioned above. Wherever possible the matter has been dealt with in chronological date order so that a clearer picture of the close association between stone supply and construction progress emerges.

In his original survey of 1802, Telford reported that the proposed line of canal was well served by raw materials including

limestone, sand and stone for bridge and lock building.(1) The amount of stone required was not expected to be very considerable as he planned to construct earth-sided locks, with only the ends encased in masonry. Each lock (25 altogether) was to require 4,400 cubic yards of rubble stone, 3,000 feet of freestone and cost £5,000.(2) The twelve accommodation bridges and twelve aqueducts were to be made of rubble stone and cost in the region of £30,000(3). Freestone was to be shipped in from Redcastle and Burghhead from the Eastern Division.(4) The majority of masonry was, however, to be constructed out of rubble stone(5) and Telford was informed that there was a more than adequate supply along the entire length of canal.(6) He did not have time on the early surveys to examine the quarries in the Middle District,(7). Freestone for the Western Division was to be shipped from the coast of Morven (Ballachulish) or the southern end of the Isle of Mull.(8) Nothing was said of the extra cost this would involve. Limestone was obtainable from Fyers, Fort William and the Island of Lismore, whilst sand was to be taken from the shores of the numerous lochs along the line of canal.(9)

Optimism over the abundance of local material undoubtedly played a key role in the scheme's acceptance by Parliament in 1803. In his report of February 1804, Telford placed the opening up of quarries and the construction of lime kilns amongst his top priorities prior to the commencement of construction work.(10) He estimated that £10,000 would be required for this operation.(11) Over the next twelve months quarries were opened at both ends of the canal. Nothing was done in the middle district as it was not intended to start work on construction there until the two end sections were completed, enabling cheap transportation of building materials and machinery.(12) A large rubble stone quarry at Clachnaharry

was opened up in the latter half of 1804, employing fourteen to twenty-four measure labourers and day labourers according to season and as many as thirty masons at intermittent periods.(13) It was about half a mile from the canal's entrance and was ideally situated for the supply of rubble stone to the locks at Clachnaharry and Muirtown, together with various accommodation bridges in the sector. The stone was transported in small locally-assembled wagons from the quarry to the construction sites via a network of plateways, details of which will be included in the Machinery section.(14) Production at the quarry rose rapidly and was well able to cope with the growing demands of the masons in the eastern district for rubble stone, which constituted the largest single building material in the locks.(15) The quarry remained in commission until 1811 after which date no further work appears to have been carried out except for a very brief period in 1814. Its closure was due to economic pressure and coincided with the virtual completion of masonry work in the district.(16)

Freestone for the Eastern Division was quarried from Redcastle on the shore opposite to Clachnaharry sea lock in the Beranly Firth. A quay was built to serve the small sloop 'Caledonia', launched in 1804 at a cost of £550 to transport the stone to Clachnaharry from where it was distributed via the plateway system to the various locks. Redcastle remained in commission virtually throughout the whole of the construction period, supplying stone for the Eastern and part of the Middle Districts.(18) At one period over sixty men were employed in blasting and general preparation work.(19) The cost of transportation was comparatively low, the seamen's wages being included in the masonry contractors' charge, although the Commissioners owned the boat.(20) A legal dispute regarding payment of rent for Redcastle Quarry appears to have restricted

output severely between 1816 and 1817 and may have played a decisive role in the Commissioners' decision to use local material for facing Fort Augustus locks in 1817-18,(21) although Redcastle stone had only been used for ^ttotal covering at Clachnaharry sea lock in 1811-12.(22) Redcastle proved expensive to work after 1809 due to the freestone being mixed with a coarser material.(23) Preparatory work at Redcastle and Clachnaharry cost over £2,000,(24) although no rent was paid for them in the early years of construction. Ownership and the payment of rent for quarries has already been detailed in the section on Land Purchase and Payment of Damages.

Telford's original turf-sided locks were quickly abandoned in favour of more practical and conventional designs,(25) requiring masonry wing walls. They were expected to cost in the region of £75,000,(26) complete with gates. Rubble stone was again intended to form the main body of the lock. In 1807 reference was made to the partial lining of lock chambers with freestone(27) and in 1811(28) Telford and Jessop decided to line Clachnaharry sea lock with Redcastle stone as the 'procuring' of Clachnaharry rubble stone for backing had become 'impracticable at any moderate expense'(29). An additional 5/- per cubic yard was added to the contract price.(30) It is clear however, that rubble stone made up the main body of the lock chambers. The evidence for pieces of stone for lock building is extremely minute and fragmentary, making it impossible to establish any clear trend in masonry prices.(31)

The rapidity and ease with which the supply of good quality stone was obtained in the Eastern District was not matched in the West. A supply of rubble stone was found at Fassefern nine miles from Corpach on the banks of Loch Eil. Two sloops were built to serve the quarries in this district, the Commissioners being

directly responsible for payment of seamen's wages (unlike C. lachnaharry).(33) Work began at Fassefern in December 1804, when 7 masons were employed, numbers rising to as many as thirty in the ensuing years.(34) In 1807, however, the Commissioners reported that Fassefern had been closed down and that another, two miles nearer Corpach, opened.(35) Presumably this was also called Fassefern, for there is no curtailment of employment figures for a quarry of this name during the period.(36) The site had been abandoned 'as the rubble stone was found consolidated into larger masses, in proportion as it lay deeper from the surface, and was consequently procured with increasing difficulty'.(37) The new Fassefern Quarry produced stone of a far better quality, suitable for facing locks and 'outside work'.(38) A pier to ease loading of the stone slopes was constructed in 1807-1808 at a cost of £421.(39) Fassefern remained in production until October 1812, closing with the completion of Banavie and Corpach Locks.(40)

A small rubble stone quarry was brought into commission some time in 1805 to provide stone for the locks and aqueducts. It was not a success, proving very expensive to work.(41) Telford reported in 1806 that a small aqueduct had been built from its stone.(42) No other record of its use survives. In 1808 the Commissioners reported that the quarries were 'in a much better state than at the time of our last report'. A new rubble stone quarry had been located in the immediate area of Banavie locks, which was expected to provide all the backing and some of facing stone for the district (43). Production commenced in July 1807, work on Banavie locks in November 1807, and terminated only with the completion of the masonry in that area.(44) A system of interconnecting plateways similar to that used in the Eastern Division was installed to facilitate communication between quarry and construction site.(45) The

immediate success of the new Banavie quarry would suggest that the old site was closed down upon its discovery. The employment records do not distinguish between Masons and Labourers working on lock construction at Banavie and those engaged on quarry work.. It is therefore impossible to ascertain how many men were employed in the quarry and how many quarry sites were in operation.(46)

The Commissioners experienced great difficulty in obtaining adequate supplies of freestone in the Western Division. Extensive searches in the Western Highlands for a possible source were made, but nothing nearer than Cumbraes, in the Forth of Clyde was found. (47) Telford's vague suggestions of 1802 regarding the Isle of Mull and Ballachulish as possible supplies proved to be groundless, although Cameron states that Ballachulish did produce granite for a short period.(48) No record of this activity, however, was recorded in the employment figures.(49) The two sloops employed in collecting stone from Fassefern were also despatched periodically to the Clyde.(50) No labourers were employed at Cumbraes, only masons, which would suggest that there was already a quarry on the site before 1803 and that the Commissioners were simply renting it for a limited period.(51) Labour figures for the quarry are not given after April 1812, the completion date for Banavie locks. Reference to Cumbraes stone was made in the 1820 Report when it was stated that freestone from the quarry was to be used in the coping for Laggan Locks.(52) The cost of shipping freestone from Cumbraes was augmented by the imposition of a 30% duty on every load of stone after 1805-1806.(53) The Commissioners regretted that so much of their budget was consumed on the purchase of freestone rather than labour:-

"Our principal expense of materials, in the course of the last year, was on account of stone for the masonry

work, nor have we any present expectation of diminishing this expense, as no suitable freestone has hitherto been discovered near the west end of the canal, and consequently it is still fetched from Cumbraes, in quantity sufficient for facing some part of the masonry of the locks'.(54)

The Western Division's shortage of cheap freestone was serious because the canal required more masonry work in that area, including four aqueducts, numerous bridges and twelve locks as opposed to the East's seven.(55) Even the highly acclaimed new Banavie Quarry proved to be more expensive than at first anticipated due to the large amount of rubbish which had to be cleared and the expense of blasting.(56)

The difficulties facing the Commissioners in the west were clearly far greater than those of the east. A considerable amount of money had been lost with the early failure of the quarries at Fassefern and Banavie (and possibly Ballachulish, together with the loss of Cumbraes after 1811). The high cost of freestone imposed a further burden on the masonry contractors.(57) Over-land carriage of Paisley stone must have exacerbated the situation.

The completion of much of the basic masonry in the 1812-13 season coincided with the closure of many quarries as has already been noted. No problems appear to have been encountered with regard to the supply of sand and lime for all districts.(58)

Banavie and Clachnaharry's working lines were possibly shortened as a result of high operating costs and may have been a contributory factor in the Commissioners' decision to establish local quarries for the remaining locks on the canal. Transportation costs would also have been prohibitive as delay in canal

construction precluded the use of cheap transport facilities. Quarries were established at Clunes to serve Gairloch in the west, Doughgarroch in the east and, most important for the long-term future of the canal, at Rushkik, to serve Fort Augustus locks.(59)

The supply of building material for the central district had been investigated in Telford's initial survey of 1802 and again in 1807 when it had been reported that an excellent building stone had been found during excavation of a new channel for the River Oich. (60) Previously, Telford and Jessop had shown little concern over the non-availability of building materials for the middle district as they had planned to ship in stone once the two end sections had been completed. Criticism over rising costs and delay made the adoption of a local material inevitable.

Exploratory work of some kind appears to have been carried out at Fort Augustus Quarry in May 1814 when eighteen measure labourers spent one month there.(61) Work started in 1817. As at Banavie no division was made in the labour figures between locks and quarries, making it impossible to calculate the numbers employed on each site.(62) As with other sites the life of Fort Augustus (Rushkik) Quarry was closely geared to lock construction and ceased upon their completion in 1821.(63) The quarry was situated on the shores of Loch Ness some distance from Fort Augustus.(64) Stone was transported by boat and transhipped into stone waggons at the landing quay adjacent to the Fort.(65) The Quarry was obtained rent free, a particularly valid point in its favour at the time, as the Redcastle dispute was costing the Commissioners a large amount of money.(66) The stone was used for facing work and was prepared by masons on site.(67) Redcastle material was still used for quoins, hollow posts and pavements,

being transported through the newly opened eastern section after mid-1818.(68) Rushkik, like so many of the Commissioners' quarries, proved expensive to operate.(69)

There is no surviving documentation which shows that Telford was ordered to open up local rubble stone quarries rather than rely on proven but expensive quarries at either end of the canal. It is certain, however, that criticism over costing drove him to take this action on more than one occasion.

The effects of this policy can be judged by an examination of the physical state of the works after its completion in 1822. George May's 1837 Report provides the most accurate impression of the canal and details the improvements necessary for its commercial success. May commenced his inspection tour of the canal in the eastern district which had been well served by Redcastle and Clachnaharry quarries. This combined with Mathew Davidson's insistence on good workmanship resulted in little or no physical deterioration.(70) "Even the local rubble stone lock, partially faced with Redcastle stone, has lasted well.(71) The middle district was described as being in a dangerous state due almost entirely to poor workmanship.(72) The Rushkik stone had not proved as durable as Redcastle or Clachnaharry material and had been built badly in certain parts of the locks.(73) Laggan locks had been built mainly of a good local granite but were faulty on account of poor workmanship.(74) Gairloch was on the point of collapse due to a combination of poor materials and construction.(75) A local stone had been used. The masonry in the remaining section, including the aqueducts, Banavie and Corpach locks, (but not the sea lock) was totally unfitted to afford that satisfactory degree of security (which I consider) essential to the purpose of the navigation.'(76) The workmanship and materials in the aqueducts were singled out as

being particularly bad, May describing it as "excrable".(77)

The fabric of Banavie locks was showing advanced signes of wear, especially the sandstone quoins and copings from Cumbrae. Only the sea lock, which had been constructed from the same materials, remained in good condition. May believed this was due to superior workmanship.

The use of Cumbraes and local rubble stone was not the main cause of the canal's rapid physical deterioration after 1830. It was undoubtedly, as May concluded in 1837, the hurried and poorly supervised workmanship, itself a reflection of government pressure over finance, which led to disaster.

Davidson had shown in the Eastern district that provided a lock was well built, local rubble stone could be used successfully. Had the Western district's masonry been properly built no doubt the material would have lasted considerably longer, as it was it had been subjected to constant movement and leakage. The Eastern division was obviously better served by materials and ideally Telford should have used them throughout the whole line of canal. Transportation and cost precluded this, however, and it is unlikely, given the circumstances surrounding supervision in the Middle and Western Divisions, that the massive rebuilding programme of the 1840s could have been avoided, irrespective of type of material used.

Notes

- 1 Report to the Treasury, T Telford, Autumn, 1801.
- 2 Survey and Report on the Highlands etc. T Telford 1802.
Estimate of the Expense of the Caledonian Canal.
- 3 Ibid. Rubble stone abutments for the swing bridges were to cost £345, using 864 cubic yards of masonry at 8/-.
- 4 Report to the Treasury, 1801.
- 5 Ibid.
- 6 Ibid. Fort Augustus had 'excellent' building stone.
- 7 Ibid. Telford expected to quarry stone along the banks of the R Spean.
- 8 Ibid.
- 9 Ibid. It is not known if Fort William lime stone was ever used.
- 10 1st Caledonian Canal Report, 1804. Ap E Explanatory Report as to the Expenditure in the first year. T Telford, February 1804. Lime kilns were built at Corpach.
- 11 Ibid.
- 12 Report by George May, 1837.
- 13 2nd Caledonian Canal Report, 1805.
Telford had been instructed by the Board to investigate the proposed quarry sites in 1804 and 1805. For numbers of workmen employed throughout the quarries' history see General Employment Figures.
- 14 Purchase of plateway started immediately after construction in all districts and consumed a not inconsiderable amount of the machinery budgets. The contractors were not involved in their purchase.
- 15 See Employment Figures.
- 16 Ibid.

- 17 6th Caledonian Canal Report, 1809. Ap B 'Investigation of Expenditure on Masonry, Telford and Jessop. The cost of the pier, which was later extended, and unspecified work at Redcastle was £1,095.
- 18 See Employment Figures.
- 19 Ibid.
- 20 6th Caledonian Canal Report, 1809. Ap B Investigation of Expenditure on masonry.
- 21 The legal action taken by Col Gratⁿ_A of Redcastle, barring the Commissioners from using the quarry had taken place in 1810, although the matter was not finally settled until 1816. No break in the employment figures is recorded for 1810, suggesting that Grant's Injunction against the Commissioners was ignored by them.
- 22 9th Caledonian Canal Report, 1812.
- 23 6th Caledonian Report, 1809.
- 24 6th Caledonian Canal Report, 1809. Ap B Masonry prices.

Clachnaharry Quarry	£581
Clachnaharry Pier	£320
Redcastle Quarry	£341
Redcastle	£741
- 25 Report of George May, 1837.

May states that the turf locks were

"an expedient which would have consumed much water and much time in the act of passing vessels and which was therefore seen afterwards most properly abandoned."

Jessop's 1804 estimate was for conventional lock designs.
- 26 1st Caledonian Canal Report 1804. Jessop's Report and Estimate.

- 27 5th Caledonian Canal Report, 1808.
- 28 8th Caledonian Canal Report, 1811.
- 29 9th Caledonian Canal Report, 1812. Ap C Report of Telford and Jessop, October 1811.
- 30 Ibid.
- 31 The Masonry Contractors were Messrs Simpson and Wilson who had worked on many previous Telford projects. The vagueness of references to contractual agreements and the disappearance of anything resembling a contract prevents any close study of the subject. The following information has been taken from the annual printed reports.

(a) 2nd Caledonian Canal Report, 1805. Ap M Prices of labour as determined by Messrs Jessop and Telford. August 1804. Prices of workmanship to be performed by Messrs Simpson and Cargill between Loch Beanley and Loch Ness.

Cut stone from Redcastle; in locks, bridges and other works from Clachnaharry to Dochgarroch, measured in the work ... 1/7d per cubic foot.

Rubble stone within the same distance, with stone from Clachnaharry and faced with Redcastle stone, the whole laid in courses and lime mortar ... 11/- per cubic yard. These figures relate to the standard lock designs and not Telford's turf locks, which had been costed in 1802 as follows:-

Rubble Stone	10/- per cubic yard
Freestone	2/- per cubic foot

The 1804 figures presumably refer to the actual price paid to the contractor rather than the price of labour.

(b) 4th Caledonian Canal Report, July 1807.

The masonry contractors at Corpach (Simpson and Wilson had

the whole line) proved that they had been undercharged. Prices for freestone were raised from 2/5d to 2/8d per cubic yard for rubble work. This was, according to the Report, the only time prices had been changed, which would indicate that freestone prices were substantially higher in the west from the very beginning of the project.

(c) 9th Caledonian Canal Report, 1812.

Telford and Jessop 'considered it reasonable' to add 5/- per cubic yard for the (rubble) at Clachnaharry sea lock. This is immediately contradicted by the statement that only Redcastle freestone was to be used. This represents a huge increase of nearly 50% on previous prices although its overall significance was not great as it related only to one lock.

In 1822, 472 cubic yards of rubble work at Corpach cost £283.

The rise in prices would appear to reflect the rising cost of labour although no details exist for the period when labour prices fell. Transport, general increases in contractors' costs and compensatory rises as a result of unforeseen difficulties all contributed to force prices up, although in the absence of details no definite course can be plotted. It is clear that costs for freestone were consistently higher in the Western Division.

32 2nd Caledonian Canal Report, 1805.

33 4th Caledonian Canal Report, 1807. Ap B 'Comparative expense of the locks finished at Corpach and Clachnaharry showing the cost of the masonry on each particular work'.

34 See Employment Figures.

35 4th Caledonian Canal Report, 1807.

- 36 See Employment Figures.
- 37 4th Caledonian Canal Report. 1807.
- 38 Ibid.
- 39 6th Caledonian Canal Report, 1809, AP D.
- 40 See Emploment Figures.
- 41 3rd Caledonian Canal Report, 1806. Ap F
- 42 Ibid.
- 43 5th Caledonian Canal Report, 1808.
- 44 Ibid. See also Employment Figures.
- 45 See Section on Machinery. The purchase of rails for both districts was recorded in the Abstracted printed accounts included annually in the printed reports.
- 46 See Employment Figures.
- 47 2nd Caledonian Canal Report, 1805.
- Freestone was to be bought from Cumbraes only 'if an extensive search for good stone in the locality failed(. The Isle of Arran was considered at this date as a possible source.
- 48 Cameron D C The Caledonian Canal, 1972, p46.
- 49 The 2nd Caledonian Canal Report, 1805, refers to the Balluchulish site which produced 'good quality' granite, although no mention is made of any of it being actually quarried.
- 50 4th Caledonian Canal Report, 1807. Ap B.
- 51 This is backed up by a statem^ent by the Commissioners in their third report (1806) which states that Cumbraes stone had been used to construct a pier at Irvine in 1792 and had shown itself to be durable and hard wearing.
- 52 17th Caledonian Canal Report, 1820.
- The 8th Report (1811) stated that the Cumbrae Quarry was exhausted and that stone of a similar quality was obtained from Paisley. The employment figures do not record this

- change of location and freestone for the Western Division continued to be referred to as 'Cumbraes' after this date.
- 53 3rd Caledonian Canal Report, 1806.
- And: Op cit, Cameron D C p63. 'every ton was subject to a royalty of 6d to the Earl of Glasgow.'
- 54 4th Caledonian Canal Report, 1807.
- 55 See General map of the canal for position of locks, bridges and aqueducts.
- 56 6th Caledonian Canal Report, 1809.
- 58 Limesmore Quarry appears to have produced a more than adequate supply of limestone for the Western Division (6th Report) 1809 and Foyers performed a similar service for the East.
- 59 See Employment figures.
- The Gairloch chamber was unique amongst the locks as it was designed to incorporate cast-iron hollow posts. (8th Report, 1811)
- 'Upon considering the great expense and inconvenience of carrying heavy freestone from the shore at Corpach up country to this lock, we have thought it preferable to adopt cast-iron for the hollow posts.'
- 60 3rd Caledonian Canal Report, 1806.
- 61 See Employment Figures.
- 52 Ibid
- 63 Ibid
- 64 See location map of quarries.
- 65 For a general description of lock construction at Fort Augustus see Robert Southey's 'Journal of a Tour in Scotland, 1819', James Thin, Edinburgh, 1972.
- 66 The Commissioners had paid over £5,000 for the use of Redcastle by 1822 (see general accounts for that year.)

- 67 15th Caledonian Canal Report, 1818.
- 68 Cameron, DC Op Cit. p60.
- 69 17th Caledonian Canal Report, 1820. The stone was reported
as being expensive to handle, implying transportation and
loading difficulties.
- 70 George May's Report, 1837.
- 71 Ibid.
- 72 Ibid.
- 73 Ibid.
- 74 Ibid.
- 75 Ibid.
- 76 Ibid.
- 77 Ibid.

CHAPTER 8

LABOUR AND WAGES, 1803 to 1802

Rises in the price of labour contributed more than any other single factor to the massive overspending on the canal project. It also ruined many road and bridge contractors who failed to take into account the possibility of rising prices in their initial contract price. It is possible that wage rates rose by as much as 50% over the period of construction. 49.7% of total construction costs (£882,310) was consumed on wages. (see appendix 4) The possible increase in wages was therefore in the region of £200,000, a colossal sum, given the total cost of the project. Before examining the cost of labour on the Caledonian Canal it is intended to examine briefly wage and labour trends on Roads and Bridges. Details of the price of labour on Highland Roads and Bridges are even less precise than on the canal and appear to have been solely the responsibility of the contractors; although the commissioners must have exercised some influence in order to prevent wage competition between the two projects. Haldane states that in the early years of the project Highland labourers exploited the increased demand for labour, moving from canal to road and bridge scheme as it suited him.(1) As on the canal, wages formed the single largest factor in the cost of a road, which ruined many of the early contractors who failed to take this into account.(2) No exact figures survive for road wages at the beginning of the project, but Haldane argues that they were possibly in the region of 1/6 a day, the ordinary rate for unskilled labour on the canal.(3) It was stated in 1805 that road work was less arduous than canal work, which could possibly indicate that rates were lower on the roads.(4) It appears, however, that wage trends and disputes

regarding wages on the canal were quickly mirrored on the roads as can be seen from the events of October 1804 when canal workmen caused a near riot over wages. In the same month Telford was writing to Dick and Readdie, the road contractors, warning them not to employ many Highland labourers in order:

"to convince the people of the Highlands that if necessary the work may be carried on without them. This will soon dissolve any weak combination that at present exist, and I have no doubt that in a very short time plenty of men will offer for employment."(5)

Details of labour trends on the canal will be given later, however it does appear that road and bridge wage trends continued to mirror those on the canal, official reference to rising costs on the roads was made as early as 1809 when Rickman wrote to Hope, commenting on the increasing financial commitments of the Commissioners.

"Do we attempt to make Highland Roads more grand than is requisite, or is the price of labour and materials doubled since we commenced our operations."(6)

General comments on high labour costs are included in subsequent reports but no details are given. There are no records of the number of men employed, although Haldane states that the average yearly number of men employed was in the region of 2,700 to 3,500.(7) It is thus necessary to examine in some detail the employment and cost of wages on the canal in the hope that further information might be found regarding roads and bridges. No information survives as to whether the men were paid by the day or by measure. It is probable, given the size and organis-

ation of most of the road contractors, that the former system was adopted as it was easier to manage and operate.

Of the two basic forms of labour employed on the project, Day and Measure, the Commissioners strove to encourage the development of the latter. A D Cameron states that measure work was a new feature peculiar to the Canal, being evolved specifically with contractual agreements in mind.(8) It was found easier to control wages when Measure was used and the Commissioners from the earliest period discouraged Day work.

In June 1804 Telford and Jessop were instructed to tour the line of canal and fix the price of labour for the various types of work,(9) although Day labourers had been employed on excavating the two basins since the previous year.(10) The Commissioners were very specific as regards wages, Telford and Jessop being instructed "To determine the mode in which the works are to be let and carried on, and the prices of labour for the different sorts of work, but in the case of labour to be paid for by the Day, the wages to be given are not to exceed the ordinary and accustomed price of the labour in the adjacent country."(11)

It had previously been reported that Day labourers were to receive 1/6d a day, which was, according to the Commissioners, average for the area.(12) Anyone demanding more was to be turned away.(13) In separate instructions Telford was ordered to ensure that:-

"In no case whatever (was he) to allow the resident superintendents to exceed the prices to be paid for labour, as previously settled by Mr Jessop and himself, without specially reporting the source and reserving the sanction of the Board thereof."(14)

The Commissioners, by these measures, hoped to establish firm

control over the type and price of labour.

Telford was in full agreement with the Commissioners (and probably the instigator of their policy) over wages as is shown by his letter to Jessop of June 1804, when he informed him that 'every part of the works which can be so managed, (are to) be executed by measure of rates or prices, to be determined by you or myself after having maturely weighed every circumstance.'(15)

This was carried out soon afterwards and the Commissioners in their next annual report gave whole-hearted approval of Telford's 'conduct in causing so great a portion of the whole labour to be done by measurement', (16) and directed him 'to persevere in this course, as the price of Day labour in the neighbouring country was not likely to be enhanced by so different a mode of payment, otherwise recommended by obvious motives of economy. On this principle it is intended that nothing shall be performed by Day labour which can be done by measurement or valuation.'(17)

The percentage of expenditure on Day labour for the 1804-5 season had been 6%(18) and this figure remained fairly constant throughout the period of construction. By May 1822 £30,885 (7.8% of total expenditure on labour) had been expended on Day labour and £377,349 on Measure.(19) The Commissioners' hope that payment by measure would protect them from the normal pressures of the labour market proved to be unfounded and wages rose steadily throughout the period. Of the £882,310 (total construction cost) consumed by May 1822, £408,234 or 49.7 went on wages.(20) The largest amounts of expenditure exclusive of wages was on machinery (£17,336), timber (£68,013) and land (£47,683).(21)

The impact of the canal project combined with the Highland Roads and Bridges scheme, and the activities of local militia was, as will be seen later, very considerable. It affected Day and

Measure work, although the latter was possibly less susceptible. The dangers of Day labour were clearly demonstrated at Corpach in November 1804 when John Telford reported that the men refused to accept 1/6d a day claiming that they knew no English and had not understood the bargain.(22) There followed an extremely tense situation in which the superintendent and his Assistant 'went in fear' of their lives. The matter was settled without increasing the rate and no similar disturbances took place.(23)

Evidence relating to the rate of individual workmen's pay is very scarce. Telford and Jessop's original 1804 Measure prices survive together with a handful of references to contractual increases, which required Board approval. Very few of the monthly paybills survive.(24) The 1804 figures should be treated with extreme care as they detail prices for particular sections of the canal, which may not have been representative of the whole line. To say, as Telford did in his 1802 survey, that the price of cutting the canal would be 10d a cubic yard when he knew that the ground varied from solid rock to gravel and sand was totally irresponsible. The other main problem associated with data relating to Measure work is the proportion of wages to contractors' fee in measurement agreements. Had the monthly pay bills been preserved in any number, this problem might have been overcome, as the amount excavated was always recorded. The annual parliamentary accounts do not record payments to individual contractors, only labour, although the few surviving paybills do contain small amounts of often confusing information:

'Payment to John Wilson' (contractor)

Work at regulating lock including masons,

48 days at 3/6d	£	s	d
	8	8	0
24 days 2/10	3	3	0

Labourers, 24 days at 2/-	2 8 0
(add 10% to the above wages being paid	1 8 4
	<hr/>
	15 12 4
	<hr/> <hr/>

The use of wage and employment figures detailed in the annual Parliamentary reports offers a possible solution to the problems of rising labour costs. Again great caution should be used as the employment figures were recorded monthly and do not take into account length of employment within that month. A labourer could be employed for only a few days and still be recorded in the figures. In order to produce an average annual wage, the monthly employment figures are totalled and then divided by twelve. This figure is then divided into the annual labour expenditure. Further difficulties occur as no monthly records of expenditure relating to specific types of labour exist. It is also extremely unlikely that men worked for the whole year.

Bearing the above provisos in mind, the average yearly wage was as follows:-

Year	Average yearly wage £	Year	Average yearly wage £
1804-1805	40.93	1805-1806	46.54
1806-1807	52.73	1807-1808	49.16
1808-1809	42.44	1809-1810	47.49
1810-1811	48.89	1811-1812	46.00
1812-1813	52.10	1813-1814	61.52
1814-1815	52.51	1815-1816	58.27
1816-1817	58.22	1817-1818	63.10
1818-1819	66.72	1819-1820	64.35
1820-1821	59.00	1821-1822	64.06

The rate varies very considerably (possibly due to the

inadequacy of the statistical information) from £40.93 to £64.35.

There is a basic upward trend however, although depressions do occur throughout. The only other indication of wage rates is given by Telford in the appendix to his Autobiography.(25) Great stress is laid on increases in the price of Day labour, which as has already been noted, was unrepresentative of employment of the project. The figures are, however, of some use for masons and carpenters:

	<u>1804</u>	<u>1812</u>
Common Labourers	1/6d per day (£27.37)	3/-d-3/6d (£59.31)
Skilled labourers	1/8d-2/- per day (£33.76)	-
Carpenters	2/3-2/6 per day (£43.34)	2/10-3/4 (£56.57)
Masons	16/- per week (£41.60)	£1 1s Od (£54.60)

The bracketed figures are yearly totals, although their validity is highly suspect as it is highly unlikely that men would have worked all the year round.(26) Telford states that measure work rose from 3d a cubic yard in 1804 to 4½d per cubic yard in 1812 which is again highly suspect as it was dependent on type of ground excavated.(27) Joseph Mitchell records that masons were paid £1 1s Od in 1820, although he was writing sixty years after the event and may possibly have been influenced by Telford's figures. (28)

It is clear, however, that a very considerable increase in the price of labour did take place and that this increase was possibly as high as 50%.(29) This radically affected the overall cost of the project, where labour made up 44% of the total expenditure.(30)

The impact of the canal works on the locality, combined with the massive road, bridge and harbour scheme, and the actions of the local militia created a labour shortage which forced up wages.

The Commissioners had taken great pains at the commencement of the project to ensure parity with other concurrent large-scale civil engineering works,(31) a difficult task in 1804. They reported that 'the price of labour on the Caledonian Canal is upon the whole moderate and reasonable'.(32) Competition for labourers and masons, however, began with the commencement of construction in 1804, of the huge network of roads and bridges, many of which were in the immediate area of the canal.(33) The canal Commissioners admitted that road labour was considerably easier and frequently used the seepage of labour to the roads as a safety valve when funds would not support a large labour force.(34)

The local militia also slowed down construction as John Telford reported in August 1805:

"All the Skye men, a large number, have been sent for to do volunteer duty"...(35)

Again in 1812 Telford complained to Rickman:

"The permanent duty of some militia corps will be a considerable draw!(36)

The great seasonal fluctuations in Highland labour due to the harvesting of crops and herrings drew many workmen away,(37) which again created an exploitable shortage, although resistance by the Commissioners was strong as can be seen from their report of 1811:

"The decrease of workmen during the winter was due to the Commissioners' unwillingness to augment the price of labour, as we thought it better that the progress of the work should be a little retarded, than we should have recourse to any encouragement beyond that which arises from the improved skill and industry of the workmen, and which has hitherto been sufficient to balance the gradually increasing price of labour."(38)

Acknowledgement of the contribution of rising labour costs to increased overall costs was given throughout the construction period and was listed by Telford in 1818 as a major factor in over-expenditure.(39)

Attempts by the Commissioners to counteract this trend by reducing the labour force had disastrous results as construction was slowed down whilst material and provisions (and so wages) continued to rise. One is forced to conclude that it was labour prices, more than any other single factor which destroyed Telford's estimates, which in turn led to the alienation of the money supply, and the economic failure of the canal. Ironically one of the long-term aims of the Government at the commencement of work - the provision of employment for Highlanders - was more than adequately catered for.

Notes

- 1 Haldane, Op cit p 70.
- 2 Ibid.
- 3 Ibid p71.
- 4 2nd Caledonian Canal Report, 1805.
- 5 Haldane Op cit p71. MR2B 2nd Report, 1805. App A.
- 6 Ibid. Rickman to Hope, 2 September 1809.
- 7 Ibid. p136.
- 8 Cameron, the Caledonian Canal, 1972.
- 9 2nd Caledonian Canal Report, 1805.
- 10 1st Caledonian Canal Report, 1804.
- 11 2nd Caledonian Canal Report, 1805, Ap B.
- 12 1st Caledonian Canal Report, 1804. Main Report.
- 13 Ibid.
- 14 2nd Caledonian Canale Report. Instructions to Mr Telford, June 1804.
- 15 Ibid. Telford-Jessop, 8th June 1804.
- 16 3rd Caledonian Canal Report, 1806.
- 17 Ibid.
- 18 2nd Caledonian Canal Report, 1805. Employment Figures.
- 19 19th Caledonian Canal Report, 1822. Accounts.
- 20 Ibid.
- 21 Ibid..
- 22 Op cit. A R B Haldane, New Ways through the Glens, 193, p81-86.
- 23 Ibid.
- 24 2nd Caledonian Canal Report, 1805.
- 25 The surviving paybills date from 1819 and continue to the end of construction.
- 26 Life of Telford written by himself, London 1838. Ap D.

- 27 The annual figures were not included in Telford's original table but have been included to form some comparison with the main wages table.
- 28 Telford, Ap D.
- 29 Mitchell, p82.
- 30 15th Caledonian Canal Report, 1818.
- This figure is given by Telford in his letter to the Commissioners of 25th May 1818.
- "The increase which has taken place in the price of food, materials and labour during the execution of the work, has not been less than from 30 to 50%."
- 31 19th Caledonian Canal Report, 1822. Accounts.
- 32 3rd Caledonian Canal Report, 1806. Main Report.
- 33 Ibid.
- 34 See A R B Haldane's Map of the Highland Roads.
- 35 See the section on Finance and the issue of Parliamentary Roads.
- 36 Op cit. Haldane, p83.
- 37 Ibid. p 82.
- 38 There are numerous references in the reports and correspondence of Highlanders leaving the canal for harvesting and fishing, perhaps the best known being Telford's letter of September 1818 (Haldane Op cit. p83).
- "The herring season has been most abundant, and the return of the fine weather will enable the indolent Highland creatures to get their plentiful crops and have a glorious spell at the whisky making."
- 39 8th Caledonian Canal Report, 1811. Main Report.
- 40 15th Caledonian Canal Report, 1818.

CHAPTER 9

LAND PURCHASE

No money was spent on the purchase of land for Highland Roads and Bridges. Haldane states that the Commissioners decided from the beginning of the project that 'the benefit to the property over which the roads passed was in itself ample compensation'.(1) A small amount was paid out in compensation for damage to fencing, but all land claims were constantly refused, even the one from Sir John Sinclair, the great champion of Highland improvement. In rejecting Sinclair's claim the Commissioners stated in their 4th Report that the principle of the Highland Road and Bridge Act was 'equality of expense between the public and the contributor'.(2) Well over £6,500 had already been spent on survey work and general management ... 'towards these numerous and heavy expenses the contributors paid no share whatever; and on this consideration we had not expected any claim of compensation for land occupied by new roads to the especial benefit of the property through which they passed.'(3) The Commissioners went on to explain that land claims usually resulted in lengthy discussions with landowners and juries; (an obvious reference to the Caledonian Canal):

'A claim for land involved in it a prospect of the further heavy expense and delay, consequent upon the summoning of juries, to which we had no inclination to resort on ordinary occasions; conceiving the powers given by the act to that effect were intended chiefly for opening the approach to Bridges.'(4)

Further small payments were made for damage to fencing up to the termination of construction work in 1821.(5) It must have been a matter of regret for the canal Commissioners that a similar policy

to that followed on roads and bridges was not implemented for their project.

Land purchase and the settlement of claims for damages consumed a considerable amount of time, effort and money on the part of the Board of Commissioners for the canal and their officers. Construction work was severely restricted on several occasions as a result of massive land payments and legal proceedings stemming from land claims, both of which adversely^e affected Telford's construction programme and costing.

Land purchase was excluded from the estimates of 1802, 1804, 1808, 1813 and 1816. No more land was purchased after this date although many damage claims remained to be settled, none of which was included in subsequent estimates.(6) The reason for the initial exclusion of land stemmed from twin misconceptions held by Telford, Jessop and the Commissioners that the land needed for the canal was of little or no commercial value and that many landowners would give it to them free of charge.(7) Telford's initial survey had stated that only the lands adjacent to Inverness were of any value,(8) a point quoted in the project's favour by the Select Committee of July 1803.(9) The wave of public enthusiasm which greeted the project's launching in 1803 resulted in several of the proprietors along the line of canal promising to donate land free of charge.(10 Evidence of this belief is to be found in the opening remark of Jessop's February 1804 estimate:

"The estimate does not include the purchase of land, much of the land is of little value, and I have presumed most of the canal owners must derive benefit from the canal, as a compensation for what may be cut away."(11)

Survey work completed shortly after the compiling of Jessop's

estimate, enabled Telford for the first time to place a value on the lands directly affected by the canal. His estimate, which was for the whole length of canal, was £15,000(12) Reasons for this surprisingly high figure, given Jessop's statement of the previous month, are best dealt with in the section on the administration of land purchase. No further land estimate was ever submitted, although the 1804 figure had been exceeded by May 1808, four months before Telford and Jessop's revised general estimate. (13) The general inadequacies of the jury system were probably to blame for this and all subsequent omissions as the Commissioner's valuations had consistently been exceeded by local land juries. Telford acknowledged this fact in his 1813 estimate, concluding that:

"such under the present circumstances, is as accurate an estimate as can be found of works of this nature, and to the amount of £234,734 must be added the value of land and damages due to Glengarry, Lochiel and others."(14)

Failure to include land prices in the estimates led eventually to its adoption by the Commissioners and Parliament as one of the main causes of overspending, together with material and labour prices. Continual disappointments over inadequate estimates led to parliamentary criticism which resulted ultimately in the early curtailment of the annual grant and project's economic failure. As a contributory factor to the failure of the estimates, land purchase must be regarded as one of the key factors in the alienation of the money supply. The problems and inadequacies of the administrative machinery created to handle land valuation and purchase were to have a direct bearing on over-expenditure. The following section will include a chronological comparison of pre-

and post-1804 land purchase administration and its main weaknesses, beginning with slowness of operation within a strict construction timetable.

Telford originally estimated that the project would require an annual grant of £50,000 over a period of seven years.(15) Hesitation and difficulty over land consumed two seasons before large scale operation could commence, and this was disastrous at a time of high wages and material inflation.(16) The initial phase of administration was geared to the belief that land would be given free of charge, or at nominal cost, as has already been mentioned. In October 1803 the Commissioners instructed Telford and Jessop to work out the line of the canal and to contact landowners "respecting the gifts of land, or the terms of the purchase thereof".(17) Discussions regarding valuation had already commenced in September 1803 when Telford wrote to Cameron of Lochiel requesting the former's terms relating to land needed for the canal. He placed great emphasis on the expected benefits of the canal and hoped that Lochiel would set an example to the other proprietors by the liberality of his terms.(18) Telford also contacted Col Fraser of Lovat at this period, who agreed to give his land free of charge.(19) An open letter was sent out to all Great Glen landowners requesting details of their terms at the end of September. Each received a map of the intended line of canal, the accuracy of which must have been in some doubt, as survey work was still in progress.(20) By this time, work had commenced in a very limited capacity at the two terminal basins, presumably as a result of small land donations by Cameron of Lochiel and Major Duff of Muirtown.(21) Further letters were again sent out in October 1803 as little or no response had been received. (22) The hope that a combination of official and personal persuasion

would cause the proprietors to outbid one another with their generosity was short-lived however, as Telford received the first of many formal applications for land valuation in December 1803 from Cameron of Lochiel.(23) In his reply to Lochiel Telford stated that he was not competent to value land in the Highlands himself and recommended William Mackenzie, land surveyor of Inverness.(24) The proposed method of payment was extremely complicated, involving payment by instalment and re-measurement upon completion, 'the balance (then being) paid according to the rates then thought fair.'(25) There was no provision for arbitration should the estimate prove inadequate. Lochiel accepted the valuation in January 1804, although reservations were expressed over payment of damages during construction.(26) No other firm agreements were reached with any of the remaining landowners who were presumably reluctant to commit themselves to accepting the Commissioners' system of valuation as there was no apparent means of appeal. Their initial enthusiasm over the project was gradually being replaced by the realisation that the longer they delayed the better the final price.(27) The general inadequacies of the land settlement issue were realised from the winter of 1803 and little further action appears to have been taken until the passing of the 2nd Canal Act in June 1804, after much delay.(28) Telford's estimate of £15,000 was prepared after the failure of the initial land negotiations although the Commissioners still hoped that some land would be given free as late as June 1804.(29)

The Act made provision for a system of jury valuation if the two parties could not agree. Every juryman was to receive payment for his services and overall responsibility for expenses fell to the party whose valuation was below that fixed by the jury. The initial valuation was to be performed by a surveyor mutually

acceptable to both parties.(30) Power was given to the Commissioners to 'enter and take possession of lands on payment or tender,' a clause designed to prevent delay or interruption of work by legal proceedings.(31) The vagueness of previous arrangements was apparently rectified but delay continued to prevent large-scale construction. This was due to further survey work rather than intransigence on the part of local landowners.(32) It was not until September 1804 that valuation commenced on the line between Inverness and Loch Ness.(33) Telford ordered George Brown to "weigh the inconvenience and advantages which will arise and fix a valuation, which to the best of your judgment shall be just between the parties."(34) Brown's valuations, together with a map of the line, was sent to each individual landowner who was requested to decide upon it or a jury.(35) Telford was encouraged by the Board to exert all his influence in favour of settlement without a jury, (36) a move which met with singular lack of success. He received orders to settle with any landlord who demanded less than Brown's valuation plus the expense of a jury, which was at that time an unknown cost.(37) Only one landowner took up this offer after much argument over delayed payment.(38) Telford began to express anxiety over the ratio between labour deployment and land availability in the Spring of 1805. He informed Rickman that the matter should be settled by the end of April so that he could 'without blame or interruption extend the workmen, which are now so numerous and increasing in that quarter over a greater length of ground.'(39) The situation worsened during the following months. At the end of April 1805 he reported to Rickman that all was going well: 'as circumstances of land will admit.'(40) The situation became critical by June 1805. Unless the land issue was settled immediately the season would be lost.(41) This appeared to be the exact

situation for which the special compulsory clause of the 1804 Act was created. This option was not used by the Commissioners, however, who preferred to enter into imprecise voluntary arrangements with landowners for the temporary use of their land until such time as proper agreements could be reached.(42) Reasons for the Commissioners' hesitant behaviour are closely connected with the landowners' rejection of Brown's valuation and insistence on settlement by local juries. The Commissioners must have considered that the risk of alienation which would have resulted from the implementation of the clause was too great. The one safeguard of the 1804 Act relating to property transference was thus rendered useless and unworkable. The Commissioners lost the initiative and had to wait until the autumn of 1805 before the matter could be finally settled.(43) The juries met to decide the valuation of the land in the Eastern Section on 2nd October 1805, with Telford and Lockhart Kinloch representing the Commissioners.(44) The awards were all higher than Brown's valuations, although the proceedings went smoothly as reported by the Commissioners:

"We have much gratification in stating that after a laborious investigation of 4 days, during which the sherrif and jurors manifested a patient attention and anxiety to do justice between the parties, verdicts of awards were pronounced on the several claims of the landowners and according to our desire, all subordinate claims of the tenants were at the same time ascertained and included therein. The sums awarded have somewhat exceeded Mr Brown's valuation and the expense of the juries has consequently been paid by us."(45)

The Commissioners were to take legal possession on 11th Novem-

ber 1805, paying interest on the purchase money from that day until the actual payment was made.(41) The end of 1805 saw the establishment of the canal on a much firmer footing than previously. Full possession had been obtained of sufficient land to commence full-scale operations. Delays had been serious, however, two years later elapsing from initial land enquiries to legal possession. The main weakness of the jury system, which had been realised by the Commissioners and their officials from an early date, was that all local jurors were either personally acquainted, or had a common interest with the landowner, as reported by James Hope in August 1805:

"Mr Telford will therefore probably find it necessary to submit this also to a jury, a recourse I am not very fond of in a remote country where jurymen are not unconnected by friendship, acquaintance or common interest."(47)

Their awards were consistently higher than those of George Brown, the surveyor employed on the majority of valuations. In 1813 he valued the Glengarry claim at £7,000, the jury awarded him £10,000 which was '£3,000 more than he was entitled to had they been honest men'.(48) The impossibility of enforcing the Right of Access clause under such a system was clear to the Commissioners from 1805. The only time they did invoke it was over the Redcastle affair when the matter was taken immediately to a court of law rather than a jury.

The administrative machinery which evolved after the passing of the 1804 Act was not changed after the initial bulk land purchase of 1805.

The high expenditure on land purchase diverted funds away from the construction budget and this led to delay and further expenditure. This section will consider the periods of high

land expenditure, namely 1805-7, 1813, 1815-16 and 1819 in conjunction with general construction expenditure.

The period 1805-7 saw the expenditure of over £15,000 on land.(49) It is difficult to assess the impact of this figure in general construction expenditure as the latter was not sufficiently established at this early period to show any clear trends. However, heavy land payments did result in an early application for the annual grant in 1805-6, Telford using them as an excuse rather than a cause:

"There is a foundation for this plea, on account of paying for land, and losing £2,000 by juries I shall endeavour to push on the lock pit at Clachnaharry."(50)

Negotiations for the purchase of land in the middle district commenced after 1811 along lines previously described. Allocations of funds for this purchase were considered in January 1812 when Telford was ordered by the Commissioners not to employ too many labourers:

..."As they intended that the expense shall not exceed £45,000 leaving £5,000 for the purchase of land and other contingencies."(51)

The effects of this policy were reflected in the season ending May 1813 which saw reduced expenditure on masonry and labour.(52) Impending land settlements also restricted expenditure in 1814 although no land payments were actually made until 1815-16 when £16,000 was expended on that commodity.(53) Had the procedure for land settlement been more efficient this delay need not have occurred. Masonry and labour figures were well below those of the peak construction years 1810-12. These figures were similarly affected in 1819 when £3,253 was spent on land and £20,899 on labour, although masonry rose considerably as a result

of lock construction at Fort Augustus.(54) It must be stated that high expenditure on timber and machinery (mainly lock gates) between 1815-1821 diverted a very considerable amount of money from actual construction work and that land purchase was subordinate to this after 1815.(55)

Closely allied to the problem of delay/over-spending through administrative inefficiency and diversion of capital was that of threatened legal action over land disputes. Construction was adversely affected on at least three occasions by threatened legal action, causing uncertainty and delay. A potentially crippling dispute which could have disrupted the whole supply of free-stone for the centre and eastern divisions began in 1808 when Grant of Redcastle requested that back-rent be paid for the quarry used by the Commissioners on his estate.(56)

The dispute will be described in some detail as it involves one of the few occasions where the Commissioners invoked the special clause of the 1804 Act. George Brown carried out the valuation which was rejected by Col Grant, successor to Grant of Redcastle who had died in the interval.(57) Grant lodged the very considerable claim of £500 per annum against the Commissioners which exceeded Brown's valuation by £460.(58) The Commissioners decided to resist the claim on 'any grounds' as there were several other quarry proprietors along the canal's line who might be tempted to put in similar demands, if Grant's proved successful. (59) Provision had been made in the 1804 Act for the opening up of quarries within a reasonable distance from the canal. Grant not only rejected the Commissioners' offer but challenged their right to open quarries, taking out a summons against them in the Court of Sessions.(60) Hope received orders to invoke the right of access clause and the matter was taken to court, being event-

ally decided in the Commissioners' favour by the House of Lords in 1815.(61) Work continued at the quarry throughout the dispute as a result of the special clause.(62) Although the Commissioners did not lose money over the issue, the uncertainty must have affected the future construction programme and ultimately the overall cost of the project.

Time and money were lost as a result of Evan Baillie's action of 1814 when he obtained an 'illegal interdict' to prevent the dredging of Loch Doughfour.(63) The whole of the 1814 summer dry season was lost and although Hope was ordered to gather information with a view to taking legal proceedings, no attempt was made to use the 1804 Act. Similar action was threatened against Glengarry after he attacked canal workmen in 1816.(64)

A dispute of a non-legal nature occurred between the Commissioners and the Board of Ordnance over occupation of land at Fort Augustus. Although the matter was never taken to court it did cost the Commissioners a large amount of time and money. Provisional agreement had been reached in 1813 and work proceeded without interruption until 1816 when monetary compensation was demanded by the Board of Ordnance.(65) This made any kind of forward planning (and therefore calculation of future costs) extremely difficult. Telford expressed anger over the Board or Ordnance's indecisiveness on more than one occasion,(66) especially when it affected work in progress. In the winter of 1818 he ordered William Hughes to proceed with dredging and extending the area around the Fort, but because of a slight variation in the line, the Board of Ordnance objected and denied that they had given authority for such action.(67) The dredging operations were suspended until the matter was cleared up.(68) Work at Fort Augustus was also affected in the long term by the delaying tactics of the Board of Ordnance

for when approval was finally given, the locks were hurriedly and badly constructed, and had to be rebuilt in the 1840s at huge expense.(69)

It is obvious from the above accounts that the greatest weakness of the land purchase administration was its slowness of operation which made it virtually impossible to plan future operations with confidence whilst land questions remained to be settled. As a result estimates were made prematurely obsolete and costs rose. Although only £48,000 was consumed on land purchase up to 1822, its cost in real terms was considerably more.

Notes

- 1 Haldane, Op cit. p60.
- 2 HR2B. 4th Report 1809.
- 3 Ibid.
- 4 Ibid.
- 5 See HR2B 9th Report, 1821 Accounts.
- 6 The Act's inadequacy was most apparent in the clauses dealing with claims for damages, for no provision was made for the imposition of a time limit on such claims. Glengarry's claim of loss of amenities was regarded by the Commissioners as potentially dangerous because, if successful, it would open the flood gates with regard to similar claims. To prevent this ever-present threat, a special Act of Parliament was obtained in 1825 which imposed a time limit on all such claims. The dangers of amenity claims without a time limit had been foreseen by Rickman in November 1824. He argued that unless a time limit was imposed "the Commissioners must justly require to be discharged of the superintendence of the canal affairs and the canal itself be advisedly left to gradual ruin."

At the end of the time embargo in February 1826, £20,000 - worth of claims had been forced out into the open, together with Glengarry's claim. The settlement of these claims did not directly affect the canal's construction costs as it was many years before they were considered. However, the potential threat of such claims in the 1820s was exploited by those who sought to cut the project's finances just at a time when it required a comparatively small amount to achieve maximum depth and thus economic viability.

- 7 See first and second Caledonian Canal Reports, in particular,
1st Caledonian Canal Report, 1804. Ap A. "Instructions to
be observed by Mr Telford.
- 8 Survey of the Highlands, 1801.
- 9 Third Report of the Select Committee on the Survey of the
Coasts etc... of the Highlands: Caledonian Canal, 14th June
1803.
- 10 See Haldane, R R B "New Ways Through the Glen"; op cit.
p 148 Col Fraser of Lovat met Telford during a surveying
trip and promised to give the land affected by the canal to
the Commissioners free of charge, Telford having taken
'great pains to bring him into this deposition'. (Telford-
Rickman, October 1803.)
- 11 1st Caledonian Canal Report, 1804, AP A.
- 12 Ibid, Ap E.
- 13 See 6th Caledonian Canal Report, 1808. Accounts ending May
1808, £16,191 was spent on land.
- 14 11th Caledonian Canal, 1814.
- 15 1802 Survey of the Highlands, presented March 1803.
- 16 Work commenced on the basins in the Autumn of 1803, employment
figures did not pick up until well into the 1805 season.
- 17 1st Caledonian Canal Report, 1804. Ap A.
- 18 SRO MT1/1. Telford-Cameron of Lochiel, 2nd September 1803.
- 19 SRO MT1/1. Telford-Rickman, 31st October 1803.
- 20 Ibid.
- 21 Major Duff later demanded payment for this land and the
affair was not cleared up until the early 1820s.
- 22 Telford-Rickman, 31st October 1803.
- 23 Telford-Lochiel, 6th December 1803.
- 24 Telford-Lochiel, 22nd November 1803.

- 25 Ibid.
- 26 Lochiel-Telford, January 1804.
- 27 The expected benefits of the canal were sufficient to increase land value. By the 1820s the value of land around Inverness had increased dramatically (see Joseph Mitchell's Report on the Highlands, 1827).
- 28 1st Caledonian Canal Report, 1804. Main Report.
- 29 Ibid.
- 30 2nd Caledonian Canal Report, 1805. Ap A.
- 31 Ibid.
- 32 Telford-George Brown, 10th September 1804.
- 33 Ibid.
- 34 Ibid.
- 35 2nd Caledonian Canal Report, 1805.
- 36 Ibid.
- 37 Over £1,431 was paid out by the Commissioners on juries, ending May 1822.
- 38 The landowner was A Mackintosh who complained that "Mr Telford assured me the money would instantly be paid without any delay."
(A Mackintosh-Hope, June 1805.)
- 39 Telford-Rickman, 6th February 1805.
- 40 Telford-Rickman, 21st April 1805.
- 41 2nd Caledonian Canal Report, 1805.
- 42 Ibid.
- 43 3rd Caledonian Canal Report, 1806.
- 44 Ibid.
- 45 Ibid.
- 46 Ibid.
- 47 Hope-Rickman, 10th August 1805.

48 Cameron, A C. The Caledonian Canal; op cit p79 Diary of George Brown.

49 See land purchase accounts:

20th Report of the Caledonian Canal Commissioner, 1823.

Land Purchase: full details of all land purchases are given:

Sundry persons for removing their
houses and damage to potatoe gardens
etc... caused by working on the line of
the canal and by quarries. £2,644

Expense of Juries 1,431

A Mackintosh for land at Holm 640

Evan Baillie for land at
Kinmylies, 1805 1,392

Evan Baillie for land at
Doughfour, 1805 514

Evan Baillie, interest on above
sums (171) days. 34

Evan Baillie, in lieu of bridges
at above places, 1817. 1,291

Total to Evan Baillie 3,934

Duncan Cameron of Loch Eil for land
at Corpach - L Lochy, 1806 2,002

Duncan Cameron of Loch Eil,
additional payments, 1814. 4,348

W Baillie for land at Dunain 4,074

W Baillie, interest on above from
11 November 1805-7 June 1806. 116

W Baillie, additional land at
Dunain, 1809. 65

W Baillie, land for Urquhart Road,
1813. 45

W Baillie, land at Castle Spiritual, 1816. 111

W Baillie Total 4,411

Provost Grant for lands at Bught	£1,500
Interest on above, 1805-1806.	70
As above for land at Torvaine	258
H R Duff for lands at Muirtown	£2,701
H R Duff, interest from November 1805- December 1806.	£148
H R Duff, land and damages at Muirtown, 1814	£364
H R Duff, removal of W Frazer's homestead 1815.	£23
H R Duff, approaches to Muirtown bridge	£11
H R Duff, damages in full 1821	£355
H R Duff, total	£3,604
W McLean for land damages at Dourghgarroch	£943
W McLean, interest on above, November 1805- January 1807.	£57
Land for new Ur guhart Road, 1813, 1819.	£297
Simon Frazer, 1809	£109
Geo Cameron of Letter Finlay, 1811, 1816	£1,330
Col Fraser of Lovat, 1813	£3,837
Glengarry for 1813 Jury Award.	£9,997
Glengarry, interest on above to 23 October 1815.	£468
Glengarry, damage to Laggan Farm	£12
Glengarry Total	£10,477
Duke of Gordon	£156
Col P Grant of Redcastle for Redcastle Quarry	£5,801
TOTAL	<u>£47,887</u>

- 50 Telford-Rickman, 17th November 1805.
- 51 Minutes of 57 Caledonian Canal Meeting, 27th February 1812.
- 52 10th Caledonian Canal Report, 1813. Accounts
- Masonry was down from £16,769 to £9,257 and labour from
£32,234 to £21,782.

- 53 See general land expenditure Accounts in Annual Reports for 1815 and 1816.
- 54 1820 saw the expenditure of £19,147 on masonry, the highest figure of the entire construction period.
- 55 See section in Timber.
- 56 5th Caledonian Canal Report, 1808.
- 57 Ibid.
- 58 Grant employed J Tait of Edinburgh to value the quarry. See J Tait to Col Grant, 27th April 1809.
- 59 Minutes of 52nd Caledonian Canal Meeting, 19th June 1810.
- 60 Minutes of 51st Caledonian Canal Meeting, 21st May 1810.
- 61 12th Caledonian Canal Report, May 1815.
- "The judgement given is not such as will encourage any person hereafter to dispute the principle for which we found ourselves bound to contend. That it is our absolute right to dig for stone within a reasonable distance of the canal, paying the proprietors of the land no more than the amount of damages sustained by him from our so doing."
- 62 The employment figures published annually show no interruption at Redcastle for this period.
- 63 Minutes of 68 Caledonian Canal Meeting, June 1816.
- 64 Ibid. Glengarry applied for an interdict to prevent dredging operations in Loch Oich in August 1816. On the morning of 3rd September he led a party of thirty men 'variously armed as if deer hunting and drove away the workmen'.
- 65 Minutes of 68 Caledonian Canal Meeting, June 1816.

- 66 16th Caledonian Canal Report, 1819.
- 67 Telford-Rickman, 20th February 1819.
- 68 Ibid.
- 69 George May stated in his report of 1837 that such was the haste to open the canal in 1822 that the cement in the Fort Augustus locks was not properly dry when the water was let in. The cost of the rebuilding in the 1840s exceeded £10,000.

CHAPTER 10

TELFORD AND THE BOARD OF COMMISSIONERS

The major source of irritation on both the Highland projects was cost, but the discussion which follows will include an examination of resident and assistant engineers, Inspectors and contractors, the line of canal and road and the design of the various features on them, and the relationship between Telford, Rickman and Hope, the principal officers of the two Boards.

The recruitment of managerial personnel was left very much to Telford on both projects, although both Boards requested that they be notified of all such appointments(1). Telford chose all his Highland Road Inspectors personally, promoting many of them from the ranks of Masons and workmen, including Alexander Easton (later Canal Superintendent), Joseph Mitchell and Alexander Martin. He appointed an ex-Ellesmere Canal Engineer John Duncombe as Chief Road Inspector in 1806 after the death of Donaldson. As on the canal Telford was given a free hand in the choice of managerial personnel and there are no records of any disension amongst Board members or contributors over his managerial appointments.

Matters appear to have been very similar on the canal. No formal instructions were inserted in the 1803 instructions except that:

"The salaries of any superintendent who may be found necessary are to be from £52 10s 0d to £157 10s 0d per annum according to their respective abilities."(2)

It would appear that, apart from the above, Telford was given a free hand in the creation of the survey team as no formal notification to the Board of its size or appointment of individual members was made. Telford subsequently requested that workmen and overseers be

appointed to excavate the basins, permission for which was given by the Board in February 1804.(3) The Board became more fully involved with the recruitment of managerial staff after the commencement of large-scale operations in the summer of 1804. Telford submitted his proposals regarding the responsibilities and appointment of the principal Superintendents to the Board in early June. These proposals, which have been detailed in a previous section, were adopted by the Board with the added proviso that ... "no permanent house is to be provided for the Superintendents' until they had given their approval and that Telford was to inform them of all subsequent managerial appointments.(4) Telford decided on the figure of £200 per annum for his senior superintendents, which the Board thought rather high, although they thought it worth it to secure experienced men.(5) It is interesting to note that Jessop and, to a lesser extent, Telford regarded the Superintendents' salaries^{as} much too low and sought on numerous occasions to have them raised.(6) The Commissioners had been formerly invested with the power to appoint officers in the 1804 Act 'taking security from those who were to have custody of money'. (7) It is clear from the events of 1804 that the Commissioners took no part in the actual recruitment of managerial staff and that they simply endorsed Telford's decisions regarding this matter. There are no surviving instances of Telford's managerial appointments receiving censure from the Board. George Brown's employment as Chief Land Valuer was approved without hesitation,(8) as was that of Alexander Easton, John Telford's successor(9) and James Davidson, who succeeded his father in 1818.(10) No attempt was made by the Commissioners to appoint construction staff except on the recommendation of Telford. The only occasion when Telford was excluded by the Board from a matter concerning the continued employment of one of his assistants was in 1812 when allegations of mismeasurement were

filed against Alexander Easton.(11) The Board reported in 1813 that they had felt obliged to exclude Telford from the proceedings as he had not only 'recommended Mr Easton to us' but because 'the accuser had also thrown out general imputations on his vigilance and skill as an engineer'.(12) To conclude, it would appear that the difficulties experienced by other civil engineers regarding the appointment of assistants did not occur on the Caledonian Canal and that Telford experienced no unpleasantness with the Board over this matter. No managerial appointments were imposed on him from above with the exception of William Jessop, whose position vis-à-vis Telford has already been dealt with. Concern over travelling expenses and salaries appearsto have worried the Commissioners far more than the actual recruitment and appointment which was left very much to Telford.(13)

Procedure over the appointment of canal contractors followed a very similar pattern, which will now be described. No action was taken on the canal until June 1804 when Telford recommended Simpson and Wilson for the masonry work.(14) Details of the contractors to be used and the management of their work, first expounded in a letter to William Jessop,(15) were taken up piecemeal by the Commissioners at their Board meeting of 11th June. No additions were made to Telford's arrangements concerning the choice of contractors or t heir management, at this period or at any later date. As has previously been noted, the Commissioners were informed of all major increases in the contractual price of the various works. On no occasion did they object to any of the price rises. They took a keen interest in the activities of the contractors, however, praising Simpson, Wilson and Cargill and Meek at regular intervals, whilst calling for greater exertions from one of the general contractors in 1810.(16) The Commissioners ordered that no further lots be let

until the contractor had finished the one he was working on.(17)

It would appear, however, that all information regarding contractors was gleaned by the Board from Telford's reports and correspondence and that all orders relating to their management originated from Telford. No reference was made in the reports or minutes to the letting of general contracts, which would imply that Telford required no Board authorisation for such actions. As with the recruitment of managerial site staff, there is no instance of the Commissioners attempting to 'impose' a contractor upon Telford or calling for him to dismiss one. They were prepared to go entirely on Telford's recommendations with regard to contractors, which was perhaps unfortunate, given the later history of the canal.

The pressures surrounding the appointment of Road and Bridge contractors were very different from those found on the canal and centred around the fact that more than one financing body was involved, namely the Board of Commissioners and the local contributors. Before a contract could be signed official approval of the contract offer had to be obtained from both the Board and the local proprietors.(18) If the offer was above Telford's estimate the contributors had to pay the extra. There was thus a very strong tendency in the early years of the project for the contributors to press for acceptance of the lowest offer of contract irrespective of the merits or otherwise of the contractor concerned. This was realised by Telford and the Commissioners after 1810, and both commented on the disastrous results of such a policy:

"Our original Estimates were inadequate, and the contractors inconsiderate in the extreme, varying from double even to triple in the amount of offers for the same work; and our desire to effect all practicable economy not being at that

time regulated by experience, offers were in some instances accepted which in the sequel

have been grievously injurious to the contractors".(19)

It also resulted in much delay and hardship to the contractors' cautioners, many of whom were ruined.(20) It is thus clear that the commissioners and the contributors had the final say in the choice of contractor. Telford's estimate of the cost was taken only as a guide in the early years of the project and was often over-ruled. It was only with bitter experience that offers nearest his estimates were accepted. There are several instances of contributors complaining about the choice of contractors, the most vicious being made in 1805 when Sir George Mackenzie of Coul accused Telford of employing his own friends as contractors, a charge which was quickly rejected by James Hope, the Commissioners' Law Agent.(21) No similar charges were made after this date.

Closely allied to the choice of managerial personnel was that of Board involvement in the line and design of a civil engineering project. As has already been noted, this often led in the eighteenth century to the abandonment of the Parliamentary Plan and the construction of 'Contour' canals. It is now intended to examine the policies of both ^{the} Boards of Commissioners and the local contributors with regard to design features, beginning with the Caledonian Canal.

The Commissioners' involvement in the routing of the canal and design of the locks, weirs, culverts and bridges was governed by two factors, expense and a statutory obligation, contained in the Second Canal Act, to ensure that 'no deviation of line (took place) without consent.'(22) It is now proposed to examine their participation in the fixing of the line of canal and subsequent changes in design, with special reference to changes in the choice of material.

Telford's proposed line of canal had been given wholehearted

approval by the 1803 Select Committee:

"Your Committee, from a full consideration of all the evidence laid down before them submit to the House their opinion that the excavations of the

Inland Navigation proposed in Mr Telford's survey ..'(23)

It was not until October 1803, however, that the Board gave official approval of the line.(24) This delay had come about as a result of extensive re-survey work, as ordered by the Board in August 1803.

Proposals for this work originated from Telford who submitted

'instructions for the consideration of the Board as to canal construction' in July 1803.(25) Survey work continued until the autumn of 1804 when the line for the Eastern and Western divisions was fixed.

(26) Board approval was again obtained and work proceeded. A similar procedure was followed in the Middle district. At no stage in the proceedings did the Commissioners attempt to interfere in the line of canal taken. They accepted Telford's proposals from the beginning. There were no rival plans or routes, which had so bedevilled private companies causing dissent and bad feeling between engineer and Committee. There were, however, deviations in the line and position and number of locks, all of which were considered by the Board.(27) The vagueness of the original survey made such changes inevitable. As George May stated in his 1837 Report, the 1803 scheme was 'very different from what circumstances rendered it advisable or necessary in most instances to adopt'.(28) The design changes approved by the Board are too numerous to record individually. None of them appears to have originated from the Board, who were happy to leave such matters to Telford and his Superintendents. It should be noted, however, that many of the major changes came about as a result of worries over costing and finance and were thus indirectly attributable to the Board, as will be seen in a later section.

It is now proposed to examine some of the more prominent design changes, especially those relating to locks and accommodation bridges. No protest was made by the Board when Jessop proposed all-masonry locks in place of Telford's turf-sided designs.(29) They did, however, order an investigation of the best size of locks by Telford and Jessop which resulted in an increased size of lock.(30) Investigations regarding the incorporation of side locks in the main locks were rejected by Telford and Jessop on the grounds of expense. (31) The Commissioners readily accepted Telford and Jessop's proposal to combine various locks on economic grounds. Changes in the size of the actual canal were not so numerous. Acting on Telford's recommendation, the Commissioners ordered a plan and estimate of the Torvaine road re-alignment 'as it is a question in which the public are concerned.'(32) Telford's proposal to reduce the width of the bottom of the canal at this point from 50 to 30 feet, so enabling a road to be built along-side, was eventually rejected and a new road built away from the canal. It would appear that further trials made Telford change his mind, rather than any specific directive from the Board.(33) The Board was closely involved in the Glengarry dispute and ordered Telford to be as conciliatory as possible. Glengarry had requested that the canal be taken along the southeast of Loch Oich: 'We have reason to hope that his wishes may be acceded to without detriment to the course of the canal, or much augmentation of expenses.'(34) They reported one year later that:

"an exact survey and admeasurement of the earth which must be removed, has taken place in consequence of the application of Glengarry and we have thus enabled to give directions to Mr Telford to enter into such explanations as will prove to him that we are sincerely desirous of consulting his convenience in so far as

it appears to be compatible with our public duty."(35)

It would appear from the above that the Commissioners were trying to be as diplomatic as possible in order to pacify Glengarry rather than instruct Telford to take a specific line at any cost. The line eventually chosen did include this route, simply because it was the best available.

Changes in the use of materials stemmed solely from Telford and Jessop, although they were introduced as a result of pressure over finance, as has been previously noted. The basic innovation with regard to materials, was the substitution of wood by cast-iron for the lock gate frames and swing bridges. No objection by the Board was recorded at the time of the substitution, probably because they were told that no additional cost would be involved.(36) When this proved not to be the case Telford was asked by the Board to justify himself. The introduction of cast-iron was given as a major contributory cause of overspending.

The joint system of financing the construction of Roads and Bridges was potentially more open to pressure, with regard to design changes, from local proprietors than on the Caledonian Canal. It would appear, however, that very few of the road routes were changed after construction began and that none were altered without the full agreement of Telford. Such changes as did take place were usually minor and placed little extra cost on the contract price. Delays and frustration did occur however, in arguments amongst local proprietors as to the best route before the official survey was drawn up. As has already been stated the Contributors and Commissioners had to give approval of the survey before the contract was drawn up. Haldane states that Telford was usually in close consultation with local proprietors when he considered the routing of roads, but that he always attempted to serve the general interest,

rather than specific individuals.(37) On many occasions the best line of road was also the most suitable for local proprietors. There were occasional differences of opinion however, which resulted in delay and occasionally total abandonment of the project. This occurred over Orin Bridge, where proprietors could not decide on the position of the bridge or the best way of financing the project.(38) Rickman expressed anger over the matter in a letter to Hope of May 1806:

"I am heartily sick of Sir George Mackenzie and his bridge, which has cost more trouble than all the roads now making in Scotland."(39)

The matter remained undecided in 1809, and Rickman again attacked the proprietors:

"It is impossible to avoid disgust with the undeserved ill-usage which we meet in attempting to benefit Ross."(40)

There are also isolated instances of the Contributors changing the specifications of contracts when acting as the main Contractor for a project. The most notable project on which this occurred was Dunkeld bridge where the Duke of Atholl:

..."in his great earnestness for the expeditious progress of the work, had employed a much greater number of labourers and Masons than was really necessary ...(and had) ... also deepened the foundations and enlarged the dimensions of the bridge beyond the original plan, which improvements (though not absolutely necessary) added much to the stability of the work.(41)

This involved a considerable readjustment of the contract price and was, fortunately, for the Commissioners, not repeated on any of the other projects. The system of financing roads and bridges

by County levy had to some extent broadened the area of interest, and did much to ensure that roads built served the whole community.

Mention has already been made of the Road Contributors and Commissioners preference for the cheapest contractors in the early years of the project. This fear of high costs was mirrored on the Caledonian Canal and gradually turned into a morbid phobia which stifled the project and lead ultimately to its near abandonment.

Over Expenditure

The principal responsibility of the Board was to ensure that the grant of money made by Parliament was issued in a correct and orderly fashion to the construction site, as noted in the finance section. All other considerations were subordinate to the issue and recording of money, which makes the Board's overall inability to control expenditure all the more puzzling. This obsession with money was applied to all aspects of construction, as Andrew May noted in his 1837 Report:

..."The great error all along has been, both on the part of its original projectors and the public generally, to exhibit in connection with a work of this nature, too morbid an anxiety for the curtailment and limitation of expenditure by every economical expedient that could be devised."(42)

This attitude was apparent from the earliest days of the project, as can be seen from the Report of the 1803 Select Committee:

..."In Mr Telford's survey, under all due regulations for the economical expenditure of such monies as may be employed in this great work."(43)

The Board's 'great displeasure' with Telford in October 1803 arose not from any misdemeanour in his official duties but from a failure

to conform with the procedure relating to the drawing of bills.

(35) As has been noted in the section on Finance, it was Telford who eventually made the system more workable. Instances of monthly estimates proving inadequate and the subsequent reduction of the labour force have already been noted in the section on Finance. It remains, however, to examine the broader implications of the issue of finance and its effect on the relationship between engineer and Board, especially after 1813, when concern was first expressed over the failure to predict the overall cost of the project. The issue of finance over the period 1813-1822 will be examined in some detail as it lies at the heart of the problem of engineer v Board.

No apparent disagreement took place before 1813 over the issue of money. The Board issued the money according to Telford's estimates and work proceeded within the confines of this framework. It was not until 1813 that Telford suggested that construction could be speeded up:

..."If Parliament should think fit to grant £80,000 in each of the next two years, there is every reason to expect that the work might be completed at that time (1817) and with due attention to economy"...(45)

Telford's realisation, at this late date, that the longer the project took the more expensive it would be, was not shared by the Board, who were empowered by the 1804 Canal Act to issue a maximum of £50,000 per annum.(46) No official comment on Telford's suggestions was recorded in the 1814 Minutes which were concerned mostly with the Glengarry dispute. When the official estimate was drawn up for expenditure in 1815, it was for the usual sum of £50,000, 'the Chancellor of the Exchequer (Board Member) having expressed an opinion that the estimate ought not to exceed the usual sum.'(47) Expenditure was extremely heavy in 1815 due mainly

to payments for land and lock gates. Rickman specified land as the urgent need for the issue of the remaining grant in 1815.(48) Telford informed the Board on 26th December 1815 that he expected to pay out £34,000 for lock gates over the next year and that a large number of workmen would have to be laid off unless the annual grant could be increased.(49) He wanted at least £70,000.(50) This letter was shown to the Chancellor and the Chairman of the Board and resulted in an enlarged estimate being sent to the Treasury for £75,000.(51) The reason for a larger sum than usual was given as 'the purchase of cast-iron materials for making lock gates'.(52) This was granted as Rickman requested the remainder of the £75,000 issued in the last Session of Parliament in September 1816.(53) Telford had been in severe financial difficulty up to this period, having a regular overdraft of over £2,000 on his canal account.(54) The request for an increased grant had resulted in the setting-up of a select committee to enquire into the 'Estimate for the Caledonian Canal', which reported in June 1816. This was presumably necessary in order to overcome the restrictions placed on the Commissioners by the 1804 Canal Act. Telford was called to give evidence and stated that in 'his opinion the Commissioners had rather under-rated the inconvenience which (might) result from dismissing a great number of the workmen now employed by them, and the extra expense which could not fail to result from withholding any part of the £75,000 proposed to be granted in the present session of Parliament"...(55)

The Committee concluded:

.." The advantage of the public will best be consulted by opening the proposed facility of communication with the Baltic Sea, as soon as may be consistent with arrangements of the Commissioners for completing this work;

and they entertain no doubt, as well from the last report of the Commissioners, as from the evidence of Mr Telford, that this object will best be attained by granting £75,000 in the present session of Parliament, for the completion of the canal."(56)

Reaction to Telford's proposals, first detailed in his 1813 estimate, had thus taken well over two years. The ever increasing financial commitments of the project had finally persuaded the Commissioners to tackle the Commons on the matter. The Commissioners had accepted Telford's belief that many jobs would be lost if no more money was granted and gave it as their main line of argument to the 1816 Select Committee.(57) Given the lengthy procedure necessary for an increased annual grant, it is perhaps understandable why the Commissioners were apparently so reluctant to apply for an increase. This difficulty makes their subsequent actions all the more difficult to understand. The usual communication was received from the Treasury in December 1816 requesting an estimate for the next year's expenditure with the added proviso that:

.."in case there should be any excess or diminution between the estimate now called for the estimate of last year, the grounds thereof to be stated."(58)

A formal request for £75,000 as agreed by the Select Committee, was submitted at the end of December.(59) In February 1817, the Chancellor of the Exchequer persuaded the Commissioners to reduce the request from £75,000 to £25,000 arguing that public opinion was against such a sum:

..."Public inconvenience might be apprehended from granting the sum accommodated by the Committee of

the House of Commons in June last.."(60)

As a result, Telford's plans for completing the canal by 1817 were completely wrecked. The cash flow problem of 1816 had been overcome by the additional grant, but the additional £75,000, which would have allowed Telford to forge on ahead to early completion, was instead replaced by only half the amount normally granted. This was at a time when pumping operations at Fort Augustus were at their most difficult and expensive.(61) The following year the usual sum of £50,000 was applied for and granted.(62) The same sum was requested for the 1819 session.(63) A 'scarcity of money'(64) at the Treasury delayed payment of the 1818 grant, forcing the Commissioners to borrow heavily. However, this incident does not appear to have been connected with disputes over further grants, but was simply an administrative holdup. In April 1820 the Treasury requested estimates for completing the canal, which were drawn up by Davidson and Easton, and amounted to £93,784 plus land claims.(65) The Commissioners persisted in their usual claims for £50,000, although later Minutes record that there was a possibility of £60,000; apparently Telford was not consulted:

"In case the expected Parliamentary grant of £60,000 shall be given with a view to open the navigation from sea to sea the Commissioners' direct application to be made for issue of half that sum as soon as possible after the application act shall be printed; and that Mr Telford accelerate the progress of the several works in such a manner as to second the intentions of Parliament."(66)

This sum was granted and work continued on the canal until all funds were consumed. The Commissioners were again forced to apply for a further £25,000 much to their annoyance and embarrassment. This

final issue was granted on 5th July 1822.(67) The canal opened in October 1822.

Virtually all of the criticism and official embarrassment over the canal would have been averted had the Commissioners met Telford's request for additional grants in 1813. The delay in any form of official request for more money and the Chancellor's insistence that the findings of the 1816 Select Committee be reversed allowed the opposition to build up which, combined with ever increasing prices, made it doubly difficult to come back for more money when funds were exhausted. The resulting panic to open the canal resulted in bad workmanship and premature opening in 1822, before it was completed. No record of Telford's thoughts on the Board's actions have survived, although it is interesting to note that he became heavily involved with the Holyhead Road project at this time, (68) leaving more responsibility to his two Superintendents. It now remains to examine the Board's reaction to Telford's estimates and failure to predict accurately the cost of the work.

Concern over costs led the Commissioners to call for estimates at regular intervals after 1810, the theoretical date at which the project was to have been completed, according to Telford's 1802 Survey.(69) It is now proposed to examine the reactions of the Board to each successive estimate. In 1809 the Board instructed Telford and Jessop to draw up an estimate for completing the canal since half the estimated expenditure had been spent. They were optimistic about its findings, believing that all problems relating to canal construction could be accurately evaluated.

'The circumstances which in the Highlands may be supposed to augment or diminish the usual expense of canal operations, having now been fully experienced, we apprehend considerable reliance

may be placed on this estimate.'(70)

The increase of £27,000 over Jessop's 1804 estimate was accounted for by an increase in the price of labour and materials. The Commissioners concluded by praising all concerned on the project:

..."The expenditure upon this extensive work to the close of the year 1809, would not have exceeded the amount at which it was originally estimated, and we think that praise is justly due to Messrs Jessop and Telford for the accuracy of their calculations, and likewise to the Superintendents and other persons employed by Mr Telford for their judicious arrangements and faithful execution of their various duties."(71)

The next estimate was made in the autumn of 1813 by Telford, who laid great emphasis on price rises and fluctuations which made it extremely difficult to pin-point the exact cause of over-expenditure.(72) A table of price rises was annexed to the estimate which satisfied the Commissioners, who were by now showing signs of anxiety over expenditure. Telford was praised for his efforts in a difficult situation and the Commissioners accepted that the work was now to cost £721,121.(73) His request for an increased annual grant has already been dealt with in a previous section. Large payments for land and cast-iron followed the 1813 estimate, which was reflected in the Commissioners' anxiety over costs, and resulted in their calling for a new estimate in 1816. They were not prepared to let Telford's previous estimate go uncriticised:

"Being aware that our present estimate is not conformable to what might have been expected from our calculation founded on Mr Telford's estimate of October 1813, we have called upon him to explain

the differences, no change of prices having been

alleged to have taken place since that time...".(74)

Telford's 1813 estimate had omitted land, management and the 'usual 10% upon engineering estimates, which (was) more than usually allowable in a work of unexampled dimensions, and which would have amounted to £23,000.'(75) In his defence, Telford stated that dredging and difficult rock cutting in the centre district had consumed much of the previous estimate. He made no reference to his failure to provide an extra 10% for contingencies, which had been included in his 1802 estimate. The Chancellor's cancellation of the increased grant was presumably in response to mounting criticism over costs. Telford's estimates could not have helped at this difficult period. He was severely criticised by the Board after the failure of his 1816 estimate, the money from which became exhausted in 1818.(76) The grant of £150,000 had failed 'to open the canal from sea to sea' as promised by Telford in 1816 and subsequent estimates were drawn up by his Superintendents, as previously noted. Considerable annoyance was expressed by the Commissioners in their report of 1818, although no censure was recorded in their Minutes, an indication of open criticism for general parliamentary consumption:

..."reverting to the former estimates which have been prepared in the course of the work, especially in the year 1816, we cannot but feel considerable disappointment at the foregoing statement. We were indeed aware that the unexampled dimensions of the canal, its junction with the sea, and with lakes ... presented unusual and indeed unprecedented difficulties, and might be allowed to account for a considerable uncertainty in the estimate, but not to the degree in which it has actually occurred, and

we have therefore called upon Mr Telford for an explanation of such unlooked for excess of expenditure"..(77)

Telford was ordered to detail all factors contributing to the high cost, all of which have been dealt with in previous sections. The Commissioners again appeared to accept Telford's answers, and went some way to amending their criticism of him in their concluding remarks:

.."setting aside Mr Telford's insufficient allowance for the above contingencies, in all other respects we have had abundant reason to be satisfied with his professional ability, and especially with his readiness of resource displayed by him in the occasional difficulties which have occurred in this arduous undertaking; least of all do we attribute any part of the excess of expenditure to want of economy, which we are convinced has been carried as far in every particular as prudential considerations seemed to permit."(78)

The desperate need to get the canal open after 1818 appears to have silenced internal criticism, although the Commissioners did complain in 1822, when they had to apply for yet another grant, that 'they had been led to expect' that the previous sum was sufficient.(79)

To conclude, the criticism of Telford by the Board over costing was fairly mild (except for 1818) when one considers the large amount of money involved. This would suggest that they believed his explanations and could see no other way of proceeding except under his direction. The years after 1813 involved some of the most difficult undertakings on the whole project and it was indeed unfortunate that finance became such a problem at this stage in the proceedings. The Board's constant worry over finance instilled economy in the minds of all concerned on the project, to its

ultimate detriment. This incipient phobia about costs, as opposed to permanence, combined with the Board's actions in 1816, was sufficient to turn an ailing but potentially sound project into a financial disaster.

The Responsibilities of Board Officials

Rickman was secretary to both Boards of Commissioners, handling all their official correspondence and Minutes. He was the link between the construction site and the Board, maintaining a voluminous correspondence with Telford on the day-to-day running of the canal and roads and bridges. This information was then presented to the Board. Rickman was also responsible for passing on all decisions taken by the Board to the various people concerned, and in the issuing of the monthly grants, estimates for which were sent to him at regular intervals by Telford. Full details of his involvement in the financial arrangements of the projects have already been given in a previous section. He acted as secretary from 1803-1829.

James Hope was Legal Agent to the Caledonian Canal Board, being based in Edinburgh. His main area of responsibility was in the purchase of land and the various problems arising from land disputes. In this task he worked closely with Telford who did a lot of the initial ground work before any land was transferred. He assumed more responsibility when any disagreement over land threatened to become serious, as in the Glengarry dispute. It is significant that Hope had no formal contact with the canal contractors, whilst on the Highland Road and Bridge project he was heavily involved in controlling their actions.

As has already been noted, Hope was responsible, together with Telford, for drawing up the road and bridge contracts, checking the security of each possible contractor and controlling

the issue and recording of interim payments to all road and bridge contractors. He also handled the canal contributors, detailing their payments, trying to ensure that no undue delays occurred. He was much more involved on the Roads and Bridges Project and formed the key link between the Board and Telford.

Telford's responsibilities have already been sufficiently discussed. It is interesting to note that both he and Rickman requested very small salaries for their posts, considering the project as a public duty. This may well have had great significance in their relationship with the Boards of Commissioners.

Notes

- 1 Second Caledonian Canal Report, 1805. Ap E Instructions to Telford.
- 2 First Caledonian Canal Report, 1804. Ap A Instructions to Telford.
- 3 Minutes of 13 Caledonian Canal Meeting, 18th February 1804.
- 4 2nd Caledonian Canal Report, 1805. Ap E.
- 5 Ibid Main Report.
- 6 Ibid. Ap D Jessop-Telford. London 9th June 1804.
"I am not at all surprised that the former should demur at it, and if he would be satisfied with £200 per an. I should consider him very moderate in his expectations as I know him qualified to deserve more."
See also Minutes of 44th Canal Meeting, May 1808.
- 7 44^o Geo III Cap 62..
This does not appear to have been implemented.
- 8 2nd Caledonian Canal Report, 1805.
- 9 Minutes of 39th Caledonian Canal Meeting, 10th July 1807.
- 10 16th Caledonian Canal Report, 1819. Main Report.
- 11 10th Caledonian Canal Report, 1813. Main report.
- 12 Ibid.
- 13 Even Telford was asked to detail his movements and received a warning from the Board in 1803 not to claim on anything other than canal business. See Telford-Rickman, 31st October 1803.
- 14 2nd Caledonian Canal Report, 1805.
- 15 Ibid. Ap C Telford-Jessop, 8th June 1804.
- 16 6th Caledonian Canal Report, 1808.
- 17 Ibid.
- 18 Haldane Op cit p54.

- 18 HR2B 8th Report, 1817.
- 20 Ibid. See also Haldane p98 Hope to Rickman, 22nd November 1820.
- ".. The result is that all the parties are bankrupt except Mr Andrew Davidson, Advocate, Aberdeen'.
- 21 Haldane, Op cit p60.
- 22 44^o Geo III Cap 62 clause XXV.
- ... shall not deviate more than 150 yards from the course or direction delineated in the said maps or plans ...
- 23 3rd Report of the Select Committee on the coasts etc of Scotland, 1803.
- 24 Minutes of 9th Caledonian Canal Meeting, 11th December 1803.
- 25 1st Caledonian Canal Report, 1804 and 1st and 2nd Board Meeting Minutes, 1803.
- 26 2nd Caledonian Canal Report, 1805. Main Report.
- 27 The first of these was in the autumn of 1803 when the board agreed to the change of position for entrance lock at Corpach. (Minutes of the 9th Caledonian Canal Meeting, 11th December 1803,)
- 28 Report on the Caledonian Canal, George May, 1837.
- 29 No official comment was made on the abandonment of Telford's original design in the minutes although the matter was discussed in the 1st Report in 1804.
- 30 2nd Caledonian Canal Report, 1805. Main Report.
- 31 Ibid. Telford and Jessop estimated that side locks would cost an additional £75,000 with small savings on repairs.
- 32 8th Caledonian Canal Report, 1811.
- 33 A D Cameron: The Caledonian Canal, 1972. Op cit p56-57.
- 34 14th Caledonian Canal Report, 1817.

- 35 15th Caledonian Canal Report, 1818.
- 36 11th Caledonian Canal Report, 1814, Ap C.
- 37 Haldane, Op cit p51.
- 38 Ibid p121-2.
- 39 Ibid p 121.
- 40 Ibid.
- 41 HR2B 3rd Report, 1807.
- 42 Report on the Caledonian Canal, George May, 1837.
- 43 3rd Report of the Select Committee, 1803.
- 44 Rickman informed Telford on 12th October 1803 that the Commissioners 'felt more displeasure than they thought fit to express at the great irregularity of drawing your bills in direct violation of your instructions.'
- 45 11th Caledonian Canal Report, 1814, Telford's estimate. October 1813.
- 46 Extract from 44^o Geo III, Cap 62.
- ... "May it please your majesty that out of the monies granted for the supply of the present year, there shall be issued and paid, at the receipt of his Majesty's Exchequer the sum of £50,000 without any deduction, to the Commissioners ... (that is to say), the sum of £25,000 being one moiety thereof, on or before the 25th July next, and the further sum of £25,000, being the other moiety thereof, on or before the 25th December next ... to be lodged in the Bank of England until the same shall be from time to time applied to the purposes of this and the said act."
- 47 Minutes of 66th Caledonian Canal Meeting, May 1815. (Proceedings).
- 48 Ibid.

- 49 Ibid
- 50 Ibid.
- 51 Ibid.
- 52 Ibid.
- 53 Minutes of 67th Caledonian Canal Meeting, May 1817.
- 54 Ibid.
- 55 Report of the Select Committee on the Estimate for the
Caledonian Canal, June 1816.
- 56 Ibid.
- 57 Ibid.
- 58 Minutes of 68th Caledonian Canal Meeting, 22nd June 1816.
Proceedings.
- 59 Ibid.
- 60 Minutes of 69th Caledonian Canal Meeting, 20th February 1817.
- 61 14th Caledonian Canal Report, 1817. Main Report.
- 62 Minutes of 70th Caledonian Canal Meeting. 1818.
- 63 Minutes of 72nd Caledonian Canal Meeting. 1818.
- 64 Minutes of 70th Caledonian Canal Meeting. 1818.
- 65 17th Caledonian Canal Report, 1820.
- 66 Minutes of Caledonian Canal Meeting.
- 67 Minutes of 77th Caledonian Canal Meeting, 23rd May 1822.
- 68 He became Engineer for the Holyhead Road in 1815 and work
commenced soon afterwards.
- 69 Telford had calculated that the canal would require £50,000
for seven years.
- 70 7th Caledonian Canal Report, 1810. Main Report.
- 71 Ibid.
- 72 11th Caledonian Canal Report, 1814.
- 73 Ibid.
- 74 13th Caledonian Canal Report, 1816. Main Report.

- 75 Ibid.
- 76 15th Caledonian Canal Report, 1818. Main Report.
- 77 Ibid.
- 78 Ibid.
- 79 Minutes of 77th Caledonian Canal Meeting, 23rd May 1822.

CONCLUSION

In assessing Telford's achievements in the Highlands it is necessary to draw a very distinct line between the Caledonian Canal and Highland Roads and Bridges, the latter being by far the most successful. There was a marked contrast in managerial organisation between the two projects. Roads and Bridges had precise areas of responsibility, with detailed specifications and contracts together with an adequate inspectorate team. These factors were entirely lacking on the Caledonian Canal where vagueness and lack of definition reigned supreme. It is thus extremely difficult to assess Telford's achievements on the Canal project.

Constant reference has been made throughout the thesis to the lack of archival material relating to certain key areas of canal construction management. This is in direct contrast to the Highland Road and Bridge scheme which is extremely well served by documentary evidence. Having examined the management of both projects it must be concluded that the organisation of the two projects was fundamentally different; it must be assumed that Telford attempted to implement a most unusual if not unique managerial system on the canal project. Whilst the Highland Road and Bridge scheme did contain many ⁿovatory features, it was basically organised along accepted lines.

Reasons for Telford's actions have been detailed in previous chapters but it is appropriate to summarise them at this juncture. The overriding feature of the organisation of the canal project was that Telford and Jessop knew personally all the principal assistant engineers and contractors. They had all been employed on former Telford and Jessop projects and all knew exactly what standards were required and the work load likely to be imposed on them. They were all proven, hence the absence of open competition

for the posts of superⁿitendents and principal contractors. Like Telford they had all risen from the ranks of stone_masons and craftsmen. It should also be noted that many of them, in common with Telford, showed an interest in free masonry. Telford's experience on the Ellesmere Canal, where there had been a large and at times fractious managerial team, undoubtedly influenced his decision to appoint a small managerial team on the Caledonian. By choosing a small, well-tried team Telford hoped to avoid the dissension and intrigue, especially with regard to proposed routes, which had been common on the Ellesmere. It is also difficult to imagine anyone purposely setting out to recruit a completely new and unt-ried team of supervisors and assistants and despatching them to the remote Highlands in the hope that they would do a good job. It should be stated that people with detailed local knowledge were employed in a supervisory capacity prior to construction; but it was the 'Ellesmere Team' which took over after the commencement of construction in July 1804. The managerial team for Highland Roads and Bridges relied to a far greater extent on personnel with detailed local knowledge and practical skill; although a prominent member of the Ellesmere Team was for some time Chief Inspector, with very little success. Telford appointed his road supervisors or inspectors from stone_masons and craftsmen.

Telford's choice of contractors on the Caledonian was also understandable given the special circumstances of the project, namely the difficulty of numerous firms tend^eing for such a vast project in a remote and difficult area. It was inconceivable that the project should be let along traditional lines, with a multitude of small contractors, all responsible for finding their own workmen, tools and men. No small contracting organisation had the finance or the ability to take on the job. The same

could be said of most of the larger concerns, whose lack of managerial organisation was perhaps best displayed by the unfortunate John Pinkerton. It should also be noted that the cost of the project, even in 1804 when it was estimated that £475,000 was required, was beyond the imagination of any contractor. Even if Telford had broken the canal's lots down into one-mile sections, each section would still have cost well over £20,000, an equally impossible sum for the average contractor. It should be noted that most of the Highland Roads and Bridges were built for less than half that sum. If the canal work had been let in lots manageable to the average contractor, the number of firms employed on the canal would have run literally into hundreds; this would have necessitated the employment of many more assistants, who would again have proved an unknown quantity. It was therefore necessary for Telford to devise a new system of 'contracting' on the Caledonian Canal. The masonry contractors on the Caledonian had all been employed on the construction of the Chirk and Pontcysyllte Aqueducts, probably the most difficult canal structures completed to date. Telford hoped to combine their technical assurance with a new degree of managerial involvement and technical decision making which was unprecedented for the period. The principal contractors on the Caledonian therefore marked the dividing point between the older type of general building/civil engineering contractor and the highly competent contractor/engineer of the later nineteenth century. The letting of contracts on the Highland Roads and Bridges project was organised along more usual lines. Each projected road or bridge was let to open competition. Preliminary investigations were made into the financial security of each contractor who was required to provide a guarantor in the event of financial difficulty. None of the road contractors were known to Telford previous to taking up

their contracts. On the larger and technically more demanding bridges, however, Telford again called in Simpson and Wilson. It would appear that they were in open competition against other firms for such undertakings, and that they were bound by the same controls, including the signing of contracts. Telford preferred to use members of his highly experienced ex-Ellesemere team of contractors on all difficult bridge projects in much the same way as foundation work on canals was performed by direct labour under the control of the resident engineer. The Highland road and bridge contractors were not so closely involved in the management of the work, which was performed by employees of the Commissioners.

The road and bridge contractors received interim payments in order that they might carry on construction work. The whole of the Road and Bridge management team was geared to ensuring that contracts were executed according to specification. This was in direct contrast to the role of the Superintendents on the Caledonian.

Having described the main features of the management of both projects, it now remains to examine both managerial schemes in practice and ascertain why the Roads and Bridges project eventually succeeded and the canal failed. Certain general observations need to be made before discussing individual features of management.

Both projects were created to alleviate social distress and stem the growing tide of emigration by providing employment in the Highlands. Both were eventually successful in this respect, although the financial collapse of certain road contractors did cause a certain amount of hardship. The canal was especially successful in providing regular spring, summer and autumn employment for as many as two thousand skilled and unskilled workmen, for a period of nearly twenty years; and it may have been this

factor which silenced opposition on over-spending for so long. The apparent loss of momentum in construction work after 1812 may also have been due to the employment factor - the provision of which appears to have assumed more importance than actual construction work and getting the canal open. George May's comment in his 1837 Report suggests that the employment argument was accepted by canal management and contractors from a comparatively early date:

.."I have reason to believe that the contractor for these locks, (Corpach) while engaged in the actual execution of the work, was fully under the conviction (which was shared by many others at the time) that the navigation was a thing which was never to take effect and that his locks would consequently never require to come into actual operation."

This attitude was not held on the Roads and Bridges scheme, probably because of the involvement of private proprietors in the financing of the various projects. This, combined with penalty clauses for delay in the written contracts, provided a sufficiently strong incentive for contractors to complete the work as quickly as possible; although there were certain occasions when successive bankruptcies amongst contractors caused prolonged delay.

The need for Roads and Bridges was at once apparent and their completion eagerly awaited by the local population. Their success, in terms of opening up previously inaccessible areas, was immediate. The canal was built for less easily identifiable reasons, many of which were no longer valid even before its completion. The most prominent of these 'reasons' was the strategic argument which was immediately cancelled out after peace with

France in 1815. This was not counterbalanced by an increase in the expected amount of merchant shipping through the canal; in fact hopes in this area began to wane after the imposition of heavy duties on Baltic timber, which effectively wiped out the trade. The canal was also not deep enough for ships even of a moderate size. All these factors, which emerged some time before the canal's opening in 1822, must have had a bad effect on the morale of all concerned, not least on Telford, who became increasingly involved with other civil engineering projects after 1815.

There were also problems of a technical nature, which although they occurred on both canal and Roads and Bridges, affected the former more adversely because of its huge cost and scale. Several of the initial road surveys had to be repeated at a later date due ^{of the original surveyors and} to incompetence, the discovery of unforeseen technical difficulties - usually connected with the nature of the ground over which the road was to pass. Despite numerous surveys and trial borings, similar difficulties were encountered on the Caledonian Canal, with the corresponding magnification of expenditure and delay. Difficulties encountered in dredging and keeping the works dry and in lining the banks placed an additional burden on the overstrained management and resources of the project.

It now remains to examine briefly individual problems on the two projects. The difficulties over canal finance were not shared to the same extent on Roads and Bridges. This was due to the joint system of financing a road or bridge. As has already been said, the Government agreed to pay half the expense of the original estimate. The other half plus any additional expenditure had to be met by the local contributors. The Government was thus able to pass on the effects of rising costs to the unfortunate local proprietors. The same could not be done on the Caledonian which was

financed entirely by the Government. Telford's decision to control canal contractors and expenditure through the monthly pay-bills could possibly have worked had it not been for the extremely high inflation rate. Wages and the price of materials were particularly hard hit by rising costs. His policy whilst maintaining a rigid adherence to financial details, allowed the canal contractor to cover up rising costs by bad workmanship. This they were able to do because of the lack of proper supervision on the actual construction sites. Had there been more supervisors on the construction sites, this at least would have been avoided. It would not have prevented over-expenditure, however, as more work of a higher quality would have been performed. Road and bridge wages appear to have been lower throughout the period of construction and, this, combined with the ability to utilise cheap local building materials, cancelled out the adverse effect of inflation. No form of management then known could have prevented the over-spending which took place on the Caledonian Canal.

Telford's decision to use a small, hand-picked team of contractors and supervisors on the canal, badly misfired as a result of rapidly rising costs and the Government's failure to inject more money into the project when it became obvious that the annual grant was becoming inadequate. It also failed because, despite his careful pre-selection, his superintendents in the critical Western division were unable to maintain control of the contractors. The choice of Mathew Davidson for the Eastern section of the canal had proved to be extremely fortunate, for Davidson managed to ensure a very high standard of workmanship throughout - as can be seen from May's Report of 1837, which listed very few defects in the Eastern section. The long delay in getting the section open was not due to managerial intransigence, but rather lack of capital. Telford was

less well served by John Telford in the Western section, who let the contractors build some of the worst examples of poor masonry ever seen on a public work. Overwork, inadequate assistance, difficulties in transporting materials, labour troubles and technical problems all contributed to his troubles, which in turn led to an early death in 1807. His replacement made efforts to reassert the authority of the Commissioners on the section, but the damage was done and the district declined rapidly after the opening in 1822. There was considerable delay in the west, due in part to bad management, but mainly to the lack of adequate finances. The absence of contracts and time clauses meant that there was no way of making the contractors work faster, even if the money had been available. The project would undoubtedly have been more successful if Telford had concentrated his efforts and resources on one section at a time. Telford's choice of personnel was no more successful on the Roads and Bridges scheme, but the organisation of the project was sufficiently strong and well-defined to carry on irrespective of such problems. The failure of the first two chief Road Inspectors resulted in delays and extra expenditure, but this was not borne by the Commissioners - the difference in costs being paid by the local contributors and the contractors.

The scale of Road and Bridge operations, although widespread, was sufficiently compact when compared with that on the canal, to allow control from a comparatively small managerial team. The use of contracts and specifications was also of great help in this area.

The canal management scheme represented a definite attempt on the part of Telford to introduce a new form of management to civil engineering projects. It was, however, essentially a hybrid, being based on personal friendship and knowledge, although the use of large competent firms for the main masonry and general work was

practiced on many later projects and gradually replaced the employment of smaller firms. The canal scheme failed because of rising costs, inadequate supervision, inadequate finance and ultimately a loss of morale. The peculiar reasons for its original construction combined with the reasons listed above were sufficient to bring about the near abandonment of Telford's original scheme and very nearly led to complete disaster. This was realised by George May in his devastatingly truthful Report of 1837 and it is to him that we must reluctantly turn for the concluding words on the project.

..."The idea of constructing a canal on so stupendous a scale was characteristic of the bold and original genius of its author, and had this great work been completed in the manner then proposed, or had the execution of its details at all corresponded to the magnitude and excellence of the design, it would undoubtedly have formed one of the noblest monuments on record, of national skill, enterprise and magnificence."

This accolade was more aptly given to the Roads and Bridges scheme.

APPENDIX I

SOURCES

A full list of all known Telford archive material has been included in the appendices. The sources for the Highland projects fall into four main categories; the official Parliamentary reports and accounts, the minutes of the Boards of Commissioners, correspondence between the various Board officials and finally contemporary printed accounts and descriptions. It is now intended to examine in some detail each category beginning with Parliamentary Reports.

PARLIAMENTARY REPORTS

Both Boards of Commissioners were directly responsible to Parliament. As a result, both published annual parliamentary reports from the inception of the projects to 1863 and 1920 respectively. They contain the most comprehensive description of the works whilst under construction. Each report consists of a general progress report compiled by John Rickman first Secretary to the Board, and signed by the Commissioners, detailing the past year's work, current projects and the various problems associated with construction. This is supplemented by a detailed technical report from the principal engineer(s) together with tables of the numbers of men employed and weather conditions. The report concluded with abstracts of accounts of monies spent during the previous year, together with a general cumulative account. Expenditure was broken down into four basic areas; labour; materials and transport; management and land purchase. Information from Parliamentary Reports has provided the basic framework for the thesis. It has been found, however; that they need constant checking with minutes and

correspondence which in many instances provide further information or clarification. The official Board reports also tend to present rather a favourable impression of how the work was progressing, especially in the case of the Caledonian Canal, where no intimation of bad workmanship was given until the 1830's. The main objectives of the report were primarily concerned with presenting a clear statement on expenditure of public funds to Parliament. Technical details in the Caledonian Canal Reports were only touched on, even by Telford in his individual report. It was not intended to give a complete picture of the managerial organisation on the project and details of this particular aspect are extremely vague, with the possible exception of the 1805 Report which contains a complete breakdown of the initial construction phase. The reports of the Board of Commissioners for Highland Roads and Bridges contain far greater detail with regard to the actual management of the project; being especially informative on the type and form of contract used and the system of road inspection. Indeed the Road and Bridge reports devote most of their space to the mishaps or otherwise of the contractors employed - in complete contrast to the Caledonian. Even the abstracted road accounts were more detailed, listing individual payments to contractors: only the monthly paybills recorded such payments on the Caledonian.

MINUTE BOOKS

The minute books of both Boards are concerned primarily with transference and recording of expenditure and land purchase. Those for the Caledonian Canal are complete for the whole of the construction period, whilst only a few isolated minutes have survived for the Highland Road and Bridge project. Technical details are not well served in either set of minutes.

CORRESPONDENCE

The final archive source is found in the large amount of correspondence and the letter books now housed in the Scottish Record Office and the House of Lords Record Office. The canal is served by a complete set of letter books commencing in 1803. The Highland Road and Bridge scheme is served by a massive collection of letters between the Board, Telford, Rickman, Hope and the various contractors and contributors involved, in all running to over 3,000 items. This material was used extensively by A.R.E. Haldane in his study, "New Ways Through the Glen", (1973).

PRINTED SOURCES

The final source used consisted of a small number of contemporary printed accounts. There are only two main accounts for the Highland Projects; Southey's "Journal of a Tour of the Highlands in 1819" and Joseph Mitchell's "Reminiscences of My Life in Highlands".

The material used for general comparative sections on civil engineering projects is taken from a variety of sources, full details of which have been given in the relevant footnotes.

ARCHIVE SOURCES

University of Aberdeen

Local History Collection: pamphlets relating to Aberdeen Harbour.

Aberdeen City Council. Aberdeen Town House Library

Aberdeen Harbour: plans of 1802, 1810 and 1831 showing proposed improvements and proposed docks.

Bath City Council. Archives Section

Details of a bridge constructed in Bristol.

Bedfordshire County Record Office

X171/205: map of Kings Lynn harbour, T. Telford, 1830.

X21/5/2: minute book of the Newport Pagnell Turnpike Trust, 1824.

Birmingham Reference Library

Boulton and Watt Collection: correspondence relating to steam engines for the Caledonian Canal, Glasgow Water Works, Metropolitan Water Supply and Holyhead Harbour. See also letter books, volumes, 23, 29, 30, 31, 34, 46 and 47.

Boston Reference Library

Item No. 5 of the Wheeler Collection: Reports on Boston Haven, T. Telford, 1823.

Buckinghamshire County Record Office

Q/AB/32: letter from Thomas Telford to Thomas Tendal, Clerk of the Peace for Bucks., re. a Mr. A. Stevens, manufacturer of Blue Lias lime.

Cambridge County Record Office

Q/RUml: Improvement of the outfall of the R. Nene.

R.59/31/40/105: longitudinal section of the R. Ouse from Earith to St. Ives. Staunch, T. Telford, 1826.

Canterbury Royal Museum

Plan relating to the proposed canalisation of the R. Stour between Canterbury and Sandwich. J. Morgan (formerly in the Institution of Civil Engineers).

City of Chester Record Office

TRB/I/FF 19r-20u: Dee Bridge Committee Minute Books.

TRB/73: Telford to Holden, Secretary of the Dee Bridge Commissioners, May 1826.

TRB/75: Copy letter, Holden to John Finchett Maddock, Town Clerk, May 1827.

222

228

Cheshire Record Office

Acc. O.478: Plan of a steam boat harbour proposed to be constructed on the northern shore of the Dee estuary, T. Telford, March 1822.
Dublin-Chester Road.

Clwyd Record Office

Hawarden Dee Clwyd River Authority Minutes including reports by Telford 1817-19.

Devon Record Office (West)

Acc. 276/20: Autograph Letter. Telford to William Stuart, 1822.
Acc. 276/25: Copy of award to the Plymouth and Dartmoor Railway Company, 1822.

Dumfries and Galloway Regional District Council

Folio of drawings, etc. on the England-Northern Ireland Road 1808.
Dundee Archives and Records Office, Department of Administration, City Chambers.
Minutes of Dundee Harbour Trustees. 1824-1966. Letter-Books 1815-1927, plans 1814-92.

Durham Record Office

Londonderry Collection: Seaham Harbour: Lo/E/594 (mainly):
Telford-Buddle correspondence, 1823 and 1833.
Abstract of Telford's estimate for completing Seaham Harbour,
27th April 1833-38 August 1835.

Edinburgh District Council, Department of Administration, City Chambers
Plans of Dean Bridge, 1829.

University of Edinburgh Library

GEN. 715/8: Instructions respecting the Glasgow and Berwick Railway, 1809.

Folkestone Library

Proposed improvements to Folkestone Harbour, 1829, signed T. Telford.

Glasgow: The Mitchell Library

Telford to Robert Wylie, Clerk to the Committee of the Glasgow, Paisley and Ardrossan Canal, 14th February 1810: 18th November 1830.

Gloucester Record Office

Papers relating to the construction of Over Bridge, Gloucester and Berkeley Canal; Mythe Bridge and Western Canal. NRA 9191.

D.2159: Gloucester and Berkeley Canal.

Telford J. Phillpott, 15, 20 May 1820.

Telford - Chairman of the Company, 31st May 1820.

Telford-Charlton, 1st September 1820.

TS207/15: Western Canal.

Copy of Survey for the Western Canal, 1819. With letter.

Q/AB/3/3: Over Bridge. Reports and specifications.

Telford-Bloxsome correspondence, 1825-31. Also Telford to Hall and to Rev. Dr. Cooke.

Q/AB3/4b: Plan of Over Bridge, January 1826.

D2079 v1/1: Tewkesbury Bridge: Plan, March 1824.

D.2593: Plan of Toll House, 1824.

Gwynedd County Record Office

Plan of the intended new road from Bangor to Holyhead (6' x 1'9").

Hertfordshire Record Office

TP5/3: London to Holyhead Road: Minutes of the St. Albans Trust, containing Telford's reports relating to the Ridge Hill improvements of 1817-26.

Hopetown

Papers of the Marquess of Linlithgow: James Hope Letter Books: 14 volumes 1803-38. Archivist: B.C. Skinner, Department of Extra-Mural Studies, 11 Buccleuch Place, Edinburgh. (NRA 13863).

Ironbridge Gorge Museum Trust

Draft versions of Telford's autobiography.

- (a) Telford's first draft version with corrections and notes. Differs in form but not content from printed version. Last section on Metropolitan Water Works missing.
- (b) Telford's second draft with notes and corrections by Telford and Rickman. Very similar to printed version.

Publication of the Autobiography

Over seventy letters and accounts relating to the preparation and publication of the Life, 1835-38. Together with details of individual projects and Telford's character.

Bewdley Bridge

J. Cargill-Telford, 1833: short history of the construction of bridge.

Birmingham & Liverpool Junction Canal

Draft letter, Telford - J. Freeth, 30th December 1832.

J. Freeth - Telford, 15th January 1833.

Notes on the construction of the Canal, T. Telford.

Buildwas and Montford Bridges

Details of the costs.

Clifton Bridge

West - Telford, 21st April 1830.

A. Nicholson: Accounts, 17th May 1830.

Clifton Bridge (cont.)

T. Rhodes,: Accounts, 1829-30.

J. Osborne: Accounts, 1832.

Various Accounts and Receipts.

Ellesmere and Chester Canal

T. Stanton - Telford, 6th January 1834.

Ellesmere Canal and Poncysllte

Willson - Telford, 1829.

Gloucester and Berkeley Canal

Over three hundred papers relating to the construction of the Gloucester and Berkeley Canal, including a large number of Telford draft reports, letters and drawings, together with general correspondence on the construction of the canal. General accounts and contracts included.

Gotha Canal

Copy Letter. King of Sweden - Von Platen, 1808.

Copy Letter. Telford - Von Platen, 2nd June 1808.

Oddy - Telford, 21st May 1808.

Von Platen - Telford, 1808.

Harecastle Tunnel

J. Potter - Telford, 8th January 1833.

Holyhead Road

Stanly Sands Embankment: Notes, T. Telford.

St. Albans and South Mimms Trust: S. Mimms and Barnet improvement specifications.

Stonebridge and Dunchurch Trust: Coventry and Allesley section specifications.

Holyhead Road (cont.)

Stonebridge and Dunchurch Trust: Meriden Hill. Specifications.

Cosford Brook Section. Wolverhampton Trust: Specifications.

Anglesey Road Estimates. Lots 1 and 2.

Holyhead Road Repairs, 1816-18, W.A. Provis.

Holyhead Road and Menai Bridge: Notes, T. Telford.

Levels between Holyhead and Shrewsbury.

3rd Menai Bridge Report, 23rd April 1819, T. Telford.

Report on the construction of the road and details of surface.

Institution of Civil Engineers

Minutes of 18th January 1834.

J. Farey - Telford, 15th January 1834.

J. Bumner(?) - Telford, 15th January 1834.

Runcorn Bridge

1. Two copies of 1814 Report with additional reports on Latchford Bridge. T. Telford.
2. Notes on the strength of Iron, incomplete. T. Telford.
3. Dimensions and estimates for the bridge, T. Telford.
4. Committee minutes, 20th May 1817.
5. Details of ironwork, T. Telford.

Salop

Two draft letters: Telford - Sir. R. Smirke. July 1833.

Three draft letters: Telford - Loxdale, August 1833.

T. Stanton - Telford, 6th November 1833.

Ross - Telford, 10th July 1833.

G. Julien - Telford, 15th July 1833.

Loxdale - Telford, 22nd July 1833, 24, 25(2), 26 July 1833:

16, 18, 19 and 22 August 1833.

Draft Letter. Sir. R. Smirke² - Loxdale, 20th July 1833.

Shubenaccachie Canal

Twenty share certificates, 1st October 1829 with Receipt.

Subscription list.

J. Bainbridge - Telford, 20th August 1833.

Notes on the proposed project, T. Telford.

Draft letter. Telford - Bainbridge, 27th August 1833.

Draft letter. Telford - Hall, 15th August 1829.

Steam Carriages and Railways, 1833-34

J. Macneil - Telford: 5 letters, 1832-34.

Robertson - Telford: 3 letters, 1833-34.

R. Browne - Telford, 23rd October, 1833.

B. Dunkin - Telford, 24th October 1833.

Kent Archives Office

Q/ROM 69: Plan of Losse Viaduct.

Report on Dover Harbour, 1834.

Lincolnshire Record Office

3 Cragg 1/35 and Smith 9/2/13: Plan of a proposed navigation from Oakham through Stamford to Boston, the Stamford Junction Navigation or 40' Drain. Surveyed by Hamilton Fulton under Telford's direction, plan drawn by W.A. Provis.

W.J.C. Little, Craig, Langholm, Dumfriesshire

Large collection of correspondence between Telford and Little, 1780-1803.

Liverpool: Hornby Library

Telford - Rev. J. Warren, 1812: Telford - J. Jardine, 1833:

Telford - Mr. Schlichtegroll (?).

LONDONThe British Library

ADD.40272: Irish Communications.

Telford - Robert Peel, 7, 18 December 1817.

ADD.40385: Liverpool Mail Road.

Copy of letter; Telford - F. Freeling

ADD.38252 Aberdeen Harbour

Telford and Jessop - James Young, 10th November, 1812.

ADD.38756: Welland Canal

Report on the Welland Canal, 1828. Telford and Nimmo.

Miscellaneous Letters.

ADD.41963: Telford - Col. Pasley, 1813-16, 1830-31.

ADD.42582: Telford - W.R. Ellicombe, 22 June 1808.

ADD.44866: Telford - Dr. Kennedy, 23rd June 1808.

ADD.37186: Telford - C. Babbage, 3rd April 1832.

Plan and elevation of St. Katherine's Dock: included in Charles Goad's fire insurance plans of London, 1886.

Corporation of London Record Office

Misc. Mss. 2793: Correspondence relating to the London Bridge Act, including eight letters from Telford to the Bridge House Comptroller, Newman, 1823.

Misc. 277.16: Proceedings of the Bridge House Committee, including copy letters and reports by Telford.

Misc. Mss. 35.25: Telford and S. Walker to Peter Jeffery, 1831.

Plan M2 (or 355): Telford/Douglas designs for a new London Bridge.

P.D.91.7: Telford's plan of Thames borings, 1823.

Greater London Record Office

GCS85: Greenwich Commission of Sewers: Letters, reports of Telford relating to the rebuilding of part of the river wall, 1826-27.

235

Greater London Record Office, Middlesex Section

Ref. M.J./SPB: 195-6, 202-3, reports relating to the rebuilding of Brentford Bridge, 1823-4.

C. Hoare & Co., Bankers

Record of Telford's account, 1805-25, drawn upon during work on Crinan and Caledonian Canals.

House of Lords Record Office

Records of the Commissioners for Highland Roads and Bridges and the Caledonian Canal, 1803-56. Approximately 1,700 documents consisting of manuscript reports, surveys, estimates, specifications and official correspondence between Telford and John Rickman, Secretary to the Commissioners.

The Institution of Civil Engineers

A major collection of documents relating to numerous civil engineering projects, largely listed by The Historical Manuscripts Commission, including:

T/BL	Birmingham and Liverpool Rail Road
T/GB	Gloucester & Berkeley Canal and Stone Bridge
T/GC	Gotha Canal
T/HO	Holyhead Road
T/HU	Huddersfield Canal
T/LM	Liverpool and Manchester Railway
T/LO	London Bridge Project and Port of London
T/LL	London-Liverpool Railway Project
T/MT	Moreton-in-theMarsh Railway
T/NC	Newcastle-Carlisle Communications
T/SC	Scotland: Miscellaneous Projects

T/SH Shaftesbury-Honiton Road

T/SW South Wales Road Survey

T/TM Thames and Medway Canal

T/TR Trent and Mersey Navigation (NRA 14021)

T/MI Miscellaneous

Two volumes of Telford Drawings: Vol. 1, Bridges, Vol. 2, Canals and Railways.

MS. Vol. "Catalogue of Maps, plans and papers of the late Thomas Telford as bequeathed to the Institution of Civil Engineers".

Disposal register of Telford Drawings: MS. List in three volumes.

MS. Pocket Notebook: architectural memoranda; Aberdeen Canal, Ballater Bridge, Gotha Canal and Corpach section of the Caledonian Canal.

MS. Vol.: Architectural notes by Telford.

MS. Vol.: Canals of Burgundy (from Perronet's work).

MS. Vol.: Caledonian Canal, containing ink and wash drawings of machinery, etc., and Runcorn Bridge.

1824-25 Edinburgh: Dean Bridge, two bound volumes of correspondence, reports, etc; correspondents include J. Jardine, J. Learmouth, J. Gillespie Graham, Jas. Hope, Chas. Atherton and J. Gibb (NRA 16921).

MS. Book of Reference, 1824: Edinburgh-Morpeth mail road.

Highland Roads and Bridges, Copy Letter Books of Joseph Mitchell, 3 Vols., March 1830 - November 1834.

MS. Report on Mills, March 1790, illustrated.

MS. pocket notebook: Runcorn Bridge. Includes chain experiments and details of Brunton's Manufactory, 1814-17.

MS. Vol.: Severn Navigation, contains reports by W. Jessop, J. Nicholls, etc., invoices from Troughton, instrument maker, to Telford for level with achromatic telescope, August 1799.

MS. Vol.: Technical notes, possibly Telford's.

Port of London Authority: Archives Division

Minutes of the St. Katharine's Dock Company.

Public Record Office

Large amount of material relating to the Holyhead Road Commissioners, including MT (Ministry of Transport) 27/73-75, reports on the Holyhead Road.

MT.27/76 and 114: Telford's reports on the London-Liverpool Road; the Ketley-Chirk Road, The Highgate Archway Company.

Also: correspondence and accounts.

Ministry of Works accounts. Works 5/199/1-202/1 (Conway and Menai Bridges).

Ministry of Works, Miscellaneous Works 6/309, 310, 314-321.

Ministry of Works, Works 6/89-91 (Contracts for Shrewsbury-Holyhead Road, containing Telford correspondence).

Ministry of Works, Works 6/385/1. Reports on repairs to Westminster Bridge. See also Works 6/422 and 423.

PROB 10/5507: C/15776: copy of Telford's Will.

Ref. No. 2968: Two plans of Ludlow Mills by Telford.

NB Records in MT27, Work 5 and Work 6 are held in the P.R.O.'s country repository and require a week's notice before they can be produced.

Science Museum Library

William Reynolds' Sketch Book, containing early Telford drawings of cast-iron aqueducts.

Transport Record Office, 66 Porchester Road (transferring to the new P.R.O. building at Kew).

Large amount of material relating to Telford's canal projects, mostly in the form of Minute Books. See papers relating to the following: Birmingham Canal; Birmingham and Liverpool Junction Canal; Ellesmere Canal; Shrewsbury Canal; Gloucester and Berkeley Canal.

University of London Library, Senate House

A.L. 478(i): Telford-Rev. John Warren, Dean of Bangor, 23 September 1811.

Northamptonshire Record Office

Passing reference only to Telford reports in the Minutes of the Dunchurch-Stratford Road.

H. Pidgeon of Shrewsbury: reference to Telford in a letter of 1845.

Public Record Office of Northern Ireland

Small amount of material relating to Irish Communications.

Re. D562/20 62: Telford to Vansittart, July 1805.

Re. D562/20 73: Telford to G. Harrison, 1807.

Re. D207/67/37: Telford to J. Foster, April 1811.

Northumberland Record Office

Reports and correspondence relating to Morpeth Bridge, including Telford-Brummel correspondence, 1828-30.

Brooks Coll. Vol. XI. Telford to Morrison, 8th January 1810;

Telford to F. Chantry, 25th December 1824.

Norwich Central Library

Report of Thomas Telford on the proposed Navigation to Norwich,
December 1822.

Nottingham Record Office

Plan of the intended navigable canal from Grantham to R. Trent,
with collateral branch from Cropwell Butler to Bingham, 1792.
(Telford plan number 3091, Telford Bequest).

University of Nottingham Library

Pw Je 810-15: Papers relating to Eau Brink Cut and the Bridge over
the R. Nene at Sutton 1819-26.

978-1015: Reports and general papers relating to Fen Drainage,
including Telford's report on Lynn Harbour.

Museum of the History of Science, Oxford.

Ms. Mus: 'The New River': extract from Telford's report on the R. Lea.

Salop County Record Office

Large amount of material relating to Telford's work as County Surveyor
for Salop, including reports, estimates and official correspondence
with the Clerk to the Justices of the Peace.

Reports and estimates: Ashford Bridge; Bolas Magna Bridge; Meole
Brook Bridge; Montford Bridge; Sleepy Messe Bridge; Chirk Bridge;
Buildwas Bridge; Ledwych Bridge; Plans relating to the Ellesmere
Canal and the Birmingham and Liverpool Junction Canal.

Map of the intended canal with a branch to join the Shropshire and
Shrewsbury Canal at or near Donnington Wood, 1825, T. Telford.

Map of the proposed Newport branch of the Birmingham and Liverpool
Junction Canal, T. Telford.

Map of the proposed Newport branch of the Birmingham and Liverpool Junction Canal with the collateral branches or Railways shown, 1826, T. Telford.

Plan of the proposed reservoir and feeder to the Birmingham and Liverpool Junction Canal at Park Heath Brook, 1830.

Plan of the proposed line of canal from the Ellesmere and Chester Canal at Middlewich, T. Telford.

See also the Diary of K. Plymley.

National Library of Scotland

MS.1054,f4: Telford's pocket book for 1833.

Telford correspondence relating to various miscellaneous subjects.

MS.594, No. 2190: Telford to Alexander Gordon, October 1805.

MS.2909.ff16: Telford to George Attwood, January 1801.

MS.2909.ff.29: Telford to S. Hawkins, December 1804.

MS.2909.ff.36: Telford to Herry, April 1809.

MS.150.f.27: Telford to J. Campbell, December 1803.

MS.3432.ff.252,262,268: Telford to the Rev. D. Lee, 1810.

MS.5319.ff.257-61: Three letters from Telford to Archdeacon Alison, 1810.

MS.2528.ff.22: Telford to Southern, February 1817.

MS.8887.ff.29-31: Telford to Lee, 1824; to J. Hope, 1833; to Charles Atherton, 1833.

MS.5670.f.34; Telford to Robert Liston, May 1823.

MS.4026,4031: Telford to Blackwood, August 1829, February 1831.

MS.2956: Telford to Mackenzie, February 1830.

MS.5509: Telford to Alison, July 1829 and September 1832.

Aberdeen Harbour

Descriptive account of Aberdeen Harbour, J. Gibb, 1833; further description J. Gibb, 1833, with notes by Telford. R. Stevenson's

Aberdeen Harbour (cont.)

account, and letter to Telford from J. Gibb, 27th July 1830.

Trading tonnage for the Port of Aberdeen.

Accounts

Bills, accounts and receipts relating to various Telford projects, together with household expenses, etc., 1825-34.

Bengal Project

^t
Letter, Col. Pasley - Telford, 6th November 1830.

Broomiclaw Bridge and Harbour

Charles Atherton - Telford, correspondence, 1833-34, with drawings.

Cleland - Telford, 1833-34.

J. Saunders - Telford, 1st April 1833.

Copy letter, Telford - Cleland, 24th October 1833.

Copy letter, Telford - C. Atherton, 24th June 1833.

Numerous accounts, 1833-34.

Correspondence relating to the laying of the foundation stone, August 1833.

Draft letter from Telford on opening.

C. Atherton - Telford, 25th January 1834.

Cleland - Telford, 3rd February 1833.

A. Turner - Telford, 24th April 1834.

Canals and Railways 1833

Draft letter, Telford to Stanton, 25th July 1833.

Correspondence relating to Col. Page; open letter, Col. Page - Canal Companies.

Printed pamphlet on Canals v Railways, September 1833, T. Grahame.

T. Grahame - Telford: 6 letters, 1833; draft letter, Telford - Grahame, 24th January 1833.

J. McNeil - Telford, 31st January 1833; Table; J. Walker - Telford.

Board of Works printed account of the cost of building materials, 1824.

Canal Navigation by Steam

J. Gibb - Telford, 10th August 1832.

Chesterfield Canal and Railway

Observations on the Chesterfield Railway.

Courtown Harbour

Papers relating to Courtown Harbour, (Exchequer Loan Commission)
1826-33.

Copy Report, Francis Giles - Telford, 9th September 1833.

F. Giles - Telford: 3 letters, 1833; copy letter and instructions,
Telford - Giles, August 1833.

Copy of Mr. Brickwood's letter of instructions; 26th July 1833.

Draft letter, Telford - Brickwood, 18th September 1833.

Statements by Harbour Commissioners, 16th June 1826.

Report on Courtown Harbour, A. Nimmo, 28th February 1830.

Copy Letter, Harbour Commissioners - Brickwood, 3rd July 1833.

Copy of Report on Courtown Harbour, 24th June 1826. T. Telford.

Copy of Conditions of Bond.

Stopford - Telford, 13th August 1833; to Brickwood, 19th August
1833.

Dundee Harbour

James Saunders - Telford: 3 Letters, 1830-33.

Edinburgh Encyclopaedia

J. Hope - Telford, 23rd March 1833.

Draft letter, Telford to Blackwood, 27th September 1833.

J. Donaldson - Hope, 21st March 1833.

Edinburgh Encyclopaedia (cont.)

Minutes of the Edinburgh Ency., 8th March 1833.

Menzies and Donaldson - Telford, 8th August 1833.

Menzies - Telford: 2 letters 1833.

Blackwood - Telford, 30th September 1833.

Glasgow and Carlisle Road, 1821-34

Specifications for road making and repairs in Lanarkshire, 1819, 1821.

Telford draft letter relating to the Milkwater improvement, 22nd April 1834.

Prices for road making

Repairs to the Glasgow-Carlisle Road.

J. Pollock - Telford: 4 letters, 1821, 1823, 1834.

Glasgow Paisley and Ardrossan Canal

Receipts, 1808-17.

Green Park and Hyde Park

Reports on the state of the Green Park and Hyde Park Reservoirs.

T. Telford, 1829.

Holyrood Abbey

Notes on the history by Telford.

Liverpool and Manchester Railway

Expenses claims for survey work, T. Telford, 1829.

London and Birmingham Canal

J. Walker - Telford, 21st October 1833.

Lynn Harbour and Eau Brink

Fred Lane - Telford; 8 letters, 1830-34.

Townsend - Telford, 1833.

Macclesfield Canal

Small number of shares, 1826; Annual General Meeting Reports 1828, 1833, 1834.

Metropolitan Water Works

T. Casebourne and G. Turnbull: detailed accounts, 1831-32.

Telford notes, 15th August 1834; Expenses form, T. Telford, 1833.

List of people employed, T. Telford.

Page from the journal of C. Bowers.

J. Rilly - Telford, 20th December 1833.

Nene Outfall

Notes by Telford.

Minutes relating to the improvement of the R. Nene (outfall).

W. Swansborough - Telford, 4th April 1833.

New Brunswick Project

E. Douglas - Telford, 24th March 1824.

Draft reply from Telford, 13th June 1825.

Major Mure - Telford, 26th January 1833, 7th February 1833.

Over Bridge

J. Cargill - Telford: 3 letters, 1823-24.

Telford's draft description of the project, similar to version in first draft of Autobiography.

St. Helens and Runcorn Railway

Brickwood - Telford, November 1833. 30th October 1833.

Harwood and Bonner - Telford, 4th November 1833.

Receipts, J. Macneil, 10th January 1833.

St. Katharine's Dock 1823-27

J. Gibb - Telford, 2nd March 1823.

W. Hazledine - Telford; 3 letters, 1827; draft letter, Telford - Hazledine, 15th May 1827.

Share Certificates.

Telford's suggestions for a contract.

10 letters to Telford, from J. Towell, J. Hall, J. Thomas, Geo. Brown, Falkner, Freeman and Milne, 1825-26.

Memorandum re Docks and Basin, Wapping.

Scottish Roads

Bound volume of Reports relating to the construction of the Glasgow to Carlisle Road and Highland Roads and Bridges (1831).

Letters relating to the Publication and Preparation of Telford's Life

Approximately 100 letters mostly relating to Telford's Scottish work, 1835-38.

Weaver Navigation

S. Fowls - Telford, January 1833, including a plan of the sea wall between the Weston Canal and the R. Mersey.

Telford notes on the project.

Scottish Record Office

Very extensive collection of documents relating to Telford's work for the British Fisheries Society and the Commissioners for Highland Roads and Bridges and the Caledonian Canal. Including the following:
GDI/522/32: Clyde Navigation Trustees. 1824-1840.

Printed Minutes considering a Bill for the Improvement of the Clyde. River and Harbour Improvements; Scots Times, 26th July 1834.

British Fisheries Society

G.D.9: Telford's letter Books relating to work at Ullapool, Lockbay and Tobermory. 4 Vols., 1790-94 mainly to the Secretary of the Society, J. Mackenzie.

G.D.9 34, 83/1, 91, 93, 94, 276, 289, 295, 298, 300, 305, 393:

Mostly reports, plans and correspondence relating to Pultney Town, etc. Correspondents: J. Mackenzie, G. Saltern, W. Smith, Macrea, Roy and Robertson.

GD18/3314: Edinburgh-London Road. Sir. Geo. Clerk - Sir. J. Hamilton Dalrymple, 28th October 1827.

GD44/53/BOX I: Bundle ONE. Fochabers Bridge.

1. Letter of the 8th November 1830.
2. J. Stewart - the Duke of Gordon, 1st October 1829.
3. Charles Gordon - J. Spottiswood, 12th November 1803.

GD46/13: Seaforth Muniments.

GD80/944: 14 letters from Col. Duncan Macpherson re. Lochlaggan Road.

GD84/2/77: Roads and Bridges in Sutherland, Caithness and Ross, 1801-27.

GD121. Box 45: Bundle 244. Highland Roads and Bridges, 1779-1822.

GD128/128/2: Lochlaggan Road, 1805-11.

.29/3 and 3a: Parliamentary Roads, 1812-33.

GD135/82-84: Telford Report. Highland Roads.

GD201/5/1231: Inverness-shire Roads. 1781-1836.

GD221: Highland Roads, pre. 1806.

GD237/130/5: Dunkeld Bridge.

GD248/950/I: Gullen Harbour Specifications, 1823

.981/3: Craigellachie Bridge, 1813-14.

.981/6: Highland Roads and Bridges, 1806-13.

GD/253/94-97: Lanarkshire Roads, 1820-1834.

Including letters from J. Pollock, J. Lamb, J. Gibb and Admiral Flemming.

GD253.150-179: Hope Letter Books and Miscellaneous material relating to Highland Roads and Bridges, 1803-38.

The Caledonian Canal

M.T.I.: Caledonian Canal Letter Books, 9 volumes, 1803-33. Contain valuable information on the construction of the Canal and its early operation.

Vol. 1, 1803-6; Vol. 2, 1806-9, mostly Telford's correspondence with J. Rickman, Sec. of the Commissioners; Vol. 3, 1809-11, mostly Telford's correspondence with J. Rickman, Sec. of the Commissioners; Vol. 4, 1811-12, mostly Telford's correspondence with J. Rickman, Sec. of the Commissioners; Vol. 5, 1812-19, mostly Telford's correspondence with J. Rickman, Sec. of the Commissioners, Vol. 6, 1819-26, Telford Correspondence with Easton, Davidson and Rickman; Vol. 7, 1826-8, Telford correspondence with Davidson and Rickman; Vol. 9, 1830-33, Telford correspondence with Davidson and Rickman.

MTI/174-176: Minutes of the Caledonian Canal Commissioners, 1803-1845.

See also MTI/203 for Reports, Estimates and instructions by Telford and Jessop, 1804-10.

Estimates 1812-19, précis of correspondence and board minutes of the Caledonian Canal Commissioners, 1812-25.

Crinan Canal

BR/CRI/8/5 including correspondence between Telford and W. Thomson, Resident Engineer of the Crinan Canal.

RHP 11615-20, 11650, 11657, 12579-12638: large number of plans relating especially to Lanarkshire East-West and North-South roads and bridges thereon.

Shrewsbury Central Library, Local History Department

Extract from the Minutes of the Ellesmere Canal Company dealing with Telford's appointment as General Agent, 1793.

Somerset Record Office

D/T/yeo.35: Minutes of the Yeovil Turnpike Trust, 1825-27, relating to Telford's proposed improvements of the Shaftesbury-Honiton Road.

Series of ten letters between Telford and John Batten, Secretary to Yeovil Turnpike Trust, 1825-26.

Telford's observations on the Shaftesbury-Honiton Road, June 1826.

DD/BR/bul: Plan of the proposed new Turnpike Road from Bath to Melksham, 1826.

Staffordshire County Record Office

M.F.76: Microfilm copies of Telford correspondence included in Staffordshire and Worcestershire Canal Company Records.

Strathclyde Regional Archives, City Chambers, Glasgow

Large amount of material relating to Telford's work in the Glasgow area.

Clyde Port Authority

T-CN 3/21: Report on the navigation of the Clyde, T. Telford, 1806.

T-CN 3/23: Report on the improvement of the Broomilaw, Telford and Rennie, 1807.

T-CN 3/32: Report on proposed docks in the grounds of Dr. Reid, 1819.

T-CN 3/34: Report on the extension of Broomilaw Quay, 1821.

T-CN 12/2: Measurements and estimates of docks proposed near the Broomilaw Quay according to a plan by T. Telford, 1820.

References in passim in the minutes and accounts of the Clyde Navigation Trustees.

City of Glasgow Records

F13/1: Papers relating to Glasgow Water Works.

D-TC 13/255: Section of Dumbarton Road to Windmillcroft, 1819,
prepared under the orders of James Sprenll, for the use of T. Telford.

D-TC 13/298: Plan for the improvement of Broomilaw Bridge, not adopted.

Trades House Records

TD219/42: Forth and Clyde Canal papers, 1819-29, and correspondence,
1767-1880. (Campbell of Succoth Records).

T-TH.1/34: Glasgow-Ardrossan Canal papers.

Work Elsewhere

D-TC 13/757: Design for a new bridge over R. Don at Balgownie, 1828.

D-TC 13/757: (Nd) Aberdeen Harbour Improvement.

T.K.F. 1/y32: Plan of a possible Turnpike Road.

Surrey Record Office

33/8/1: Reference to Telford in the minutes of the Commissioners for
rebuilding Kingston Bridge.

42/67/1: Commissioners' account.

The Royal Library of Sweden

Papers relating to Telford's involvement in the construction of the
Gotha Canal, from the private correspondence of Count Baltzar von Platen.

Telford to Von Platen: 4 letters, 1808, 1828.

NB The Institution of Civil Engineers has obtained copies of
documents relating to the Gotha Canal from the Canal Office,
Motala, Sweden.

National Library of Wales

N.L.W. 10885 C: Note on the Holyhead Road, together with an estimate;
T. Telford, March 1822.

N.L.W. 14005 C: Telford to Hazledine, March 1822.

Chirk Castle Documents, Group E, No. 253: Thomas Lovett to Richard
Middleton concerning Telford's plan for Chirk Bridge, 1793.

Worcestershire Record Office

County Council Archives relating to Bewdley Bridge: r.250.1: three
office copies of a plan, elevation and section of Bewdley Bridge.

x.250: Plan of Bewdley Bridge, signed T. Telford.

705.550. Parcel number 303: 18 letters, diagrams, estimates and
other material relating to the construction of Bewdley Bridge, including
two letters from Telford to J. and S. Baker, 1795-96.

705.550. Parcel number 303: Account book for building Bewdley Bridge,
1797-1804.

Yorkshire Archaeological Society, Leeds

Slingsby papers: Report on the Knaresborough Canal, T. Telford, 1818.
(NRA 12891).

North Yorkshire County Library, Museum Street, York

York City Archives, M4: Minute Books of the Ouse Navigation Committee.
21st October 1833, includes a letter from Telford recommending a
Mr. Rhodes as Surveyor.

PRINTED PARLIAMENTARY REPORTS

1803-1834

1803

A Survey and Report of the Coasts and Central Highlands of Scotland.

T. Telford, 5th April 1803.

2nd Report from the Committee on the Survey of the Coasts of Scotland
Roads and Bridges, 3rd June 1803.

3rd Report: Caledonian Canal.

4th Report: Naval Stations and Fisheries, 20th June 1803.

1804

Report on the Crinan Canal Companies petition, 25th June 1804.

1st Report of the Commissioners for the Caledonian Canal.

1st Report of the Commissioners for making Roads and Building Bridges
in the Highlands of Scotland.

1805

2nd Report of the Commissioners for making Roads and Building Bridges in
the Highlands of Scotland, 19th June 1805.

2nd Report of the Commissioners for the Caledonian Canal.

1806

3rd Report of the Commissioners for the Caledonian Canal.

1807

3rd Report on Highland Roads and Bridges, 6th August 1807.

4th Report of the Commissioners for the Caledonian Canal.

1808

5th Report of the Commissioners for the Caledonian Canal.

1809

Report of the Select Committee on the Act now in force regarding the use of Broad Wheels and on the preservation of the Turnpike Roads and Highways of the Kingdom, 21st May 1809; 2nd Report, 30th May 1809; 3rd Report, 19th June 1809.

Report from the Committee appointed to examine Telford's Report and Survey relative to communications between England and Ireland by the North of Scotland, 15th June 1809.

4th Report on Highland Roads and Bridges.

6th Report of the Commissioners for the Caledonian Canal.

1810

1st Report of the Select Committee on Holyhead Road and Harbour, 21st March 1810.

2nd Report on the Holyhead Roads and Harbour, 9th June 1810 - pp.38-100 (including Rennie's 1802 Report and proposals for a bridge at Menai.

Report on Howth Harbour, 13th April 1810.

7th Report of the Commissioners for the Caledonian Canal.

1811

Report from the Committee upon the Roads between Carlisle and Port Patrick, 13th May 1811 (including Bridge designs).

Report from the Committee on Holyhead Road, 30th May 1811 (including Telford's original plans for Conway and Menai Bridges).

5th Report on Highland Roads and Bridges, 11th April.

8th Report of the Commissioners for the Caledonian Canal.

1812

9th Report of the Commissioners for the Caledonian Canal.

1813

6th Report on Highland Roads and Bridges, 26th March

10th Report of the Commissioners for the Caledonian Canal.

1814

11th Report of the Commissioners for the Caledonian Canal.

Statement on Highland Roads and Bridges, April.

1815

Report on Highland Roads and Bridges, 14th April.

Report from the Select Committee on Carlisle and Glasgow Roads,
28th June 1815.

Report from the Select Committee on Holyhead Road, 6th June 1815.

12th Report of the Commissioners for the Caledonian Canal.

1816

Reports from Committee on Estimates for the Crinan Canal, Caledonian
Canal, Highland Roads and Bridges,

13th Report of the Commissioners for the Caledonian Canal, 17th May 1816.

2nd Report of the Commissioners for the Repair of Highland Roads.

Report of the Commissioners for repairing the roads between London and
Holyhead by Chester and between London and Bangor by Shrewsbury,
May 1816.

Report of the Committee on Holyhead Harbour, 12th June 1816.

Crinan Canal papers, including Telford's Report of 1813.

1817

1st Report from the Select Committee on the roads from Holyhead - London
3rd June; 2nd Report, 6th June; 3rd Report, 23rd June; 4th Report,
3rd July; 5th Report, 7th July.

8th Report on Highland Roads and Bridges, 19th March 1817.

14th Report on the Caledonian Canal.

1818

15th Caledonian Canal Report, 1st June 1818.

4th Report on the repair of Roads and Bridges in Scotland.

1819

Holyhead Road, 1st Report from the Select Committee on the Road from
London - Holyhead, 2nd March 1819;

2nd Report, 6th April;

3rd Report (Menai Bridge), 29th April;

4th Report (Post Office Packets), 24th June 1818 (19?);

5th Report (Holyhead Mails and Packets), 6th July;

6th Report (Turnpike Trusts between London and Holyhead).

Papers relating to the building of a Bridge over the Menai Strait,
18th February 1819.

Report of the Select Committee on the Highways of the United Kingdom and
Minutes, 25th June 1819.

16th Caledonian Canal Report.

5th Report on the Repair of Roads and Bridges in Scotland.

1820

1st Report from a Select Committee on the Road from London, by
Coventry to Holyhead. Bridge at Conway, 27th June 1820;

2nd Report, Turnpike Trust, 28th June 1820.

1820 (cont.)

Holyhead Road: Reports of Mr. Telford to the Committee for the improvement of the Holyhead Road, upon the State of the Road between London and Shrewsbury: first report, 5th June; second report, 30th June.

Annual report on the Shrewsbury and Bangor Ferry Road, 5th June 1820.

17th Report on the Caledonian Canal, 1st June 1820.

6th Report on the Repair of Roads and Bridges in Scotland, March 1820.

Telford's Report on Northern Roads, 14th July 1820.

1821

18th Report on the Caledonian Canal.

9th Report of the Commissioners for Highland Roads and Bridges.

Report of the progress and present state of the Angelsey Road - Menai Bridge.

Report of the state of the road, T. Telford to the Commissioners.

Report of the state of the road from Shrewsbury to Bangor Ferry, 23rd March.

1822

Telford's Report on the Holyhead Road, March 1822.

Holyhead Harbour papers: Estimate.

19th Caledonian Canal Report and estimates, May.

8th Report on Highland Road and Bridge Repair, 22nd March 1822.

Report of the Select Committee on the Morpeth and Edinburgh Road, July 1822.

Annual Report on the Shrewsbury - Bangor Ferry Road, 1822, March.

1823

Report from the Select Committee on the Glasgow and Port Patrick Road,
24th June 1823.

20th Caledonian Canal Report.

9th Report on repair of Highland Roads and Bridges.

Annual Report of the Commissioners, Shrewsbury-Holyhead, 18th March 1823.

Report by Telford on the State of the Road from London to Holyhead,
April 1823.

1824

Report from the Select Committee on the Glasgow and Port Patrick Roads,
17th June 1824.

21st Caledonian Canal Report.

10th Highland Road and Bridge Repair Report.

Annual Report on the Shrewsbury and Holyhead Road, March 1824.

1825

Report of Evidence for Western Ship Canal.

22nd Caledonian Canal Act, May 1825.

11th Report on the Repair of Highland Roads and Bridges.

Annual Report on Shrewsbury-Holyhead Road, 1825.

Telford's Report on the Berwick and Morpeth Road.

1st Report on building churches in the Highlands of Scotland.

1826

Minutes of the Evidence taken before the Committee on the Norwich
and Lowestoft Navigation Bill, 26th April, 1826.

2nd Report of the Commissioner for Building Churches in the Highlands
and Islands.

1823

Report from the Select Committee on the Glasgow and Port Patrick Road,
24th June 1823.

20th Caledonian Canal Report.

9th Report on repair of Highland Roads and Bridges.

Annual Report of the Commissioners, Shrewsbury-Holyhead, 18th March 1823.

Report by Telford on the State of the Road from London to Holyhead,
April 1823.

1824

Report from the Select Committee on the Glasgow and Port Patrick Roads,
17th June 1824.

21st Caledonian Canal Report.

10th Highland Road and Bridge Repair Report.

Annual Report on the Shrewsbury and Holyhead Road, March 1824.

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11th Report on the Repair of Highland Roads and Bridges.

Annual Report on Shrewsbury-Holyhead Road, 1825.

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Minutes of the Evidence taken before the Committee on the Norwich
and Lowestoft Navigation Bill, 26th April, 1826.

2nd Report of the Commissioner for Building Churches in the Highlands
and Islands.

12th Highland Road and Bridge Repair Report, 23rd March 1826.

3rd Annual Account on the Holyhead and Howth Harbour, 29th April 1826.

Shrewsbury - Bangor Ferry Annual Report, 20th March 1826.

South Wales Road Survey, Postmaster General's Letter to the Treasury, 18th April 1826.

1827

1st Report of the Select Committee at the Milford Haven Communication, 11th April 1827.

2nd Report of above, 14th June 1827.

Annual Report, Shrewsbury-Holyhead Road.

Telford's Report on the Liverpool and London Road.

3rd Report of the Commissioners for building New Churches in Scotland.

13th Highland Road Repair Report.

23rd Caledonian Canal Report.

1828

Report on the Whetstone and St. Albans Turnpike Trust.

Report of the Commissioners on the Supply of Water to the Metropolis, 21st April 1828.

Annual Report on the Shrewsbury-Holyhead Road.

4th Report of Highland Churches.

14th Highland Road Repair Report.

24th Report on the Caledonian Canal.

1829

Annual Report, Shrewsbury-Holyhead Road, March 1829.

Telford's Report on London-Liverpool Road, April 1829.

15th Road Repair (Scotland) Report, March 1829.

25th Caledonian Canal Report, May 1829.

5th Report on Highland Churches, June 1829.

1830

Report of the Select Committee on the Holyhead and Liverpool Roads,
May 1830.

2nd Report of above, July 1830.

Report of the Select Committee on the State of the Northern Roads,
March 1830.

7th Report of the Commissioners for the Holyhead and Liverpool Roads.

Annual Report on the Shrewsbury-Holyhead Road.

16th Highland Road Repair Report.

26th Caledonian Canal Report.

1831

Annual Report of the Shrewsbury-Holyhead Road.

17th Highland Roads Report.

Select Committee on Steam Carriages.

6th Highland Church Report, October 1831

Report of the Commissioners on the Holyhead Road, October 1831.

Ditto, 8th Report, September 1831.

27th Caledonian Canal Report.

1832

28th Caledonian Canal Report, August 1832.

18th Highland Road Repair Act, March 1832.

9th Report of the Commissioners of the Holyhead Road, July 1832.

Annual Shrewsbury-Holyhead Report, March 1832.

1833

19th Highland Road Report.

Annual Holyhead Road Report.

10th Report of the Commissioners for the Holyhead Road.

1834

Report of the Select Committee on Metropolis Water Supply, August 1834.

1839

Report from the Select Committee on the Crinan and Caledonian Canal,
21st August 1839.

1840

Report of the Select Committee on the Caledonian Canal, June 1840.

1863

58th Report on Caledonian Canal, 7th July 1863.

Final Report of the Commissioners for the Repair of Highland Roads.

NOTE

The post 1834 Reports on the Caledonian Canal and Highland Roads and Bridges have been included as they contain much valuable material relating to the administration and maintenance of these works.

COMPANY AND PRIVATE REPORTS

1796-1834

1796

Report on Parker's Cement, T. Telford. British Library.

1801

Report by Telford to the Committee of the Ellesmere Canal.

1804

'Suggestions relative to the Canal from Glasgow to the West Coast of the County of Air', T. Telford to the Earl of Eglinton.

1805

Report on the Glasgow-West Coast of Air Canal and Harbour at Ardrossan
Nay, T. Telford.

Report of the Committee of the Ellesmere Canal.

Report on the General State of the Grand Junction Canal, May 1805.

1808

Report on the Intended Cumberland Canal from Bowness to Carlisle,
T. Telford. Institution of Civil Engineers.

1810

Report on the Edinburgh Water Supply, T. Telford.

Report on the Stamford Junction Canal, T. Telford.

Report on the Glasgow - Berwick Railway, T. Telford.

Report on Shoreham Harbour, T. Telford.

1811

Report on the Supply of water to the City of Edinburgh.

1813

Report on the improvements of the supply of water of the City of Edinburgh, Telford and Hope. Institution of Civil Engineers.

1814

Report on Dundee Harbour, T. Telford.

1815

Report on the Edinburgh Glasgow Union Canal, Telford and Baird.
Both Institution of Civil Engineers.

1817

Report on the River Dee Navigation, T. Telford. (Annual reports produced up to 1829).

Report on the Edinburgh and Glasgow Union Canal, T. Telford and Baird. Institution of Civil Engineers.

Reports on the Proposed Suspension Bridge at Runcorn, Telford.

1820

Report on Catterick Bridge, T. Telford.

1821

Report on the River Clyde. Strathclyde Regional Archives.

Report on the New Ferry Harbours on the Coast of Fife, T. Telford.
Institution of Civil Engineers.

1822

Report on the Norwich Navigation, T. Telford. Norwich Central Library.

1823

Report on the Eau Brink Cut, T. Telford and J. Rennie. University of Nottingham Library.

1824

Report on the English and Bristol Ship Canal, T. Telford.

1827

Report on the proposed New Sea Port on the Rivers Dee and Mersey,
Telford, Nimmo and Stephenson.

1829

Report on Morpeth Bridge, T. Telford.

Report on the Liverpool and Manchester Railway, T. Telford.

203

PRINTED WORKS BY TELFORD

Including Critical Reviews of Autobiography and Obituaries

Plymley, Joseph. General view of the Agriculture of Shropshire, London, 1803. Contains a chapter on canals by Telford.

Edinburgh Encyclopaedia. Contributed Articles on Architecture, Bridge Building and Canal construction.

Rickman, J. (Edited). The Life of Thomas Telford written by himself, 1838. Atlas to the Life of Thomas Telford, 1838.

Brewster, Sir David. Review of Autobiography, Edinburgh Review, October 1839.

Southey, R. Review of Autobiography, Quarterly Review, January-March 1839.

Annual Register, 1834: Obituary Notice.

DATE	ENGINEER	CANAL	SALARY	SOURCES
1769	Brindley	Coventry	£150 p.a.	Boucher, James Brindley, 1968, p67 -68.
"	"	Oxford	£200 p.a.	ibid.
1768	"	Droitwich	£60 p.a.	ibid.
1768	"	Birmingham	£200 p.a.	ibid.
1771	"	Chesterfield	£300 p.a.	ibid
1766	"	Trent & Mersey.	£200 p.a.	ibid
1768	Smeaton	Forth & Clyde.	£500 p.a.	Lindsay, The Canals of Scotland, 1968, p20.
1768	Watt	Monkland	£200 p.a.	ibid.
1793	Telford	Ellesmere	£300 p.a.	Hadfield, The Canals of the West Midlands, 1968, p169.
1800.....	no further information available.			

Appendix 2. Table of Engineers Salaries, 1750-1830.

CALEDONIAN CANAL - BREAKDOWN OF EXPENDITURE

Appendix 3.

	1805			1806			1807		
	Yearly Expenditure	% Total	Cum. Total Expenditure	Yearly Expenditure	% Total	Cum. Total Expenditure	Yearly Expenditure	% Total	Cum. Total Expenditure
1. Management	[1] 2304	7.6	3382	[1] 1802	3.6	5184	1181	2.2	6329
2. Timber & Machinery	17790	47.2	20004	12692	25.6	33696	3655	6.9	37349
3. Quarries & Transport	4604	11.17	5016	10366	20.0	15382	14658	27.72	30040
4. Labour by day and by measure	15032	29.34	15697	21765	45.2	37457	22929	43.9	60386
5. Land	183	.4	183	[3] 5216	10.5	5399	10233	19.4	15623
TOTALS	[2]38114	-	44282	[2]51841	-	97118	52656	-	149774
Notes	<p>[1] The headings have ^{been} grouped from the following titles which were entered separately in the official accounts.</p> <ol style="list-style-type: none"> unchanged timber and machinery treated separately. includes quarries, shipping, and horses. labour by day and labour by measure treated separately. unchanged <p>[2] The totals do not include charges made for workmens' accommodation and stamps and postage as these are of no real importance. They will be given, however for 1822, the year of the opening</p> <p>[1] The table was started in 1805, the first full year of canal construction, although work had been going on since the autumn of 1803 in a very low key as can be seen from the cumulative totals of 1805.</p> <p>[2] All accounts from 1803 onwards were audited and totalled ending May of each year.</p> <p>[3] Land purchase heading includes payment of damages.</p>								
Sources	2nd Caledonian Canal Report	3rd Caledonian Canal Report			4th Caledonian Canal Report				

	1808		1809		1810	
	Yearly Expenditure	% Total Yearly Expenditure	Yearly Expenditure	% Total Yearly Expenditure	Yearly Expenditure	% Total Yearly Expenditure
	Cum. Total Expenditure		Cum. Total Expenditure		Cum. Total Expenditure	
1. Management	1765	4.2	8094	3.1	1475	2.9
2. Timber & Machinery	4143	9.8	41492	11.7	4048	7.9
3. Quarries & Transport	14164	33.92	44204	36.52	16310	32.4
4. Labour by day and Measure	21015	50.3	81401	46.7	27935	55.6
5. Land	127	.3	15750	.9	250	.4
TOTALS	41214	-	190941	-	50018	-
Sources	5th Report on the Caledonian Canal		6th Report on the Caledonian Canal		7th Report on the Caledonian Canal	

1811

1812

1813

	Yearly Expenditure	% Total Expenditure	Cum. Total Expenditure	Yearly Expenditure	% Total Expenditure	Cum. Total Expenditure	Yearly Expenditure	% Total Expenditure	Cum. Total Expenditure
1. Management	1221	2.2	12220	1522	2.5	13742	1943	3.9	15636
2. Timber & Machinery	6521	12.11	57492	7831	12.9	65323	12239	24.8	77562
3. Quarries & Transport	15522	28.9	92876	16796	27.85	109672	9257	18.75	118929
4. Labour: day & measured	28299	52.9	159215	32234	53.6	191432	21782	44.0	213214
5. Land	1733	3.2	18174	597	.99	18773	3887	7.8	22660
TOTALS	53296	-	339977	58980	-	398942	49108	-	448001
Sources	8th Caledonian Canal Report			9th Caledonian Canal Report			10th Caledonian Canal Report		

	1814			1815			1816		
	Yearly Expenditure	% Total Expenditure	Cum. Total Expenditure	Yearly Expenditure	% Total Expenditure	Cum. Total Expenditure	Yearly Expenditure	% Total Expenditure	Cum. Total Expenditure
1. Management	1547	4.1	17234	1956	3.7	19180	1389	2.6	20569
2. Timber & machinery	4080	10.8	81642	11886	22.5	93528	16279	31.3	109807
3. Quarries & Transport	10839	28.88	129768	6742	12.64	136510	4473	8.37	140983
4. Labour: day and measured	21818	52.9	[1]235032	24424	46.1	[1]259456	21080	40.5	280536
5. Land	871	2.3	23531	7500	14.2	31031	8624	16.6	39655
TOTALS	39155	-	487156	52496	-	539652	51845	-	591550
Notes	[1] The cumulative labour total for 1814 is given in the Report as £233,085.			[1] Cumulative total given in report as £257,510.					
Sources	11th Caledonian Canal Report			12th Caledonian Canal Report			13th Caledonian Canal Report		

1817

1818

1819

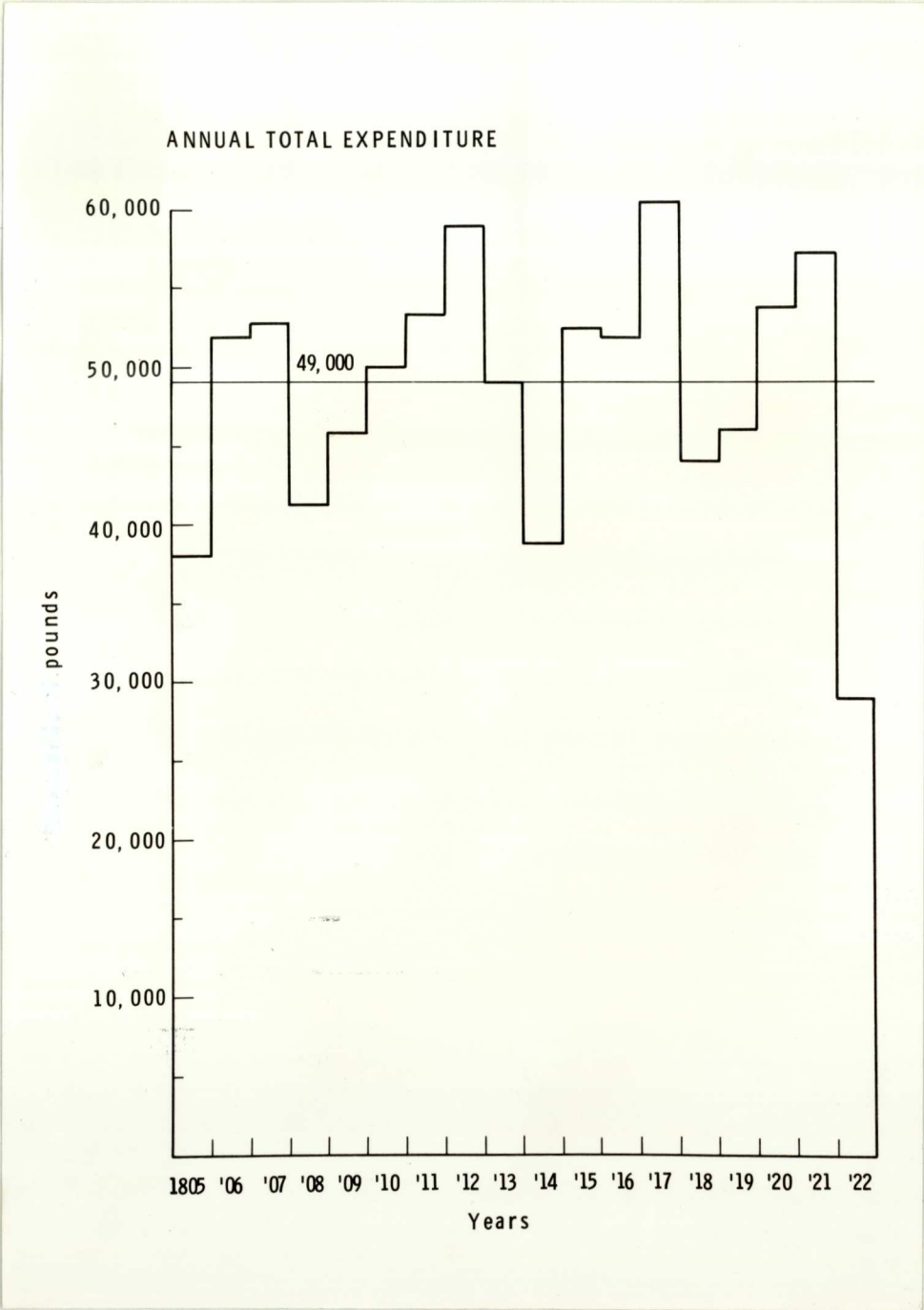
	Yearly Expenditure	% Total Expenditure	Cum. Total Expenditure	Yearly Expenditure	% Total Expenditure	Cum. Total Expenditure	Yearly Expenditure	% Total Expenditure	Cum. Total. Expenditure
1. Management	1539	2.7	22108	1394	3	23502	1317	2.7	24819
2. Timber & machinery	24033	43.0	133840	14370	31.7	148210	8533	17.9	156743
3. Quarries & Transport	5568	9.7	146551	6581	14.4	153131	12001	24.7	165132
4. Labour by day & measure	28402	50.98	308938	22139	48.87	331077	20899	43.9	351976
5. Land	1054	1.89	40709	323	.7	41032	3253	6.8	44285
TOTALS	60596	-	652146	44806	-	696952	46003	-	742955
<u>Sources</u>	14th Caledonian Canal Report			15th Caledonian Canal Report			16th Caledonian Canal Report		

1820

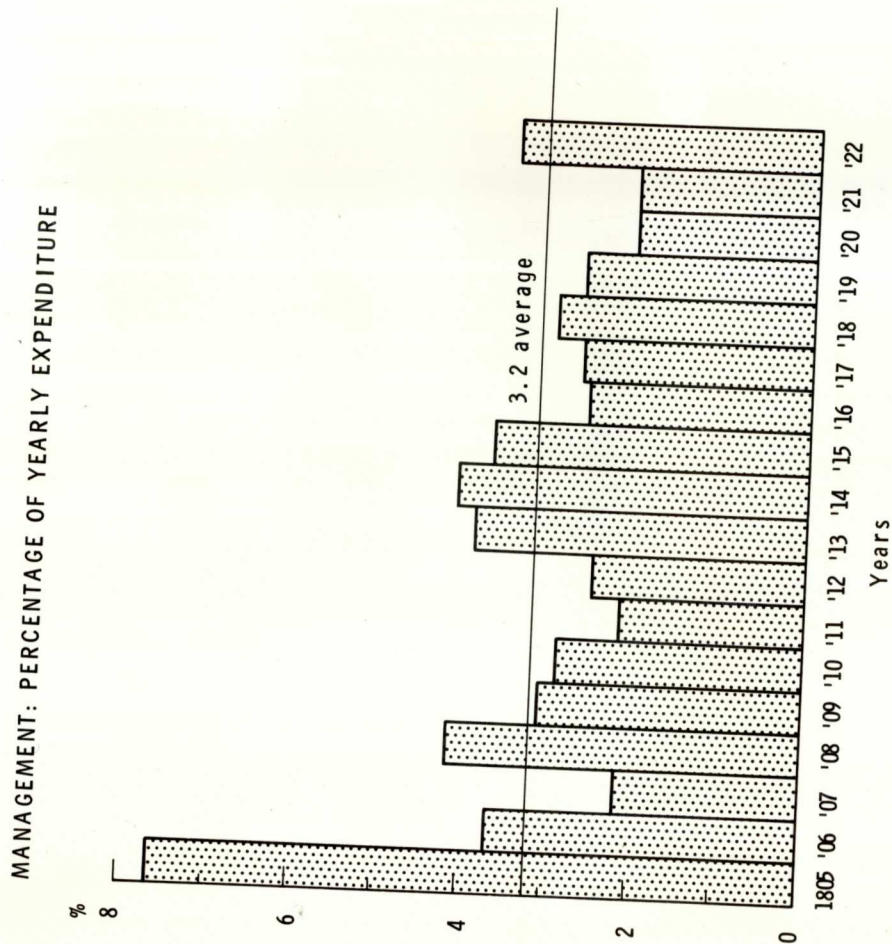
1821

1822

	Yearly Expenditure	% Total Expenditure	Cum. Total Expenditure	Yearly Expenditure	% Total Expenditure	Cum. Total Expenditure	Yearly Expenditure	% Total Expenditure	Cum Total Expenditure
1. Management	1152	2.1	25971	1209	2.1	26974	1038	3.5	28013
2. Timber & Machinery	7546	13.8	164289	19992	34.7	184281	6217	18.8	185,349
3. Quarries & Transport	19147	34.2	184279	14404	25.0	198683	6101	21	204784
4. Labour by day and measure	24069	44.0	376045	20614	35.7	396659	14673	49.7	408234
5. Land	1804	3.3	46089	993	1.72	47084	598	2.0	47683
TOTALS	53718	-	796673	57212	-	853681	29225	-	882310
<u>Sources</u>	17th Caledonian Canal Report			18th Caledonian Canal Report			19th Caledonian Canal Report		

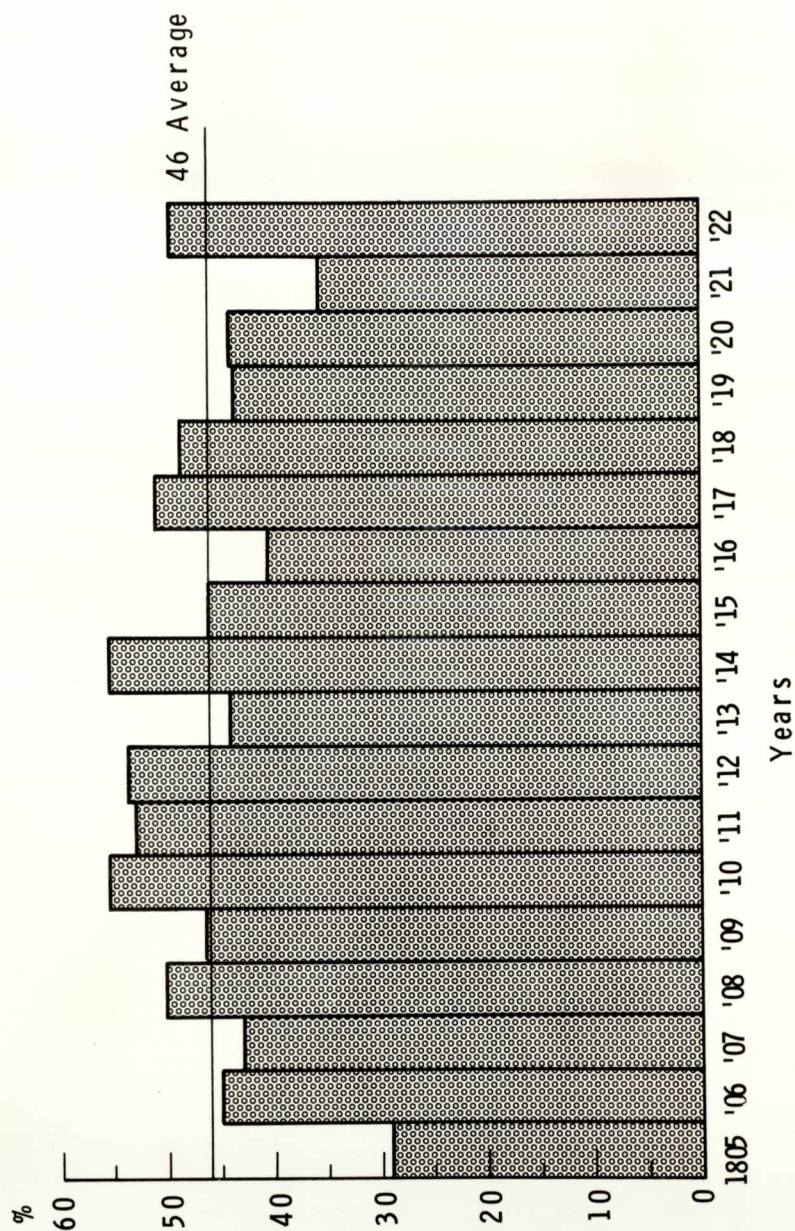


Appendix 4.Graph showing the Annual Total Expenditure on the Caledonian Canal, 1805-1822.



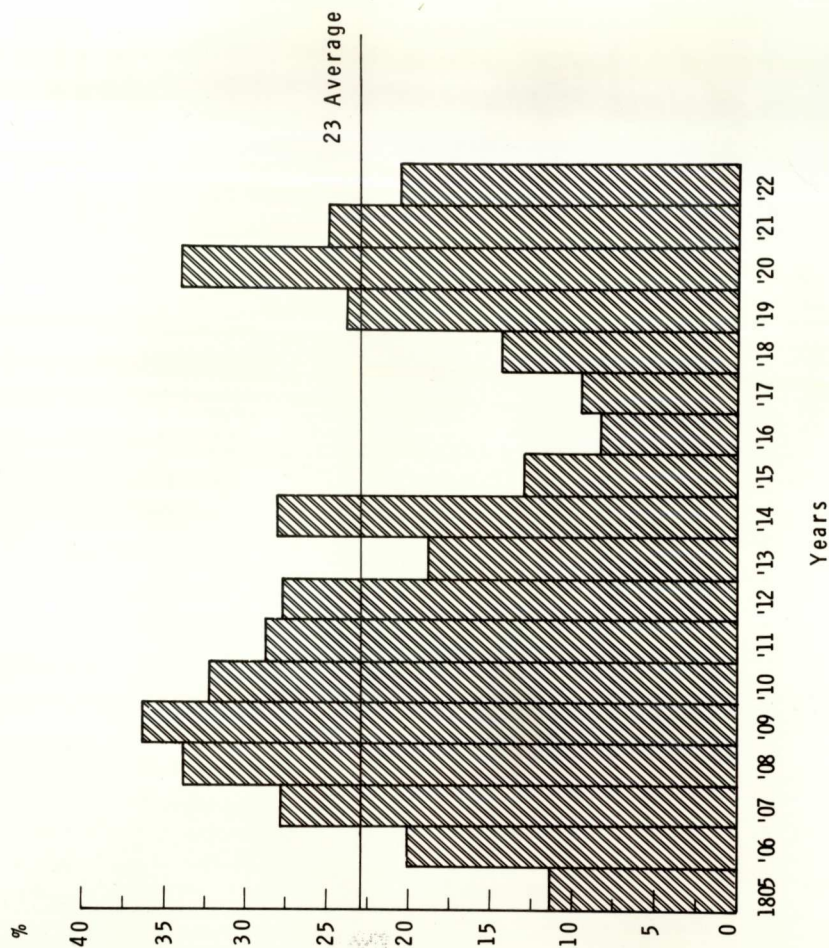
Appendix 4.Graph showing the percentage of yearly expenditure on Management on the Caledonian Canal,1805-1822.

LABOUR BY DAY AND BY MEASURE: PERCENTAGE OF YEARLY EXPENDITURE



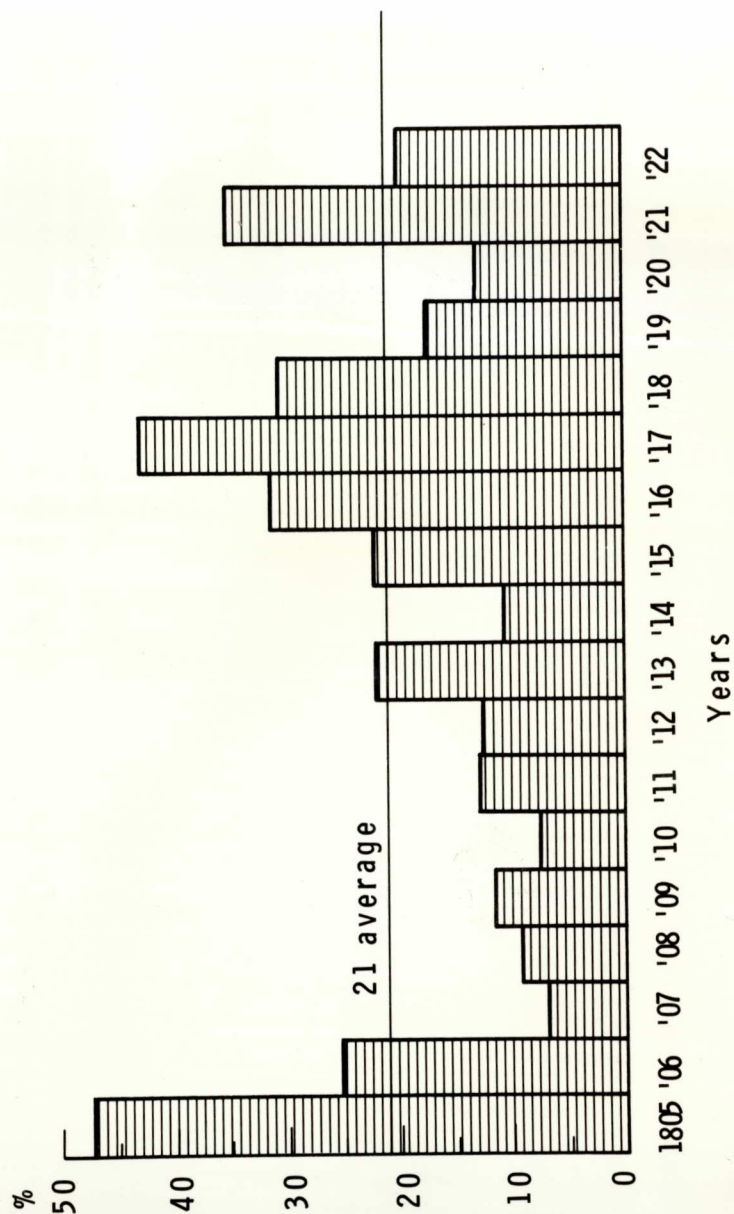
Appendix 4. Graph showing the percentage of yearly expenditure on Labour by Day and by Measure on the Caledonian Canal, 1805-1922.

QUARRIES AND TRANSPORT: PERCENTAGE OF YEARLY EXPENDITURE



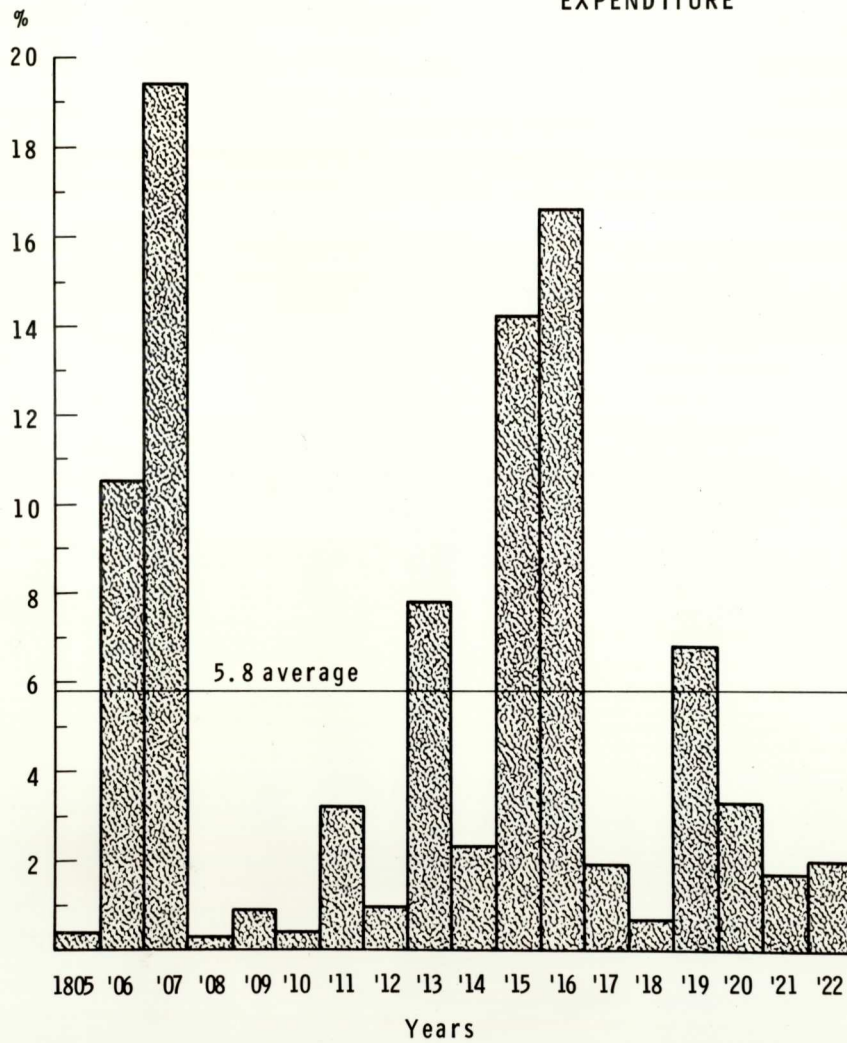
Appendix 4. Graph showing percentage of yearly expenditure on Quarries and Transport on the Caledonian Canal, 1805-1822.

TIMBER AND MACHINERY: PERCENTAGE OF YEARLY EXPENDITURE



Appendix 4. Graph showing percentage of yearly expenditure on the Purchase of Timber and Machinery on the Caledonian Canal, 1805-1822.

LAND PURCHASE AND DAMAGES: PERCENTAGE OF YEARLY EXPENDITURE



Appendix 4. Graph showing percentage of yearly expenditure on Land Purchase and Payment of Damages on the Caledonian Canal, 1805 - 1822.

<u>Appendix 5</u>	£
Alford Bridge	2,000
Alford Road	4,089
Ardelne Road	720
Ardnoe Road	1,300
Arran Roads	3,888
Asheik Road	2,482
Asheik Ferry Pier	1,536
Avoch Harbour	1,056
Ballater Bridge	3,904 319
Ballenoch Road	783
Ballichernoch Road	726
Ballintraed Landing Pier	2,333
Bamff Harbour	16,000
Beauley Road	7,797
Black Isle Road	8,422 3,521
Bonar Bridge	13,971
Broadford Road	3,000
Burgh-Head Harbour	4,000
St Catherine's Ferry Pier	166
Channery Pier	1,300
Conan Bridge	6,854
Craigellachie Bridge	8,200
Creech Road	1,616
Crinan Road	287
Cullen Harbour	4,141
Dingwall Canal	3,800
Dunbeath Road	14,448

<u>Names of Roads, Bridges and Harbours</u>	<u>Joint Expenditure</u>
Dunkeld Bridge	13,361
Dunrobin Road	6,897
Fairness Bridge	1,255
Fearn Road	10,782
Findhorn Road	4,603
Fleet Mound and Roads	9,290 2,499
Fort Augustus Road	856
Fortrose Harbour	4,015
Frazerburgh Harbour	11,321
Glasgow Road	50,000
Glendaruel Road	3,839
Riddan Road	395
Glengarry Road	8,339
Glenmorrison Road	4,630
Glensheill Road and Glenelg Road	14,918 8,806
Kyle Rhea Ferry Piers	1,146
Gourdon Harbour	2,000
Helmsdale Bridge	2,176
Inverfarigag Road	4,128
Invergordon and Inverbreckie Ferry Piers	1,437
Invermorrison Road	4,892
Islay Road	1,513
Jura Road	4,330
Small Isle Harbour	747
Keils Road	228
Keils Ferry Pier	130
Kilmelford Road	2,050

<u>Names of Roads, Bridges and Harbours</u>	<u>Joint Expenditure</u>
Kintail Road	10,611
Kirkwall Harbour	3,912
Kishorn Road	5,301
Laggan Road	23,293
Lanarkshire Roads	
Loch Carron Road	4,538
Divisions	1,072
	3,596
	7,674
	7,058
	1,163
	1,887
Lochie Side Road	5,179
Loch-na-Gaul Road	8,711
Lochie Ferry Piers	329
Lovat Bridge	8,802
Moy Road	3,374
Moydart Road	11,703
Corran Ferry Piers	993
Nairn Harbour	3,225
Peterhead Harbour	7,800
	23,400
Portmaholmach Harbour	3,168
Portree Road	5,000
Portree Pier	692
Potarch Bridge	4,067
Rhiebuie Road	7,106
Sconser Road	4,572
Skibo Road	4,557
Snizort Road	4,238
Spey-Side Road	6,521

Stein Road	3,679
Strachur Road	2,333
Strath Fleet Roads	
Strath-Glas Road	13,051
Strath-Spey Road and Bridges	1,568
Tain Road	8,004
Tarbet Harbour	1,705
Thurso Road	13,365
Tobermorey Harbour	2,853
Tongue Road	16,552
Trotternish Road	7,605
Wick Bridge	2,000