DOCTOR OF PHILOSOPHY

The economic and technological development of the slate quarrying industry in the Nantlle Valley, Gwynedd

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SUMMARY OF

"THE ECONOMIC AND TECHNOLOGICAL DEVELOPMENT OF THE SLATE QUARRYING INDUSTRY IN THE NANTLLE VALLEY, GWYNEDD."

In this thesis the author seeks to identify and analyse the main factors which influenced the economic and technological development of the slate quarries of the Nantlle Valley, Gwynedd. The subject is characterised by a complex interaction of a variety of external and local factors, and is consequently discussed thematically. Whenever possible, the local trends are placed within the context of the general history of the North Wales slate industry, which itself was subject to the broader economic and technological developments in the U.K. and other countries.

<u>CHAPTER 1</u> discusses the general development of the slate industry at Nantlle from its possibly Roman roots to the present day. This is done within the context of the industry regionally, and with reference to the role of market forces on the fortunes of the individual quarries.

<u>CHAPTER 2</u> analyses the sources of capital and investment which was vital for the development of the quarries, categorises the different types of capital structures which were found in the industry in response to changes in legislation and financial systems, and attempts to analyse the overall profitability of the quarries.

Summary

CHAPTER 3 discusses the modifications required at Nantlle in the quarrying and production methods, to cope with the local conditions of geology, topography and landowning.

CHAPTER 4 charts the mechanisation of the various processes involved in slate quarrying, and identifies the role of the Nantlle quarries in the application of various technologies to different strands of the industry.

CHAPTER 5 discusses the economics and practical problems of transporting the finished products from the quarries to the markets, and describes the different systems used locally at various periods of time.

APPENDICES contain additional data and technical information, supplementing that provided in tables and illustrations within the text.

DECLARATION

This work has not previously been accepted in substance for any degree, and is not being concurrently submitted for any degree.

Signed: .... (candidate)

Date: ......28 March 1996..........................

STATEMENT 1

This thesis is the result of my own investigations, except where otherwise stated.

Other sources are acknowledged by notes giving explicit references. A bibliography is appended.

Signed: ... . (candidate)

Date: ....28 March 1996......................

STATEMENT 2

I hereby give consent for my thesis, if accepted, to be available for photocopying and for inter-library loan, and for the title and summary to be made available to outside organisations.

Signed: .... (candidate)

Date: ....28 March 1996......................

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This thesis is, above all, a testimony to the generations of quarrymen who have toiled in the slate quarries of the Nantlle district. I am deeply indebted to all of the quarrymen and former quarrymen who co-operated wholeheartedly over a period of three decades with the efforts of the author to trace the details of machinery, structures and operators of the quarries. In the face of the destruction of most of the relevant primary documents, this invaluable information would otherwise have ultimately been lost with the passing of these eye-witnesses, who are individually credited in the Bibliography.

This thesis is also dedicated to the memory of the late D. Dylan Pritchard, M.A, a native of the Nantlle district, whose comprehensive research of the economics of the slate industry has provided a firm foundation for the efforts of the present author in the same field.

I also wish to thank the staff at the Caernarfon Records Office, at University of Wales, Bangor, at the National Library of Wales Aberystwyth, and also the Economic Development & Planning Department of Gwynedd County Council, for their courteous and efficient service and advice. Antur Nantlle and Gwasg Dwyfor, Pen-y-groes, generously provided photocopying facilities, and their support is gratefully acknowledged.

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PREFACE

North-west Wales was formerly the world's leading producer of roofing slates and slab products, exploiting an abundant supply of this fissile rock within the Cambrian, Ordovician and Silurian strata of the region. An existing small scale productive capacity of long standing was transformed during the eighteenth and nineteenth centuries by largely external investment into a major industry which expanded on the basis of the superior quality and competitive pricing of its products. The profitability of this industry was subsequently boosted by the increasing demands of urban and industrial developments both in Britain and abroad.

The wide distribution of the slate strata throughout North Wales encouraged attempts to exploit this natural resource in many localities throughout the region. Nevertheless, fewer than a half of the four hundred or so slate quarries which were opened in this region enjoyed any degree of commercial success, and the main economic strength of the industry was restricted to no more than ten per cent of this total. The main concentration of the largest and most profitable quarries was located within the five districts of Bethesda, Llanberis and Nantlle (in Caernarfonshire) together with Blaenau Ffestiniog and Corris (in Merionethshire).

This thesis seeks to investigate the inter-related economic and technological development of one of the major slate-producing districts, namely the Nantlle Valley. This area affords and opportunity to analyse the economic and financial forces which affected the slate industry across a wide spectrum of scale and types of capitalist concerns.

Furthermore, an evaluation of the development of quarrying techniques and technology can be gleaned from the responses of the slate proprietors to the challenging technical problems encountered in this district.

Notwithstanding the historical complexity of discussing the economic history of about forty original quarry sites within the Nantlle district, many of which had been amalgamated to form the main sites recognised today (see Table 1, below), the inter-relationship of the various topics within the field of study has dictated the structuring of this thesis on a thematic basis.

Following a preliminary summary of the history of the Nantlle slate quarrying district (Introduction), subsequent chapters discuss (1) economic developments, (2) financial considerations, (3) working practices, (4) the mechanisation of quarrying processes, and (5) the development of transport systems. It should be stressed that the social history of the Nantlle district is not included in this thesis, primarily due to considerations of text length, and also because this forms part of a wider subject which has already been discussed in several academic studies and publications.

Any study of the slate industry in the Nantlle Valley has to contend with the potential confusion arising from the variations in size and title at different periods of the large number of quarries found in this area. In order to overcome the difficulty of defining the relative scale of the individual quarries, a standard simplified categorisation of 'large' (categories A & B, Table 1 below), 'medium' (categories C & D) and 'small' (categories E & F) is used within. More accurate data for individual quarries are available in the Appendices.

TABLE 1

CATEGORIES BY FINAL WORKING SCALE OF NANTLLE SLATE QUARRIES (MAIN SITES)

GROUP A	GROUP B	GROUP C
Dorothea	Alexandra	Braich
Penyrorsedd	Cilgwyn	Cloddfa'r Coed
	Cloddfa'r Lôn	Coedmadog
	Moeltryfan	Fron
	Talysarn & Blaen Cae	Fronheulog
		Galltyfedw
		Penybryn (New)
		South Dorothea
		Tanrallt
		Tynyweirglodd

GROUP D	GROUP E	GROUP F
Gwernor	Brynfferam	Bryncastell
Llwydcoed	Crown New	Chwarel Wm. Owen Jones
Old Braich	Foel Clynnog	Cilcoed/St.Beuno?
Ty Mawr East	Old Penybryn	Coch-y-bîg/St.Winifred?
Ty Mawr West	Pwll Fanog	Cwm Dulyn
Tyddyn Agnes	Singrig	Gelli Bach
	Twll Coed	Pretoria
	Twll Llwyd	Talmignedd
	Ty Mawr West Green	Ty'n Llwyn
	Ty Mawr East Green	Upper Tyddyn Agnes
	Taldrwst Lower	
	Taldrwst Upper	

GROUP CRITERIA FOR TABLE 1

A Largest quarries in district, employing at maximum 550-600 men.
B Large concerns, employing up to 400 men at peak.
C Medium-sized concerns, employing up to 250 men.
D Medium-small quarries, employing up to 100 men.
E Small quarries, employing up to 50 men, with some production.
F Trial (failed) quarries, with little production achieved.

INTRODUCTION

The historical perspective

The Nantlle district, located seven miles south of Caernarfon, is an area distinguished by marked contrasts between its constituent sub-divisions. Its focus is the main valley, a glacial trough at around 400-feet above sea level, which cuts into the Snowdon foothills with an east to west orientation. To the north and south of the western end of the valley, the 2,000 foot high peaks give way to tracts of moorland plateau of around 1,000 feet altitude [1]. The valley mouth opens to the west onto a platform of glacial debris before plunging down to a narrow coastal strip which has suffered considerable marine erosion which is still continuing (see Figure 1).

The fertile western, lower-lying ground and the grazing land of the upland plateau both supported human settlements of some density from very early times. Despite the destruction of several ancient sites during the nineteenth century, there still survive a number of denuded fortified settlements and clusters of round-houses (known locally as *Cytiau Gwyddelod*) [2]. Furthermore, the cultural associations of the district with one of the epic lores of the *Mabinogion* places Nantlle in an important position in the heritage of the Welsh nation. The root-name of 'Nant-lleu' is itself directly derived from that of the principal character, *Lleu Llaw Gyffes*, and the district abounds with distinctive place-names which provide a continuing reference to this legend [3].

The coastal lowland along the western perimeter of the Nantlle district became the main centre of settlement in this area during the Middle Ages because of its relatively rich agricultural land, with the upland *hafotai*

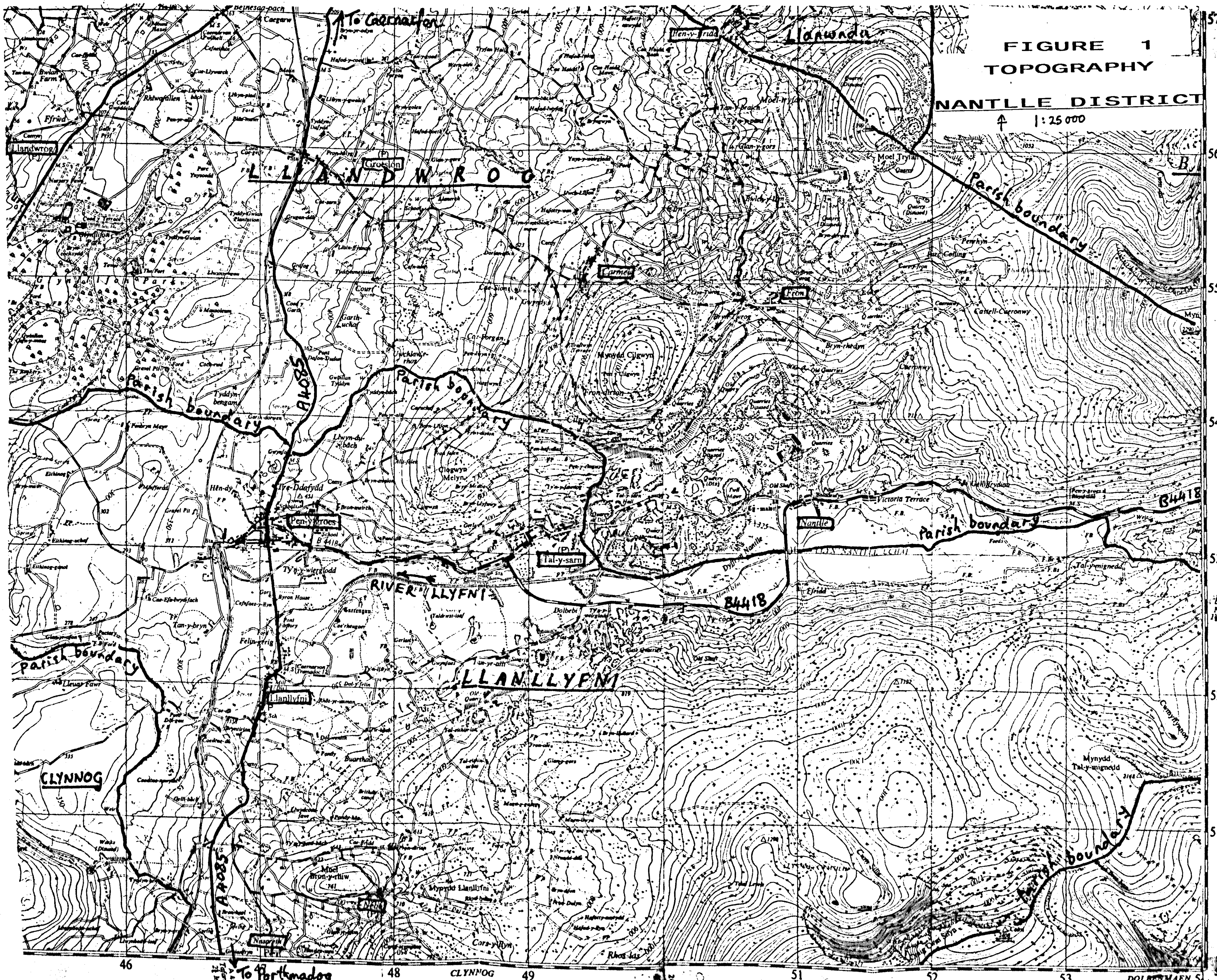


FIGURE 1
TOPOGRAPHY
NANTLLE DISTRICT
1:25 000

being occupied principally during the summer as part of the agricultural system of trans-humance. Whereas the long-standing occupation of the land near the coast had been organised within the Welsh land tenure system (comprising of the *trefi* of Dinlle, Eithinog, Llyfni and Penarth within the *cwmwd* of Uwch-Gwyrfai in the *cantref* of Arfon), the thickly afforested valley floor and much of the eastern upland was for centuries reserved as a royal hunting ground for both the Welsh and subsequent English ruling dynasties [4].

With the exception of some portions of the upland commons that remained in the hands of the Crown until the 1960s, the central and south-western portions of the Nantlle district were progressively developed into freehold agricultural holdings from the fifteenth century, although the piecemeal progress of the de-aforrestation that was largely completed during the seventeenth century created a jig-saw pattern of private landholdings. This was in stark contrast to the more orderly pattern of discrete landed estates established on the coastal lowlands by virtue of a process of gradual evolution. Although the fragmented landowning pattern of the main valley was subsequently rationalised through purchases and inheritances, and much of the area became absorbed into larger landed estates, there remained a complex interlacing of properties which was to have an important effect upon the subsequent development of the slate industry (see Chapter 3, infra) [5].

The Nantlle district was blessed with a variety of natural resources which had the potential to provide a greater source of wealth than the original agricultural economy. Metal ores of copper, lead, manganese and zinc were present in the Ordovician strata found on the south and east flanks of the valley, and were exploited with various degrees of success at different periods from the Bronze Age to the 1920s. The majority of the metallic ores were, however, economically disappointing in comparison with the copper deposits, because the veins were either too thin or were not sufficiently rich in metal content [6].

Despite the undoubted periodical importance during the eighteenth and nineteenth century of the Drws-y-coed copper mines, which achieved the deepest metal-ore workings in Snowdonia, their contribution to the economic prosperity of the Nantlle district was eclipsed by the development of the slate industry in this area. The quarries at Nantlle worked the same body of Cambrian strata that provided the vast wealth for the owners of the famed Dinorwic and Penrhyn quarries, at Llanberis and Bethesda respectively. However, the impressive scale of profitability that was achieved in those two giant concerns was not shared by the quarry operators at Nantlle despite the initial optimistic indications to the contrary [7]. The reasons for the reversal of the early promises of economic domination of the slate industry by the Nantlle district was intimately associated with a complex interaction of a range of geological and human factors, which are discussed thematically in this thesis.

Within the measure of total productive capacity, the Nantlle Valley had once been the premier producer before being overtaken firstly by the Penrhyn Quarry (Bethesda) in the mid-eighteenth century, and secondly by the Dinorwic Quarry (Llanberis) by *c.*1820, and after *c.*1860 the Nantlle quarries dropped a further place in the league table behind the rapidly-developing quarries of the Ffestiniog district [8]. Despite employing just over three thousand men and producing over 50,000 tons of roofing slates *per annum* at its peak during the last quarter of the nineteenth century, within the regional maxima of fifteen thousand men and some half-a-million tons *per annum* [9], the economic effect of the high proportion of smaller, less productive concerns at Nantlle tended to predominate. Although its minority of larger concerns were amongst the best slate quarries in North Wales (see Appendix 1), the lack of a co-ordinated development of the best slate reserves in favour of multiple individual concerns caused wide fluctuations in the economic fortunes of the district in response to the cyclical trends in the market (see Chapter 1).

The expansion of the indigenous slate industry after the end of the eighteenth century, exerted a considerable influence over the economy of the Nantlle Valley, as did its long decline from *c.*1880. The original predominance of agriculture in the local economy was consequently submerged by the slate industry, which became the dominant economic activity of the district for a century and three-quarters after *c.*1790 [10]. This growth in the scale of slate quarrying can be charted in the Population Census Returns (see Table 2 and Figure 2, below).

TABLE 2

ANALYSIS OF CENSUS DATA, NANTLLE DISTRICT 1801-1881 [12]

YEAR	DISTRICT TOTALS	CHANGE	PARISH SUB TOTALS							
			Clynnog (Agricult)		Llanwnda (Semi-agri)		Llandwrog (Industrial)		Llanllyfni (Industrial)	
1801	4,122	---	1249	---	826	---	1175	---	872	---
1811	5,252	*+22%*	1508	*+17%*	1023	*+19%*	1593	*+26%*	1128	*+23%*
1821	5,767	*+9%*	1695	*+11%*	1141	*+10%*	1749	*+9%*	1182	*+5%*
1831	6,469	*+11%*	1731	*+2%*	1264	*+9%*	1923	*+9%*	1571	*+25%*
1841	8,080	*+20%*	1789	*+3%*	1586	*+20%*	2688	*+29%*	2017	*+22%*
1851	8,090	*+0.1%*	1650	*-8%*	1607	*+1%*	2823	*+5%*	2010	*-0.3%*
1861	8,518	*+5%*	1671	*+1%*	1660	*+3%*	2825	*+0.1%*	2362	*+15%*
1871	10,995	*+23%*	1635	*-2%*	1992	*+14%*	3425	*+18%*	4013	*+41%*
1881	13,456	*+18%*	1615	*-1%*	2815	*+12%*	4136	*+17%*	5520	*+27%*

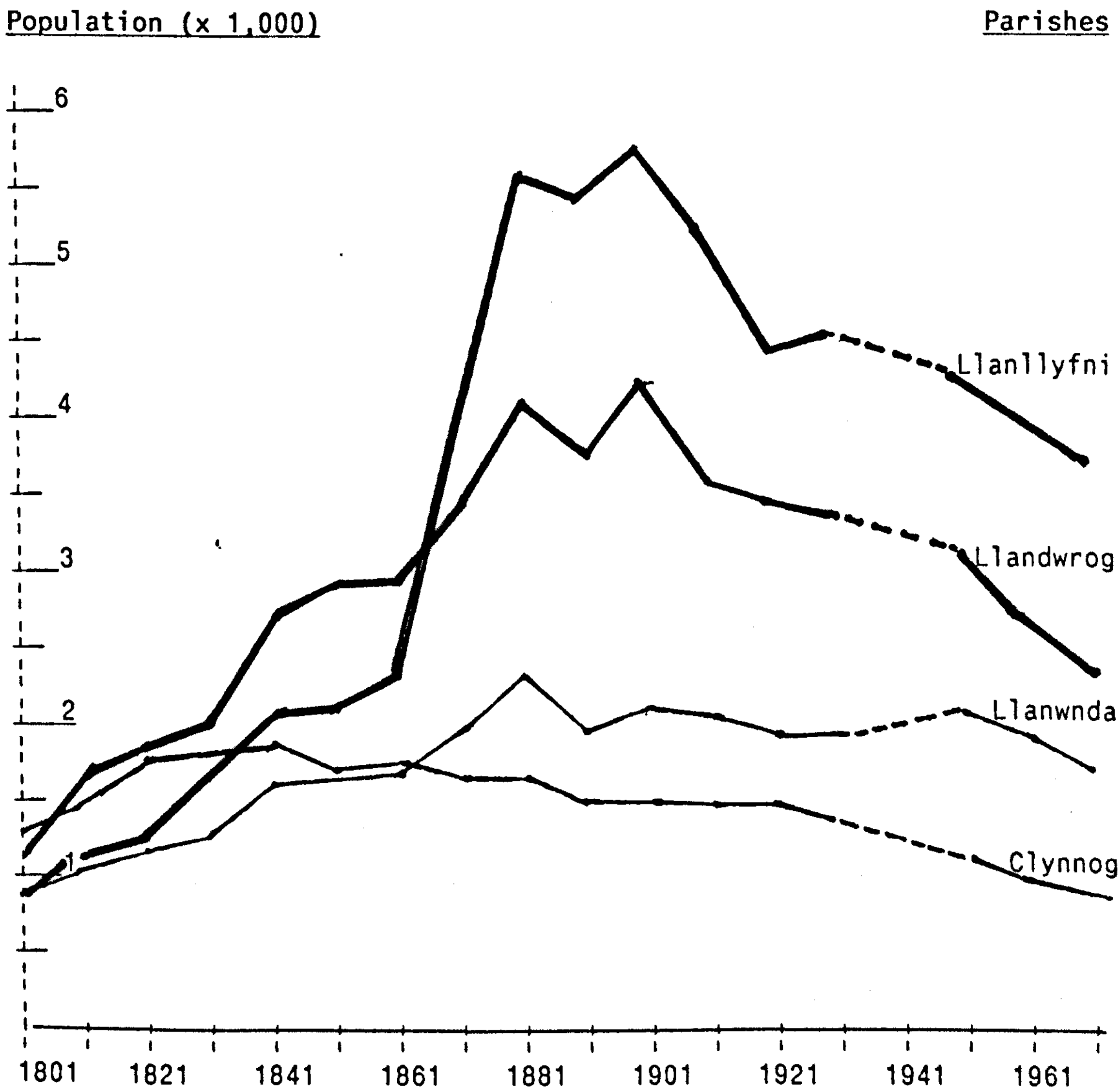
KEY

District Total of parishes of Clynnog, Llandwrog, Llanllyfni and Llanwnda
(Agricult) Predominantly agricultural economy
(Semi-agri) Around equal economy of agriculture/industry
(Industrial) Predominantly industrial economy

FIGURE 2

POPULATION TRENDS

NANTLLE DISTRICT 1801–1971



See TABLES 2 & 3, pages 4 and 6, for corresponding data.

Whereas the fecundity of the local population accounted for a certain proportion of the increased numbers of inhabitants, the attractions of employment in the developing slate quarries over agricultural work generated a growing trend of in-migration into the district during the first three-quarters of the nineteenth century. The greatest source of these migrant workers was the contiguous districts of Llŷn and Eifionydd, whereby the indigenous Welsh culture of the quarries was reinforced, thus ensuring that slate quarrying in this and other districts in the region remained, in the words of A.H.Dodd (1931):-

"... the most Welsh of Welsh industries" [11].

Whereas the expertise of the skilled quarrymen was largely vested amongst the indigenous families of quarrymen in the early period, the first generation of incoming agricultural workers provided the significant numbers of labourers that were required to carry out tasks such as development work, rubble clearance and operating the transport system within the quarries. Craftsmen such as carpenters, blacksmiths and stonemasons were also available from the existing rural economy, but specialists such as miners, mechanical engineers and steam-engine drivers had to be imported during the first half of the nineteenth century from distant industrial areas such as Anglesey, Cardiganshire and Flintshire (in Wales) and from all parts of England, especially Cornwall. The higher grades of staff in the English-owned quarries, that is, the civil engineers, chief clerks and quarry and shipping agents, were also hired from external sources until persons with the requisite skills were available locally in the second half of the nineteenth century [13].

The three decades from *c.*1850-*c.*80 were a period of exceptional expansion in the Welsh slate industry. The construction during this period of new centres of settlement such as the large villages of Pen-y-groes and

Tal-y-sarn to house the enlarged workforce, had both an economic and a sociological effect upon the Nantlle district. On the one hand, the new quarry villages provided amenities previously unavailable in this district, such as commercial services and a wide range of shops. A new urban society consequently developed in parallel to the existing rural one that was based on the quarryman-cottagers [14].

The almost total reliance on a single industry was ultimately to trigger a chronic economic depression in the Nantlle Valley when the slate quarries entered a long cycle of decline from the 1880s, albeit temporarily reversed during the 1890s. This can be seen in the Census data in Table 3 below, and the population change graph, Figure 2, below.

TABLE 3

ANALYSIS OF CENSUS DATA, NANTLLE DISTRICT 1881-1971 [15]

YEAR	DISTRICT TOTALS	CHANGE	PARISH SUB TOTALS Clynnog (Agricult)		Llanwnda (Semi-agri)		Llandwrog (Industrial)		Llanllyfni (Industrial)	
1881	13,456	---	1615	---	2185	---	4136	---	5520	---
1891	12,192	*-9%*	1490	*-8%*	1954	*-11%*	3780	*-9%*	4968	*-10%*
1901	13,612	*+10%*	1497	*+0.5%*	2107	*+7%*	4247	*+11%*	5761	*+14%*
1911	12,846	*-6%*	1483	*-0.9%*	2054	*+3%*	4084	*-4%*	5225	*-9%*
1921	11,189	*-9%*	1496	*+0.9%*	1855	*-10%*	3421	*-16%*	4417	*-16%*
1931	10,968	*-2%*	1281	*-14%*	1850	*-0.3%*	3317	*-3%*	4520	*+2%*
1941	No census		----		----		----		----	
1951	10,428	*(-5% on 1931)*	1112	*(-13%)*	2020	*(+8%)*	3036	*(-9%)*	*4260*	*(-6%)*
1961	9,472	*-9%*	1035	*-7%*	1845	*-9%*	2624	*-14%*	3968	*-7%*
1971	8,510	*-10%*	895	*-14%*	1655	*-10%*	2325	*-11%*	3635	*-8%*

KEY

District Total	of parishes of Clynnog, Llandwrog, Llanllyfni and Llanwnda
(Agricult)	Predominantly agricultural economy
(Semi-agri)	Around equal economy of agriculture/industry
(Industrial)	Predominantly industrial economy

The cycles of economic depression post-1880 in the slate industry particularly affected the small concerns at Nantlle (see Chapter 1). The closure of several of the weaker concerns led to unemployment, poverty and an emigration of the most mobile members of society, that is the young, the ambitious and the better educated. Similarly, the mass enlistment of young men into the armed forces, and of women into war-work throughout Britain during the 1939-45 conflict, broadened the horizons of those involved and who survived. Consequently, many who returned to Nantlle after demobilisation were unable to accept the restricted lifestyle and lack of prospects that awaited them, and soon departed [16].

For those who remained in the Nantlle district, employment opportunities in the slate industry continued to decrease and the numbers of quarrymen diminished rapidly after *c*.1950. The new industries that were established in the Pen-y-groes and Caernarfon areas by the late 1950s and the high wages available from employment in temporary civil engineering projects brought relative affluence in its wake, creating a lifestyle that bore little resemblance to that which had preceeded it [17].

The nature of the workplace in those quarries that had survived also saw a fundamental change during the 1960s and 1970s. The Victorian machinery which served in the golden age of quarrying at Nantlle, although increasingly outmoded, had been retained because investment capital had long dried up in the industry (see Chapter 2). However, in one last desperate attempt to stem their collective decline, most of the leading Welsh slate quarries sought to modernise (see Chapters 3 and 4), a transformation to the detriment of recent ambitions of exploiting the heritage industry in this district [18].

Introduction

The increasing dereliction of the quarry sites at Nantlle, together with environmental 'improvements' through land reclamation projects, threaten to erase the physical evidence of the *raison d'être* for the existence of the communities and settlements in the valley. The highlighting of the national importance of the slate industry has been successfully undertaken by recent researchers [19]; the present author hopes that this thesis will similarly contribute to the raising of an awareness of the importance of his native 'square mile' as an integral part of that industry.

NOTES: INTRODUCTION

1. See Bassett, T.M. and Davies, B.L., (1977), Atlas Sir Gaernarfon, (Caernarfon), pp.10-11, 22-27, for climatic and topographical details.

2. Ibid., pp.30-52, 60-62; Ambrose, Parch W.R., Hynafiaethau, Cofiannau a Hanes Presennol Nant Nantlle, (Penygroes 1872, adargraffiad Llanllyfni 1985), pp.6-16; Inventory of the Royal Commission on Ancient Monuments in Wales & Monmouthshire, Vol.II, (London 1960), parishes of Clynnog, Llandwrog, Llanllyfni and Llanwnda.

3. Found in the tale of 'Math, Son of Matholwch.' See Jones, G. & Jones, T., (translators), The Mabinogion, (London, 2nd edition 1974), pp.55-75; Bassett & Davies (1977), Atlas Sir Gaernarfon, op.cit., pp.64-67;.

4. Ibid., pp.68-71; Ambrose, op.cit., Chapter III, pp.22-39; Dodd, A.H., A History of Caernarvonshire 1284-1900, (Caernarfon 1968, republished Wrexham 1990), pp.11-13; Williams, W.G., 'Rhedynnog Felen', Moel Tryfan i'r Traeth, (ed. G.H.Williams, Penygroes 1983), pp.13-25; Richards, G., 'Rhanbarth Uchaf Dyffryn Nantlle,' [T]ransactions of the [C]aernarfonshire [H]istorical [S]ociety, Vol.34, (1973), pp.106-107.

5. The main sources for the medieval to Stuart period in the Nantlle district are Atlas Sir Gaernarfon, op.cit., pp.68-101, 116-118, 120-125, 140-141; Ambrose (1872), op.cit., pp.16-50; Williams, W.G., 'Eithinog', Cymru, Ionawr-Chwefror 1923; idem., Arfon Y Dyddiau Gynt, (Caernarfon n.d., c.1930); idem., 'Y Tryfan,' T.C.H.S., Vol.2, (1940), pp.58-70; idem., 'Hen Deuluoedd Llanwnda - Y Pengwern,' T.C.H.S., Vol.4, (1942), pp.19-34; idem., Moeltryfan i'r Traeth, op.cit., Sections 1-2; Richards (1973), op.cit., pp.96-106; Jones, Parch Owen, (ed., 1875), Cymru: in Hanesyddol, Parthedegol a Bywgraphyddol, Cyf.II, (Llundain), entries for Llandwrog (pp.56-57), Llanllyfni (pp.155-157), Llyfni (p.205), and Nantlle (pp.354-355).

6. References to metal mining at Nantlle can be found in Atlas Sir Gaernarfon, op.cit., pp.150-152; Ambrose (1872), op.cit., pp.72-73; Bick, D., The Old Copper Mines of Snowdonia, (1982), pp.33-49; Dodd, A.H., The Industrial Revolution in North Wales, (Cardiff 1933, republished Wrexham 1990), pp.154, 165. The possible Bronze Age origin of the Drws-y-coed copper mines has been confirmed by Mr Peter Crew , archaeological officer of the Snowdonia National Park field study centre at Plas Tanybwlch, an expert in early metal mining.

7. Pritchard, D.Dylan, 'Investment in the Slate Industry, Parts 1 & 2', Quarry Managers' Journal, (January & February 1943) pp.254-258 and

pp.297-300, deposited in the Caernarfon Records Office (XM 1366); idem., 'Aspects of the Slate Industry, No.11,' Quarry Managers' Journal, op.cit., (March 1944), pp.416-7; Jones, R.M., (1981), The North Wales Slate Quarrymen 1872-1922, (Cardiff), pp.8-9, 12; Lindsay, Jean, (1974), A History of the North Wales Slate Industry, (Newton Abbot), pp.56, 66, 78, 97-8, 125, gives data on profits for comparison to be made.

For general accounts of the slate industry on a regional basis see Dodd (1933), op.cit., pp.203-222; and Lewis, E.Llewelyn, (1927), The Slate Industry, (Denver, Colorado U.S.A.).

8. Comparison of data from various sources, especially in Lindsay (1974), op.cit., Chapters 2-6; and Pritchard, D.Dylan, 'The expansionist phase in the history of the Welsh slate industry', T.C.H.S., Vol.10, (1949), pp.65-78.

9. Estimated figures based on data from ibid; see also Davies, T., 'The Arfon Quarries', Planet, Vol.30 (January 1976), p.9; and Dodd (1933), op.cit., p.221, compared with data relating to the Nantlle quarries collated in the Appendices to this thesis.

10. T. Davies, 'The Arfon Quarries,' op.cit., pp.7-9; Lindsay (1974), op.cit., pp.67-78, 121-128; Richards, G., 'Crefftau a Diwydiannau Dyffryn Nantlle', T.C.H.S., Vol.31, (1969), pp.115-134; Roberts, G.T., 'Arfon', T.C.H.S., Vol.1, (1939), pp.55-67; W.G. Williams, Moel Tryfan i'r Traeth, op.cit., pp.52-72, 'Anesmwythyd yn Arfon.'

    Dr R.M. Jones (1981), op.cit., p.14, has suggested that one of the benchmarks that identified the change from an agrarian to an industrialised society, and thus economy, was the deliberate creation of a waged labour-force to replace the older system of small-scale independent producers. The equilibrium point was passed in the slate-quarrying parishes at Nantlle by the late-eighteenth century and the process continued with an increased pace throughout the nineteenth century.

11. Dodd (1933), op.cit., p.203. This trend is reinforced in an analysis by Dr R.M. Jones (op.cit., pp.23-24), of the origin of the inhabitants of the village of Nantlle, from the 1871 census returns. He found that of the 659 residents, only 229 (thirty-five per cent) had been born within the parish. Of the remaining 420 inhabitants, the majority were of Welsh birth (384 persons), with 319 originating from other parishes in Caernarfonshire and only 65 originating from elsewhere (being 50 persons from Anglesea and 15 from Merioneth); only seven per cent of the village residents were from outside Wales, these being principally company staff recruited from Liverpool and Lancashire.

12. Author's analysis of a compilation of Census Returns for the parishes of Clynnog, Llandwrog, Llanllyfni and Llanwnda in Tomos, D., (1980), Llechi Lleu, (Groeslon), p.73.

13. W.G. Williams, Moel Tryfan i'r Traeth, op.cit., pp.114, 116, 'Chwarel a Chapel;' details of occupation and parish of birth on Census Returns of Llanllyfni Parish 1851, 1861 & 1871.

14. Dodd (1933), op.cit., p220. For further details on the history and social conditions of the quarrymen cottagers see Hughes, M., Bywyd yr Ucheldir, (Caernarfon 1973); Jones, R.M. (1981), op.cit., pp.19-25; Parry, T., Tŷ a Thyddyn (Caernarfon 1972); Roberts, A., Y Tyddynwr Chwarelwr yn Nyffryn Nantlle, (Caernarfon 1969); Thomas, D., Cau'r Tiroedd Comin (Liverpool, n.d., *c*.1930), pp.29, 58-59; Dewi Tomos (1980), op.cit., map p.70; W.G. Williams, Moel Tryfan i'r Traeth, op.cit., pp.73-82, 'Rhostryfan.' See also the more general sociological accounts in Jones, R.M., 'Y Chwarelwr a'i Gymdeithas yn y Bedwaredd Ganrif ar Bymtheg,' Côf Cenedl I (1986), pp.127-145; and Roberts, D., 'Y Deryn Nôs a'i Deithiau: diwylliant derbyniol chwarelwyr Gwynedd,' Côf Cenedl III (1988), pp.153-179.

    Of the forces influencing social changes, W. Gilbert Williams, in 'Chwarel a Chapel,' op.cit., suggested that the increase in industrial employment was the key factor because the previously isolated agricultural workers were brought together into a communal workplace. This, Williams argued, fostered an environment that was conducive to the interchange of ideas which consequently encouraged the dissemination of new political and spiritual ideologies.

15. Present author's analysis of a compilation of Census Returns for the parishes of Clynnog, Llandwrog, Llanllyfni and Llanwnda by Dewi Tomos (1980), op.cit., p.73.

16. Ex.info; T. Davies (1976), 'The Arfon Quarries,' op.cit., pp.10-11; Lindsay (1974) op.cit., p.300; Richards, A.J., (1995), Slate Quarrying in Wales, (Llanrwst), p.183. Alun Jones, 'Recent developments in the slate quarrying industry of Caernarfonshire,' (Thesis 1977, in Caernarfon Records Office, XM 1956), p.6, quotes a memo. from the Gwyrfai Rural District Council, dated 1945, which stated that the number of quarrymen employed at Nantlle in 1944 was 450, with another 669 men in the forces and 771 in war industries. See also Note 14, supra.

17. T. Davies (1976), op.cit., pp.15, 22; Quarry Managers' Journal, May 1943, p.560. There had been an attempt to counter the catastrophic decline in the slate industry at Nantlle and Ffestiniog from 1946 by seeking Development Area status under the 1946

Distribution of Industries Act, although with little result until the late 1950s.

18. See The Slate Industry in Wales: its conversation, preservation and interpretation,' (National Museum of Wales, Cardiff, April 1981). The amount of original plant & machinery remaining in the Nantlle quarries is now much reduced on that extant even thirty years ago. A golden opportunity in the field of heritage has been lost, especially in the case of the numerous nineteenth century steam winders which were scrapped at the Dorothea Quarry in 1963. A 'near-miss' was a proposed narrow-gauge railway centre at the Penyrorsedd Quarry, a joint-enterprise of 1974-77 between enthusiasts and the quarry proprietors, which was ultimately abandoned by the latter because of financial considerations [see Caernarfon Records Office, G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry, Directors' Files 13.1, & 13.2].

19. The main contemporary leaders in various aspects of research in this field are Professor R. M. Jones (University of Wales, Bangor) and Dr Dafydd Roberts (National Museum of Wales, Gilfach Ddu Slate Museum, Llanberis) on the social aspects of the slate industry, and Dr M. J. T. Lewis (University of Hull) on the historical and technological perspectives.

CHAPTER 1

ECONOMIC DEVELOPMENTS

The development of the markets for the produce of the North Wales slate industry has hitherto been a subject investigated by only a minority of researchers. Yet, the economic development of the industry on a local basis was to a large extent controlled by market forces, and consequently this is a key issue in gaining an insight into the general pattern of development of a complex quarrying district such as the Nantlle Valley. This chapter considers the impact upon the Nantlle quarries of the economic forces shaping the fate of the slate industry on a regional basis, and therefore draws upon the pioneering work of A. H. Dodd, E. Llewelyn Lewis and especially that of D. Dylan Pritchard [1], although their conclusions have been reassessed in the light of new knowledge.

Dylan Pritchard divided the economic history of the Welsh slate industry into three distinct phases, with the transitions occurring at *c.*1790 and 1877; these were chronologically termed the **'early period'**, the **'expansionist phase'** and the **'decline phase'** respectively. The basis of this general categorisation still stands after subjective reappraisal and is adhered to in this thesis as sub-sections a, **b** and c, below. It is possible, however, that a trend of **new expansion** after *c.*1975. albeit only affecting the Nantlle district after *c.*1980 (sub-section **d.**, below) may represent another transition point, leading into a new period of revitalisation for the slate industry of North Wales.

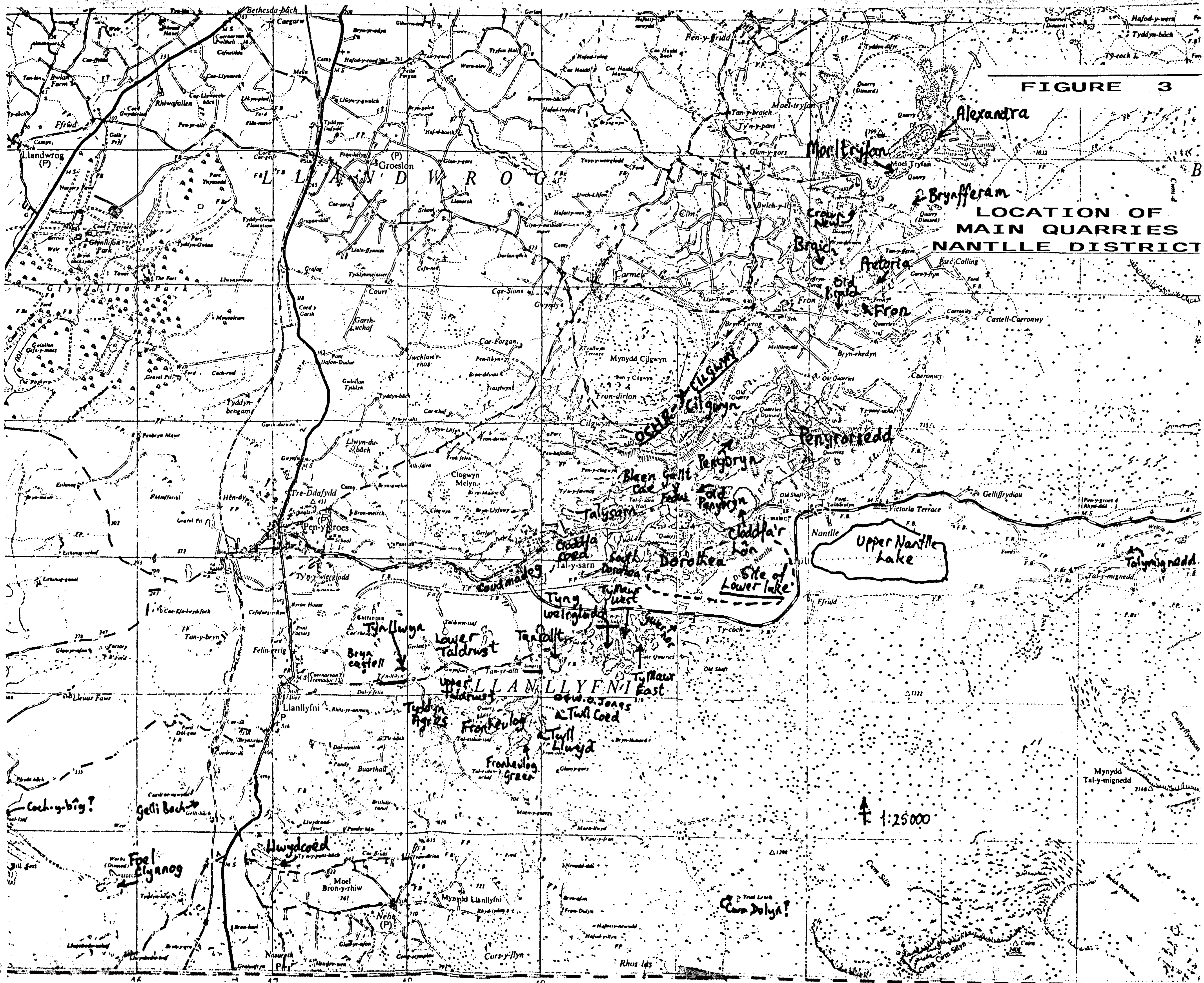


FIGURE 3

LOCATION OF MAIN QUARRIES NANTLLE DISTRICT

(a). The early period of quarrying pre-c.1790

The most comprehensive sources of information regarding the development of the slate industry at Nantlle are a number of late-nineteenth century essays on local history [2]. The consensus of contemporary opinion, based upon folk-lore and surviving physical features now destroyed, was that the industry had early origins in this district, and that the most probable site of the first exploitation of slate in the area was on a hillside of 'waste' land in the parish of Llandwrog known as Ochr-y-Cilgwyn (the site of the later Cilgwyn Quarry, see Figure 3, below). At this location workable blocks of slate were easily extracted from frost-shattered outcrops, and the unusual tolerance of the rock to allow splitting to be conducted from both sides and top surfaces was an invaluable aid to the early quarrymen [3].

Unfortunately, the evidence relating to the earliest period of slate quarrying at Nantlle is both circumstantial and sparse. In the first instance, the quarrying of the slate beds may have a tenuous link with the presumed early mining of copper at Drws-y-coed (see Introduction above). The proximity of the easily-extracted slate outcrops at Ochr-y-Cilgwyn to the route of a supposed Roman road leading to these mines from Caernarfon [4] inevitably raises the possibility that Nantlle was the source of the flooring slabs and crude roofing slates used in the construction and rebuilding in the second and third centuries A.D., respectively, of the legionary fort of *Segontium* (Caernarfon) [5]. Whereas the slates uncovered during the investigation of the site of this fort and its adjacent Mithraic temple might have originated from the Llanberis district or even the Ogwen Valley, the circumstantial evidence (above) in support of Ochr-y-Cilgwyn seems stronger on balance.

Almost nothing is known of the history of the Nantlle Valley in the subsequent ten centuries. However, from May to July 1284, a residence at Baladeulyn (Nantlle) belonging to the deposed Welsh ruling dynasty was occupied by Edward 1st of England during his triumphal tour of the newly-conquered principality of the late Gruffydd ap Llewelyn [6]. Were it possible to confirm the lore that this building was roofed with slates [7], the source of the material would almost certainly have been the Ochr-y-Cilgwyn outcrops, which were only a quarter-of-a-mile distant.

Despite the lack of specific documentary evidence of slate quarrying in the Nantlle district during this period, this does not preclude the likelihood of this activity having taken place on a limited scale. The most probable market for slates from the putative Ochr-y-Cilgwyn quarries in the Middle Ages was a local one. Although there are no earlier extant documentary references to the use of slates at Nantlle than an entry in the Llanllyfni parish register of 1688 recording a payment of 3*s*.0*d*. (15p.) to Robert William [*sic*], a slater [8], it appears that slates had been used locally over several centuries for roofing and flooring the more important contemporary secular and ecclesiastical buildings [9]. This practice must have become increasingly popular in the Nantlle district by the seventeenth century, as testified by a number of original slated roofs of this period which have been identified during field-studies [10].

The payment to Robert William (above) was inclusive of the purchase and carriage of the slates used [11]. Although it is not specified in the extant accounts, it is most probable that he had extracted and dressed these slates from a so-called "quarry of convenience" [12] according to local custom during the formative years of the industry. These quarries were worked 'as required' by the contracting slaters, and represented the first stage of the commercial development of the industry.

Notwithstanding this local market, there appears to have been a parallel 'export' trade in slates from Caernarfonshire. This probably originated in the period immediately post-dating the conquest and subsequent subjugation of Gwynedd in 1282, whereby a limited market demand for roofing slates was created in the new Edwardian boroughs of North Wales and at the border stronghold of Chester [13]. Water-borne transport was utilised wherever possible to circumvent the difficulties of carrying the heavy loads of fragile slates overland [14], and this was reflected in the location of the main contemporary sources of slates at Llechan (up-valley of Conway) and from the quarries of the Ogwen Valley, which were within a feasible distance of the sheltered loading point of Abercegin, near Bangor [15].

Although there is no evidence of this trade having been carried out in the Nantlle district during the thirteenth and fourteenth centuries, the ease of accessibility of the haven of Foryd Cove from the Ochr-y-Cilgwyn quarries (see Chapter 5) could have allowed the Nantlle district an access into the coastal market. That this had occurred by the sixteenth century is almost certain, because the shipments of slates recorded in the extant Caernarfon Customs papers commencing in the 1580s almost certainly originated from Nantlle [16]. The volume of this trade in slates from north-west Wales is difficult to determine because of incomplete or missing shipment data, exacerbated by the recording in the earliest period of the actual count of slates in contrast to the later figures of cargo weight [17]. However, a conversion formula devised by Dylan Pritchard (1942) provides a rough comparison of both sets of figures. His analysis showed an increase in the trade from the Customs districts of Beaumaris and Caernarfon by a factor of approximately five between 1688 and 1730, with a further tenfold increase from 1730 to 1793 [18].

It is, however, unlikely that slate quarrying became a significant industry at Nantlle until the dawn of the eighteenth century. A letter in the Penrhyn MSs, dated 1738,[19] suggests that there then existed at Nantlle an organised industry that was significantly more successful than its main rival in the Ogwen Valley. It may consequently be surmised that in order to reach the position of commercial and technical sophistication so implied, an important phase of development must have taken place at Nantlle, possibly commencing during the second half of the seventeenth century. This is supported by an entry in the parish register entry of 1696 at Llanllyfni recording an occupation of 'slate cutter' (that is, a sawyer of slabs), suggesting that commercial production had already commenced in this district [20].

This evolution of the slate industry involved a progression from occasional to full-time slate quarrying, a process which must have largely depended upon the slow growth of the external market for slates, given the limitation of local market saturation. The commencement of a more widespread use of slate for roofing throughout Britain can be traced to the Tudor era, accelerating after the civil war, when economic and social changes brought about those changes in building methods which provided an opportunity for the Welsh slate industry to develop beyond its medieval confines. The demand for additional housing increased throughout the country between 1500 and 1700 due to the almost doubling of the British population over these two centuries. Architectural changes involving the substitution of brick and stone for timber frames in a wide range of new commercial and domestic buildings brought about a greater use of heavier roofing materials than had hitherto been common [21]. Within this context, it is also tempting to speculate that the great fire of 1666 at London might have contributed to the introduction of slates as non-combustible roof cladding, into densely-populated towns and cities [22].

Consequently, there unfolded a golden opportunity for the promotion of any roofing material which could be produced at a sufficiently high volume at a consistent quality, provided the price was competitive at the point of use. Within this expanding market, English clay roofing tiles enjoyed an overwhelming early advantage, particularly in areas close to the clayfields and where coal was also available for firing. Flag-stones and thick slates were also popular in districts where suitable material was available close at hand, but the sale of these products further afield was severely restricted by the inherent difficulty and high cost of contemporary overland transport [23].

North Wales was geographically remote from the main centres of population growth in England during the sixteenth and seventeenth centuries, although the rapidly expanding city of Dublin was almost visible on the horizon from the Ochr-y-Cilgwyn quarries on a fine day. However, the proximity of the most important early quarries to the coast ensured that this city and the other main contemporary centres of economic development of Bristol, Liverpool and London were easily accessible by sea, thus overcoming the restrictions in trade imposed by the problems of land transport (see Chapter 5).

A maritime trade in a variety of commodities already existed between the havens of the North Wales coast and the English ports, and this would have provided the foundation for the development of links between the slate producers and the wholesale buyers *via* entrepreneurial ships' masters. Subsequently, an intermediate tier of local merchants developed, which increasingly fulfilled an important role of assuming the responsibility for selling the slates. This relief from the financial risks of the early speculative wholesale trade was particularly beneficial to the small-scale quarry operators which dominated the Nantlle district at this time. The continued existence of minor quarries in this district into the present century perpetuated the survival of these independent local merchants despite the cultivation by bigger concerns during the intervening period of expansion of the industry of direct links with the market [24].

The development of strong trading links between the Welsh slate quarries and the building industry was parallelled during the eighteenth century by improvements to the product range and quality as the result of technological advances (see Chapter 3). The market success of Welsh slates was especially enhanced by improvements in craft skills which allowed the exploitation of deeper rock bodies which resulted in the increased availability of the premier grade of thin slates in progressively larger sizes. These bigger slates had a greater covering capacity per unit sheet at a reduced weight, consequently requiring less supporting timber that on a roof covered with the thicker, smaller clay tiles or the slates obtained from English and Scottish quarries. Thus, Welsh 'best' slate became a favourite of wholesalers purchasing by weight and selling by count, and of speculative builders anxious to maximise profits by minimalising expenditure [25]. Whereas the Nantlle quarries were the first to achieve this technological breakthrough and thus reap the benefits in terms of popularity in the wholesale market and building trades, this lead was soon eroded by the diffusion of working techniques and practices, whereby the produce of all the major slate quarries working the Cambrian strata in Caernarfonshire had become practically uniform by the 1790s [26].

In addition to the growth in the market demand, local considerations were also important in the successful establishment of slate-quarrying as an industry at Nantlle at this early date. A fortuitous combination of the retention of the manorial lordship by the Crown and its concurrent lack of interest in the upland commons consequently under its control [27] enabled the parishioners of Llandwrog to exploit the slate rock at Ochr-y-Cilgwyn without hindrance for hundreds of years. This technical trespass was justified locally by an unilateral extension by the parishioners of the historical rights of turbary to cover slate quarrying [28]. Being free of rents and royalties until well into the eighteenth century (see below), the early independent Llandwrog quarrymen were thus able to benefit from an undiminished gross profit, whilst living rent-free on subsistence smallholdings encroached on the upland commons near the quarries, a lifestyle which seems to have been passively encouraged by local squires and the parish vestry [29]. This contrasted with their counterparts in the Ogwen Valley, who paid rent to the Penrhyn estate, became bound by strict working rules, and were to be tied to a sole-agency sales system [30].

Whereas the independence of the quarrymen/proprietors of Ochr-y-Cilgwyn was briefly threatened in 1738 by the unsuccessful pleading of the Penrhyn slate agent upon his employer to gain control of the Llandwrog common [31], the Crown 'wastes' at Nantlle were eventually destined to fall under the control of a local landowner, albeit with unexpected results. A Crown lease of the 'wastes' in eight Caernarfonshire parishes including Llandwrog, was granted in May 1745 by the Treasury to Sir John Wynne of Glynllifon [32], although the subsequent conduct of the lessee suggests that the exploitation of minerals was not his principal aim.

The Glynllifon Crown lease had important implications for the future of quarrying at Nantlle. Had Sir John taken a direct control of the Ochr-y-Cilgwyn quarries in a similar manner to the actions of Richard Pennant, the first Baron Penrhyn, in the case of the Ogwen quarries in 1783-85 [33], then the subsequent history of slate quarrying at Nantlle would have taken a different course. In the event, Sir John Wynne passed over this opportunity, possibly as an act of political patronage. After apparently allowing the quarrymen free tenure of the workings for three decades, an annual *per capita* rent was levied on the Ochr-y-Cilgwyn quarries in 1776 by Sir John's son, Thomas (the first Lord Newborough), although at a peppercorn charge of one groat per man (that is, 4*d.*, approximately 2p.) [34]. Consequently, this example of the intervention of an important local landowner protected a large group of independent quarrymen/proprietors from the grasp of external capitalists until subsequent events led to the granting of a new Crown lease on this ground in 1800 to one company (see sub-section b., below, and Chapter 2) [35].

Notwithstanding its unexpected benevolent effect upon the pre-existing quarries of Ochr-y-Cilgwyn, the Crown lease of 1745 (above) is also likely to have played a role in the expansion of quarrying at Nantlle onto adjacent private lands [36]. One possible result of this lease may have been the restriction of quarrying rights on the Crown 'wastes' to tenants of the Glynllifon estate, with the result that an impetus was created for the development of new sites by persons who did not qualify for the new concessions. Furthermore, this development during the mid-eighteenth century of additional quarries probably represented an increased awareness by local entrepreneurs of the potential of the slate trade, which was sufficiently developed to repay with profit the costs of rents, royalties and financial investment (see Chapter 2). This hypothesis is supported by the recorded establishment of a remote offshoot of one of the Ochr-y-Cilgwyn concerns at Ceunant-y-Diffwys (at Ffestiniog) in the 1760s, marking the first commercial development of the industry in that district. This episode illustrated the economic confidence of the quarrymen-entrepreneurs of the Nantlle district who were masters of their own concerns and who were employers of labour, in contrast with the more limited scope of the partnerships of quarrymen who leased pits on the Penrhyn Estate [37].

By *c.*1790, the dozen small quarries at Ochr-y-Cilgwyn employed around 130 masters, labourers and boys [38], and had been complemented by new quarries at Yr Allt Lechi, Cloddfa'r Coed, Cloddfa'r Lôn, Galltyfedw, and 'Twll Cornwall', all located on the lower slopes and floor of the valley below the older workings, and at Buarth Fotty, Singrig, Ty Mawr, and Tynyweirglodd on the southern side of the vale (see Figure 3, above). The entrepreneurs who developed this new batch of quarries were local persons, either quarrymen or farmers having some available investment capital, later supplemented by members of the squirearchy and professions in the Caernarfon area [39]. The productive capacity of the Nantlle district thus increased rapidly, enhancing its undoubted primacy within the fledgling North Wales slate industry. However, this development of a patchwork of independent units of production was ultimately to prove disadvantageous during the subsequent era of expansion (see below), and Nantlle was consequently eclipsed by the co-ordinated large-scale capital investments at the Dinorwic and Penrhyn quarries in Llanberis and the Ogwen Valley respectively [40].

(b). The expansionist period *c*.1790–1877

The transition point of *c*.1790 identified by Dylan Pritchard as the dawn of the aptly-termed 'expansionist phase' [41] in the history of the slate industry of North Wales, is a representative date rather than a specific one. It encompases the gradual establishment between *c*.1783 and *c*.1800 of the first stages of a capital-intensive organisation as a replacement of the domination of the industry by independent quarrymen-proprietors. The transition date also marks the commencement of nearly eight decades of accelerating growth in the North Wales slate industry, which was remarkable in its scale and longevity. This was by no means a linear process, but was a complex pattern of large upturns interspersed by downturns in demand, albeit with the trend always towards an increase in output and sales. This exponential growth continued until 1877, when a watershed was reached at the peak, after which a long era of decline was entered (see sub-section c, below).

Despite the development of a substantial export trade during the nineteenth century, the mainstay of the Welsh slate industry remained the home (U.K.) market. Consequently the underlying economic trend of this industry shadowed the cycles in the U.K. building industry, albeit with a slight lag. The period from 1801-1881 was one of rapid growth in the population of Britain from 8.893 million to 25.974 million, when the number of dwellings consequently increased from 1.633 million in 1801 to 5.218 million in 1881 and census data showed the building trades as being only second to agriculture in terms of importance by 1831 [42]. However, the correlation was not perfect because of the influence of separate cycles in various sectors of the export trade and of the counter-effects of increasing competition on the home market from both rival roofing products and imported foreign slates [43].

The first phase of major expansion *c.*1790-*c.*1830

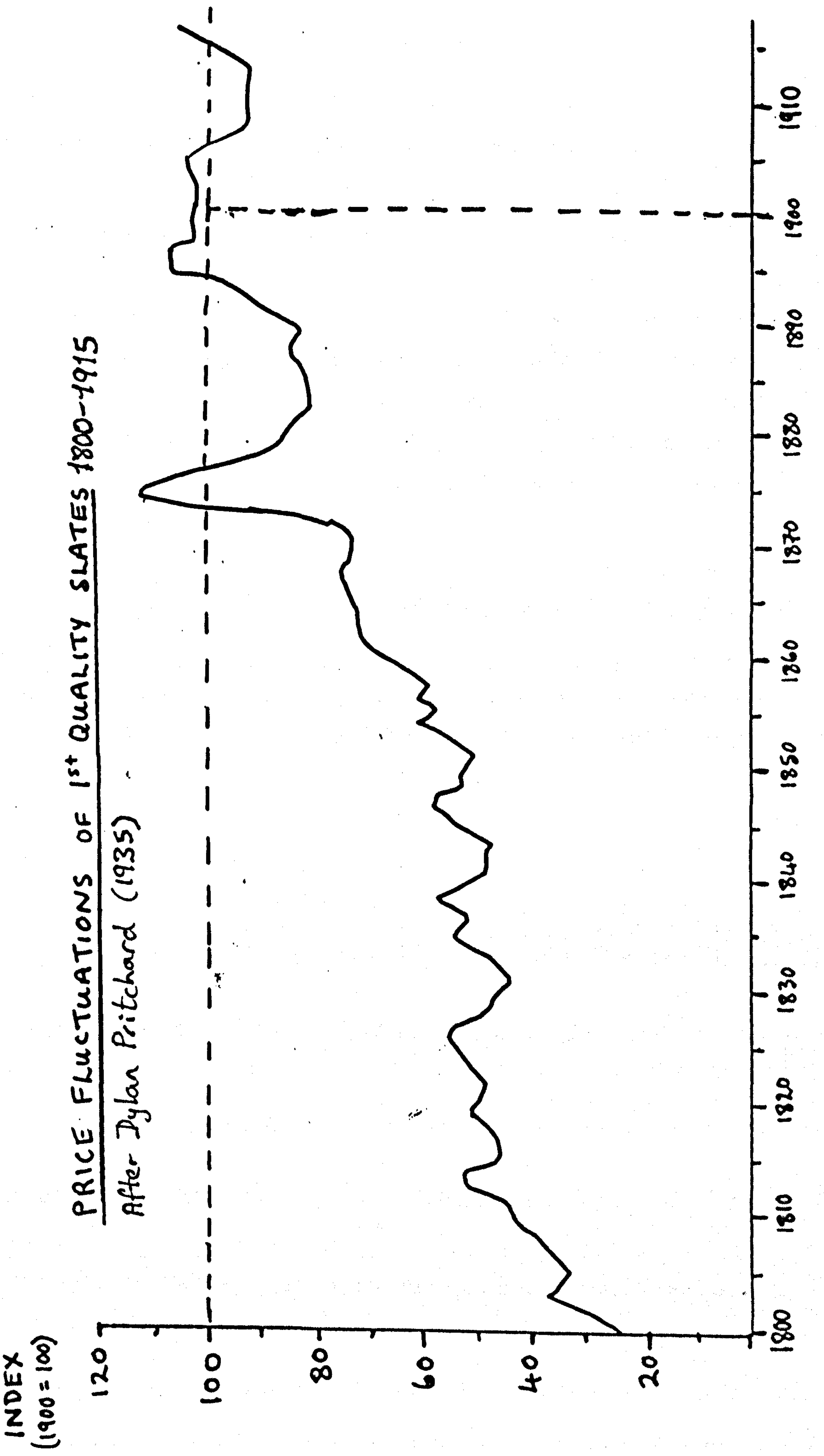
The dramatic rise of the North Wales slate industry to a dominating position in the world roofing-material market was achieved through the interaction of several economic and technological factors, of which the most important were price competitiveness and product quality. Whereas producers of all types of roofing materials also experienced increased sales as a result of an upsurge in demand after *c.*1790, the main beneficiary of growth in the building industry during the nineteenth century was undoubtedly the slate industry of North Wales [44]. The strong preference that had developed during the previous century for the product of this industry in the important high-volume price-conscious market of speculative building (see sub-section a., above) was reinforced by further increases in the margin of price-on-delivery in favour of Welsh slates over competing roofing materials after *c.*1790 [45]. This was achieved through the development of a specialised local maritime industry characterised by strong internal competition, which resulted in a constant reduction in freight rates for the slates from the late-eighteenth to around the end of the nineteenth centuries (see Chapter 5) 46.

Whereas this trade was initially restricted to sea-ports and inland districts served by navigable rivers, the development of the canal network after the 1770s made the transport of Welsh slates to the new industrial centres of the north and midlands of England a cost-effective proposition for the first time [47]. It was this combination of the rapid development during the late-eighteenth century of both established commercial centres and the new industrial towns in tandem with improved transport systems, that was the key factor which boosted the slow expansion already achieved by the Welsh slate industry.

This growth in the slate trade had, according to Dylan Pritchard, outstripped the productive capacity of the Welsh quarries by the early 1790s, although the boom was short-lived as the result of the outbreak of war against France in 1793 [48]. This conflict, which was probably the first to have a major impact upon the Welsh slate industry, fortunately coincided with a period of a growing domination of the product in the roofing market, in marked contrast to the major wars of the first half of the twentieth century (see sub-section c., below). Thus, the demand for slates recovered steadily after an initial period marked by a catastrophic reduction in the U.K. building industry following the outbreak of war. However, wartime increases in shipping costs due to higher rates of maritime insurance and the imposition of a transport tax continued to be a burden, with the latter remaining in force until 1831 [49].

The return of brisk demand for slates by 1799 was the result of the optimism of investors in the successful conduct of the war, and the Peace of Amiens in 1802 sparked off a resumption of the pre-war building boom, which fed back to the Welsh slate quarries. This was mirrored in the cyclical gentle upwards movement of the market price of Welsh slate from 1800, a trend which is can be followed in Dylan Pritchard's Slate Price Index (1800-1915), which is reproduced in Figure 4, below [50]. The subsequent thirteen years witnessed a greater degree of investment in, and development of the Welsh slate industry than had hitherto been undertaken, with the quarries at Nantlle benefiting from an inflow of capital largely from locally-based entrepreneurs (see Chapter 2). New companies took over the Cloddfa'r Coed, Penybryn and Talysarn quarries (see Figure 3, above), which were significantly developed as a result [51], but the premier local concern of this period was the Caernarfon-based Cilgwyn & Cefn Du Slate Company (of 1800). This company became infamous for its forceful displacement of the independent quarrymen from

FIGURE 4



PRICE FLUCTUATIONS OF 1st QUALITY SLATES 1800-1915 large tracts of Crown lands in the face of strong resistance [52], but it ultimately failed in its bid to secure a place in the ranks of the premier slate producers both for want of sufficient capital and the ineffective utilisation of its available financial resources [53].

The brisk trade of the post-war years was almost instantaneously curtailed by the brief resurgence of Napoleon in 1815. The resulting panic created in the U.K. financial markets precipitated a rapid slump which ultimately fed back to the Welsh slate quarries, precipitating a slump in demand. This stagnation was soon overturned in the aftermath of Waterloo, but against expectations there was no subsequent restoration in slate prices despite a strong recovery in demand after Wellington's victory. The resulting overproduction of slates by the Welsh quarries, caught out by the suddenness of the slump, sparked off a price war involving the three biggest Welsh producers, a situation which was only reversed as the result of the establishment in 1817 of a cartel amongst the major protagonists [54].

This seems to have been the first occasion on which the largest slate producers had sufficient individual power to attempt to squeeze the remainder of the industry in the self-interest of maintaining output in the face of a shrinking market. The creation by very wealthy sole proprietors of a pair of giant productive units, namely the Penrhyn and Dinorwic quarries had by this period created both an economic and a productive imbalance in the Welsh slate industry, where up to half the total output was produced by these two large concerns, which were consequently able to wield a powerful economic influence [55].

When operating in concert, the Dinorwic/Penrhyn cartel dictated the price and discount levels of the remaining producers because of the implicit threat of flooding the market with cheap slates from the large stockpiles which they were able to maintain. On the rare occasions when the Dinorwic and Penrhyn quarries fell out with each other, the resulting price war brought ruin to the smaller producers and also to larger ones suffering from cash-flow problems resulting from the interaction of proportionately greater production costs on an insufficient capital base.

In contrast to the Dinorwic and Penrhyn concerns, which were an amalgamation of formerly independent small quarries, the fragmentation of the slate industry in the Nantlle district as small-scale productive units exposed its quarries to the full force of external economic influences. Each small concern in the district was in direct competition with its neighbours and they often co-existed in a state of mutual antagonism. Furthermore, the geographical concentration of the numerous quarries resulted in an interference with each other's development because of their close physical proximity. Their economic survival in the increasingly competitive trading environment of the first part of the 'expansionist phase' was to a large extent dependent upon the scale of the overall growth in demand for slates which, outside of the cyclical slumps, was tending to be in advance of the growth of the productive capacity of the industry for technical reasons (see Chapter 3).

The rapid increase in demand during the boom cycles drew investment into the slate industry, and the Nantlle district provided ample entrepreneurial opportunities. Yet, the high frequency of the market fluctuations gave little time for the new concerns to establish themselves securely. This was especially true when these companies had to undertake expensive initial development work on the expectation of recovering the investment over a long term. Thus, the price war of 1815-17 and subsequent recurrences, had a damaging effect upon the slate industry at Nantlle, where a number of concerns that had only been established post-1800 had to close. The most important of these were the Hafodlas (Cloddfa'r Coed), Penybryn and Talysarn companies, which all folded due to the accumulation of trading losses [56].

Despite the short-term effects on the most vulnerable quarry concerns, the price-war may have contributed to the increased general market demand for slates after 1817 by making the product more competitive. Sales accelerated in the early 1820s (see Figure 4, above), with the regaining of some stability in slate prices being fortuitously attained just at the onset of a major period of mill and factory building in England. This boom surged dramatically in 1825, resulting in the exposure of the Welsh slate industry to the share-speculation fever which swept the U.K. economy in that year (see Chapter 2). However, the inherent instability of this boom precipitated a financial crisis in 1826, plunging the general economy into recession, with a knock-on effect being experienced in the slate trade [57].

In common with previous experience, this downturn was shortlived but the Welsh slate industry again suffered a long-term collapse in prices due to cut-throat competition between the Dinorwic and Penrhyn quarries, who fought a private battle to maintain an undiminished share of the market [58]. The slate industry at Nantlle had only partially recovered from the setback of the late-1810s when the effects of this second price-war swept through the smaller quarries with a vengeance. The inevitable result was the collapse of many of the new Nantlle companies, who saw their profit margins shrink away. However, the repercussions were on this occasion much more serious than a decade earlier, with the failure of the new operators of the Talysarn Quarry (in 1826), Cloddfa'r Coed Quarry (alias Hafodlas, in 1828) and the

Coedmadog Quarry (in 1829) being overshadowed by the collapse of the once omnipotent Cilgwyn & Cefn Du Slate Company in 1831 [59].

The closure of four of the largest concerns in the Nantlle Valley between 1826 and 1831, together with several more marginal 'fair weather' quarries, was a serious economic blow to the district. Although these losses were balanced to some degree by the establishment of a number of new companies, including the highly capitalised joint-stock company at Talysarn Quarry (in 1827) and William Turner's development of 'Cloddfa'r Llyn' in 1829 (which became the famed Dorothea Quarry in due course), none of these new enterprises were initially very prosperous because the damaging economic forces remained in play [60]. Slate prices remained at a low level for several years due to the rampant internal competition within the industry and was not even ameliorated by an upsurge in demand after 1827. However, the overdue revoking in 1831 of the slate transport tax (see above) provided the much-required fillip which re-invigorated the economic structure of the Welsh slate industry and initiated a second phase in its period of expansion [61].

The second phase of expansion *c.*1831-1877

With the dawn of the second half of the 'expansionist phase' after 1831, the Welsh slate industry entered a period of more rapid development than had been attained to date. The total output of the industry doubled from 1830-40 and the overall trend continued on an upwards path even during the 'hungry forties', a decade that was characterised by economic instability. This was expressed in the domestic slate market as wild fluctuations in demand ranging from two deep depressions (in 1841-43 and 1847-48) involving temporary collapses of the general building industry during financial crises, which flanked a short mid-decade boom (from 1844-47) associated with 'railway mania' [62]. The demand curve returned to an upwards trend after 1848, when much of this success can be directly attributed to competitive pricing, aided by a continuation of the trend of decreasing transport costs (discussed in Chapter 5) [63].

Yet, despite the general upturn in the slate industry during the 1830s-40s, the benefit was again unevenly distributed. A contemporary commentator recalled that the recovery was more marked in slate districts outside Nantlle and his testimony seems to be supported by the known histories of individual quarries in this area [64]. In 1843-44, for example, two important concerns crashed; the Cilgwyn Quarry (G.A. Muskett, proprietor) closed with alleged debts of around £20,000 and the Talysarn Slate Company was also wound up, having dissipated a capital sum of at least £24,000 with very meagre returns since its incorporation in 1827 [65].

The problems experienced by the Nantlle quarries in the 1830s-40s can be best explained by comparing this district with another, namely Ffestiniog, which had a similar economic structure, but which experienced almost unbroken economic expansion from the 1820s, at a time when the industry at Nantlle lay in the doldrums [66]. The adverse effects of geological and technical problems on the profitability of several quarrying concerns at Nantlle (see Chapters 2 and 3) contrasted with the more ordered slate deposits found at the newer quarries at Ffestiniog [67]. Also, the dark-grey Ordovician slates worked at Ffestiniog were not in direct competition with the Cambrian blue and purple slates produced by Penrhyn and Dinorwic, whereas the Nantlle quarries shared the same market niche as these two major productive units [68].

Thirdly, the major Ffestiniog slate producers enjoyed a further market advantage by virtue of the personal efforts of a number of its quarry owners to develop the existing small export market to the Continent in the aftermath of the Hamburg fire of 1842, an initial coup which became a great breakthrough due to the tariff-reducing Cobden Treaty of 1860 [69]. Whereas this export trade was not exclusively in the hands of the Ffestiniog quarry owners, the early establishment of agency contracts must have tied up many sales outlets in their favour [70]. This, and strong competition from Dinorwic and Penrhyn, probably explained the contemporary claim that in contrast to their heavy dependence upon the home market, the Nantlle quarry proprietors showed little interest in exporting, a statement which has been corroborated by the recent work of Dr. Lewis Lloyd on the port of Caernarfon [71].

Dr. Lloyd has shown that almost all of the Caernarfon shipments of slates were to English ports, with the main destinations being Liverpool, industrial northern England and London. The data for 1859 seems typical, listing only twenty-two shipments to the Continent corresponding to two per cent of the total number of slate cargoes cleared from the port in that year [72]. Furthermore, the early intimate ties between many of the Nantlle slate-producing companies with the U.K. retail slate trade (see Chapter 2) had been maintained and moreover strengthened over time, particularly in the case of the many speculative concerns that were found in this district during the 1850s and 1860s [73].

The development of the slate-slab trade after *c.*1840 might have provided Nantlle with the only opportunity to escape the domination of Dinorwic and Penrhyn in the roofing slate market. There had been an early slab industry in this district, although predominantly for the local market, but the 'veins' which provided this material appear to have been too thin to exploit on a large scale [74] although the growth of a market for dressed slabs encouraged a number of attempts to branch out into this trade during the 1850s-60s [75]. However, the strong competition from slabs of superior quality which were quarried in Ireland (in the 1840s), Llangollen (in the 1850s) and Corris (from the 1860s) rapidly killed this last attempt to market slate-slabs from Nantlle [76].

By the 1850s, despite minor reversals in the export sector, the global demand for every type of slate product accelerated [77]. The population of Britain continued to increase and additional housing, commercial properties and municipal buildings were being erected in the new industrial centres, nearly all of which were roofed with Welsh slates. The export trade was similarly expanding and the cumulative effect by 1857 of the total demand was that it exceeded the available supply of slates despite the increasing output of the industry [78].

At Nantlle, the late-1840s and the 1850s witnessed an economic expansion on three fronts, that is, the growth of existing quarries such as Cloddfa'r Lôn, Penybryn, Penyrorsedd and Talysarn, the exploitation of undeveloped sites such as Alexandra, Blaen Cae, Coedmadog, Fronheulog, Moeltryfan and Plas Du (or Tanrallt), and the reopening of defunct established quarries such as Cilgwyn and Dorothea (see Figure 3, above) 79. This expansion in production potential, although muted locally for reasons already explained, can be followed in the individual shipment totals from Caernafon Harbour (1845-1875), collated by Dylan Pritchard, and reproduced in Table 4, below. Despite a significant increase in output throughout the Welsh slate industry after 1850, by 1860 the lead time of demand on supply was about four months and this mis-match of orders and dispatch was increased to a peak of nearly four years in 1863-65. Prices increased commensurately (see Figure 4, above), with spot premiums being generally charged in excess of the official list prices [80].

Chapter 1: Economic Developments

The 1860s and 1870s were the golden age of the Welsh slate industry, and the Nantlle quarries fully partook of the huge expansion in demand which was characterised by soaring market prices (see Figure 4, above). Almost every possible piece of ground in the district containing any grade of slate rock was either being worked, promoted, bought or sold during the first half of the 1860s (see Table 5, below). Even the smaller sites became keenly sought-after by companies with money to burn, having been infected with the contagious excitement of the 'slate-rush', but where naive investors provided rich pickings for professional speculators (see Chapter 2) [81].

The upwards trade cycle post-1850 was not, however, an unbroken one. The upturn in demand which had commenced just before 1850 was partly checked in 1866 due to a severe banking crisis which ultimately fed back to the building industry, for example by ruining several railway companies who were in the process of constructing new facilities [82]. This setback was short-lived and by 1867 the slate boom had resumed its upwards trend at a frenzied rate until 1870, when it was arrested a second time by two unrelated, yet coinciding events. The first of these was a drastic reduction in the largest export market as a result of the Franco-Prussian war and the second was the concurrent arrival of a hiatus on the British house-building cycle [83]. Whereas the reduction in export demand hardly affected the Nantlle quarries directly (see above), the dual effect of a slowing down of the domestic market and its subsequent flooding by slates normally earmarked for export, must have had a significant impact upon sales.

The slate boom recovered its momentum by 1871, and demand continued to rise until it was nearly triple the rate of supply by 1873-74. Some of this advance was specifically channelled to the quarries of Nantlle during the temporary loss of the output of both Dinorwic and Penrhyn as the result of strikes at these two concerns in 1874, thus creating a short-term local bonanza [84]. This shortfall provided an opportunity for the 'Caernarfon group' of quarries to briefly break away from the economic domination of these two giant concerns [85] by setting their own price levels at a twenty per cent premium for the remaining years of the boom. Such an unprecedented degree of economic independence could not, however, have been achieved without the majority of Nantlle's quarry proprietors having been prepared to put aside their personal rivalries and combine within an owner's association, the Carnarvon Slate Club [*sic*], established in 1872 [86].

Despite gaps in the available data, the effect of the boom on the Nantlle quarries can be followed from a restrained use of the extant figures (see Table 4, below). For instance, the records of the Caernarfon Harbour Trust show an average 20,000 tons of slates being handled from the Nantlle quarries *per annum* (excluding shipments *via* merchants) in 1845-55, increasing to around 40,000 tons in 1870, exclusive of the unrecorded total forwarded from the quays to the standard-gauge rail-head after 1852 (see Table 4, above) [87]. In default of comprehensive output figures, an estimate of the high-point of slate production at Nantlle was likely to have been in the order of around 70,000 tons in 1877 [88].

Employment data for Nantlle during this period, although incomplete, also show the upwards trend (see Table 5, below). In 1863 one source listed (incompletely) a total of 1,548 men working in fifteen concerns in the district [89], with another giving the 1872 total (excluding the Alexandra Quarry plus several minor concerns) at 2,042 employees in twenty production units [90]. At the peak year of 1877, a total of 2,705 men were

TABLE 4

NANTLLE SHIPMENTS #1
FROM CAERNARFON HARBOUR

Based on draft data abstracted by Dylan Pritchard in C.R.O., XM/1487

QUARRY	TONS OF SLATES DISPATCHED UNDER TITLE OF QUARRY						
in 1845 tonnage order	1845	1850	1855	1860	1865	1870	1875
	Pre- Nantlle direct U.K. rail link					Post- link	
Talysarn	6650	2206	3127	-	252	7005	4151
Cloddfa'r Lôn/Penybryn.	6394	9530	5275	6493	8184	7629	2066
Dorothea	4823	3683	6079	7808	10285	13563	9514
Penyrorsedd	4612	3242	1844	974	5365	1072	6681
Cilgwyn	507	408	4433	7361	6405	4819	6401
Hafodlas/Pwll Fanog ...	266	309	116	253	362	188	-
Ty Mawr (East)	181	533	236	539	704	157	-
Tynyweirglodd/Dot. West	139	578	186	88	1047	-	-
Galltyfedw	-	309	116	253	435	-	582
Ty Mawr West	-	87	233	-	-	-	-
Braichrhydd	-	70	-	247	34	808	86
Moeltryfan	-	-	622	487	499	1022	1405
Fron	-	-	387	556	2124	-	-
Tanrallt (Plas Du)	-	-	114	68	-	1089	-
Gwernor	-	-	-	410	-	-	-
Fronheulog/Nantyfron...	-	-	-	318	152	-	-
Taldrwst	-	-	-	160	236	-	-
Coedmadog	-	-	-	-	1649	2919	1865
Brynfferam	-	-	-	-	-	140	-
Alexandra	-	-	-	-	-	-	891
NANTLLE SUB-TOTALS	23572	20955	22768	26015	37733	40411	33642
South Llanberis Totals	3386	1859	1352	1077	7392	8259	3637
Gwyrfai/Snowdon Totals	-	-	-	76	1650	-	296
Merchants & Others	1065	34	-	-	-	-	1000
HARBOUR GRAND TOTALS	28023	22848	24120	27168	46775	48670	38575
Nantlle % of Grand Total	84.1	91.7	94.4	95.8	80.7	83.0	87.2

TABLE 5

NANTLLE EMPLOYMENT STATISTICS #1

QUARRY	1864	1872	1873	1877	1882	1883	1889	1893	1895
Dorothea	400	500	500	520	533	481	550	420	518
Penyrorsedd	400	160	???	460	261	230	390	448	471
Alexandra	12	??	140	???	195	182	230	232	242
Cilgwyn	200	200	260	300	300	215	318	282	304
Moeltryfan	50	66	??	??	81	70	150	160	290
Cloddfa'r Lôn/Penybryn	200	280	??	300	234	240	-	-	-
Talysarn [TS]	24	290	??	525	[400..???+TW.360...310]				259
Braich(rhydd) [B]	18	150	20	??	124	99	[in CM]	80	66
Cloddfa'r Coed	-	*	4	60	secret		150	-	-
Coedmadog [CM]	20	109	??	30	100	135	80+B	-	-
Fron [+Old Braich 1868]	40	100	70	120	60	75	8	-	-
Fronheulog	??	69	80	90	98	69	??	76	100
Galltyfedw	??	??	12	*	-	-	??	??	36
Penybryn (New)	[part of Cloddfa'r Lôn Co. until 1892]							-	32
South Dorothea	[part of TS until 1878]				70	92	??	126	130
Tanrallt	??	*	40	80	-	-	-	-	2
Tynyweirglodd	50	*	??	100	secret		-	-	-
Gwernor	??	*	20	25	-	-	-	32	10
Llwydcoed	14	*	??	-	6	6	secret	-	-
Ty Mawr East	40	*	20	50	20	20	??	-	-
Ty Mawr West [TW]	60	*	?	20	[...in TS figure..]				5
Tyddyn Agnes [TA]	??	*	[20+TL]	*	-	-	??	-	15
Brynfferam	??	??	??	-	10	18	2	?	5
Foel Clynnog	??	??	??	-	17	10	-	-	-
Pwll Fanog	??	??	??	2	-	-	-	-	-
Singrig	??	-	-	-	-	-	-	-	-
Taldrwst	20	*	??	??	-	-	-	-	-
Cilcoed/St Beuno?.....	Trial	-	-	-	-	-	-	-	-
Cochybîg/St Winifred?	Trial?	-	-	-	-	-	-	-	-
Cwm Dulyn	?	-	-	2	-	-	-	-	-
Ty'n Llwyn [TL]	?	*	[in TA]	*	-	-	-	-	-
Others [marked *]	+??	*118	+??	*25+?	-	+??	+??	-	-
TOTAL (/invalid data)	1548+	2042+	inv	2705+	2509+	inv	2236+	2166	2380
No. of Quarries	28	25	25	22	19	19	18	13	18
No. Operating Units .	28	24	24	22	17	17	16	11	14

Key: - quarry closed; ? operating, but no figure given; * in 'others.'

Refs: J.O.Griffith (1864); Dolgellau Records Office, Greaves MS 58; J.E.Thomas (1873); C.R.O., XM392/1; U.C.N.W., Nantlle 1; H.M.I. Annual Reports (1882-93); Home Office Mineral Statistics (1882-83); J.Griffiths (1889); W.J.Parry (1890); Report of Royal Comm. on Quarries (1893).

at work in the eighteen quarries that were recorded by a third source [91], although this list excluded the Moeltryfan group of five concerns which possibly employed up to 600 additional men, giving an estimated peak official figure of around 3,300 quarrymen [92].

Further analysis of the extant data reveals, however, that the economic benefits of the great boom of the 1850s-70s was by no means evenly distributed throughout the slate industry. A significant imbalance existed, for example, within the slate quarries of the Nantlle district which mirrored the industry as a whole. In 1850, despite an increase from eight to ten in the number of Nantlle quarries shipping from Caernarfon harbour since 1845, the four main concerns accounted for ninety per cent of the recorded tonnage, which was a fifteen per cent increase [93]. Similarly, the 1877 employment figures for the district show that seventy-eight per cent of the total recorded workforce was concentrated in five concerns, which represented less than a third (numerically) of the quarries listed [94].

One effect of this imbalance was the economic weakness of the majority of the slate concerns in the Nantlle valley, which were only sustained by the unprecedented level of demand and high prices of this period. Despite the relatively slight overall impact of the 1866 and 1870 trade reversals noted above, they were of sufficient magnitude to cause the closure of a number of the least financially secure quarry companies at Nantlle, with a consequential denting of investment confidence for the first time since the 1840s [95].

Storm clouds were also collecting on the economic front. The mis-match of spiralling demand and a shortfall of supply despite a continuous increase in output during the 1860s-70s, created a seller's market of exceptional ferocity [96]. The gross over-demand which swamped the quarrying concerns bred arrogance and greed within the trade. This manifested itself in such practices as summary price rises, over-strict terms of credit and the dumping of sub-standard material on desperate trade outlets at unreasonable prices. Consequently, customer loyalty was eroded concurrently with a reduction in the competitiveness of Welsh slates [97].

Despite the resistance of the economically-astute Merionethshire Slate Quarry Owners' Association (of 1875) [98], the price of Welsh slate was eventually to reach unsustainable levels, when the new status of the product as a premium commodity was solely maintained by the exceptional demand [99]. The average wholesale price increased by thirty per cent in the decade after 1866, reducing the margin of the on-the-roof price of Welsh slates over clay tiles to only one per cent [100], and even slates imported from the U.S.A. could successfully compete with the Welsh product on the U.K. market during most of the 1870s [101].

The perception of the major Merionethshire slate proprietors of the dangers inherent in the volatile economic structure of the industry was well founded. In the face of a history of cyclical trends in the market any expectation of a permanence of the high sales and prices, which were required to maintain the myriad of speculative and high-investment quarrying concerns that had been established during this period, was foolish optimism. The Welsh slate producers were rudely awoken from their complacency by economic events described below, and the U.K. record output of 504,000 tons achieved in 1877 was to be the peak of the great upward cycle [102]. An inevitable reversal in the fortunes of slate quarries of North Wales was on the horizon, and when the bubble broke in 1878, events unfolded rapidly and with devastating results.

(c). Cycles of decline 1878-c.1980

Of the many cyclical reversals in the market demand for its product during the nineteenth century, that experienced by the North Wales slate industry immediately after reaching its peak of activity in 1877 had the greatest impact. This downturn differed from its predecessors by heralding the dawn of the long-drawn contraction of the industry. It is therefore pertinent to consider the differences in the circumstances on this occasion so as to identify why trade down-turns in previous years were staging posts on the upward trend in the industry, while the converse was true after 1877.

The first setback (1878-94)

The North Wales slate quarries had been initially shielded from a persistent general depression in the U.K. economy from the mid-1870s by a growing export trade and the remarkable resilience of investment confidence in the domestic building industry. Nevertheless, the insulation of the construction trades from the troubles of the general U.K. economy could not last indefinitely. Thus the overdue pause in the cycle of domestic speculative building experienced in 1878 resulted in a dip in demand for slates. This reduction was not particularly serious in terms of its scale and there was a small recovery in demand for slates in 1879. However, this was insufficient to absorb the resultant over-optimistic increase in the output of the Welsh quarries onto a market which was also occupied by cheaper imported slates from the U.S.A. The domestic market was consequently flooded and stock-piles amassed at the quarries, forcing prices and discount levels further downwards on the reduced 1878 rates (see Figure 4, above) [103].

This mis-reading of the scale of the upturn was not in itself a major disaster, because prices and sales were still at a very high level, but it had a greater psychological effect than an economic one, being a blow to the confidence of an industry which had experienced an almost unbroken state of progression since about 1850. However, a repeat of this error in 1881-82, on the occasion of another slight upturn in the home demand together with an awakening of the darkest forces of internecine rivalries, turned a minor setback into a major crisis [104].

On this occasion, the Welsh slate industry had geared itself to an excessively optimistic level. Consequently, there was a vast over-production for the actual level of demand and an enormous glut of unsold slate accumulated. A gradual increase in production levels was unattainable in the case of the North Wales slate industry, where internal competition and self-interest was extremely strong and where the two largest producers stood aloof from the remainder. Instead, there was a scramble for a reduced market share in which only the strongest concerns survived.

During the 1880s the Dinorwic and Penrhyn quarries used their tremendous economic power within the industry to maintain output levels regardless of the effect upon the remainder of the industry, a not unreasonable trading tactic from their individual points of view. They achieved this objective by co-ordinating the slashing of prices and increasing discounts, which had the collective effect of dumping a large volume of accumulated stocks on the market. This inevitably had catastrophic results on the remainder of the industry, particularly in those districts such as Nantlle, which produced the same type of slate as Dinorwic and Penrhyn, that is, the Cambrian blue and purple.

Consequently, neither the Caernarfon nor the Ffestiniog quarry owner's associations (see Part b., above) were able to hold together in the face of the unregulated drop in prices brought about by the cut-throat competition. The agreed common price structures quickly collapsed as members sought to protect their businesses by following the example of the largest producers, although few had the financial reserves to absorb the reduced profit margins that this involved [105].

The joint-discounting and dumping policy perpetrated by Dinorwic and Penrhyn continued well into the 1880s and assumed the character of a vicious spiral. By *c.*1885 the wholesale price of slates had dipped below the point where any further gains in sales volume were possible and further discounting on selected grades and sizes by the Dinorwic-Penrhyn cartel assumed the status of loss-leading, that is selling below the actual cost of production [106]. The smaller quarries had no hope of following this trend and those at Nantlle having high fixed costs of haulage or pumping saw their profits slashed, and any concerns having to service accrued debt came under a severe threat of financial failure.

In an attempt to prevent the demise of the remainder of the industry, the majority (numerically) of producers in Caernarfonshire and Merioneth set a common price list for 1885, so as to stabilise the free-fall [107], but this could only be a palliative while Dinorwic and Penrhyn continued to refuse to co-operate. Yet, a stabilisation of prices was achieved in 1885-86 because of a shortfall in supply caused by the lockout at Dinorwic from October 1885 to March 1886 and this proved a life-line for many smaller concerns in the short term [108].

The only sector of the trade which continued to increase in volume at a rate reminiscent of the 1870s was exports, hitting a peak in 1889, but this was of little avail to areas such as Nantlle, which dealt predominantly in the home market [109]. The only silver lining to the black clouds of the 1880s was the cessation of slate imports and the improved competitiveness of Welsh slates against clay tiles as a consequence of the price reductions. Yet, the consequential increase in sales of Welsh slates only partially retarded the downwards trend in prices in a commodity market which was still excessively over-supplied and wracked by internal subterfuge [110].

Although satisfactory comparative statistics are not available across the industry, it is clear that the slate quarries at Nantlle were adversely affected in the 1880s to a greater extent than any of the remaining major slate-producing districts. Furthermore, the recession appears to have lasted longer at Nantlle than elsewhere because the initial contraction that was common throughout the industry was extended in this district as a result of additional factors of a localised nature.

In the first phase of the downturn, from 1882 to 1887, the available output figures for the Nantlle district (Table 6, below) show that the nine main concerns were able to maintain their production levels at the expense of the marginal quarries, which were badly affected. This they achieved by slashing prices and advancing trade discounts, a policy which was to weaken their financial stability in the long term. Thus, despite the maintenance of shipments by rail from Nantlle Station from 52,000 to 56,000 tons between 1882 and 1887, these quarries suffered a drastic secondary decline in a period when the improved economic climate was reversing the slump elsewhere. The scale of the local difficulties is apparent from the shipment figures, which suffered a continued annual reduction in output, with the minima of 39,070 tons being reached in 1893, this being a reduction of around a quarter on the 1887 total [111].

TABLE 6

NANTLLE SHIPMENTS STATISTICS #2

QUARRY	1882	1883	1884	1887	1888	1889	1890	1891	1892
Dorothea	15049	15994	16333	14760	15438	14583	14321	9816	10117
Penyrorsedd	9708	4679	7493	7950	8597	10126	11723	10808	10749
Alexandra	no data for shipments via Dinas Junction								
Cilgwyn	8706	7044	6926	6142	6795	6435	5620	5256	4985
Moeltryfan	no data for shipments via Dinas Junction								
Talysarn	9836	11666	10766	9547	9059	9884	7389	6904	6163
Braich	no data for shipments via Dinas Junction								
Cloddfa'r Coed .	3219	2227	2863	3649	2239	1902	786	-	-
Coedmadog	1670	1771	3314	4638	2575	544	526	-	-
Fron	no data for shipments via Dinas Junction								
Fronheulog	911	3020	1504	1557	557	321	268	1240	730
Galltyfedw	-	-	*	-	-	-	-	-	-
Penybryn	509	4791	2610	1954	*	69	13	-	-
South Dorothea .	828	807	835	553	2185	2384	2164	1940	2733
Tanrallt	-	-	-	-	-	-	-	-	-
Tynyweirglodd ..	*	*	*	*	-	-	-	-	-
Gwernor	640	631	[537.	...155	..111]	122	22	96	212
Llwydcoed	no data for shipments via Penygroes								
Ty Mawr East ...	*	*	*	-	*	*	-	-	-
Ty Mawr West ...	*	*	*	*	*	*	*	*	*
Tyddyn Agnes ...	-	-	-	-	-	*	-	-	*
Brynfferam	no data for shipments via Dinas Junction								
Merchants	1695	3742	3575	1487	2494	3153	2724	2991	3129
DATA TOTALS....	52771	55376	56776	52392	49939	49637	45576	39070	38818

KEY: [....] data listed under personal shipper, provisionally correlated to a quarry by the present author.
- no figure given; quarry recorded elsewhere as closed.
* no figure given, but quarry working and shipping within a parent concern's total, or via a merchant.

Ref: Caernarfon Records Office, X/Dorothea Ms 5, ff.181-183, 'Tonnages of Slates Sent From Nantlle Station.'

This accelerated decline of the slate industry at Nantlle in the late-1880s and early 1890s was in part the consequence of the headlong unrestrained expansion of the quarries during the 1860s and 1870s (see Part b., above). The high rate of growth of the industry in this district had resulted in the speculative development of a significant number of quarries which had no long-term commercial future outside periods of high demand, but which contributed to the over-supply into the mid-1880s, to the detriment of potentially better concerns [112]. The catalogue of closures of such concerns can be followed in the employment data in Table 5, above.

Furthermore, the cumulative historical effects of the high density of workings in the district and technical problems associated with open-cast deep-pit quarries (see Chapter 3) were important local factors. Some companies, such as those operating the Dorothea, Penyrorsedd and Talysarn quarries were able to struggle through this critical period, albeit with some difficulty of which the catastrophic flooding of the first named, in 1884-85, was the single most important event. Both the Coedmadog and Cloddfa'r Coed quarries were abandoned (in 1890 and 1891 respectively), after being flooded by the river Llyfni, and the formerly important Cloddfa'r Lôn Quarry had to finally close in 1890 after weathering a series of crises brought about by incompetent management policies [113]. The total of men discharged through closures between 1885 and 1892 amounted to around six-hundred, not including an unrecorded number sacked due to reductions in the workforces of those quarries still operating (see Table 7, below). Thus, by 1893 the economic future of the Nantlle district was severely blighted and seemed almost beyond recovery [114].

Chapter 1: Economic Developments

The last boom (1895-1903)

The boom experienced by the North Wales slate quarries in 1895-1902 was an important cross-roads in the history of the industry. This recovery was the result of a variety of factors, including an ending of the long general depression in the U.K. economy. The resulting expansion in the building industry, particularly the development of housing projects in city suburbs, provided a welcome boost for the demand for slates and boosted their market price (see Figure 4, above). The Welsh slate quarry proprietors considered this major and rapid improvement in trade as a permanent return to the heady days of the 1860s and 1870s, but the boom turned out to be the first in a series of diminished upturns which characterised the complex cycles of decline in the Welsh slate industry after 1877 [115].

The error of the Welsh slate producers in displaying excessive optimism during the mid-1890s, was excusable. The most visible economic indicator available to the quarry owners, that is, their individual sales volume, shot up after 1895 at a rate not encountered since the 1870s. However, the rapid revitalisation of the industry exposed serious weaknesses in its organisation and the response of the Welsh producers to the new market conditions of the 1890s illustrated that the lessons of previous errors had not been learnt [116].

With hindsight, it is clear that the 1890s boom was double-edged. The restoration of a strong demand and stable prices was long overdue if the Welsh slate industry was to survive on a major scale. Yet, fate dealt a cruel blow by creating a deluge of orders on a weakened industry that was ill-prepared for such an event. Demand grew so rapidly after 1895 that it soon overwhelmed the producers, who only achieved increases in the average scale of production to a level that was not much greater

TABLE 7

NANTLLE SHIPMENTS STATISTICS #3

QUARRY	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902
Dorothea	10564	13183	14500	15094	14566	14310	14418	14233	14780	14703
Penyrorsedd ..	8593	11220	9946	12959	13714	12732	14522	12413	12337	12402
Alexandra	.... no data for shipments via Dinas Junction									
Cilgwyn	5117	5554	5272	5843	7699	6120	5921	6480	6793	7410
Moeltryfan ...	.... no data for shipments via Dinas Junction									
Talysarn	6037	7561	6763	5490	5911	8030	9571	8837	9690	12079
Braich	.... no data for shipments via Dinas Junction									
Cloddfa'r Coed	-	-	-	*	*	*	*	*	*	*
Coedmadog	-	-	-	-	132	2565	3297	2990	2946	3101
Fron	-	-	- shipment via Dinas Junction -						-	ibid
Fronheulog ..	1063	773	592	466	780	1271	1617	1255	1845	2041
Galltyfedw ...	*	*	*	393	683	2269	2476	2215	2305	2019
Penybryn	-	-	*	*	284	1157	889	1448	1574	1909
South Dorothea	2984	3750	3339	2593	2942	3421	3555	3265	2770	2488
Tanrallt	-	-	*	*	*	*	*	*	*	*
Tynyweirglodd	-	-	-	*	77	353	598	630	749	1062
Gwernor	181	255	257	462	121	135	129	96	177	317
Llwydcoed ...	-	-	-	-	-	-	-	-	-	-
Ty Mawr East .	[320...	522...	373...	915..	2913]	672	84	*	*	11
Ty Mawr West .	*	*	*	-	-	*	*	*	*	*
Tyddyn Agnes ..	-	-	*	-	206	*	757	531	449	413
Brynfferam ...	..... no data for shipments via Dinas Junction									-
Merchants	2204	3410	2192	6250	8856	[.......not recorded........]				
DATA TOTALS	37063	26228	45045	51219	58911	53035	57834	54393	56415	59685

KEY: [....] data listed under personal shipper, provisionally correlated to a quarry by the present author.
- \- no figure given; quarry recorded elsewhere as closed.
- * no figure given, but quarry working and shipping within a parent concern's total, or via a merchant.

Ref: Caernarfon Records Office, X/Dorothea Ms 5, ff.181-183, 'Tonnages of Slates Sent From Nantlle Station.'

than during the depressed 1880s [117]. This general trend identified by Dylan Pritchard is mirrored in the contemporary output of the Nantlle quarries (see Table 7, above), where the maximum tonnage handled by the railway depot was 58,911 tons of slates in 1897, which was only eleven per cent greater than the figure for 1887. However, due to the extended recession at Nantlle, the 1897 figure was a significant improvement of thirty-seven per cent on the lowest point of 1893 (see above) [118].

The supply problem affecting the Welsh slate industry in the 1890s differed from that encountered in the 1860s and 1870s. In the previous period of boom, a deluge of orders had swamped a growing industry working at full capacity. On this occasion a smaller increase in demand could not be met by an industry weakened by the closure of many quarries during the 1880s slump, and where the surviving concerns were incapable of substantially boosting their output due to two decades of reduced capital investment. Furthermore, because the majority of Welsh slate quarries were old, they consequently suffered from the law of diminishing returns and there were few new slate deposits of great value that had not already been exploited [119].

The upturn in sales that commenced in 1894-95 led both to the restoration of full production in those concerns which had survived the slump on a reduced scale of working and the reopening of many of the quarries at Nantlle. Official employment figures for the district (see Table 5, above and Table 8, below) increased substantially from about 2,600 men in December 1882 to a peak of 3,111 in December 1898 [120]. Most of the reopened sites were either occupied by gangs of independent quarrymen or were merged into existing concerns, and in neither case was development work generally possible because investment capital was becoming scarce in the industry [121].

TABLE 8

NANTLLE EMPLOYMENT STATISTICS #2

QUARRY	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906
Dorothea	532	515	530	490	508	521	515	492	475	476	477
Penyrorsedd	627	544	613	553	550	557	670	522	547	620	477
Alexandra	257	252	239	231	234	214	221	232	210	194	208
Cilgwyn	315	350	331	347	338	314	289	247	230	222	210
Moeltryfan	200	228	236	258	256	281	290	285	276	276	253
Talysarn	292	266	238	250	269	236	225	325	280	236	221
Braich	56	62	77	70	39	67	81	89	83	76	67
Cloddfa'r Coed ..	44	82	113	114	86	128	119	108	105	99	68
Coedmadog	2	107	158	150	143	158	140	150	162	128	121
Fron & Old Braich	9	28	50	40	-	-	31	33	42	50	40
Fronheulog	91	114	87	91	104	85	90	104	63	50	57
Galltyfedw	93	96	99	94	96	98	64	99	80	67	54
Penybryn	5	53	70	53	63	81	116	123	116	102	78
South Dorothea ..	148	124	121	119	108	110	100	112	107	103	102
Tanrallt	18	29	28	16	5	62	78	69	78	77	90
Tynyweirglodd ...	3	28	41	46	53	63	56	50	40	43	12
Gwernor	13	5	4	14	15	9	8	12	13	10	14
Llwydcoed	-	-	-	-	-	-	-	-	-	-	?
Ty Mawr East	22	24	32	20	20	12	11	10	13	12	5
Ty Mawr West	-	-	7	-	-	4	12	12	5	7	-
Old Penybryn	[part of Penybryn to 1900]						-	18	8	7	3
Tyddyn Agnes	23	17	30	10	2	4	2	?	3	6	6
Brynfferam	5	4	4	4	8	11	-	-	-	-	-
Gelli Bach	3	3	3	3	2	?	-	-	-	-	-
Taldrwst	-	-	-	?	-	-	-	-	-	?	-
Talymignedd	8	1	-	-	-	-	-	-	-	-	-
Ty Mawr Green ...	[.......part of Ty Mawr West to 1904.......]									5	?
United Qs Green .	[.......part of Ty Mawr East to 1905...........]										5
TOTALS	2766	2932	3111	2973	2899	3015	3130	3092	2864	2866	2568
No. of Quarries	22	22	22	22	20	21	21	21	21	23	23
No. Operating units	16	16	16	16	15	16	15	15	15	17	17

Key: - quarry closed, or work suspended
? working (occasionally or part of year), but no figure given

Refs: H.M.Inspectorate of Quarries Reports (1896-1906), Appendix 'List of Quarries.' Data refers to December employment figures submitted in the annual returns from quarrying concerns.

Chapter 1: Economic Developments

An analysis of the employment data for Nantlle shows that little had changed in the economic organisation of the slate industry in this district since the 1870s. Over two-thirds of the Nantlle quarrymen in 1898 were employed by only six concerns and the remaining sixteen quarries retained less than 100 men each, but just over a third of the total workforce was employed by only two companies [122]. This imbalance was indicative of a fundamental weakness in the financial structure of the industry in the district, which was to lead to a dramatic contraction in its scale of working during the forthcoming period of bad trade.

The shortfall in the supply of Welsh slates to the expanding home market of the late-1890s was partially ameliorated in the short term due to the slow decline of the export trade after 1889 [123]. This reduction in exports can be traced to the development of the slate reserves of several countries constituting the main foreign market of Welsh slates, together with an increase in the productive capacity of factories producing cheaper alternative roofing materials. The most important of these foreign slate-producers, of which France and the U.S.A. were the most prominent, eagerly seized the opportunity to capitalise on the inability of the Welsh quarries to satisfy the growing U.K. market and data show a steep growth curve in imports of cheaper foreign slates after the mid-1890s. Furthermore, British-made alternative roofing materials were also able to gain a firmer foot-hold, with new products such as cement tiles (for domestic use) and corrugated iron (for industrial and agricultural buildings) being provided with an opportunity to prove their worth [124].

An unexpected boost to these competitors of Welsh slates was provided by the loss at a crucial period of accelerating demand of the vast productive capacity of the Penrhyn Quarry due to a strike lasting from September 1896 to August 1897 [125]. This event also provided a bonanza for the remainder of the Welsh slate industry including the Nantlle quarries, but the potential short-term benefit of windfall profits resulted in the raising of prices to the maximum level that the market could bear. The Nantlle quarry owners, under the banner of the Caernarvon Slate Quarry Owner's Association (of 1886-1914), were especially aggressive in this field, illustrated by the monthly increases recorded to premiums on their published price lists [126].

Unfortunately, this marketing policy created long-term repercussions which severely damaged the Welsh slate industry. The greatly increased price of Welsh slates in 1896-97 enhanced the competitiveness of its many rivals in all of its markets, a trend aided by the establishment of a London-based marketing agency by the U.S.A. slate producers. A further example of the damaging results of the greed which infected the industry in this period was the permanent loss to cement tiles of a portion of the important German market, caused by the diversion of Welsh slate from the export trade to supply the more remunerative home market [127].

This gathering of storm clouds seemed to make little impression on the Welsh producers, who remained blinkered by the excess demand in the short term. By 1898, the quarries of North Wales were enjoying their best trading period since 1877, but this upturn from the depths of the 1880s recession unfortunately proved a false dawn [128]. The last half of 1899 and the early months of 1900 showed ominous signs of a slackening in demand for Welsh slate, although the overall roofing market was not diminished. However, an unexpected respite was earned when the roofing-slate market was thrown into turmoil during the first years of the new century by a recurrence of industrial strife at the Penrhyn Quarry [129].

Despite the common perception that the 1900-03 Penrhyn Quarry strike was the prime cause of the calamity that was to befall the Welsh slate industry at the dawn of the present century, this was not strictly true. The changes in the market economics that were to result in the displacement of Welsh slate from its position of pre-eminence were already in place by 1900. Furthermore, the stoppage at Penrhyn delayed the onset of the forthcoming reversal by temporarily restoring the shortfall in the output of Welsh slates, thus explaining the second, slightly higher peak in 1902 of 59,685 tons of slates dispatched from Nantlle station (see Table 7, above) [130]. The strike was a catalyst which brought all the inherent faults in the marketing and organisation of the industry to a head and the subsequent recession in the Welsh quarries was consequently more rapid and catastrophic than it might otherwise have been [131].

Continued decline (1904-14)

The return to work at Penrhyn in 1903 marked the close of the last great boom experienced by the Welsh slate industry and initiated a period of decreased demand which lasted until 1913. The initial problem was one of over-supply following the addition of the Penrhyn output to that of an industry working at full capacity and supplying a market which had become a very competitive one.

Yet, this reduction of the supply shortfall was to some extent beneficial to the Welsh slate industry in that it tempered the excessive price premiums charged during the boom (see above), thus improving the competitiveness of the product against foreign imports. Unfortunately, this potential consolidation coincided with a large downturn in the U.K. house-building industry that was caused by excessive speculative construction in the previous decade. Thus there was a glut of slates from all sources on a market which was also crowded with alternative roofing products, which resulted in a sharp drop in prices. Significantly, on this occasion the traditional bolt-hole available for the Welsh industry in the form of the export trade was also diminishing due to circumstances already described above, and this added to the volume of produce chasing a reducing home market [132].

The downturn in the slate trade during the first decade of the present century was much more serious than that of the 1880s. Thus, the smaller-scale operators such as the majority of the quarries in the Nantlle valley were severely squeezed by internal competition within the industry for a reduced global market. Furthermore, the reduced prices were a body-blow to the high-cost larger concerns in this district at a period of increasing production costs [133]. The scale of the problems at Nantlle post-1903 can be gauged from the catalogue of closures and scale-reductions which devastated the economy of the district in the decade before the First World War (see Tables 8 above, and Tables 9 & 10 below). Both the Coedmadog and Tynyweirglodd quarries closed in 1908 (with over 250 men being dismissed), followed by Braich and Fronheulog in 1911 (sacking about 80 men each), with Cloddfa'r Coed, Tanrallt and Gwernor following suit in 1913 (with approximately 150 job losses) [134].

These abandoned sites were good 'lower-second' or 'third division' concerns, and with the exception of Tynyweirglodd none of these quarries were ever worked again on anything except a squatter basis. Even the Dorothea Quarry was forced to close down two of its four pits in August 1908 with the loss of over 200 jobs, this number being nearly half of its workforce [135]. In 1905-13, the rate of job losses amongst the Nantlle quarrymen at thirty-eight per cent, was greater than in any other slate producing district, with the total number employed in 1913

TABLE 9

NANTLLE EMPLOYMENT STATISTICS #3

QUARRY	1907	1908	1909	1910	1911	1912	1913	1914	1916
Dorothea	481	311	287	310	316	330	320	311	276
Penyrorsedd	549	551	444	500	489	451	461	454	71
Alexandra	217	222	245	221	222	217	216	220	3
Cilgwyn	191	190	213	211	214	205	193	140	86
Moeltryfan	232	191	145	113	146	144	139	79	-
Talysarn	168	203	238	207	180	201	219	214	110
Braich	53	90	105	80	22	-	-	-	-
Cloddfa'r Coed ..	62	64	100	73	51	7	-	-	-
Coedmadog	119	130	-	-	-	3	7	-	-
Fron & Old Braich	50	40	12	-	6	9	6	-	-
Fronheulog	44	25	13	12	10	4	5	-	-
Galltyfedw	33	38	44	42	51	60	64	71	53
Penybryn	80	82	53	59	68	64	59	61	-
South Dorothea ..	103	106	108	120	124	112	102	112	-
Tanrallt	53	79	78	78	60	69	56	2	-
Tynyweirglodd ...	-	-	-	-	-	-	-	-	-
Gwernor	13	19	15	10	9	6	6	12	-
Llwydcoed	16	21	22	30	24	14	19	21	-
Ty Mawr East	?	-	5	4	5	4	-	7	-
Ty Mawr West	-	-	26	30	31	28	28	32	9
Old Penybryn	4	2	-	-	-	-	-	-	-
Tyddyn Agnes	-	-	-	-	-	-	-	-	-
Ty Mawr Green ...	5	-	-	-	-	-	-	-	-
United Qs Green .	4	?	-	-	-	-	-	-	-
Brynfferam	-	-	-	-	-	-	-	-	-
Cloddfa'r Lôn ...	-	-	-	-	-	-	-	5	3
Gelli Bach	-	-	-	-	-	-	-	-	-
Taldrwst	-	-	-	-	-	-	-	-	-
Talymignedd	-	-	-	-	-	-	-	-	-
Twll Llwyd	[part of Tanrallt Quarry until 1912]						3	7	2
TOTALS	2286	2364	2153	2100	2028	1928	1903	1748	613
No. of Quarries	21	19	18	17	18	18	17	16	9
No. Operating units	15	15	15	14	15	15	15	14	9

Key: - quarry closed;
? quarry working occasional or for part of year, figure not given.

Refs: H.M.Inspectorate of Quarries Reports (1907-1916), Appendix 'List of Quarries.' Data refers to December employment figures submitted in the annual returns from quarrying concerns.

TABLE 10

NANTLLE SHIPMENTS STATISTICS #4

QUARRY	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913
Do'thea	14064	11907	12902	14319	13636	10162	8953	8066	7643	9067	9079
P'sedd	11950	10491	11720	17019	11016	11949	10036	9040	10429	9905	10513
Alex	4496	3733	...... no data for shipments via Dinas Junction								
Cilgwyn	5270	5158	4837	4295	3828	3710	4496	4154	5369	4029	3785
M'tryfan	6411	5480	...... no data for shipments via Dinas Junction								
Talsarn	13256	9476	9670	9297	7731	5299	6767	7651	6381	7243	5641
Braich	1701	1366	....no data for shipments via Dinas Junction							-	-
C' Coed	*	*	*	*	*	*	*	*	*	*	-
C'madog	3065	2391	2319	2774	2816	3239	1290	-	-	*	*
Fron	422	948	...... no data for shipments via Dinas Junction								
F'heulog	1860	1142	1045	1058	938	583	414	454	492	290	*
G'fedw	1992	1562	1615	1145	598	844	1049	894	1973	2272	1852
Penybryn	2233	2384	1740	2334	2033	1806	1634	1814	1904	1180	1305
S D'thea	2754	2405	2177	2918	2702	2479	2532	2736	2106	2883	2300
Tanrallt	*	*	*	*	*	*	*	*	*	*	*
T'glodd	561	698	617	287	18	-	-	20	-	-	-
Gwernor	233	171	119	132	54	83	127	140	*	*	*
Llwydcoed	-	-	-	.... no data for shipments via Penygroes							
Ty Mawr E	124	50	98	93	21	44	-	20	-	-	-
Ty Mawr W	*	*	*	-	-	-	96	242	*	*	608
T' Agnes	280	276	290	177	-	-	-	-	-	-	-
Brynfferam	-	-	-	-	-	-	-	-	-	-	-
Others	-	-	-	-	-	-	-	-	-	-	418
NANTLLE STATION TOTALS	57642	48111	49349	55848	45391	40198	37394	35231	36297	36873	35501
+ DINAS	70673	59638	-	-	-	-	-	-	-	-	-

For expanded quarry titles, see previous tables, supra.

<u>KEY</u>: [....] data listed under personal shipper, provisionally correlated to a quarry by the present author.

- no figure given; quarry recorded elsewhere as closed.

* no figure given, but quarry working and shipping within a parent concern's total, or via a merchant.

<u>Refs</u>: Caernarfon Records Office, X/Dorothea Ms 5, ff.183-184, 'Tonnages of Slates Sent From Nantlle Station;' XD 35/420, ff.2, 71-72.

being reduced to fifty-six per cent of the 1898 total and the number of operating quarries in the area having diminished from twenty-one to sixteen [136].

The scale of social distress in this district was sufficient to cause considerable concern to the local authorities, who instigated public work schemes to alleviate the worst of the suffering. A large number of unemployed quarrymen were forced to leave the area to seek work, with the majority of them congregating in a number of South Wales coal mining villages such as Bedlinog, Clydach Vale and Treharris [137]. The government was requested to assist by reducing the relatively high rents and royalty rates of the Crown quarries at Nantlle, but despite remitting the unpaid due of a number of the quarries, no further intervention was forthcoming from that quarter [138]. However, by 1913 the demand cycle was on the upturn once again and the second half of that year was the best trading period for several years [139]. Despite a dip in sales during the first months of 1914 The immediate prospects for the Welsh slate industry looked optimistic by the early summer when, in August, the old world order fell apart.

The First World War and its legacy (1914-39)

Amongst the first commercial victims of the First World War was the Welsh slate industry, which suffered the simultaneous collapse of both its Continental and U.K. markets. Within a month of the declaration of war, most of the Welsh slate quarries were either closed or had adopted short-time working to service the trickle of orders being received. At Nantlle, only the Dorothea Quarry remained open on a full-time basis during the first year of the war, albeit with a reduced workforce [140]. A large number of unemployed quarrymen volunteered for the armed forces and others found employment in the coal industry and in war-work; one source recorded that around three-quarters of the workforce left the slate industry between 1914 and 1918 (see Table 9 above and Table 11, below) [141].

However, by 1916 there was a slight upturn in demand for slates as a result both of stockpiling by optimistic retail merchants in readiness for the expected post-war boom and due to War Office contracts for roofing new munitions works. The latter were finally awarded to the industry as the result of persistent lobbying of the War Office by a number of Ffestiniog quarry owners. The intervention the local member, David Lloyd George M.P. (Caernarfon Boroughs), in his role as the Minister for Munitions, and as Prime Minister after 1916, was probably crucial in this respect, although his government subsequently dismayed the slate producers by listing the industry as non-essential in 1917 [142]. Consequently, despite the reopening of several mothballed quarries (many of these being at Nantlle) the loss of manpower from the industry due to conscription, hampered the production effort. With typical pragmatism, Lloyd George's wartime government solved this problem by importing foreign slates to make up the shortfall [143].

The economic cost of the First World War on the Welsh slate industry was great, and its former pre-eminence was never restored after the cessation of hostilities in November 1918. The immediate effects of the war were three-fold. Firstly, the quarries were slow to recover their productive capacity after 1918 because of the combination of a deficit of development work coupled to an initial shortage of able-bodied skilled men [144], thus providing an opportunity for competing roofing products to gain a further hold on the U.K. market [145]. Secondly, a combination of higher wage rates and inflated fuel costs after 1916, in tandem with the

TABLE 11

NANTLLE EMPLOYMENT STATISTICS #4

Sites occupied by contractors marked +

QUARRY	1918	1920	1922	1925	1928	1931	1934	1937
Dorothea	214	264	425	416	400	356	434	359
Penyrorsedd	140	515	480	519	523	339	345	351
Alexandra	73	181	168	184	154	-	+	+
Cilgwyn	51	86	90	114	120	-	143	102
Moeltryfan	28	121	157	182	166	-	117	69
Talysarn	40	99	117	-	25	40	+	+
Braich	-	-	-	-	-	-	+	+
Cloddfa'r Coed ..	-	-	+	+	+	+	+	37
Coedmadog	-	+	+	+	+	+	+	+
Fron & Old Braich	-	-	17	8	?	+	8	7
Fronheulog	-	11	23	56	78	65	46	36
Galltyfedw	38	65	70	89	95	75	[in Dorothea]	
Penybryn/C'Lôn...	-	110	114	126	136	87	+	+
South Dorothea ..	2	83	[..........in Dorothea total...........]					
Tanrallt	-	-	-	-	-	-	+	+
Tynyweirglodd ...	-	22	3	3	2	-	4	39
Gwernor	-	-	-	-	-	-	-	-
Llwydcoed	-	5	?	+	+	-	-	-
Ty Mawr East	-	9	3	2	13	-	-	-
Ty Mawr West	-	9	3	10	5	-	-	-
Tyddyn Agnes	-	-	-	-	-	-	-	-
Brynfferam	-	-	-	-	-	-	-	-
Crown New	[...............started 1934..............]						13	13
Gelli Bach	-	-	-	-	-	-	-	-
Taldrwst	-	-	-	-	-	-	-	-
Talymignedd	-	-	-	-	-	-	-	-
Twll Coed	[part of Tanrallt until 1912]				?	-	-	-
Twll Llwyd	3	10	4	?	4	3	5	11
TOTALS	589	1590	1674	1709+	1721+	965	1115	1024
No. of Quarries	9	15	16	14	16	8	11	12
No. Operating units	7	12	12	10	12	6	8	9

Key: - quarry closed
? working occasionally or part of year, no figure given.

Refs: H.M.Inspectorate of Quarries Reports (1918-1937), Appendix 'List of Quarries.' Data refers to December employment figures submitted in the annual returns from quarrying concerns.

increased expense of working the remaining deeper rock bodies, pushed up the price of Welsh slates [146].

Consequently, the increasing proportion of the U.K. slate market was filled by the produce of low-cost Continental quarries, with the cheaper imports reaching a peak of 51,000 tons in 1926 [147], and British mass-produced asbestos and cement tiles gained a further market advantage, increasing in output from 200,000 tons in 1912 to 1,200,000 tons in 1935 whereas the production of Welsh slates fell by 75,000 tons in the same period [148]. Thirdly, with the reopening of an increased number of the mothballed slate quarries by 1919-20, competition on the home market intensified because the slate export trade failed to recover to its pre-war level, settling at only about ten per cent of its previous amount [149].

The reopening of the majority of the slate quarries at Nantlle by 1920 suggested to local observers that a recovery to the pre-war level of production was at hand (see Table 11, above) [150]. This was reinforced by a mini-boom in 1920-21 as the result of a government house-building programme known as the Addison scheme, which boosted demand by means of volume stock purchases of slates coupled to the placing of long-term supply contracts. Unfortunately, the cancellation of this construction programme in 1922 resulted in the flooding of the market with discounted government slate stocks. This destroyed the profitability of several of the most vulnerable quarry concerns, making them less able to face the more hostile economic and market climate encountered by the slate industry during the mid- and late-1920s [151].

Despite the huge increase in demand for roofing materials as a result of two house-building booms in the U.K., in 1923-29 and 1933-39 respectively [152], the demand for Welsh slates continued to decrease as the result of the marked reduction in competitiveness of the product [153]. Despite a series of reductions in wages and prices between 1921 and 1932 [154], every move by the Welsh quarries was matched by their overseas counterparts, which sold consistently at on average half the price of the home product [155]. British roofing tiles had also become less expensive than Welsh slates by the 1920s as a result of the mechanisation of the production process [156], the price advantage of asbestos tiles being twenty per cent by 1924 [157]. Furthermore, changes in aesthetic tastes which came about with the promotion of new methods of roof construction also militated against the market appeal of the traditional dark Welsh slates in favour of the red tiles [158].

Whereas the resulting decrease in the number of operating slate quarries benefited the surviving concerns in a shrinking market, the maintenance of the productive capacity of the biggest quarries such as Dinorwic, Penrhyn and Oakeley had dire economic effects on an area of smaller concerns such as the Nantlle Valley. Thus, the inter-war years witnessed a period of retrenchment and quarry closures in this district on a scale in excess of that afflicting the remainder of the industry (see Table 12, above). The economic depression at Nantlle was consequently very severe during the world-wide slump of 1929-32 and was magnified by the exceptionally severe weather which ruined many productive rock faces in the first months of 1929 [159].

The catalogue of the failure by 1931 of half of the quarry concerns operating at Nantlle in 1922 (see Table 11, above), commenced with the demise of the once very important Talysarn Quarry in 1925, followed by a spate of smaller concerns including the small but highly productive Galltyfedw Quarry in 1931, followed by the Penybryn Quarry in 1932. Even highly capitalised, efficient concerns were not immune. Of the three quarries taken over by the Amalgamated Slate Association Ltd. in 1918, the two least cost-effective units (Cilgwyn and Moeltryfan quarries) were closed in 1929, and even the Alexandra Quarry, equipped with modern electric plant, succumbed in 1930. Over 400 men lost their livelihoods with the folding of the Amalgamated Slate Quarries, and the adjacent mountain village of Rhosgadfan consequently experienced almost total unemployment while the district in general had an average of some thirty-eight per cent of the insured population jobless [160]. The Nantlle quarries officially employed a workforce of 1,721 men in twelve operating units in December 1928, but by December 1931 the total was slashed to 965 quarrymen in six concerns, which was only just over a quarter of the numbers working in the industry in this district in 1898 [161].

However, one sector of the slate industry that benefited from these changes was that of green and 'rustic' slates, which came into vogue for up-market properties during the inter-war years [162]. Consequently, the production of these varieties of slates became highly profitable during the 1920s and 1930s, in a direct contrast to the decreasing profitability of the blue and purple varieties. Unfortunately, the green slate was the rarest variety in Wales whereas it was common in the quarries of north-west England [163]. The most extensive Welsh green slate vein was found and worked at Nantlle, but it was for the most part very narrow and costly to extract, and only one local concern had sufficient capital to fully exploit this new market [164].

It was as the result of the scarcity of the green slate that an innovative attempt was made to permanently tint the standard blue or purple slates with translucent pastel colouring agents so as to take advantage of this new market demand. A company, partly owned by the quarrying concerns including the Dorothea Quarry (Nantlle), was set up in 1927 to exploit the process, with the first plant producing these so-called 'colloidal slates' being set up at Ffestiniog. However, the product was a commercial failure both on economic and technical grounds and no additional facilities were ever installed elsewhere [165].

After 1932, the Welsh slate industry felt the benefit of the improvement in the U.K. economy [166], although the reduced productive capacity of the industry following the closures over the previous decade, made the quarries unable to adequately respond to increased demand during the phenomenal housing boom of the mid-1930s [167]. The increase in business confidence at Nantlle was most apparent in the re-opening of the ex-Amalgamated Slate quarries by the new Caernarvonshire Crown Slate Quarries Co.Ltd., aided by a large Treasury loan [168], but the mood of optimism was also infecting established concerns, several of whom commenced development work and installed new machinery [169]. Several well-known names were, however, absent from the lists of operating sites (see Table 11, above) and examination of official statistics shows that this recovery was only a relative one from a deep trough to a level of production equal to the depressed 1900s.

Whereas the Bethesda workforce increased by seven per cent from 1928 to 1934 and that at Llanberis was only reduced by six per cent, the serious degree of contraction of the industry in Ffestiniog of nineteen per cent was dwarfed by the thirty-six per cent drop in the employment totals at Nantlle. There were only 1,115 quarrymen officially at work in the Nantlle district in December 1934 and by December 1937, this figure had dropped to 1024 men, although the number of operarting sites had increased by one to a total of twelve (see Table 11, above). The last employment census before the outbreak of war, conducted in July 1939;

showed the number of quarrymen at Nantlle having reduced again to only 800, this being only a quarter of the 1898 peak total [170].

Contraction in output (1939-1980)

The outbreak of the Second World War in September 1939 brought about a collapse in the U.K. building industry, as had occurred in 1914. What remained of the slate export trade also ceased but this was of minimal importance by this date. Thus the majority of Welsh slate quarries were forced to close during the first few months of the war and the remainder had to drastically reduce their scale of production.

The younger men were absorbed into the armed forces and others went into alternative war-related occupations both in the locality and in England [171]. On this occasion, the military war-effort provided no commercial opportunities for the slate industry because of the preferential use of cheap, light materials such as asbestos sheets and corrugated iron to roof barracks and other installations [172]. However, the changing methods of warfare compared with previous conflicts created a new and unexpected strategic role for the Welsh slate industry, although in retrospect the final result was far from favourable for its long-term survival.

German bombing of British industrial centres and port facilities during the *blitz* of 1940-41, followed by the rocket campaign against London in 1944, destroyed a huge number of domestic properties and severely damaged several million other adjacent houses [173]. These were mostly older properties roofed with Welsh slate. The repair of the blast-damaged houses became a vital necessity, both on economic grounds and for the maintenance of morale and therefore an abnormally huge demand for slates was created [174]. This was possibly magnified by the inability of the tile industry to provide sufficient substitute roofing material for replacement roofs, due to factors such as restrictions on oil-based fuels.

From February 1941, the Welsh slate industry was placed under the control of the Ministry of Works and Building by the provisions of statutory emergency powers legislation and by the autumn it was registered as an Essential Industry. The day-to-day control of the industry was delegated to the Slate Quarries Executive Committee based at Port Penrhyn, Bangor, one of many so-called 'sectional committees' set up to superintend specific industries. It was made up of area representatives of the employers under the chairmanship of a Ministry official, namely R. W. Jones formerly of the North Wales Quarrymen's Union [175].

This local secretariat carried out the edicts of the Ministry appertaining to the regulation of the production side of the industry regarding such matters as sales and price levels; wages; the supply of consumable materials, plant, machinery and fuel; and even special ration provision for the employees. The main quarries at Nantlle, namely the Crown Company, Dorothea and Penyrorsedd, were consequently included in this controlled group, but it is known that some of the minor Nantlle quarries also continued to work during the war under less stringent regulation [176].

The operation of the major quarries was geared to the requirements of the war effort, both in terms of their organisation of labour and in terms of their production. It was probably through the Executive Committee that pressure was brought to bear on the quarry proprietors by the Ministry, to maximise output at the cost of ruining the quarries in the short term in the greater national interest and this patriotic call was certainly heeded. The example of the Dorothea Quarry was typical in this context. Practically no development work was undertaken during the four years of wartime operation, such that the investment and gains made in the efficiency of the concern during the 1930s were all but lost by 1945, leaving the Company in dire straits at the onset of the peace [177]. Some recompense must have been promised for this commercial sacrifice, but the reconstruction of other industries was to take precedence and the slate industry was soon to find itself being cast adrift in a very hostile commercial situation [178].

An unprecedented step was taken by the incoming Labour Government of 1945 in its retention of wartime controls over certain industries so as to facilitate the difficult transition to a peacetime economy. One of those industries was Welsh slate-quarrying, whose total output was required, under controlled price conditions, for the completion of the housing repair programme [179]. Thus, the industry suffered a further four years of restrictions under the Ministry of Works before it was able to compete on the open market [180]. The scale of future problems can be gauged from comparative production data for the first eleven months of 1945 which showed a seventy per cent increase in the output of the English tile industry whereas the output of Welsh slate grew by only forty-five per cent [181]. The threat to the future of the slate industry by being denied access into the booming post-war free market was apparently of no consequence to a government in dire economic difficulties. The only crumb of comfort offered was a committee of enquiry which produced a technical report suggesting methods of improving the efficiency of the industry, although no grant aid was forthcoming to implement any suitable proposals [182].

Paradoxically, although its larger quarries were to suffer from the shortfall of investment capital required to restore their productive efficiency, these years of post-war trade restrictions provided a temporary mini-boom to the minor quarries in the Nantlle district. A number of these sites were reopened in the late 1940s by English builders' merchants who wished to circumvent the bureaucratic system by obtaining their slates at source (see Table 12, below). This activity continued for a number of years after the relaxation of restrictions, but had ceased by the mid-1950s due to the poor quality of the quarries being worked and the increased availability of better slate at competitive trade discounts from the larger producers in the later diminishing and over-supplied market [183].

With the return of the free market in slates by 1950, the immediate problem facing the Welsh slate industry was that of re-establishing its position in the roofing material market. Changing architectural styles and building techniques made slate increasingly redundant and its continuing high price made it less competitive against tiles wherever traditional types of domestic buildings were being erected, even within the hinterland of the quarrying areas themselves. However, the slate industry remained to a great extent locked in a time warp in terms of its technology and working practices. In the latter case, the most potentially damaging factor was the attitude of the producers to advertising and marketing, which varied within the individual concerns from apathy to cut-throat internecine rivalry [184].

The fate of the Welsh slate industry in the post-war period coincided with Dylan Pritchard's accurate prediction extrapolated from historical precedents, that a significant contraction in the level of production would occur unless the situation was addressed either from within the industry or in the form of political interventionist policies. Neither was forthcoming during the 1950s, which consequently witnessed a significant shrinking of the industry in the face of diminishing demand in all its market sectors except for the provision of damp-proof courses in brick walls, which was an outlet that remained almost exclusively dominated by slates in the absence of suitable alternative materials [185].

With the exception of the independent contractors producing damp-proof slates, of which Nantlle Valley had the highest concentration in the industry (see Chapter 3 and Table 11 above and Table 12, below), the decline during the 1950s in the economic importance of slate quarrying in the district (see Table 12, below) followed the industry-wide trend of this period. Closures occurred across the spectrum of quarry size, with a reduction in the number of operating sites from fourteen in 1950 to eight in 1955 including the Cilgwyn, Fron, Penybryn, South Dorothea, Tynyweirglodd and Tanrallt quarries. Concurrently, the surviving largest concerns shed labour in order to balance their reduced sales income against the mounting production expenses, albeit at the cost of decreasing their ability both to develop new rock reserves or to respond to any future increase in demand. Whereas the post-war opening total (December 1946) of around 450 men employed in the Nantlle quarries was half the immediate pre-war figure, by 1960 the number had dwindled to only about 220 men [186].

In the face of such an alarming contraction of the industry it was essential that the proprietors developed an identifiable market niche for slate where its unavoidable premium price would not be a disadvantage and also that the methods of production were modernised so as to reduced production costs. Yet, despite the continued reduction in demand for roofing slate, the 1960s commenced encouragingly for those concerns which had survived, because the reduced internal competition in the slate trade increased the individual sales figures. Furthermore, all the major quarry proprietors had finally become organised in an new owners' association (revived in 1943) which maintained common price levels, although it failed to tackle marketing issues because of the continued resistance to the concept of a common cause [187].

A diversification of products within the industry also assisted in revitalising the most progressive concerns such as the Dorothea Quarry at Nantlle. Polished and 'naturally riven' flooring slabs and tiles became the vogue in the upmarket interior decorating market for a number of years, and slab cladding made a good initial impact as decorative panelling on plain concrete structures. Slate craftwork proved very remunerative on a small scale but had an insufficient market to rescue a whole industry. Crushed slate and its derived slate brick industry also showed considerable promise, but the combined output of Penrhyn Quarry in the former trade and Dinorwic Quarry in the latter was sufficient to saturate the available demand [188]. Tourism was also tapped as a minor source of revenue by the Dorothea Quarry, which offered for 2*s*.6*d*. (12½p.) per head a demonstration of slatemaking at the mills and a view of the "deepest man-made hole in Britain". However, the early volume of car-owning visitors was low in the mid-1960s and the Dorothea site had been closed and stripped before the heritage industry enjoyed its huge upsurge as the result of the increased individual mobility of the 1970s [189].

Yet, despite the innovations, the main problem of the Nantlle slate industry during the early 1960s was a shortage of finance to capitalise on the greater demand for slate products [190]. However, the mini-boom was brought to a rapid end as the result of a collapse of confidence in the pound following the election of a Labour government in 1964. One of the many effects of the resulting credit squeeze implemented in the 1965

TABLE 12

NANTLLE EMPLOYMENT STATISTICS #5

Sites occupied by contractors only, marked +

QUARRY	1946	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995
Dorothea	136	*150*	*180*	*80*	*60*	2	+	-	-	-	-
Penyrorsedd	180	*160*	*120*	*100*	*70*	30	15	15	-	10	17
Alexandra	+	[combined with Moeltryfan]					-	-	-	-	-
Cilgwyn	40	13	+	+	+	-	-	-	-	-	-
Moeltryfan	66	75	62	36	38	4	-	-	-	-	-
Talysarn	+	-	-	-	-	-	-	-	-	-	-
Braich	+	+	+	+	-	-	-	-	-	-	-
Cloddfa'r Coed .	+	+	-	-	-	-	-	-	-	-	-
Coedmadog	+	+	+	+	-	-	-	-	-	-	-
Fron &Old Braich	+	*10*	+	+	-	-	-	-	-	-	-
Fronheulog	2	*10*	*10*	*4*	*2*	3	3	1	1	-	-
Galltyfedw	+	+	-	[in Dorothea]			-	-	-	-	-
Penybryn	[in Dorothea]-			-	-	-	-	-	-	-	-
South Dorothea .	-	[in Dorothea]			-	-	-	-	-	-	-
Tanrallt	+	*8*	*6*	*2*	-	-	-	-	-	-	-
Tynyweirglodd ..	5	*20*	-	-	-	-	[with Twll Coed]			-	-
Gwernor	-	-	-	-	-	-	-	-	-	-	-
Llwydcoed	-	-	-	-	-	-	-	-	-	-	-
Ty Mawr East ...	-	-	-	-	-	-	-	-	-	-	-
Ty Mawr West ...	-	-	-	-	-	-	-	-	-	-	-
Tyddyn Agnes ...	+	+	-	-	-	-	-	-	-	-	-
Brynfferam	-	*2*	*1*	-	-	-	-	-	-	-	-
Crown New	-	-	-	-	-	-	-	-	-	-	-
Gelli Bach	-	-	-	-	-	-	-	-	-	-	-
Taldrwst	-	-	-	-	-	-	-	-	-	-	-
Talymignedd	-	-	-	-	-	-	-	-	-	-	-
Twll Coed	-	*6*	*6*	-	*2*	4	7	2	-	-	-
Twll Llwyd	4	*10*	*6*	*3*	*3*	4	3	4	2	2	2
TOTALS	453+	464+	391+	225+	175+	47	28	22	3	12	19
No. of Quarries	8	14	10	8	8	8	5	5	3	2	2
No. Operating units	5	9	8	6	6	6	4	4	2	2	2

Key: *italic data* author's estimates for 1950-65; - quarry closed.
Refs: H.M.Inspectorate of Quarries, 'List of Quarries', 1946; Caernarfon Records Office, G.P.Jones Collection, papers of the Caernarvonshire Crown Slate Co., and Nicholson Quarries Ltd.; estimates (*in italic*) and data collected post-1970 by the present author.

Finance Act, was a reduction in the rate of building and repair of domestic properties, which represented the last major market for the Welsh slate industry [191].

This new cycle of decline rapidly reversed the gains made in the early-1960s, creating in its wake a vicious circle of strangulated cash-flow, manpower reductions, a freeze on development work and consequential reduced production capabilities within the individual quarry concerns. In an attempt to circumvent this damaging series of events, the three major concerns of the Nantlle district investigated a merger in 1965 and again in 1969, but did not proceed further (see Chapter 2, part a). However, cash-flow problems caused the demise of both the Dorothea Quarry in 1969 followed by Moeltryfan Quarry (alias Crown) in 1972 (see Table 12, above) [192], this period also witnessing the demise of Dinorwic (Llanberis) and Oakeley (Ffestiniog), two of the leading Welsh slate concerns. As a result of the loss of both Crown and Dorothea, the number of Nantlle quarrymen in 1973 had been reduced by half from the 1969 total of around 170, with the vast majority of those remaining in the quarries being employed at the Penyrorsedd Quarry, the last large-scale producer in the district (see Table 12, above) [193].

Despite the collapse of the market in the traditional blue and purple slate market, there was by the mid-1960s a renewed interest in the architectural applications of green and rustic slates as had also been the case in the 1920s. This product had lapsed after its temporary popularity in the inter-war years into a state of stagnation other than for limited specialised applications served by two or three diminutive local concerns competing with the Cumberland quarries. A major investment in the Nantlle green slate was initiated in 1972 by the Cocklebank Conservations Ltd., a company with a history as peculiar as its title. Despite the huge initial expenditure, this concern was doomed to failure from the outset because of the poor quality of the green vein in its first acquisition at Twll Coed, followed by the ineffective development of the potentially valuable Tynyweirglodd Quarry after 1974. Although this concern lingered on until 1984 and still nominally survives under new ownership as a producer of crushed slate aggregate, the number of employees rapidly dropped from an initial ten men to an average of only four during most of the 1970s [194].

The continued survival of the Penyrorsedd Quarry until nearly the close of the 1970s was, paradoxically, the result of its refraining from excessive technological innovation. This had initially been due to operational reasons, but latterly the Company feared the fate of the Dorothea concern, ruined when caught in a borrowing cycle during a collapsing market (see above). Consequently, despite suffering from a slow reduction in the output capacity of its quarry through a lack of sufficient development of fresh rock, the capital balance sheet of the Penyrorsedd Company remained healthy because of its prudent stock investments and lack of debt. Nevertheless, upon the raising of the question of Penyrorsedd's viability in 1977, the Company's capital reserves were distributed amongst the shareholders in preference to risking their loss in further quarrying developments [195].

The closure of the Penyrorsedd Quarry in 1978 represented a major event in the economic history of the Nantlle district. This was the last large quarry in the area, and its demise marked the end of an era, although its workforce had diminished progressively to only fifteen men at its closure [196]. Following the suspension of work at the diminutive Twll Coed pit by 1980, the slate industry in the Nantlle Valley consisted of the two quarrymen at Twll Llwyd and one occasionally at

Fronheulog Green (see Table 12, above) [197], this being probably the lowest employment figure in the quarries since at least the seventeenth century. Whereas most commentators (including the author) had no expectation of a revival in the fortunes of the industry locally, subsequent events proved otherwise, albeit on a modest scale.

(d). A new dawn, post-1980

Whereas the viability of the surviving rump of the Welsh slate industry during the early 1970s had depended to a great extent upon the repair trade [198], an important reversal in what had appeared to have been its terminal decline was brought about after the mid-1970s as the result of a convergence of a number of factors. The most important of these were:- (a) a new architectural fashion for natural products; (b) an increase in building developments within the zones of planning restrictions in Gwynedd; (c) a revival of overseas demand for Welsh slates; (d) active marketing by a new generation of astute managers; and (e) technological advancements in the utilisation of crushed slate aggregate. The introduction of local authority grant aid for renewing old slate roofs was also of crucial importance, especially in view of the requirement within designated areas of Gwynedd to use new slates of a matching type, which could only be obtained from the local quarries [199].

The growth in demand for slates and slate products created a large shortfall in supply during most of the 1980s, barring the recession of 1981-82, whereby cheaper imports from Spain and more recently from Newfoundland, together with a newly-developed reconstituted slate/resin tile gained inroads into the U.K. market [200]. Furthermore, a reduction of the maximum rate of local government roofing grants in 1991 together with the abolition in 1992 of certain local planning regulations, weakened the strong level of local demand whilst concurrently opening that same market to the cheaper Spanish slates, which had been barred from Gwynedd for two decades. However, the resurgence since *c.*1980 of a global export trade for Welsh slates, in which the long-term supply contracts with trade outlets in Germany and Holland have proved the most beneficial features, together with the sale to the manufacturers of the epoxy tiles of slate waste, has largely compensated for the invasion of the home market by the competing slate products [201].

The most tangible benefit of the first phase of this latest market upturn was the consolidation of the economic base of the North Wales slate quarries which had survived the rapid decline of the first half of the 1970s. However, the mini-boom which developed in the late-1970s was characterised by a spate of reopening of abandoned quarries, which were almost entirely located in the Ffestiniog district, where the greatest entrepreneurial effort was concentrated. Elsewhere in the region, many derelict quarries were concurrently acquired both by existing quarry companies and by external investors as future reserves of workable slate and rock-aggregate [202].

In the case of the Nantlle Valley, the most important result of the current mini-boom was the reopening in 1979 of the mothballed Penyrorsedd Quarry by the newly-constituted Nantlle Slate Quarry Company Ltd., part of the Ffestiniog Slate Group of companies. The adoption of modern mechanised quarrying techniques by this concern (see Chapter 3) enabled it to undertake a comprehensive development of the quarry using a minimal labour-force, currently standing at seventeen men. Whereas a long-term capital commitment on this scale would have proved extremely risky to an operator entering the slate trade for the first time, the advantages of inter-quarry loaning of spare plant and an established marketing/sales structure within the Group overcame this problem.

A number of other sites in the Nantlle district have been promoted for reopening during the 1980s and early-1990s, of which the most promising are the Alexandra/Moeltryfan (or Crown) Quarry and the Dorothea site, which includes the Blaen Cae, Cloddfa'r Lôn, Galltyfedw, Penybryn, South Dorothea and Talysarn quarries. Yet, despite the failure to come to fruition of these proposals to recommence roofing-slate production, several disused quarries were reactivated during the 1980s and early-1990s as sources of slate aggregate (see Chapter 3). Of these, the two largest operators are the reconstituted Cocklebank Conservations Ltd., part of the Ffestiniog Slate Group since 1984 (see above and sub-section c., above), extracting from the Fronheulog and Tynyweirglodd sites, and Watkin Jones Ltd., at the Ty Mawr East Quarry. Only six men are involved in the operation of these aggregate sites, in addition to the current total of slate quarrymen in the Nantlle district (May 1995) of around twenty men, a figure which has been maintained for around fifteen years except during an interregnum from 1984-88, when the number was reduced to only two men, due to a temporary suspension of work at the Penyrorsedd Quarry (see Table 12, above) [203].

What does the future hold for slate quarrying in Gwynedd generally, and within the Nantlle district in particular?

The market conditions for slates in the mid-1990s are in as much of a state of flux as was the case a century earlier, and the only safe predictions are the continuance of the innate volatility of the market and the importance of localised factors to the fate of individual concerns. A likely increase in the demand for rock-aggregate, together with a possible development of alternative uses for the waste, might yet overturn the traditional economics of the industry [204]. In addition to increasing the viability of existing concerns, this might also provide an incentive for the reopening of some defunct quarries, assuming that environmental considerations within the planning laws can be satisfied.

NOTES

CHAPTER 1

Abbreviations

C.R.O. Caernarfon Records Office (Gwynedd Archives Service)
Q.M.J. Quarry Managers' Journal
S.T.G. Slate trade Gazette
T.C.H.S. Transactions of the Caernarfonshire Historical Society
U.C.N.W. University College of North Wales (now University of Wales, Bangor).

Part a

1. The pioneering accounts of the economic history of the North Wales slate industry on which most later works are based are found in Dodd, A.H; The Industrial Revolution in North Wales, (Cardiff 1933, re-published Wrexham 1990) pp.203-222; and Lewis, E.Llewelyn, The Slate Industry, (Denver, Colorado, U.S.A. 1927); together with the authoritative accounts by Pritchard, D.Dylan, in Q.M.J., 1942-49 (see C.R.O., XM 1366), in which the historical information is based upon his thesis 'The Slate Industry in North Wales: a study of the changes in economic organisation from 1780 to the present day' (Bangor 1935).

   The most detailed of the contemporary economic regional histories of the industry are Lindsay, J., A History of the North Wales Slate Industry, (Newton Abbot 1974) and Richards, A.J., Slate Quarrying in Wales, (Llanrwst 1995).

2. See Bibliography, sub-list of Nantlle secondary local history sources for full details. The most useful general *eisteddfod* competition essays in this category, which are widely quoted in this chapter are:- (a) C.R.O., XM 392/1, by "Diwyd" (unidentified *nome de plume*) of 1877; (b) U.C.N.W., Nantlle Ms 1, by John Hughes ("Alaw Llyfnwy"), entered in the same competition as (a) above ; and (c) an essay by "Sylwebydd" (John Griffiths) of 1889, of which a version edited by his son, W.J.Griffiths, was published under the title Chwarelau Dyffryn Nantlle a Chymdogaeth Moeltryfan, (Conway *c.*1930). See also, Richards, G., 'Chwareli Dyffryn Nantlle,' T.C.H.S., Vol.29, (1968), pp.5-24.

3. John Griffiths, Chwarelau Dyffryn Nantlle, op.cit., pp.64-65, 69. Because the slates at Ochr-y-Cilgwyn could be split along their sides in addition to the usual top surface, the yield per block was greatly improved in the early period, when the crudeness of the preparation process often failed to create a good cross-cut face.

4. Ambrose, W.R., Hynafiaethau, Cofiannau a Hanes Presennol Nant Nantlle, (Penygroes 1872), p.51 refers to this as local folk lore, based upon some surviving physical evidence at that time.

5. C.R.O., XM/392/1, f.3; Boon, G.C., 'A Temple of Mithras at Caernarvon - Segontium,' Archaeologia Cambrensis, Vol.CIX, (1960), pp.136-172, references to slate roofing pp.141-2, p.150, p.157, p.170 and to sawn slate slab p.171; Lindsay (1974), op.cit, p.18.

6. Lindsay, loc.cit.; Ambrose, Nant Nantlle, op.cit., pp.22-25; Bassett, T.M. and Davies, B.L., Atlas Sir Gaernarfon, (Caernarfon 1977), pp.82-83, refers to two visits by Edward 1st to Baladeulyn (on 9-10 May and 9 June-3 July 1284 respectively) during the triumphal victory tour of Gwynedd.

7. The earliest published reference found for this alleged slated roof at Nantlle in the 1280s appears in Griffith, J.O. ("Ioan Arfon"), Llechfeini Sir Gaernarfon,' (Tremadog 1864, reprint of article in Y Brython, 1863), p21. Subsequently, versions have appeared chronologically in W.R.Ambrose (1872), Nant Nantlle, op.cit., p.74; by the 'Special Correspondent' of the *Carnarvon & Denbigh Herald* (1873) - see The Slate Quarries of North Wales in 1873, (ed. M.J.T.Lewis), p.66; Davies, D.C., A Treatise on Slate & Slate Quarrying, (1877; 2nd ed., 1887, p.161), and by J. Griffiths (1889), Chwarelau Dyffryn Nantlle, op.cit., p.64, reappearing in Lindsay (1974), op.cit., p.18.
The origin of this claim is likely to be, in part, the researches in early manuscript sources by the Rev.John Jones of Llanllyfni (1786-1863), a noted antiquarian (see Ambrose op.cit., p.23 para.3, and p.47 for biographical details), although the story might also have been preserved in folk-lore. For example, "Hugh Miller" (Rev E. Stephen, *Tanymarian*), 'Chwarelau Arfon a Meirion,' in Blaenffrwyth Ardudwy, (Bethesda 1855), referred (p.124) to the visit of the King to Nantlle and to the alleged contemporary slate quarrying in this district, a more confused version of which was repeated in a prize essay C.R.O., XM 392/1 (unpublished, 1877), f.2.

8. G. Richards, 'Chwareli Dyffryn Nantlle,' op.cit., p.7; Tomos, Dewi, Llechi Lleu, (Groeslon 1980), p.15.

9. Dodd, Industrial Revolution, op.cit., p16.; C.R.O., XM 392/1, f.3. Later rebuilding has unfortunately swept away all traces of medieval roofs from structures in the Nantlle district. Possible construction dates for dates for local ecclesiastic buildings and manor houses can be found in Ambrose op.cit., pp.16-39, 74 and in the publications of W. Gilbert Williams passim., (see Bibliography).

10. C.R.O., XM 392/1, ff.6-7; Inventory of the Royal Commission on Ancient Monuments in Wales & Monmouthshire, Vol.II, (London 1960), parishes of Clynnog, Llandwrog, Llanllyfni and Llanwnda, passim.; author's fieldwork. Good examples of early slated roofs can presently be found on the derelict farmhouses of Penybryn and Talysarn Uchaf in the Parish of Llandwrog and on the former house (now a derelict cowshed) at Caerengan, Llanllyfni.

11. Dewi Tomos (1980), Llechi Lleu, op.cit., p.15.

12. This apt term is attributed to Dr M.J.T.Lewis (University of Hull).

13. See reviews of the early use of slate in North Wales in Dodd, op.cit., p.204; and Dylan Pritchard, 'The Early Days of the Slate Industry', Q.M.J., July 1942, pp.30-33. Lindsay (1974), op.cit., pp.14-23 refers to the slating of several medieval buildings in North Wales, for instance Llewelyn's Hall at Caernarfon in 1317 (p.19), Conway Castle by 1287, and many buildings in the latter town by 1399 (pp.19-20). The border port and fortress at Chester also had slated roofs in 1358-60 (p.20), as had the late thirteenth century Bishop's palace at Gogarth near Conway (p.20).

14. Dylan Pritchard, Q.M.J., July 1942, op.cit., p.30; Lindsay (1974), op.cit., p.12; Jones, D.C., 'A Relic of the Slate Trade on the Menai Strait,' Cymru a'r Môr, Vol.2, (July 1977), pp.13-15 describes the remains of a boat carrying slates, which may have dated from the middle ages.

15. Dylan Pritchard, Q.M.J., July 1942, op.cit., p.31; Lindsay (1974), op.cit., pp.14, 20, 22. The 'Ogwen quarries' later became the renowned Penrhyn Quarry. Reference to the early quarries at Llechan and Maenan in the Conwy Valley was kindly supplied by Dr D.Rhys Gwyn.

16. Barfoot, P.; & Wilkes, J.; Universal Directory of Trade Commerce and Manufactures, (1790), Vol.2, p.532; The Cambrian Register, (1795), Vol.1, p.285; Dylan Pritchard, Q.M.J., July 1942, op.cit., p.30 and Lindsay (1974), op.cit., p.24 both quoting statistical analysis of the extant Customs records in Lewis, E.A., Welsh Port Books 1550-1603, (London 1927), also incorporated into Thomas, D., 'Llechi a Llongau,' T.C.H.S., Vol.1, (1939), pp.68-84.
It appears that the south Llanberis/Waunfawr quarries, which were the only alternative sources for the slates shipped from Caernarfon in this early period, were much less developed than the quarries of Nantlle and in 1795 still made only a relatively small contribution to the trade of the port.

17. Dylan Pritchard, Q.M.J., July 1942, op.cit., p.30-32.

18. Pritchard, loc.cit., quoting data from E.A. Lewis, op.cit., and David Thomas (1939), Llechi a Llongau, op.cit.; idem., Hen Longau Sir Gaernarfon, (Caernarfon 1952), pp.21-82, passim. The amounts were 1,089,000 slates (870 tons) in 1688; 2,434,500 slates (2,340 tons) in 1730; and 23,930 tons in 1793.

19. U.C.N.W., Penrhyn Ms 1967, of which parts are quoted by Lindsay (1974) op.cit., pp.30-35. There is a fuller quotation from this important letter, which provides details of the organisation of the early commercial working of the quarries at Nantlle, in Dylan Pritchard, 'New Light on the History of the Penrhyn Slate Quarries in the Eighteenth Century', Q.M.J., September 1942, p.118.

20. Richards, G., 'Crefftau a Diwydiannau Dyffryn Nantlle' T.C.H.S., Vol.31, (1969), p.116; see Chapter 4 *infra* re. production technology regarding early slate-slab tombstones dating from 1720 at Llanllyfni.

21. Dylan Pritchard, Q.M.J., July 1942, op.cit., p.30.

22. There was a social connection of long standing between Caernarfon and London through the local gentry - see Dodd, A.H., A History of Caernarvonshire, (1968 & 1990), passim.

23. References to the early quarrying of slate outside Gwynedd can be found, for instance, in D.C.Davies (1887), op.cit., pp.161-163; Dylan Pritchard, Q.M.J., July 1942, op.cit., p.30; idem., 'Aspects of the Slate Industry: The History of the English and Scottish Slate Industry, Part I', Q.M.J., March 1945, pp.393-399 and Part II, January 1946, pp.339-343; Lindsay (1974), op.cit. pp.21-23; Williams, M., The Slate Industry, (Shire Album 168, 1991), passim.
With regards to the constraints imposed by transport systems on the sale of Welsh slates, D.C.Davies (1887), op.cit., p.174, cited the example of inland Shrewsbury using clay tiles almost exclusively until the arrival of the railway in the 1840s or 1850s whereas Chester (on the then navigable river Dee) had used slates for roofing from a very early date. See also Note 47.

24. A discussion of the role of slate merchants can be found in Dylan Pritchard, 'Aspects of the Slate Industry: The expansionist period (1793-1877), Part VI.,' Q.M.J., August 1944, pp.72-74; The Joint Research Dept. of the T.U.C. and the Labour Party, The Slate Quarrying Industry of North Wales, (1923), pp.26-31; Lindsay (1974), op.cit., pp.100-101, 186-187. The last independent local slate merchant, G.H.Richards & Co., Caernarfon, only recently passed into the hands of a large regional roofing concern.

25. Dylan Pritchard, 'Aspects of the Slate Industry: The expansionist period, Part III,' Q.M.J., May 1944, p.519; idem., Q.M.J., June 1944,

'Aspects of the Slate Industry..., Part IV', p.549, on the market advantages of thin slates; idem., Q.M.J., September 1942, op.cit., p.120.

26. Dylan Pritchard, Q.M.J., August 1944, op.cit., pp.71-72. Although the produce of the Caernarfonshire quarries became virtually homogenous by the 1790s due to the dissipation of craft skills and technology, the marketing standards regarding grade descriptions varied considerably amongst the individual concerns.

27. The gradual increase in interest of the Crown Estate Commissioners in the mineral wealth of the Welsh mountain 'wastes' by the late eighteenth century and the resistance of contiguous landowners to the Crown's claims upon this land, has not been researched in detail. However, examples of this friction can be found in Lewis, M.J.T. and Williams, M.C., Pioneers of Ffestiniog Slate, (1987), passim.

28. References to the working practices at the early quarries at Nantlle can be found in local history secondary sources (see Bibliography), and especially C.R.O., XM 392/1, Chapter II, ff.6-188; C.R.O., XM 1758/Addit.89.

29. Williams, W.Gilbert, 'Rhostryfan, Hanes Dechreuad a Chynnydd y Pentref,' Moel Tryfan i'r Traeth, (G.H.Williams ed., 1983), pp.73-82.

30. Details of the changes in the capital organisation of the Penrhyn Quarry in the early eighteenth century can be found in Dylan Pritchard, Q.M.J., September 1942, op.cit., pp.117-122; Lindsay (1974), op.cit., pp.41-42.

31. In U.C.N.W., Penrhyn Ms 1967, quoted by Pritchard, loc.cit.; Lindsay (1974), op.cit., p.32.

32. U.C.N.W., Porth yr Aur Ms 27201, abstract of lease to Sir John Wynne, 25 May 1745; Pritchard, loc.cit.; Lindsay (1974), op.cit., p.67.

33. Details of further changes in the organisation of the Penrhyn Quarry in the 1780s-90s can be found in Dylan Pritchard, 'The Financial Structure of the Slate Industry of North Wales 1780-1830,' Q.M.J., December 1942, p.210; Dodd, op.cit., pp.206-7; Lindsay (1974), op.cit., pp.41-54.

34. Dylan Pritchard, Q.M.J., September 1942, op.cit., p.119; Lindsay (1974), op.cit., pp.30, 67, 69; M.J.T.Lewis, 'Chwarel y Diffwys to 1800,' (unpublished research document, *v.*3, November 1986), pp.47-49. The imposition of the rent on the quarry proprietors at Ochr-y-Cilgwyn coincided with the ending of the 31-year term of Sir John Wynne's lease and the refusal of the Crown to renew it in the

name of Sir Thomas Wynne, who nevertheless remained as a tenant-at-will until the 1790s (see note 35, below).

35. Ibid. The history of the Ochr-y-Cilgwyn quarries can also be found in the local history essays, particularly C.R.O., XM 392/1, op.cit.; U.C.N.W., Nantlle Ms 1, op.cit.; J.Griffiths, Chwarelau Dyffryn Nantlle, op. cit. The Crown tried to reassert its rights on the Ochr-y-Cilgwyn quarries in 1791 by letting the quarries annually at 10*s*.6*d*. (half a guinea, now 52.5p.) per man, but the opposition of many of the existing quarry proprietors, influenced by the Glynllifon estate agent, ensured that the efforts of the local Crown Agent came to nought until the Cilgwyn & Cefn Du Slate Company petitioned London for a lease, and was supported in its subjugation of the independent quarrymen by the Crown Commissioners.

36. The first spread of the quarries from Ochr-y-Cilgwyn appears to have been to the adjacent properties of Galltyfedw and Talysarn, into which the direction of the slate beds could be followed. Later quarries were opened with increasing distance from this early nucleus.

37. Lewis, M.J.T., and Williams, M.C., (1987), Pioneers of Ffestiniog Slate, op.cit., pp.6-9; Lewis, 'Chwarel y Diffwys...,' op.cit., pp.47-49.

38. National Library of Wales, Glynllifon Ms 84, ff.56*v*.- 96*v*; and U.C.N.W., Porth yr Aur Mss 27204-27209 (summarised by Dylan Pritchard in C.R.O., XM 4874/6) relate to the independent Ochr-y-Cilgwyn quarries in the 1790s.

39. See Bibliography of local history for sources and Note 2 above. See also Chapter 2 *infra*, re. the financing of the industry.

40. Dylan Pritchard, 'Investment in the Slate Industry 1830-1930,' Q.M.J., January 1943, pp.254-5; idem., Q.M.J., July 1942, op.cit., p.32; Dodd, op.cit., pp.205-209; Lindsay (1974), op.cit., Chapters 2 and 3 passim.

Part b

41. Dylan Pritchard, 'Aspects of the Slate Industry No.11: The expansionist period, Part I,' Q.M.J., March 1944, pp.416-419; idem., 'Aspects..., Part II,' Q.M.J., April 1944, pp.468-471; idem., 'Aspects..., Part III,' Q.M.J., May 1944, pp.516-519.

42. Pritchard, op.cit., 'The Expansionist Phase in the history of the Welsh Slate Industry,' T.C.H.S., Vol.10, (1949), pp.65-66; idem., Q.M.J., July 1942, op.cit., p.30.

43. Pritchard, op.cit., 'Aspects of the Slate Industry No.5: Foreign Relations,' Q.M.J., September 1943, pp.116-119; idem., 'Aspects... No.6: Foreign Relations,' Q.M.J., October 1943, pp.174-178; idem., 'Aspects... No.8: Foreign Trade in Slate during the present century,' Q.M.J., December 1943, pp.253-256; idem., 'Aspects.... No.9: Foreign Trade....,' Q.M.J., January 1944, pp.318-321.

44. Pritchard, 'Expansionist Phase...', T.C.H.S., (1949), op.cit., pp.72-74; idem., Q.M.J., July 1942, op.cit., p.30; Burnett, J., A History of the Cost of Living, (Penguin 1969), p.195 refers to the rate of growth of new British industrialised towns and cities other than London, of which Birmingham, Leeds and Manchester (threefold population increase), Aberdeen and Glasgow (fourfold increase), and Bradford (an eightfold increase) were the greatest. In the mid-eighteenth century (pp.170-1) the main centres of population had been London (700,000 population) and Bristol (100,000 residents), with the much smaller Norwich (60,000), Manchester (50,000), Liverpool (35,000) and Birmingham (30,000) being the remaining major concentrations. The growth of industrial centres during the eighteenth century is discussed in detail by Paul Mantoux (1927) in The Industrial Revolution in the Eighteenth Century, (re-published London 1961), Part I, Chapter 2, pp.91-132, and Part III, Chapter 1, pp.341-364. The increasing domination of the roofing market by Welsh slate is shown by the correlation (slightly time-lagged) between the cycles in the building trade as measured by the U.K. output of bricks, see Shannon, H.A., 'Bricks - a trade index,' Economica, (1934), and Cairncross, A. & Weber, B., 'Fluctuations in building in Great Britain, 1785-1849, Economic History Review, 2nd Series IX, (1956), 2.

45. Pritchard, Q.M.J., May 1944, op.cit., p.516; Thomas, D., (1949), Old Ships and Sailors of Wales, passim; Eames, A., Llongau a Llongwyr Gwynedd, (1976), passim.

46. Dylan Pritchard, Q.M.J., May 1944, op.cit., pp.516-519. David Thomas (1949), Hen Longau..., op. cit., pp.84-143. See also Chapter 5 *infra*, re. primary transport systems.

47. Pritchard, Q.M.J., April 1944, op.cit., p.471; Mantoux (1927), The Industrial Revolution in the Eighteenth Century, op.cit., Part I, Chapter 2 (VII), pp.120-132 discusses the expansion of the canal system and its consequences; Burnett, J. (1969), A History of the Cost of Living, op.cit., p.158 refers to freight carriage rates on canals being a quarter of the cost of road transport after 1760; Lowe, J.R., (1977), Welsh Industrial Workers Housing 1775-1875, p.4, refers to each district in Wales having its own tradition of house building style using local materials before the development of 'bulk carriage systems' which brought such products as North Wales

roofing slates to displace the old order. Lowe cites the example of Merthyr Tydfil connected to Cardiff dock by canal in 1794, having slated roofs whereas the Rhymni Valley (4 miles distant) still used stone slab roofs until the arrival of the railway in the 1830s. See also Note 23, *supra* and Chapter 5 *infra*, re. primary transport systems.

48. Dodd, The Industrial Revolution..., op.cit., p.206; E.Llewelyn Lewis (1927), The Slate Industry, op.cit., p.9; Lindsay (1974), op.cit., p.88; Dylan Pritchard, Q.M.J., July 1942, op.cit., pp.31-32 and Table 3; idem., Q.M.J., March 1944, op.cit., p.417. Pritchard was of the opinion that the slate quarries of the Nantlle district were initially sheltered from the full force of the slump because its mainstay market in Ireland was exempt from the slate transport tax. However, this market also collapsed in 1797-98 due to the adverse political climate in that country and the Nantlle quarries were therefore forced to compete for a share in the already depressed English market. John Burnett, A History of the Cost of Living, op.cit., pp.196-7 suggested that the French Wars marked the commencement of the 20 to 30 years short trade cycles (fluctuating within the so-called 'Kondratieff' 50 to 60 year long waves) which characterised the British economy thereafter, this being the result of increasing industrialisation taming some of the natural forces which previously affected the supply and prices of commodities. Burnett identifies developments in the iron and textile industries, coupled with steam power, as driving the spectacular up-phase in the economy in the 1770s-1793.

49. Dodd (1933), op.cit., p.206; E.Llewelyn Lewis (1927), op.cit., pp.9, 16; Lindsay (1974), op.cit., pp.89-92; Dylan Pritchard, Q.M.J., March 1944, op.cit., pp.416-417 and September 1943, p.116. A roofing tile tax of 3*s*. (15p.) per thousand was also imposed in 1793 and was increased to 4*s*.10*d*. (24½p.) in 1794, and bricks were also subject to taxation. The transport tax on slates was initially levied at a rate of twenty per cent of the value of the cargo at the port of delivery, but the rate was increased to thirty-two and a half per cent in 1809, although it was subsequently reduced to twenty-six per cent in 1814 with the expiry of one of the added duties. The tax as originally applied, had a more pronounced effect upon distant destinations, but was after 1823-24 made more equitable by a revision of its basis to a flat-rate system calculated on either count or weight, depending on the type of slate involved.

50. Dylan Pritchard, Q.M.J., March 1944, op.cit., p.418.

51. For example, at Nantlle, companies were formed to work the following quarries:- Cilgwyn (1800); Talysarn (1805); Penybryn (1808) and

Cloddfa'r Coed (1812). See Pritchard, Q.M.J., December 1942, op.cit., pp.211-213; Alun J.Richards (1995), Slate Quarrying in Wales, op.cit., p.31; individual quarry histories in C.R.O., XM 392/1, U.C.N.W., Nantlle Ms 1, and J.Griffiths, Chwareli Dyffryn Nantlle, op.cit; documents in U.C.N.W., Porth yr Aur Mss., re. Cilgwyn Quarry (Mss 27201-29075), Cloddfa'r Coed Quarry (Mss 29479-29724), Penybryn Quarry (Mss 30104-30133) and Talysarn Quarry (Mss 30134-30148); see also Chapter 2 *infra*, re. Capital & Finance.

52. U.C.N.W., Porth yr Aur Mss 27210-27222, re. Cilgwyn lease of 1800; ibid., Mss 27223-27241, 27252-27254, 27259-27262, 27267-27269 and 27359-27386 re. trespass actions against the independent quarrymen at Cilgwyn. These documents are summarised by Dylan Pritchard in C.R.O., XM 4874/6. See also Lindsay (1974), op.cit., pp.70-73, 75-76; Richards, op.cit., p.23; Williams, W.Gilbert, 'Chwarel a Chapel,' Moel Tryfan i'r Traeth, op.cit., pp.110-113.

53. The business records of the Cilgwyn & Cefn Du Slate Company (of 1800-31) can be found in U.C.N.W., Porth yr Aur Mss 2710-29075, passim., summarised in research notes by Dylan Pritchard, C.R.O., XM 4874/6. See also Lindsay (1974), op.cit., pp. 72-73. 76-78; Alun Richards (1995), op.cit., pp.34-35.

54. Dylan Pritchard, Q.M.J., March 1944, op.cit., p.418. The three main slate concerns of the 1800s were (in order of diminishing size) Penrhyn Quarry, Dinorwic Quarry and Diffwys Quarry (Ffestiniog), the last being replaced in the hierarchy during the late 1820s by the Rhiwbryfdir Quarry (Welsh Slate Company, Ffestiniog). For the early history of the Ffestiniog concerns, see Lewis & Williams (1987), op.cit., Pioneers of Ffestiniog Slate.

55. E.Llewelyn Lewis (1927), op.cit., p.10; Pritchard, Q.M.J., July 1942, op.cit., p.32; idem., Q.M.J., December 1942, op.cit., pp.210-211; idem., 'Investment in the Slate Industry 1830-1930,' Q.M.J., January 1943, pp.254-255; idem., 'Investment...., Article II,' Q.M.J., February 1943, p.297; See Chapter 2 *infra*, Capital & Finance.

56. References to closures of quarries at Nantlle in this period can be found in the individual site histories included in the local history essays C.R.O., XM 392/1; U.C.N.W., Nantlle Ms 1; and J.Griffiths (1889), Chwareli Dyffryn Nantlle, op.cit. See also Lindsay (1974), op.cit., pp.97-98 and Note 51 *supra*, Porth yr Aur Mss, loc.cit.

57. Dodd (1933), op.cit., pp.214-217; E.Llewelyn Lewis (1927), op.cit., p.16; Lindsay (1974), op.cit., p.88; Dylan Pritchard, Q.M.J., March 1944, op.cit., p.418. There were two bursts of activity separated by a lull in 1820.

58. Pritchard, loc.cit. Prices held initially, but dipped when the Dinorwic/Penrhyn quarries cartel broke up because of the severity of the downturn in trade; Williams, R., 'Hunangofiant Chwarelwr: 1., Bore Oes Chwarelwr, 1813-1839,' Cymru, XVII, (1899), p.57, referring to the Penrhyn Quarry shedding men at a rate of several hundred per month in 1825 and the situation at Nantlle also being grim for employment.

59. References to closures of quarries at Nantlle in this period can be found in the individual site histories included in the local history essays C.R.O., XM 392/1, U.C.N.W., Nantlle Ms 1, and J.Griffiths (1889), op.cit.; U.C.N.W., Porth yr Aur Mss 2710-29075 re. the Cilgwyn & Cefn Du Slate Company's main operation at Cilgwyn Quarry.

60. References to the reopening of quarries at Nantlle in this period can be found in the individual site histories included in the local history essays C.R.O., XM 392/1, U.C.N.W., Nantlle Ms 1, and J.Griffiths (1889), op.cit. See also Lindsay (1974), op.cit., pp.121-126. For a comprehensive history of the Dorothea Quarry see Jones, G.P., 'The Dorothea Slate Quarry *c.*1820-1970,' (M.A. Thesis, Bangor 1980).

61. Dodd (1933), op.cit., pp.218-219; E.Llewelyn Lewis (1927), op.cit., p.16; Lindsay (1974), op.cit., p.25; Dylan Pritchard, Q.M.J., March 1944, op.cit., pp.416-419. Pritchard considered that the repeal of the slate tax was more likely due to the abolition of sea-borne coal duty than the vociferous protests of the producers at the tax advantage gained by the Cumbria slate region due to an anomaly. The officials who collected the coal duty were also responsible for collecting the slate duty, and once the former was repealed, it was not sufficiently remunerative to maintain the bureaucracy just for the slate tax.

62. E.Llewelyn Lewis (1927), op.cit., p.16; Lindsay (1974), op.cit., pp.117-118, 192-193; Dylan Pritchard, Q.M.J., April 1944, op.cit., p.468; Alun Richards (1995), Slate Quarrying in Wales, op.cit., pp.88, 40-46. The background to the economic fluctuations of the 1840s can be seen in Ward-Perkins, C.N., 'The Commercial Crisis of 1847,' Oxford Economic Papers II, (1950), and the importance of the expansion of the railway network is discussed by Baxter, R.D., 'Railway Extension and its Results,' Journal of the Statistical Society, XXIX, (1866). J.Burnett (1969), A History of the Cost of Living, op.cit., pp.197, 202, identifies the 1840s-70s upwards trade cycle in the British economy as being based on the development of railways and the steel industry.

63. Dylan Pritchard, Q.M.J., March 1944, op.cit., pp.418-419; idem., April 1943, op.cit., p.379; idem., April 1944, op.cit., p.468;

Lindsay (1974), op.cit., pp.185, 196-198; Richards (1995), op.cit., Chapter 7, pp.115-125 .

64. Robert Williams (1900), Cymru, XVII, op.cit., p.57; references to individual quarry histories at Nantlle in this period can be found in the local history essays C.R.O., XM 392/1; U.C.N.W., Nantlle Ms 1; and J.Griffiths (1889), Chwareli Dyffryn Nantlle, op.cit. The period 1830-60 is particularly bereft of primary quarry documents for this district.

65. References to the Cilgwyn and Talysarn quarries in the 1840s can be found in the individual site histories included in the local history essays (ibid.), of which the most informative is J.Griffiths (1889), op.cit., pp.21-22, 70-73

66. Richards A.J., A Gazeteer of the Welsh Slate Industry, (1991), Section 8; E.Llewelyn Lewis (1927), op.cit., p.11; Lindsay (1974), op.cit., pp.136, 140-144, c.f., the Nantlle quarries, passim. For further details of the Ffestiniog quarries, see Jones, J.G., 'The Ffestiniog Slate Industry; the industrial pattern to 1831,' Transactions of the Merioneth Historical Society, Vol.VI, Part 1 (1969), pp.50-65; idem., 'The Ffestiniog Slate Industry..., 1831-1931,' op.cit., Vol.VI, Part 2, (1970), pp.191-213.

67. Dylan Pritchard, Q.M.J., December 1942, op.cit., p.213, refers for example, to problems in developing the Cilgwyn Quarry in 1800-30. A report on the prospects of the Talysarn Quarry (by John Robinson, 1868) similarly catalogues the errors of previous operators (MS in possession of author, kindly supplied by Dr W. Slatcher, per Dr Dafydd Gwyn). The geology of the Ffestiniog quarries is described by D.C. Davies (1877), Slate & Slate Quarrying, op.cit., Chapter VIII, and F.J.North (1925), The Slates of Wales, op.cit., pp.24-29.

68. Dylan Pritchard, Q.M.J., May 1943, op.cit., p.425.

69. See E.Llewelyn Lewis (1927), op.cit., p.17, for a discussion on tariff reform with regards the slate trade; Dylan Pritchard, 'The expansionist Phase...' T.C.H.S., (1949), op.cit., pp.76-78; idem., Q.M.J., September 1943, op.cit., pp.116-119; idem., ibid., April 1944, op.cit., p.468. Lloyd, L., (1989), The Port of Caernarfon 1793-1900, p.43, refers to the French tariffs on slates being reduced from a range of 22½ to 148 per cent per long thousand (or *mille* of 1,260 slates) to an uniform 3*s*.4*d*. (16½p.) per numerical thousand, in December 1860. For further details of the Cobden free trade agreements, see Redford, A., The Economic History of England 1760-1860, (London, 2nd ed., 1960), pp.200-201.

70. Dylan Pritchard, Q.M.J., September 1943, op.cit., pp.117-118; idem., 'Aspects of the Slate Industry: The expansionist period IV,' Q.M.J., June 1944, p.551. Exports reached 12,700 tons in 1866, increasing to 51,500 tons by 1869; Lindsay (1974), op.cit., pp.194-196.

71. Lewis Lloyd (1989), The Port of Caernarfon, op.cit., pp.2, 35-49.

72. Op.cit., p.44.

73. Shareholding in quarrying concerns by builders & merchants can be traced from abstracts of the Public Records Office files of defunct Joint Stock companies, per J.S.Wilkinson, in the C.R.O. search-room reference library.

74. The most important market for Nantlle slabs was for tombstones, in which trade the Cilgwyn and Cloddfa'r Lôn Quarries were the early major local sources, these being joined by the Dorothea Quarry in the 1840s. See Chapter 4, *infra*.

75. For example, investments were made with regards to slab working at the Fron, Penyrorsedd and Talysarn quarries in the 1860s, but with little success. Even George Eugene Magnus of the Plimlico works (London), the 'king' of the slab trade, had little success in an entrepreneurial venture at the Tanrallt Quarry (Carnarvonshire Slate Co.) from 1853. The author is indebted to Dr Dafydd Gwyn for access to biographical details of G.E.Magnus.

76. For details of slab quarries outside Nantlle, see D.C.Davies (1877), op.cit., passim; Gwyn, D., 'Valencia Slate Slab Quarry,' Journal of the Kerry Historical & Archaeological Society, No.24, (1991, pub.1995), pp.40-57; Alun Richards (1995), Slate Quarrying in Wales, op.cit., pp.64-66; idem., Slate Quarrying at Corris, (1994), passim.

77. See E.Llewelyn Lewis (1927), op.cit., p.17 for analysis of prices and sales in the 1850s; Dylan Pritchard, Q.M.J., April 1944, op.cit., pp.468-469; D.C. Davies, Slate & Slate Quarrying, op.cit, p.173-176; Lewis Lloyd (1989), op.cit., pp.42-43; Lindsay (1974), op.cit., Chapter 6, passim.

78. Lewis Lloyd, loc.cit.; Pritchard (April 1944), loc.cit.; J.R.Lowe (1977), Welsh Industrial Workers' Housing, op.cit., passim.

79. Lindsay (1974), op.cit., pp.122-128. References to the development of quarries at Nantlle in this period can be found in the individual site histories included in the local history essays C.R.O., XM 392/1; U.C.N.W., Nantlle Ms 1; and J.Griffiths Chwarelau Dyffryn Nantlle, op.cit.

80. Dylan Pritchard, Q.M.J., April 1944, op.cit., p.468.

81. J.O.Griffith ("Ioan Arfon") (1864), Llechfeini Sir Gaernarfon (Tremadog, 3rd ed. 1882), pp.24-28 gives a contemporary view of quarrying speculations; Pritchard, Q.M.J., January 1943, op.cit., p.256 (quoting articles by T.C.Smith in the Mining Journal, *c*.1860); idem., Q.M.J., February 1943, op.cit., pp.297-298; idem., 'Investment in the Slate Industry 1830-1930 Article III,' Q.M.J., March 1943, pp.318-319; Lindsay (1974), op.cit., Chapter 6, passim.; Alun Richards (1995), Slate Quarrying in Wales, op.cit., pp.44-46, Chapter 7 pp.115-125.

A contemporary account of the individual quarries and the quarrymen of Nantlle in the 1860s can be found in J.O.Griffiths (1863-4), op.cit., pp.21-23; C.R.O. XM 1758/addit.146, Blagur Llyfnwy (1863); and Richards, R., 'Nantlle and its Slate Quarries,' Miscellaneous Poems..., (Bangor 1868), pp.132-138.

Further details of historical developments at Nantlle during the 1860s-70s can be gleaned from the dispatches by the unidentified Special Correspondent of the *Carnarvon & Denbigh Herald*, possibly Morgan Richards *(Morgrugun Machno)*, republished as The Slate Quarries of North Wales in 1873 (ed., M.J.T.Lewis 1987), pp.62-75, and from the local history essays C.R.O., XM 1758/addit.89 (of *c*.1875); C.R.O., XM 392/1 (of 1877); U.C.N.W., Nantlle Ms 1 (of 1877); and J.Griffiths, (1889), Chwarelau Dyffryn Nantlle, op.cit. The accuracy of the critical comments on the potential of the quarries, which are a characteristic of these competition essays is, with hindsight, remarkable, testifying to the expertise of the respective authors in the working practices of the industry.

82. Pritchard Q.M.J., March 1943, op.cit., p.319; Southgate, G.W., English Economic History. (London, revised 1962), p.304, fn.2. The collapse of the clearing bank of Overend Gurney sent shock-waves through the U.K. financial markets

83. Dylan Pritchard, Q.M.J/, March 1943, op.cit., p.319-320 and April 1944, p.468.

84. Loc.cit; idem., Q.M.J., November 1943, op.cit., p.243.

85. Pritchard, Q.M.J., March 1944, op.cit., p.418 and August 1944, op.cit., p.75. The Dinorwic and Penrhyn quarries had controlled the wholesale price of Welsh slates from the 1790s by acting as a private cartel wielding sufficient economic power to threaten any dissenters within the industry by summarily dropping prices below cost. Thus, the publication of the Dinorwic and Penrhyn price lists every January had set the standard for the remainder of the industry and none of their competitors had hitherto committed themselves until after that annual event.

86. Pritchard, Q.M.J., August 1944, op.cit., p.75.

87. Calculated from Caernarfon Harbour Trust data, abstracted by Dylan Pritchard (in C.R.O., XM 4874); Lewis Lloyd (1989), Port of Caernarfon, op.cit., pp.43-45.

88. Estimated by extrapolation of extant data, assuming that the peak year at Nantlle corresponded to the general peak for the industry at 1877. For a review of the state of the industry at Nantlle in 1877, see C.R.O., XM 392/1, passim.; and U.C.N.W., Nantlle Ms 1, passim.

89. Data in J.O.Griffiths ("Ioan Arfon"), Traethawd Ymarferol ar Lechfeini Sir Gaernarfon, (1863), op.cit., (3rd ed. 1882), p.23.

90. Dolgellau Records Office, Z/DBE/58, p.27.

91. C.R.O., XM 392/1, f.52.

92. Estimated using an extrapolation of available data for the Crown group of quarries.

93. Calculated from Caernarfon Harbour Trust data, abstracted by Dylan Pritchard (in C.R.O., XM 4874).

94. Derived from data in C.R.O., XM 392/1, f.52.

95. See D.C.Davies (1877), Slate & Slate Quarrying, op.cit., Chapter XXI on causes of failure in slate quarrying. See also Chapter 2 *infra,* 'Capital & Finance'

96. D.C.Davies, op.cit., p.173; Dylan Pritchard, Q.M.J., March 1943, op.cit., p.319 and August 1944, op.cit., p.74.

97. Pritchard, loc.cit., August 1944; Lindsay (1974), op.cit., p.246; Richards (1995), Slate Quarrying in Wales, op.cit., p.117.

98. Pritchard, Q.M.J., August 1944, op.cit., p.75. The Merionethshire slate proprietors sought to restrain price rises so as to prevent the development of a wage spiral.

99. Dylan Pritchard, Q.M.J., March 1943, op.cit., pp.319-320; idem., Q.M.J., August 1944, op.cit., pp.73-74.

100. Ibid., May 1944, op.cit., pp.516-518.

101. Ibid., September 1943, op.cit., p.118. D.C.Davies, op.cit., when discussing the imports of slates from the U.S.A. in 1877 (First ed., unaltered text in the 3rd. ed., 1887 pp.176-179), was dismissive of their threat to the Welsh slate industry.

102. Pritchard, Q.M.J., April 1944, op.cit., p.469. D.C.Davies (op.cit., in his First ed., 1877, surprisingly unaltered in the 3rd ed., 1887 p.179), displayed the typical misplaced optimism prevailing in the industry during the 1870s in one of his concluding statements, viz.:-

"We may conclude that there is no reason to fear from ...the effects of competition any permanent decline in the demand for our slates for many years - may I not safely say for generations? - to come."

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103. See Beales, H.L., 'The "Great Depression" in Industry and Trade,' Economic History Review, V, (1934), 1, for general overview of this period; E.Llewelyn Lewis (1927), The Slate Industry, op.cit., p.17; Lindsay (1974), North Wales Slate Industry, op.cit., p.246, although she attributes the end of the great boom to 1881; Dylan Pritchard, Q.M.J., March 1943, op.cit., p.320; Alun Richards, (1995), Slate Quarrying in Wales, op.cit., p.126.

104. Pritchard, Q.M.J., September 1943, op.cit., pp.118-119; idem., 'Aspects of the Slate Industry No.7: Two Lessons from the Past,' Q.M.J., November 1943, pp.233-235. The presence of U.S.A. slates in the U.K. market helped drive prices down after 1877. These imports only ceased in 1883 when U.K. slate prices dropped through the floor.

105. Pritchard,'Aspects of the Slate Industry No.1: A Welsh Slate Producers' Association Advocated,' Q.M.J., May 1943, p.425; idem., Q.M.J., November 1943, op.cit., p.234. Within the slightly-recovered market, this over-supply could only be maintained by discounting prices by 30 to 45 per cent.

106. Pritchard, Q.M.J., May 1943, loc.cit. The Quarrymen's Union was firmly of the opinion that the 'big two' had driven the average price about 15 per cent below what the market could sustain, and it was suspected that the motive was to destroy local small-scale competitors.

107. Pritchard, Q.M.J., May 1943, op.cit., p.423; C.R.O., X/Dorothea 903.

108. Lindsay (1974), op.cit., p.248; Dylan Pritchard, Q.M.J., November 1943, op.cit., p.234; Alun Richards (1995), op.cit., p.138.

109. Pritchard, Q.M.J., October 1943, op.cit., p.174. The highpoint of U.K. slate exports was 1889, when 79,900 tons were shipped, of which 78 per cent went to Germany. Thereafter the volume began to drop owing to resurgence of protectionist trade policies.

110. Pritchard, Q.M.J., September 1943, op.cit., p.118; and ibid., November 1943, op.cit., pp.234-235.

111. C.R.O., X/Dorothea Ms 5, ff.181-2, data of slate shipments from Nantlle station; Alun Richards (1995), op.cit., pp.127-128, 141, which

compares the productivity of the Nantlle quarries within the Welsh industry.

112. Examples of poor quality quarries at Nantlle were in general concentrated on the southern side of the valley, and included Foel Uchaf, Gelli Bach, Llwydcoed, Singrig, Taldrwst Lower, Taldrwst Upper, Ty Mawr East, Ty Mawr West, Ty'n Llwyn and Tyddyn Agnes, although some such as Brynfferam, Galltyfedw and individual pits within more successful larger concerns were to be found in the generally better quarrying area north of the the Llyfni river. A review of the state of the industry at Nantlle in 1886, including critical observations on the potential of the individual sites, can be found in a trio of near-identical competition essays, viz:-, C.R.O., XM 4874/47 by "Clorianydd" (John Paull); U.C.N.W., Nantlle MS 2, "Hen Chwarelwr" (unidentified author); and U.C.N.W., Bangor MS 3139. Also see J. Griffiths, Chwarelau Dyffryn Nantlle (1889), op.cit., passim, and the report of the Special Correspondent of Y Genedl, 4 November 1891, on the Nantlle quarries.

113. Ibid; reports of H.M.Inspectors of Mines (1875-1893), and H.M.Inspectors of Quarries (post-1893), North Wales sub-district. For a detailed account of the disaster at Dorothea Quarry, see C.R.O., X/Dorothea Mss 614 and 1234.

114. Ibid; Alun Richards (1995), op.cit., p.129.

115. E.Llewelyn Lewis (1927), op.cit., p.17; Dylan Pritchard, 'Investment in the Slate Industry Article IV,' Q.M.J., April 1943, p.377; Lindsay (1974), op.cit., pp.247, 252; Alun Richards (1995), op.cit., p.141; John Burnett (1969), A History of the Cost of Living, op.cit., pp.204-5, suggests that the general upturn in the British economy after 1896, although based on expanding industrial output, was tempered in most sectors by the loss of its former near-monopolist position to recently industrialised countries. This trend was mirrored in the slate industry.

116. Nantlle shipment data, C.R.O., X/Dorothea 5, ff.181-4. Lindsay (1974), op.cit., quotes the industry output data showing an increase from 352,186 tons in 1891 to a peak in this trade cycle of 488,885 tons in 1898.

117. Dylan Pritchard, Q.M.J., March 1943, op.cit., p.322.

118. Nantlle shipment data, C.R.O., X/Dorothea 5, ff.181-2.

119. Dylan Pritchard, 'Aspects of the Slate Industry No.2: Causes of Contraction in the Slate Industry; Analysis by Quarrymen's Union,'

Q.M.J., June 1943 p.471; idem., Q.M.J., March 1943, op.cit., p.322; idem., Q.M.J., November 1943, op.cit., pp.234-235.

120. Data collated from the Appendices to the Annual Reports of H.M.Inspectors of Mines & Quarries 1883-1898 in the Caernarfon Records Office, supplied by J.S.Wilkinson.

121. Pritchard, Q.M.J., March 1943 op.cit., p.322.

122. H.M. Inspectorate data for Nantlle quarries. See note 120.

123. Lindsay (1974), op.cit., pp.251-252; Dylan Pritchard, Q.M.J., March 1943, op.cit., p.322; Alun Richards (1995), op.cit., p.160. This reduction in exports was largely the result of the return of protectionist trade policies in the western European markets after 1890. See also note 124.

124. Pritchard, Q.M.J., October 1943, op.cit., pp.174-178; and November 1943, op.cit., p.233; Lindsay (1974), op.cit., pp.253-254; Richards (1995), op.cit., p.132. Slates imported from the U.S.A. were 25 per cent cheaper than the Welsh product in 1898.

125. Pritchard, Q.M.J., March 1943, op.cit., p.322; idem., Q.M.J., October 1943, op.cit., pp.175-176; idem., Q.M.J., November 1943, p.232; Lindsay (1974), op.cit., p.253; Richards (1995), op.cit., p.146. For details of the eleven month stoppage at the Penrhyn Quarry see Lindsay (1974), op.cit., Chapter 13. See also note 129.

126. Pritchard, Q.M.J., May 1943, op.cit., p.423; C.R.O., X/Dorothea 563, p.446, lists changes in discounts and premiums on the standard price lists for this concern from 1894-1922.

127. Pritchard, Q.M.J., October 1943, op.cit., pp.174-178 and ibid., November 1943, pp.232-233.

128. Pritchard, Q.M.J., November 1943, loc.cit., Table 1. The output of the North Wales slate quarries peaked at 488,000 tons in this trade cycle.

129. For an appraisal of the economic effects of the Penrhyn disputes, see Pritchard, Q.M.J., November 1943, op.cit., pp.232-233. Lindsay, (op.cit., p.255), also refers to the effect of the Boer War on the slate trade *via* business confidence and interest rates. Short reports on the state of the slate trade from 1898-1902 appear in C.R.O., X/Dorothea Ms 5, ff.45-74.

130. Nantlle Shipment data, C.R.O., X/Dorothea Ms 5, ff.183-4; Lindsay (1974), op.cit., p.255; Richards (1995), op.cit., p.152.

131. Pritchard, Q.M.J., November 1943, op.cit., pp.232-236; Richards (1995), op.cit., p.157.

132. Dylan Pritchard, Q.M.J., April 1943, op.cit., p.377; idem., Q.M.J., June 1943, op.cit., pp.471-472; idem., Q.M.J., October 1943, op.cit., pp.174-178; idem., Q.M.J., December 1943, op.cit., p.254; idem., Q.M.J., January 1944, op.cit., pp.318-321; idem., 'A Plan for the Slate Industry: 1. Historical Retrospect,' Q.M.J., May 1946, p.559; E.Llewelyn Lewis (1927), The Slate Industry, op.cit., pp.18-21, discusses in detail the complicated problems faced by the industry after 1903; see also Lindsay (1974), op.cit., pp.247, 255; and Richards (1995), op.cit., pp.158-162.

133. Short reports on the state of the slate trade from 1903 to 1914 appear in C.R.O., X/Dorothea Ms 5, ff.75-110. The Dorothea Quarry, for example, faced huge costs associated with flood protection measures from the 1890s to the 1920s (see G.P.Jones, 'The Dorothea Quarry....' op.cit., Chapter 3); also Richards (1995), op.cit., p.161 for details of costs faced by quarries at Nantlle.

134. Details of closures based on H.M.I. Lists of quarries, see Note 120 *supra*. For local history post-*c.*1905, see Hughes, I., (1990), Chwareli Dyffryn Nantlle, passim. References to the social distress at Nantlle by 1913 are found in Lindsay (1974), op.cit., p.259 and Roberts, D., (1982), Y Chwarelwyr a'r Sowth, p.12.

135. C.R.O., X/Dorothea Ms 5, f.93, journal entry dated 8 August 1908.

136. Abstracted from data in H.M. Inspectorate annual reports, see Note 120, *supra*.

137. Carter, H., 'Urban & Industrial Settlement in the Modern Period, 1750-1914,' Settlement & Society in Wales, (ed. D.H.Owen, 1989); Dafydd Roberts (1982), Y Chwarelwyr a'r Sowth, op.cit., passim; C.R.O., G.P.Jones Mss (uncatalogued), notes by Dr Dafydd Roberts from the S(late) T(rade) G(azette), National Library of Wales HD 9621 (1912-49 only), references from August 1912, October 1912, February 1913, August 1913 (Leader), January 1914. The author's maternal great grandfather and two great uncles were amongst the unemployed Nantlle men who worked in the South Wales mines in the 1900s.

138. C.R.O., XM 669/2, press cuttings from Y Genedl *c.*1905-1907, regarding the average double rate of the royalty paid by Crown quarries compared with those lased from private landlords.

139. C.R.O., X/Dorothea Ms 5, ff.106, 110. The Dorothea Company returned a profit of £2,211 in the second half of 1913, ten times the figure

for the previous six months, but the trade declined again in the first half of 1914.

140. Dylan Pritchard, Q.M.J., April 1943, op.cit., p.378; idem., Q.M.J., June 1943, op.cit., p.472; idem., Q.M.J., January 1944, p.319 and Table 1; S.T.G., notes, op.cit., November 1914, quoting a Board of Trade report of September 1914, referring to the closure or short-time working of the quarries at Nantlle; 'Unemployment in Wales,' The Welsh Outlook, December 1914, p.496. Short reports on the state of the slate trade from 1914-18 appear in C.R.O., X/Dorothea 5, ff.111-116.

141. S.T.G., notes, op.cit., February 1917, April 1917 and May 1917; C.R.O., XM 99/67, data; Richards Slate Quarrying in Wales (1995), op.cit., p.164.

142. S.T.G., notes, op.cit., October 1915, quoting The Master Builder; ibid., February 1916, quoting The Manchester Guardian; ibid., January 1917, quoting a Board of Trade report of November 1916.

143. S.T.G., notes, op.cit., July 1917 stated that the Government overcame the reduction in roofing material production by ordering substitute materials from a Swiss firm.

144. Richards (1995), op.cit., pp.165-166, quoting the S.T.G., notes, op.cit., January 1918, trade forecast.

145. Dylan Pritchard, Q.M.J., December 1943, op.cit., Table 1 p.254; S.T.G., notes, op.cit., January 1918 and December 1918. Asbestos/cement and clay tiles increased greatly in popularity after 1918.

146. Pritchard, Q.M.J., May 1946, op.cit., p.562; S.T.G., notes, op.cit., June 1924 and October 1924; E.Llewelyn Lewis (1927), op.cit., pp.22, 27; Lindsay (1974), op.cit., pp.284-285; Richards (1995), op.cit., pp.165, 167.

147. Pritchard, Q.M.J., June 1943, op.cit., pp.473-4 and December 1943 op.cit., Tables 1-3 and 5, pp.254-256; S.T.G., notes, op.cit., April 1923, December 1925, July 1926 and June 1929. The sources of imported slates in the 1920s and 1930s were mainly from Belgium, France, Ireland, Norway and Portugal. Even Germany was supplying slates to the U.K. by 1925.

148. Pritchard, Q.M.J., June 1943, op.cit., p.473; idem., 'Aspects of the Slate Industry No.3: Slates v Tiles,' Q.M.J., July 1943, p.34; idem., Q.M.J., December 1943, op.cit., Table 1, p.254; S.T.G., notes, op.cit., June 1919, October 1920, May 1924 and October 1924.

149. Pritchard, Q.M.J., December 1943, op.cit., pp.253-257, and January 1944, op.cit., Table 1, p.319; S.T.G., notes, op.cit., January 1918, December 1918, April 1923 and June 1929; Lindsay (1974), op.cit., pp.294-295. With the post-1914 loss of the important German market and a general decline elsewhere because of increased transport costs and competition from low-cost indigenous quarries protected by trade tariffs, the exports of Welsh slates decreased from 16,700 tons in 1913 to 2,900 tons in 1922, and then remained relatively constant until 1939.

150. New companies commencing work at Nantlle post-1918 included the Amalgamated Slate Association Ltd and the Vronlog Green Slate Quarry Co.Ltd. Several smaller quarries were also reactivated. See Richards (1995), op.cit., pp.165-166 for a general assessment of the boom.

151. S.T.G., notes, op.cit., June 1921, November 1921 quoting The Times Trade Supplement. Government orders of 22 million slates for over a million new houses, were placed in 1919, but the Welsh industry could only initially supply sufficient slates to roof 66,000 houses. Private customers were lost to alternative suppliers after the commandeering of large slate stocks by the Department of Material Supply. In the wake of the abandonment of the Addison programme in the Spring of 1921, slate merchants were induced to purchase the huge accumulated government stock of slate, thus forcing some Welsh quarries having to curtail their working hours on account of the countermanding of orders and the accumulation of stock-in-hand.

152. Dylan Pritchard, Q.M.J., July 1943, op.cit., p.34; S.T.G., notes, op.cit., November 1926 and April 1931; Lindsay (1974), op.cit., pp.290-291. The U.K. data for house building showed a significant (albeit cyclical) growth between 1918 and 1939. Annual totals averaged around 120,000 in the 1920s, peaking at around 321,000 *per annum* by the mid-1930s.

153. F.J.North, 'The Slate Industry: a statistical examination,' Q.M.J., June 1933, pp.82-86; Dylan Pritchard, Q.M.J., July 1943, op.cit., pp.36-37; idem., Q.M.J., January 1944, op.cit., Table 4, p.321; idem., Q.M.J., May 1946, op.cit., p.562; T.U.C./Labour Party Joint Research Dept., The Slate Quarrying Industry of North Wales, (Caernarfon 1923), pp.25-6; S.T.G., notes, op.cit., January 1925. The average wholesale price of Welsh slate increased by 200 per cent between 1913 and 1920, which was a greater amount than in the case of any other roofing materials.

154 The Slate Quarrying Industry of North Wales, (1923), op.cit., pp.25-6; S.T.G., notes, op.cit., December 1921, June 1922; July 1922; June 1923; June 1924, January 1930, April 1931 and October 1932 refer to price and wage reductions between July 1920 and October 1932.

155. Dylan Pritchard, Q.M.J., January 1944, op.cit., p.321; idem., 'Aspects of the Slate Industry No.10: Free Trade versus Protection,' Q.M.J., February 1944, pp.269-370; S.T.G., notes, op.cit., May and November 1916, January 1920, July 1926 and April 1931; The Slate Quarrying Industry of North Wales (1923), op.cit., pp.25-6; Richards (1995), op.cit., pp.170-171. One reason for the low cost of imported slates was that the wage rates of the overseas producers were said to be only half the U.K. rate. A broad comparison of roofing-material price increases shows that whereas the cost of Welsh slates on the home market increased to a maximum of 244 per cent above the 1909-13 average during the inter-war years, the equivalent advancement in the price of foreign slates was only 119 per cent.

156. Pritchard, Q.M.J., July 1943, op.cit., pp.36-37 and ibid., May 1946, op.cit., pp.562-563; S.T.G., notes, op.cit., October 1912, April 1913, May 1924 and October 1924. The production system in the slate quarries was 'inelastic' in that the quality and specification of the output was dependent upon uncontrollable factors such as geology, and a response to increases in market demand required a long lead-time because the methods of developing new rock-faces was antiquated. In comparison, the increasing mechanisation of the roofing-tile industry within a 'mass-production' system made the supply of these products 'elastic', in that the producers could more readily respond to fluctuating market demands in both product specification and output levels.

157. Pritchard, Q.M.J., July 1943, op.cit., p.36; S.T.G., notes, op.cit., May 1924, October 1924 and September 1929; Lindsay (1974), op.cit., p.258. The development of asbestos tiles appear to date from *c.*1910.

158. Pritchard, Q.M.J., June 1943, op.cit., p.473; idem., Q.M.J., July 1943, op.cit., pp.35-36; idem., Q.M.J., 'Aspects of the Slate Industry No.4: Roofing Fashions,' August 1943, pp.81-84; idem., Q.M.J., May 1946, op.cit, p.561; Lindsay (1974), op.cit., pp.258, 291. Criticism of the aesthetic characteristics of 'slate tiles' originated with William Morris in the 1890s. Furthermore, the disintegration within three decades of some of the poorest quality Belgian and French slates that had been imported in the 1900s, militated against the reputation for quality enjoyed by the product in general.

159. S.T.G., notes, op.cit., January 1929, quoting the Caernarvon & Denbigh Herald report of a spate of rockfalls at Nantlle; Richards (1995), op.cit., p.172.

160. Nantlle quarrying data collated by the author; S.T.G., notes, op.cit., November 1929, referring to large queues at Penygroes labour exchange; ibid., March 1930, referring to the sacking of 82 men at the Penyrorsedd Quarry plus another 50 by the Dorothea Company, with 'hundreds' out of work in the Nantlle district; ibid., November 1930, referring to the crash of the Amalgamated Slate Association Ltd, and the Dorothea quarry commencing a 3-day week. The virtual total unemployment at Rhosgadfan was reported in 'The Slate Trade depression', Liverpool Daily Post, 15 December 1930, p.13. See also summary of individual quarry histories in Idwal Hughes (1990), Chwareli Dyffryn Nantlle, op.cit., and C.R.O., G.P.Jones Nantlle MSS uncatalogued), Humphreys, O., 'Datblygiad Chwarelyddiaeth Dyffryn Nantlle yn y Chwarter Canrif Diwethaf' (unpublished essay, 1945).

161. Data collated from H.M.Inspectorate reports 1928 and 1931 (see note 120); Richards (1995), op.cit., p.173.

162. Pritchard Q.M.J., August 1943, op.cit., p.83. Green slates had, since at least the 1850s, been more expensive than the blue slates, because of their rarity, although the market was subject to wild fluctuations in demand. Rustic slates are ones exhibiting red/brown coloration resulting from the weathering of their high hydrated iron content.

163. Pritchard Q.M.J., June 1943, op.cit., p.474; ibid., January 1946, op.cit., p.342 and March 1946 op.cit., pp.459-460; Richards (1995), op.cit., p.179.

164. The most successful green slate quarry at Nantlle inter-war, was Fronlog Quarry. Smaller scale operations were also conducted in the green vein at Gwernor, Llwydcoed (or 'Greenarvon'), Twll Coed, Twll Llwyd (or 'Tanrallt Green'), Tynyweirglodd, Ty Mawr East and Ty Mawr West (or 'Welsh Green'). See Idwal Hughes (1990), Chwareli Dyffryn Nantlle, op.cit.; Owen Humphreys (1945), 'Datblygiad Chwarelyddiaeth Dyffryn Nantlle...', op.cit.; and G.P.Jones, 'The Gwernor Slate Quarry,' T.C.H.S., Vol.48, (1987), pp.47-73.

165. Pritchard Q.M.J., August 1943, op.cit., pp.83-4; S.T.G., notes, op.cit., March 1937 and October 1939; Lindsay (1974), op.cit., p.292. 'Colloidal slates' were cheaper than Westmoorland greens, but had a price premium of from 6*d.* to 10*d.* (2½p.- 4½p.) per square yard on the price of ordinary blue/purple roofing slates. The product failed commercially because of (a) technical problems with the colour-fastness of the colloidal film; (b) the price premium was too great; and (c) there was market resistance to the idea.

166. Pritchard Q.M.J., July 1943, op.cit., p.36; ibid., May 1946, op.cit., p.562, and January 1944, op.cit., Table 4, p.321; S.T.G., notes, op.cit., August 1933; Richards (1995), op.cit., pp.178-179. The U.K. market price of Welsh slates increased by 32 per cent between 1933 and 1937, in comparison with an average increase of 7 per cent in that of foreign slates. However, intrinsic problems continued to stifle the recovery of the industry, see the controversy in the local press, viz: H. Ewart Jones, 'What's wrong with the slate industry,' Caernarvon & Denbigh Herald, 25 October 1935; A. P. Percival 'What's wrong with the slate industry: A reply to Mr H. Ewart Jones, ibid., 29 November 1935; and Dylan Pritchard 'What's wrong with the slate industry: The output in North Wales,' ibid., 6 December 1935.

167. Pritchard Q.M.J., July 1943, op.cit., p.36.

168. C.R.O., G.P.Jones/Nantlle Mss, Crown Quarries (Letters from the Crown Commissioners, 1932-36, uncatalogued). The Caernarvonshire Crown Slate Quarry Co.Ltd. received grants totalling about £20,000 in 1932-36 from the Government to finance the clearance of around 200,000 tons of debris from the Alexandra, Cilgwyn and Moeltryfan quarries as a job-creation programme for the large number of unemployed quarrymen in the Rhosgadfan district.

169. For example, the investment upon development undertaken at the Dorothea and Penyrorsedd quarries after 1932. See Richards (1995), op.cit., p.175; G.P.Jones, 'The Dorothea Slate Quarry...' op.cit., Chapters 1 and 3; C.R.O., G.P.Jones/Nantlle Mss, Penyrorsedd Quarry (Notes from Directors' files 1930s, uncatalogued).

170. Derived from H.M.Inspectorate data for the Nantlle quarries (see note 120). The drop in employment at Nantlle in 1937 is significant in view of the boom reported in the industry in general, see Anon.,'The present position and future prospects of the slate industry,' Q.M.J., March 1937, pp.426-427. See also Dylan Pritchard, 'Slate Production: Nantlle District and a New Industry. Some Quarrying Statistics,' Caernarvon & Denbigh Herald, 4 February 1938.

171. Lindsay (1974), op.cit., p.297; Richards (1995), op.cit., p.182; S.T.G., notes. op.cit., May 1940, refers to the Quarrymen's Union figures of a 50 per cent reduction in the industry's workforce as a result of the war.

172. S.T.G., notes, op.cit., January 1940 and May 1940. Goronwy Owen M.P., (Caernarfonshire) tried to no avail to persuade the War Office to use slates for roofing military buildings.

173. Richards (1995), op.cit., p.182; S.T.G., notes, op.cit., June 1941 and November 1944, quoting articles in the Caernarvon & Denbigh Herald.

174. Lindsay (1974), op.cit., p.297; S.T.G., notes, op.cit,, October 1940, January 1941 and June 1941 quoting articles in the Caernarvon & Denbigh Herald. In June 1941 it was reported that only one third of the pre-war employees remained in the slate industry, and that in Caernarfonshire in January 1941 there were only 400 men left in the Nantlle quarries, 700 at Dinorwic and 1,100 at Penrhyn.

175. C.R.O., XM 1956, Jones,A., 'Recent Developments in the Slate Quarrying Industry of Caernarvonshire,' (Thesis, 1977), p.8; S.T.G., notes, op.cit,, August 1941 and November 1941.

176. Minutes of Slate Quarrying Executive Committee, per Wynne Quarry Museum, Clwyd. The author is indebted to Mr Richard Williams (Llanrwst) for bringing these documents to his attention.

177. G.P.Jones (1980), 'The Dorothea Quarry...,' op.cit., Part 1.

178. S.T.G., notes, op.cit., March 1944 commented on the first report of the Welsh Reconstruction Advisory Council, which displayed a lack of any interest in the plight of the slate industry. However, the S.T.G., of November 1944, quoted 'The slate industry after the war', an article in the Caernarvon & Denbigh Herald, which claimed that the Government had placed the slate industry high in its list of priorities and was to tackle the pressing problem of depleted manpower by searching out ex-quarrymen in the armed forces;

179. Lindsay (1974), op.cit., p.299; S.T.G., notes, op.cit., June 1946, quoting the Manchester Guardian, 22 June 1946, that the Ministry of Works had appointed a 'working party' to investigate the requirements of the industry. Quarry owners were asking for protection in the market after the release of restraints, by having public housing schemes use slates.

180. Richards (1995), op.cit., pp.182-184; S.T.G., notes, op.cit. August 1949, announced removal of restrictions on roofing new buildings with slate.

181. Dylan Pritchard, Q.M.J., May 1946, op. cit., pp.560, 563. Pritchard refers to the disproportionately greater contraction of the industry in Nantlle and Ffestiniog.

182. Pritchard, op.cit., 'The Welsh Slate Committee,' Q.M.J., July 1946, pp.36-39; idem., The Slate Industry of North Wales: statement of the case for a plan, (1946), passim; S.T.G., notes, op.cit., August 1949. Pritchard was advocating a planned re-development of the Welsh slate industry so as to overcome the decline which would follow his predicted post-war cycle peak *c.*1950. Ministry of Works, The Welsh Slate Industry: Report by the Committee appointed by the Minister of Works (H.M.S.O., 1947); Prof.G.Hibberd, 'A Survey of the Welsh Slate Industry' (privately-circulated report, sponsored by the Ministry of Works, 1948, regarding technological developments in general, with specific recommendations for individual quarrying concerns).

183. Information re. merchants' operations at quarries in Nantlle was obtained from interviews with former employees and from the files of the Caernarfonshire County Council in the possession of Gwynedd County Council Mineral Planning Department. The author is indebted to Mr J.Gibbins of the latter dept., for his assistance in tracing these documents.

184. Lindsay (1974), op.cit., p.301; Richards (1995), op.cit., pp.184-185; ex.info., Mr.M.J.B.Wynne Williams, former managing director of the Dorothea Quarry.

185. Dylan Pritchard, 'Aspects of the Slate Industry No.1: A Welsh Slate Producers' Association Proposed,' Q.M.J., May 1943, pp.422-426; idem., Q.M.J., May 1946, op.cit., pp.563, 565; House of Commons, Speech by T.W.Jones M.P., (Merioneth), 'The Decline in the Slate-quarrying Industry,' Extract from the official report Monday 10 March 1958, (H.M.S.O., 1958) 6pp; Alun Jones (1977), 'Recent Developments in the Slate Quarrying Industry...' op.cit., p.24, tabulates the declining numbers of slate quarrymen in Caernarfonshire, from 8,227 in 1938 to 4,050 in 1946, 2,510 in 1959, and 1,200 in 1965 to only 372 in 1971.

186. Richards (1995), op.cit., p.183; ex.info.; C.R.O., G.P.Jones Nantlle Mss (data from uncatalogued documents rescued from defunct quarries).

187. C.R.O., XM 1956, Alun Jones, op.cit., pp.17-18 (summarising C.R.O., X/Dorothea Mss 625-628); ex.info., M.J.B.Wynne Williams, who blamed the impotence of the Association in the mid-1960s on the persistence of the old Dinorwic/Penrhyn perception of superiority.

188. G.P. Jones (1980), 'The Dorothea Slate Quarry...,' op.cit., Chapter 3; C.R.O. X/Dorothea Mss, files re. 1960s; C.R.O. G.P.Jones Nantlle Mss, Penyrorsedd Quarry File 11.1, report dated 23 December 1965 on Dorothea modernisation scheme; Houston, W.J., 'New Developments at Dorothea Slate Quarry,' Q.M.J., February 1964, pp.67-70, concluding with Major A.I.Wynne Williams' remark, which epitomises the attempts at modernisation during the 1960s, viz:- "The day of the man with a pick and shovel is over"; Lindsay (1974), op.cit., pp.295-296; Richards (1995), op.cit., p.203. The commercial production of crushed slate had commenced around 1919 in North Wales, although the idea had been mooted as far back as 1854 (see "Hugh Miller" op.cit., p.111).

189. Ex.info; witnessed by the author.

190. Private investment in the slate industry had started to decline in the 1880s and the losses experienced during the trade depressions of the 1900s and 1920s destroyed the last vestiges of confidence. Finance from other sources was also difficult to obtain. See Chapter 2, *infra.*

191. See Richards (1995), op.cit., pp.188-189; C.R.O., XM 1956, Alun Jones (1977), op. cit., p.13, refers to redundancies at Dorothea and Penyrorsedd in October 1965, with the former concern commencing short-time working because of the drop in orders.

192. Ibid., pp.30-57; ex.info., M.J.B.Wynne Williams; witnessed by the author; Ivor Wynne Jones, 'Day to day in Wales,' Liverpool Daily Post, (January 1976 regarding the demise of the slate industry since the 1960s; ex.info., M.J.B.Wynne Williams (Dorothea Quarry) and Walter Riley (Crown Quarries); witnessed by the author; C.R.O., G.P.Jones Nantlle MSS, Penyrorsedd File 11.1 re. proposed amalgamations 1865-66 and 1969-70, donated by Mr S.Darbishire, former managing director of the Penyrorsedd Slate Quarry Co. Ltd.

193. Author's estimate.

194. Ex.info., Mr R. E. Esplin and Mr D. A. Owen (managing director and works manager, Cocklebank Conservations Ltd in 1970s); C.R.O., G.P.Jones Nantlle Mss, Twll Coed documents and Tanrallt Estate deeds (uncatalogued).

195. Richards (1995), op.cit., pp.187-188, although he incorrectly attributes the construction of the road into the pit to this Company. C.R.O., G.P.Jones Nantlle Mss, Penyrorsedd Files 1.2, 6.1-6.4, 8.3, 9.1, 9.2, 15.2 (Directors' and managers' reports). The Penyrorsedd general manager, O. G. Williams, summarised the policy of the quarry Company in 'An heir for the declining Duchess,' Industrial Diamond

Review (July 1972), pp.294-298 thus:- "Being smaller in size and resources than some of our competitors, we couldn't afford to take too much of a chance, so we sat on the fence for a while and learned from other people's mistakes."

196. Ibid., File 16.1, re. liquidation of the Penyrorsedd Company in 1979. Closure had been considered several times between 1970 and 1974, when short-term unsustainable trading losses threatened the future of the Company on several occasions, although the concern weathered each storm until the problems became finally untenable without committing the shareholders' invested financial reserve fund to further development work.

197. Witnessed by the author.

198. The quarries producing slate & slab in Gwynedd are (June 1996):
Bethesda
Penrhyn Quarries (Mc Alpine Slate Products Ltd.)
Nantlle
Penyrorsedd Quarry (Nantlle Slate Co. Ltd./Ffestiniog Slate Group)
Twll Llwyd, Llanllyfni (W. H. Humphreys & Sons)
Ffestiniog
Cwmorthin (a private partnership)
Graig Ddu (Cwtybugail Slate Co. Ltd./Ffestiniog Slate Group)
Gloddfa Ganol (Gloddfa Ganol Slate Co./Ffestiniog Slate Group)
Llechwedd (Greaves Welsh Slate Co. Ltd.)
Maenofferen (Greaves Welsh Slate Co. Ltd.)
Oakeley (Ffestiniog Slate Co. Ltd./Ffestiniog Slate Group)
Corris
Aberllefenni (Wincilate Ltd.)

199. Ex.info., Gwynedd County Council, Planning Dept.; See also Richards (1995), op.cit., pp.189-204. A joint-marketing company for the Welsh slate industry was set up in December 1995, this being the first time that all of the main concerns have joined together to promote the common product, on the pattern suggested by Dylan Pritchard in the 1940s.

200. 'M.P. wants talks on slate imports,' Caernarvon & Denbigh Herald, 4 November 1983, p.7; 'Spanish slate quarry threat,' ibid., 2 December 1983; ex.info., Mr Peredur Hughes (manager of the Penyrorsedd Quarry), who kindly showed samples and sales literature to the author; Richards (1995) op.cit., pp.201, 204, although his claim that the Brazilian slates are cheaply priced is not correct; ex.info Mr Bryn Hughes, commercial manager of the Penrhyn Quarries, who supplied an analysis of the slate trade post-1980, viz:-

The world market for slates increased fourfold from 1980-89 except in France, which showed a decrease. The 1989-91 U.K. recession was a setback, but by 1995 the total demand has returned to the mid-1980s level. Currently, the U.K. quarries produce 50 per cent of the demand of the home market, of which over half is for non-domestic architectural applications. However, the sales of the cheaper products of the Spanish quarries (who account for 80 per cent of world roofing slate production) make up the remaining half of the U.K. market.

201. Ex.info., Gwynedd County Council, Planning Dept.; ex.info., Mr W Roberts, director of the Ffestiniog Slate Group; Richards, Moorehead & Laing, in a report to the Dept.of the Environment, Slate Waste Tips and Workings in Britain, (H.M.S.O., 1995), Chapter 2, p.20, Tables 2 and 2B, provides data for the slate industry of North and Mid-Wales in 1992, when 26,250 tons of roofing slates were produced and 1,530 men were employed. The U.K. demand for roofing slates in 1992 amounted to about 80,000 tons, of which the Welsh quarries supplied about half.

202. This concentration at Ffestiniog is explained by the defunct sites being either already owned by working concerns, or were available for purchase or leasing. This situation was not duplicated elsewhere to the same extent at that time.

203. Witnessed by the present author.

204. Report on the closure of Penyrorsedd due to safety concerns, Caernarfon Herald, (Caernarfon district edition), 16 November 1984; report commissioned by Gwynedd County Council, Economic Development Dept., on the slate industry in the county (1995), summarised in 'County dominate slate market,' Caernarfon Herald, (Caernarfon district edition), 17 March 1995, p.16, and 'Slate industry is set for a bright future,' ibid., 31 March 1995, p.17; ex.info., Mr Peredur Hughes, Penyrorsedd quarry manager, who kindly supplied output data for his quarry, having increased from about 500 tons in 1993 to over 1,000 tons in 1994.

CHAPTER 2

CAPITAL AND INVESTMENT

The complexity of the pattern of capital structures in the slate quarries of the Nantlle area precludes its presentation in an entirely chronological account. Part (a) of this chapter consists of a general account of the investment trends in the Nantlle quarries, but the discussion of the capitalistic structures of the various concerns over a time-scale (Part b) is best presented in discrete categories. The chapter concludes (Part c) with an appraisal of the factors which appear to have controlled their profitability.

(a). The Sources of Investment

The overall trend of the history of investment in the slate industry shows consistency in terms of the general themes, with some individual variations at district level. At the dawn of the commercial era of the slate industry around the end of the seventeenth century, the basic unit of capitalism in the quarries appears to have been the partnership of a number of working quarrymen-proprietors, employing a number of labourers for non-skilled tasks [1] (see Part b (i) below). This must have been a naturally-evolved system of long-standing, being probably loosely based upon the system of craft guilds. The level of financial investment in such cases would have been minimal, but the input of skill and effort upon the part of the quarrymen-proprietors was of an equivalent value to an injection of cash, and was of greater practical use.

Up to the late eighteenth century the slate industry had lagged behind other extractive industries such as metal mining, in terms of capital investment structure [2]. Yet, by the eighteenth century there were signs of developments in this field in the Welsh slate industry, particularly at Ochr-y-Cilgwyn (Nantlle) and at an offshoot operation at Diffwys (Ffestiniog) [3]. Unfortunately, this blossoming of native enterprise was progressively stifled during the closing decades of that century by the influx of external commercial interests which accelerated during the 1800s, spurred on by the success of individual entrepreneurs such as Richard Pennant (at the Penrhyn quarry) by the 1780s, and others after 1800 at Llanberis, Ffestiniog and elsewhere [4]. Most of the industry at Nantlle remained free of external control until the dawn of the nineteenth century, although the evidence for the existence of some non-working sole proprietors (see Part b (ii) below) in this district by the 1760s-70s suggests that the process of change had commenced here contemporaneously with that at the Penrhyn Quarry [5].

Dylan Pritchard stressed the importance of the events within the first part of this so-called 'expansionist phase' (*c.*1780-*c.*1830), in which the Welsh slate industry was reorganised into a capitalistic form which enabled output to be increased in response to the rapidly expanding demand that was created by the industrial revolution [6]. Slate quarrying consequently developed from a low-investment, small-scale level of operations into a highly capital-intensive business at the higher end of the production scale by the second part of the 'expansionist phase' (*c.*1830-1877) [7]. The operators of deep mines and open-cast pits in particular were faced with the extra costs of purchasing and operating winding and pumping plant in order to maximise their production levels, and the progressive adoption of processing machinery added to the capital outlay required (see Chapter 4). This additional expenditure was especially heavy at Nantlle, especially in the case of the low-lying sites abutting the lake, where pumping costs were very high and where rubble had to be raised up to high-level tipping banks (see Chapter 3).

As a consequence, the means of raising capital for funding quarrying enterprises also became increasingly sophisticated. Few individuals possessed the means to proceed as a sole trader in this industry by the middle of the nineteenth century. Thus, investors increasingly formed combinations (or 'companies') to pool their resources and to spread the risk. The range of available types of capital organisations was enlarged during the nineteenth century to include a legally-defined form of partnership based upon fractional ownership, and a re-juvenation of the discredited joint-stock company structure, based on transferable unit shares, later available with the protection of a limitation in the shareholders' liabilities upon liquidation (see sub-section b, below).

An important feature of the Welsh slate industry was the persistence of the older types of capital organisation and their co-existence alongside the newer forms. This mixture of old and new was very evident in the slate quarries of the Nantlle district. This area had the biggest concentration of individual quarries of any of the slate-producing districts and the variation in scale of these sites presented the greatest opportunity within the industry for the whole range of types of capitalist organisations to co-exist. Some sites supported concerns having an investment of up to £100,000 whereas others were operated by partnerships of quarrymen investing their skill, energy and a proportion of the profit, net of a living wage. The high proportion of smaller quarries thus satisfied the aspirations of the independently-minded entrepreneur of limited means and contributed significantly to the local economy in the period of the demise of the more vulnerable high-cost concerns.

A further noteworthy feature of the economic history of the slate industry, which was very evident in the Nantlle district, was the rapid turnover of individual concerns in the majority of sites. Only a minority of concerns had life-spans in excess of about two decades and many never reached double figures. This characteristic was also shared with the metal mining industry and was attributable to a variety of factors, of which the most common was the lack of profitability of a large number of the quarries except in the favourable climate of economic booms. Thus, the slate industry at Nantlle, following the general trend of the major centres of slate production in North Wales, had a relatively small core of long-lived profitable concerns which were outnumbered by the mass of second quality quarries and other marginal workings, the latter being only fleetingly worked in the periods of best trade.

Entrepreneurs, shareholders and speculators

The economic history of the slate industry is as concerned with people as it is with marketing and technology. Behind the dry lists of quarry operators and financial statistics there can be discerned both the hopes and disappointments of those individuals who invested in the quarries and the wilful plotting of others who made a living from share promotions and speculations.

Of the hundreds of persons who were involved in the provision of capital for the development of the slate quarries at Nantlle, remarkably little is known of the majority. The 'sleeping partners' and ordinary shareholders of most of the slate companies were remote from the day-to-day working of the quarries and can no longer be identified unless their names survive on extant primary documentation. However, of those that can be traced, although a remarkably high proportion of the ordinary shareholders of the slate-quarrying companies in the Nantlle district from the 1820s were Welsh (see below), the majority were English. They were often businessmen, sometimes having connections with the building industry, or were middle-class investors such as higher members of the armed forces, the Church, or other individuals of means. Yet, the vast majority lost their money through the premature liquidation of the grand concerns in which they had placed their faith and their cash.

On the other hand, the names of the active proprietors and executive members of companies are generally better known, particularly when they had been very successful, spectacularly unsuccessful or fraudulent in their business enterprises. Some individuals were more prominent than others because of their standing in society, particularly in the case of aristocrats such as the Earls of Shrewsbury and of Stafford, respectively [8]; their Lordships Abinger [9], Gower [10] and Trevor [11]; the Barons Deramore [12]; and Sir John Kennaway [13], who all graced the folios of Burke and Debrett. Others stand out because they were colourful characters such as the members of parliament who were to be found amongst the principal shareholders of local companies from 1827 to 1860, including (briefly) the controversial Charles Bradlaugh [14].

Within the extant lists of investors, some from the professional classes conjure an impression of staid and perhaps pompous people, as befitted their positions as solicitors, accountants, naval admirals, army officers and clerics [15]. Others come to life from the pages of documents as dynamic, exciting personalities. The latter included the Rev. John Jones (of Tal-y-sarn), a charismatic former quarryman, who became the most influential Methodist preacher of his time and who used his position to attract Welsh investment into the Dorothea Quarry venture of 1849 [16]; also his eldest son, John Lloyd Jones, who combined a sharp intellect with an inherited skill for communicating, forsaking his natural calling to the pulpit for an early career as a slate salesman, later becoming a slate producer and latterly promoting and selling quarries [17].

Others included George Eugene Magnus, the London slab merchant who went from Judaism to Methodism to Freethinking [18]; John Robinson, a wily ex-banker and engineer who had the 'common touch' and displayed generosity to his men but elevated the methods of evading his creditors to the status of an art-form [19]; and William Arthur Darbishire, a quick-tempered abstentionist disciplinarian and individualist of immense practical ability but having a strong sense of duty in the provision of welfare for his workforce [20]. Last, but not least, were the fraudulent speculators such as St.Pierre Foley, who suffered the double-edged accolade of being "...of Irish and geological celebrity" [21]; also Foley's one-time partner, Winfield Attenborough, a London solicitor, of whom Lord Newborough's agent said that he "...was not worth powder and shot" [22]; and Thomas Harvey, another London solicitor, whose skill in defrauding shareholders in the Pennant Valley in the 1870s-80s owed much to a successful apprenticeship misappropriating the funds of investors at Nantlle a decade earlier [23].

Within the male-dominated society which presided over the era in which the quarries were developed, women did not feature prominently even though many concerns included female shareholders. A few ladies broke the mould by actively managing the affairs of their respective concerns, and of these three persons stand out. Although nothing is known of Shân Bontfaen [24], who allegedly co-owned the Cloddfa'r Lôn Quarry in the eighteenth century, she is worthy of mention because of her representative role as a named person within a group of otherwise anonymous females who are thought to have played a part in the early years of the quarries at Nantlle. Second in the list was Miss Elizabeth Lydia Cane [25], who during the 1840s caused some comment by her idiosyncratic methods of carrying on the business of her deceased brother at the Penyrorsedd Quarry, although her tenure at the works was more successful and of greater duration than many of her local male competitors. Last chronologically, but not least in terms of her presence, was the redoubtable Mrs Mary Barnes (neé Darbishire) [26], who ruled the fractious Board of another Penyrorsedd Company as a matriarch during the 1920s, but whose oft criticised lack of understanding of practical quarrying was no greater than the complementary ignorance of the majority of her male colleagues.

The most influential of all the entrepreneurs who developed the slate industry at Nantlle was a local man, John Evans, born at Talymignedd Farm in the parish of Llanllyfni in 1766. By the 1790s he had established himself as a solicitor at Caernarfon by way of a practical training in a Bangor practice. His clients included many important local landed estates and he was prothonotary of the court of quarter sessions. Having had some managerial experience of the slate industry with his first employers, Evans with a number of partners from the landowning classes was granted a Crown lease of the Ochr-y-Cilgwyn commons at a time when the ownership was in dispute and the local quarry owners were refusing to acknowledge Crown rights. His was the company which wrested the control of the industry from the early quarrymen-proprietors at Nantlle by ejected the sitting proprietors, albeit with considerable difficulty and some legal skulduggery [27].

By this and other actions, Evans became the object of hate and fear amongst the local populace. In such circumstances lay the seeds of an anecdote which reported that in response to a Sunday school examiner at Nantlle in the 1820s, a child was said to have satisfactorily answered "God" when asked who had made the world, but in reply to the follow-up question of who *controlled it*, the retort was "John Evans Twrne" [28]. Yet, despite his power, Evans cannot have been immune to the troubles afflicting his personal life. Having fallen out with his business partners and with his only son estranged, the crumbling business empire passed to a nephew upon Evans' death in 1827. But, it quickly became apparent that the brittle structure of a web of business interests spread over two counties was only held together by the prowess of the wily old solicitor, and by 1831 it had all fallen apart [29].

The route by which a number of these entrepreneurs entered the slate industry of North Wales and specifically established businesses in the Nantlle district, is recorded or can be traced with a reasonable degree of accuracy. Yet, in general, the motives of individual persons who invested in the quarries is probably the least understood aspect of the economic history of the slate industry. In certain cases, it is possible to discover prior business links which provide strong evidence of motive, for instance the trading connections of English and local merchants with the quarries [30]. Yet, in the case of the important individual entrepreneurs such as John W. Greaves, Samuel Holland, and William Turner, it is likely that their presence in North Wales and their involvement in the slate industry, was partly one of chance [31].

In the early nineteenth century, the ranks of these entrepreneurs were increasingly swelled by private investors, who were usually inactive (or 'sleeping') partners, solely interested in gaining a return on capital placed into the care of others [32]. By virtue of the contemporary unlimited liability associated with all business holdings, these investors tended to be persons of independent financial means. However, an investment in mining and quarrying was a particularly risky affair under such onerous rules, and Edmund Hyde Hall, as early as 1810, commented in his account of Caernarfonshire that:-

it was "...lamentable to see the small capitals of industrious individuals ...thrown away in gambling speculation ...because the quarries of a few great capitalists have proved ...prodigiously productive" [33]. The capitalistic development of the slate industry was at that date only in its infancy, but the truth of Hall's observation was to remain valid for nearly a century.

The influx of capital into the Welsh slate industry was, however, not uniform, and Dylan Pritchard identified a correlation between cycles of investment in the quarries and that of building activity within the British economy [34]. Yet, the increasing flood of investment into the Welsh slate industry testifies both to the persuasiveness of the company promoters and to the hunger of the public for reaping the promised instant rewards of capitalism. Furthermore, the rush of registrations after 1855 of limited-liability companies operating slate quarries shows that this industry was a particular favourite [35]. However, these investors were to quickly discover that the inflated promises that were a characteristic of contemporary share prospectuses rarely transformed into dividends, and that the majority of shareholders in slate concerns suffered complete losses of their funds.

The main problem with the slate industry as an investment was that despite the highly-effective publicity given to the slate industry in specialist publications such as the *Mining Journal*, [36] supplemented in the 1860s-70s by a number of very popular investment text-books [37], most of the opportunities on offer were bad risks. During the great years of the zenith of the industry from the late 1850s to 1877, the pages of the *Mining Journal* were packed with share promotions, with each claiming some affinity with one of the well-known leading concerns in the relevant districts. This share-marketing ploy was very successful, because the three great slate concerns of Dinorwic, Penrhyn and the

Welsh Slate Company (Ffestiniog), representing some sixty per cent of the productive capacity of the Welsh slate industry, were estimated to be generating total profits of up to £200,000 per annum in this period [38]. Consequently, the greater part of the output of the industry was being produced at a very high rate of profit, and it was therefore inevitable that the claim was made that the Welsh slate industry provided the safest investment and highest returns in Britain [39]. In such circumstances it was only to be expected that every little hole in the ground was at some occasion hailed by company promoters to be potentially a 'second Penrhyn Quarry' if only a sufficient amount of capital was subscribed to develop the site!

However, the only opportunity for investing in the industry lay in the remaining forty per cent of quarries (on an output basis) which were not producing exceptional profits. The best of the remaining quarries were a category of concerns such as the Dorothea and Penyrorsedd quarries (Nantlle), and Llechwedd or Votty & Bowydd (at Ffestiniog) for example, none of which achieved more than half the profit levels of the top three, above [40]. Yet, most of these profitable 'second division' quarries were held by stable, long-lasting private companies by the 1860s, and were not accessible to the average investor [41]. Therefore, nearly all the company promotions of the third quarter of the nineteenth century were restricted to the least profitable bulk of the industry, which produced only around twenty per cent of the output tonnage.

Despite the basic flaw in the investment opportunities on offer, as outlined above, there was nothing intrinsically unethical in the role of the company promoter. He was an essential component in the system and his activities were beneficial to an under-developed industrial area which suffered from the disadvantage of being distant from the source of finance (that is, England). As with any act of salesmanship, it was not surprising that the details supplied to potential investors concerning the quarry for sale, were invariably on the optimistic side [42]. Often, the main promoter was a middle-man between the eventual purchaser and a primary promoter, who was often a local quarryman/entrepreneur who had prospected a virgin site with the aim of selling his take-note or lease to an incoming larger concern. This process had been a feature of the capitalist side of the industry from early in the nineteenth century, and was an important facet in the growth of the industry in general and at Nantlle in particular [43].

On the other hand, there was an ill-defined, yet ethically important boundary between promotions and speculations. The latter can be defined as large-profit sales with dishonest intent, of concerns which had little chance of success. Such quarries were most often marginal ones which only worked periodically, and for these hopeless sites a grand prospectus would be drawn up with confederates supplying untruthful glowing reports on the property [44]. On the strength of these reports, inflated prices were often obtained for mineral leases that had been previously been cheaply bought by the speculator. An excellent example of this at Nantlle was the purchase of the Tynyweirglodd Quarry lease in 1849 for £800 by a speculator (W. Attenborough; see p.110, *supra*), who promptly re-sold it to two English gentlemen four days later at £14,000 [45].

High sale prices had been a feature of the speculative side of the industry from very early days, this probably being a mixture of profiteering and reclaiming investments in the quarries. The fortunes of the vendors of slate quarries were, however, mixed during the early nineteenth century. Nantlle's then premier concern, the Cloddfa'r Coed Quarry, failed to sell for a reasonable £4,000 in the wartime economic climate of 1800, but the adjacent undeveloped maze of small workings collectively known as the Talysarn Quarry attained an exorbitant £24,000 in 1827 in the wake of a great investment boom. The Dorothea Quarry was a bargain at £3,000 in 1849, just prior to the start of the 'golden years' of the industry, when sale prices shot up to a range of £10,000 to £33,000 in the 1860s and 70s, before dropping by up to ninety per cent in the ensuing trade depression. The long-term trend in this district, which was typical of the industry in general, is illustrated by the prices attained for the leasehold interest in the Fron Quarry, viz: £35,000 in 1867; £26,230 in 1873; £10,000 in 1882; and only £600 in 1902 [46].

The direct result of the inflated purchase prices of the boom years was the burdening of fledgling concerns with a shortfall of liquid capital from its birth. A local historian and quarry agent, John Paull (1886), provided one contemporaneous example in the flotation of a company to work the small Llwydcoed Quarry (near Llanllyfni). Despite the poor trade in that year, the vendor had succeeded in obtaining £20,000 for his interests, a figure thought by Paull to be far in excess of the likely return from the investment of the residual £10,000 of the concern's capital on developing this site [47].

The purchase of a quarry lease was, however, only the first pitfall facing any inexperienced concerns entering the industry. For want of practical knowledge, most new companies employed consulting agents, a class of persons commonly afflicted by lapses in integrity. Sometimes the former vendor was hired simply on the basis of having some prior experience of slate quarrying, a veritable guaranteed path to disaster. Characteristically, the next act in the mounting tragedy was a period of intense activity by the proud new proprietors, with the construction of inclines, buildings and installing new machinery being favourite policies.

However, very soon the early return on the investment promised in the first annual company meeting became calls for more capital in the second year, and by the third year the awful truth of the intrinsic unprofitability of the quarry (usually due to indifferent rock quality) would begin to dawn. Perhaps there would be an attempt to salvage the situation by pouring even more money into the venture, or to capitalise on the outwardly impressive assets of the doomed enterprise by a sale to a new group of potential victims, but the usual result in less than a decade was liquidation of the company and the total loss of the investment. This left the site vacant, ready for either the original speculator or another of the same ilk, to carry out the same ruse again, albeit under a different site name [48].

The principal years for the speculator were those of the great boom of the slate industry from *c.*1857-77, although a number continued to operate on a more restricted scale up to the middle decades of the present century. After 1877, the slate industry declined in a complex cycle of diminishing booms and investors who had not lost out to share speculators during the 1860s-70s were very likely to have lost their money in the serious slumps of 1880-95 or 1903-13 instead (see Chapter 1, above). Only the very few concerns working the best quarries survived those unhappy years, albeit paying greatly reduced dividends.

The first great recession of the 1880s had a particularly damaging effect upon public confidence in the industry and consequently the influx of new capital diminished greatly in its wake. In a throwback to the circumstances of the early nineteenth century, most founders of new concerns after that decade were already involved in the slate industry directly or through the merchandising or building trades and what new investment that came in was on the restricted scale of private concerns; the age of the large public floatation of quarry companies had come to an end. This trend away from its enjoying immense public interest as a vehicle for investment was further magnified by subsequent periods of deep decline, notably 1903-13 and post-1922. In the latter case the problem was compounded by changes in the laws of personal taxation after 1914 which were blamed for the decline in the numbers of private investors in U.K. industries in general [49].

The ebb and flow of Welsh investment at Nantlle

A large proportion of the capital invested in the slate quarries of North Wales during the late eighteenth and very early nineteenth centuries had local origins, although several of the entrepreneurs were settled incomers [50]. The source of the investment funds was from a variety of origins such as landed estates, commerce, professions such as banking and the law, and to a smaller extent from the trading profits of individuals within the slate industry itself [51].

However, after the end of the Napoleonic war, increasing amounts of this finance came from outside the local region, with the initial trickle turning into a flood by the middle years of the century. During the first quarter of the nineteenth century the influence of the indigenous population upon the capitalistic side of the industry became marginalised. Former independent proprietors became part of the growing class of industrial workers and ownership was increasingly found in the hands of companies, of which the earliest of these at Nantlle involved local gentry and solicitors [52]. This transformation was by no means peaceful, and was marked by a determined, if ill-fated resistance on the part of a number of the original operators during the early years of the century. However, by 1815 even the fiercely-independent quarry proprietors of Ochr-y-

Cilgwyn (Nantlle) had yielded control of the last bastion of the former system to the external capitalists [53].

There were a number of attempts made to reverse the trend of English domination of the slate industry, of which the Dorothea Slate Company (of 1849) at Nantlle, was a notable example. This concern was the first important capitalist venture in the slate industry by the local Welsh community on the basis of a public flotation. Unfortunately, the contemporary local society did not support a sufficiently numerous indigenous professional (or 'middle') class before the 1870s and consequently its ability to raise sufficient capital to take over a slate quarry of a significant size, was severely restricted. In the case of the Dorothea Company, only about half the share flotation was taken up in the Nantlle district by farmers, the better-off quarrymen/cottagers and small-scale businessmen, and it required the influx of external funds to get the concern off the ground [54].

Furthermore, soon after the commencement of operations by this 'local' concern, fractiousness between diverse groups of shareholders split the Dorothea Company, a process which appears to have been encouraged for reasons of personal ambition by a few individuals who held seats of power in its management. The resulting split of the shareholders into two or three opposing camps was disastrous in a concern which attempted to manage its business *via* a full members' committee, an organisation which reflected the influence of Calvinistic Methodism which was its single unifying factor. However, the rapid fall into disillusionment of the majority of shareholders had by 1860 resulted in the controlling interest in the Company having fallen into the hands of a single family, but continued infighting was not resolved until a single individual had acquired almost three-quarters of the share [55].

The moribund state of the Dorothea Slate Company under its original democratic constitution prior to its subsequent blossoming as the personal fiefdom of John Hughes Williams (of Llangernyw and later of Caernarfon), highlighted the difficulty of mounting a broad-based Welsh challenge to the increasing dominance of the slate industry by English companies [56]. Moreover, although the disillusionment of the Nantlle-based Dorothea shareholders was a blow to the progress of Welsh capital as an organised force into the slate industry, it was the aftermath of this adventure which provided the *coup de grace* to this particular episode.

Many of the disgruntled local shareholders of the Dorothea Company retained ambitions to continue in the slate trade, and the proceeds of the sale of their shares (at four times the face value) was earmarked for the flotation of a new Welsh public joint-stock company, which was being promoted on a regional basis in 1858-59. This concern, titled 'The Coedmadog and Cloddfa'r Coed Welsh Slate Company,' proposed to take leases on the above named quarries at Nantlle in the first instance, but its ambitions were unfullfilled as the result of a disputed lease clause that could not be resolved. The ensuing crisis of confidence on the part of the shareholders of the new concern caused its dissolution, and the private company subsequently set up by a hard core of the more resolute would-be entrepreneurs also failed to make any headway, possibly because of an insufficiency of capital [57].

The result of the limited resources and, perhaps, a lack of resolve, of the Welsh investors at Nantlle in the late-1840s and in the subsequent decade was a failure to grasp the opportunity to re-gain local control over a number of potentially profitable quarries that were then standing idle (see Chapter 1, above). These quarries, the chief being Cilgwyn and Talysarn, had failed commercially because of the inexperience of their

English entrepreneurs and management, not from the want of workable slate rock. Had the local Welsh investors - many of whom were experienced quarrymen - been sufficiently confident, or able, to take over these sites at this juncture, they would have benefited from the profits which went to the subsequent new English owners during the great boom years of *c.*1855-1877 [58].

The indigenous population of the Nantlle district were, however, not totally entrepreneurially inactive during the mid-nineteenth century. On the one hand, the lure of short-term windfall profits encouraged a number of small-scale local entrepreneurs to sell their holdings in potentially successful concerns to incoming companies for a premium price in the decades immediately preceding the 'golden years', above [59]. On the other hand, the personal capital amassed by such classes of workmen as bargain-takers, senior staff and managers during the golden age of the industry (roughly 1855-77), seems to have gone into maritime undertakings in preference to being (metaphorically) 'poured into useless holes in the ground' as was the case with the savings of English investors (see above) [60]. This preference may have been due in part to the witnessing of the collapse of many speculative quarrying share-promotions at sites where the risk of failure were odds-on, whereas the vital role of ships in the transport chain for slates provided guaranteed dividends to their owners (see Chapter 5) [61].

Independent local operators were thus, after the 1840s, largely restricted to the margins of the slate industry at Nantlle because of the locking-up of the best quarries by a succession of capital-intensive English concerns. Consequently, the local entrepreneurs continued their speculative prospecting, and gangs of quarrymen often rented some of the sites vacated by the defunct companies, scavenging workable rock using low-cost extraction and processing techniques (see Chapter 3) [62].

Yet, despite pushing aside the local entrepreneurs into a subsidiary role, the influx into Nantlle of capital from outside the area was economically highly beneficial. Without the huge sums drawn in from England, the North Wales slate quarries could not have been developed sufficiently to allow the massive expansion in output from around 100,000 tons in 1832 to 450,000 tons half a century later [63]. This investment was encouraged by factors such as expanding domestic and foreign markets and the virtual absence of effective competition (see Chapter 1).

A resurgence of Welsh investment into the slate industry had to await the emergence of a middle-class with sufficient financial means and ambition to emulate its counterpart in England. This process was encouraged to a great extent by the promotion of Welshmen to the positions of senior management in a number of the larger English concerns at Nantlle during the 1860s, usually replacing Englishmen who had not generally been very successful in their posts. Thus, by the mid-1870s a small core of local business expertise had developed to a sufficient degree to encourage confidence in the ability of Welsh concerns to enter the mainstream of the slate industry. That the main sphere of their influence was confined to Nantlle and to a lesser extent at Ffestiniog, was largely due to the opportunities afforded through personal connections and the greater opportunities of acquiring viable quarries in these districts than elsewhere [64].

The leading light of this new wave of Welsh quarry owners was Griffith Williams (one-time quarry agent and merchant of Caernarfon) [65] who had interests in several of the most successful of the Welsh companies at Nantlle in the 1870s and 1880s, all of which were interlinked through common shareholders within the restricted circle of a Bangor-Caernarfon Liberal clique.

In addition to Griffith Williams (above), the other main investors in these concerns were Griffith Davies (a doctor, of Caernarfon) [66], Thomas Lewis (a merchant, of Bangor) [67], Hugh Pugh (a banker and shipowner, of Caernarfon) [68], Morgan Richards (a slate-merchant, of Bangor) [69], John Roberts (a draper, of Bangor) [70] and John Thomas (a shipowner, of Caernarfon) [71]. After *c.*1890 a second generation of Welsh entrepreneurs came to fore at Nantlle, including William David Williams [72], Thomas Charles Lewis [73], and others [74], but there were also some incorporations involving independent quarrymen, such as the Ty Mawr East Slate Company Limited of 1909 [75].

The concerns operated by the persons named above were in general private (or 'closed') companies, where shareholders were recruited by invitation only. Welsh public flotations in slate quarries were a rarity, with the Moel Tryfan Slate & Slab Quarries Company (of 1876) being the only known example at Nantlle [76]. This was possibly due to such factors as the personal aspirations of the promoters during the relatively affluent years of the 1870s, and a restriction of investment capital to the most affluent groups during the subsequent depression in the local economy.

It is not surprising that as in the case of external investments in the Nantlle district, those Welsh concerns occupying the best quarrying sites enjoyed the greatest degree of success. Of these, the most long-lived were the aforementioned Moel Tryfan Company (of 1876-1918) and the Bangor & Carnarvon Welsh Slate Company (operating the Cloddfa'r Coed

Quarry *c.*1876-96). Unfortunately, these new Welsh companies were largely relegated to the less profitable sites because none of the better quarries at Nantlle came on the open market during this era. Thus, concerns such as the Vron Welsh Slate Quarry Co. Ltd., (1901-*c.*1914), the Vale Slate Company (Tynyweirglodd Quarry, from 1884-*c.*90) and the Tynyweirglodd Welsh Slate Company (*c.*1900-*c.*05) fared badly because of unsatisfactory geological conditions and consequential high operating costs [77].

Furthermore, this phase of local investment coincided with the closing years of the great boom and the commencement of the price wars of the 1880s (see Chapter 1, above). Thus, their working of those quarries which in general only yielded a standard output of second and third quality slates having a low market value of their during trade depressions, squeezed the new local companies hard and consequently stunted their development. The resulting reduction in profitability acted as a constraint on continued capital investment, resulting in the premature closure of several of these Welsh-run quarries during the early 1890s.

Subsequent attempts by a new generation of local entrepreneurs to establish commercial businesses were rarely successful because of the increasing difficulties of the slate industry following the short boom of 1896-1902. One local casualty of the 1903-19 slate depression was a group of entrepreneurs loosely-titled David Williams & Co., (Caernarfon, see above), which unsuccessfully tried to develop, work and then sell the Fron & Old Braich, Gelli Bach, Llwydcoed and Ty Mawr East quarries in the decade before the outbreak of the First World War [78].

Only two concerns sporting 'local' credentials enjoyed any degree of success in the Nantlle district during the first quarter of the twentieth century. The first was the Old Penybryn Slate Quarries Company Ltd., (1907-30, working the Galltyfedw and Old Penybryn Quarries). This spawned a clutch of associated concerns including the Welsh Green Slate Quarry Co. Ltd., (1908-28 at Ty Mawr West Quarry), the Greenarvon Slate Quarry Co. Ltd., (1910-28, at Llwydcoed Quarry), and operations under several names at the Talysarn & Blaen Cae quarries (1926-*c.*1931), all of which came under the generic title of Daniel Evans & Co., Slatemerchant, Caernarfon [79].

The second inter-war local concern of note was the Amalgamated Slate Association Ltd., Caernarfon (1918-30), which took over the interests of the three separate concerns who had operated the Alexandra, Cilgwyn and Moeltryfan (Crown) quarries before the First World War. Despite a high initial capitalisation of over £40,000 in subscribed shares (of the £50,000 nominal capital), this concern, in common with Daniel Evans' more tenuous empire, collapsed in the wake of the major world-wide economic depression of the late 1920s. The demise of these companies can be attributed in part to the adverse trading conditions of that period, although the decreased revenue from sales by 1929 was only the final nail in their coffins. All of these concerns were already suffering financial problems before the economic crash, this being attributable to the commonplace problems of quarrying at Nantlle, that is, a combination of high operating costs, technical problems and the prior pillaging of the sites by previous lessees in anticipation of the non-renewal of their expiring leasehold terms (see Chapter 3, below) [80].

In contrast to the incorporated local concerns (above), the fortunes of the indigenous Welsh small-scale proprietors improved during the inter-war period. A new class of quarry proprietor arose at Nantlle in the 1920s, namely the 'tip contractor.' The rise of the damp-course slate market at the end of the nineteenth century had already encouraged individuals and groups of men to take contracts for sifting through the waste tips of operating quarries for useable material to supply the new grades of slates (see Chapter 3, below). However, the demise of several important quarries at Nantlle in the inter-war period and after 1945, provided the opportunity for local entrepreneurs to take a lease or a tenancy on complete quarries, which were subsequently sub-contracted in sections to a self-employed workforce extracting workable blocks from rock-faces, tips, structures and building masonry in a highly profitable zero-investment, scavenging operation [81].

The ebb and flow of the economics of the slate trade even turned against the tip contractors in the long term, when the use of slates in damp-proof courses was largely discontinued in the 1960s. Yet, Welsh investment in the slate industry locally entered a new phase in 1979 when the Ffestiniog Slate Group set up the Nantlle Slate Quarry Co. Ltd., to operate its newly-acquired Penyrorsedd Quarry. Financial information concerning this Company is not available, but the scale of expenditure at this site, witnessed by the author, suggests that an investment amounting to several hundreds of thousands of pounds has been undertaken here. The source of most of this on-going investment is, however, likely to be from re-invested profits rather than from outside sources, which would beneficially reduce the exposure of the concern to external financial pressures.

Amalgamations and take-overs

Multi-site concerns were not a totally new phenomenon throughout the Welsh slate industry, and within the Nantlle district the Cilgwyn & Cefn Du Slate Company (1800-30) and the Moel Tryfan & Penybryn Slate Company (*c.*1836-80) for example, had operated a number of individual sites in parallel during the first half of the nineteenth century, although neither had sufficient capital to prosecute the developments successfully [82]. Even smaller concerns at Nantlle could be theoretically regarded as multi-quarry operations by virtue of the inclusion within their leasehold 'setts' of a number of individual pits, many of which having originated as small independent quarries during earlier periods of development [83].

By the late-nineteenth century the circumstances surrounding quarry amalgamations at Nantlle and elsewhere were very different from those operative during the 'expansionist phase' of the industry (that is, c.1790-1877). The climate of expansion and unbridled optimism had been replaced by the need to strengthen the individual financial and productive base so as to improve the prospects of survival in the face of hostile trading conditions. By *c.*1890, the main quarries at Nantlle were well into their maturity, and the cumulative effects of digging large holes in the ground and depositing the huge volume of waste nearby had caused the bottom of the valley to become overwhelmed by the industry. Except for one or two examples of a more limited scale in other districts, this was the most concentrated area of overlapping independent workings found in the industry.

The virtual disappearance of virgin land to expand the workings within the main area of working required a different organisational outlook to that of the earlier years and the increasing costs of operating the concerns bore particularly hard on the medium-sized concerns of the Nantlle district. These operations were sufficiently large to require machinery and support staff, thus generating high fixed costs, but were too small to enjoy the economies associated with increased scale. Additionally, and crucially, the capital resources of these concerns were usually severely limited owing to a variety of factors, making their cash-flow extremely vulnerable to any unexpected high expenditure. Serious landslides and catastrophic flooding took their toll on several of the middle-ranking Nantlle concerns between 1880 and 1900 (see Chapter 1, above) and the harsh realities of the roofing-product markets, where Welsh slate was being successfully challenged by imports and substitutes compounded the mounting financial pressures.

Consequently, a trend emerged in the slate industry in general from *c.*1880 towards larger commercial units amongst the middle-ranking quarries, although the pace at which this could be achieved was dependent upon the acceptability of other concerns to merge or be taken over, or upon the availability of idle quarries to be leased [84]. The voluntary mergers of a number of the larger Nantlle concerns had been seriously discussed during the 1880s, for example the proposed union, in various combinations, of the Braich & Coedmadog Company, the Talysarn Quarry, Tanrallt Quarry and the Penyrorsedd Quarry, but nothing came of these merger schemes [85]. Proposals during the late 1890s for major industry-wide amalgamations of the most profitable concerns also failed to materialise. In the latter case, the external promoters were hopelessly over-optimistic in believing that the disparate interests in the industry could ever have been successfully brought together [86].

Of the possible strategies for restructuring outlined above, it was the acquisition of idle sites which proved the most popular at Nantlle. It was by far the cheapest option, with the *in situ* plant and machinery of the previous operator being available at scrap prices during liquidation sales and the buildings erected upon the site being protected from demolition by standard clauses in quarry leases. Consequently, once started, the pace of rationalisation at Nantlle was quite rapid. In 1880 only two pairs of quarries at Nantlle were worked in tandem, but by 1910 the number of multi-site companies had greatly increased (see Tables 5 & 8, Chapter 1, supra) [87].

Within the context of this 'rationalisation' of the slate industry at Nantlle since *c.*1880, the largest combine that existed in this district was the Talysarn Slate Quarries (John Robinson, proprietor). This group was derived from the ashes of the British Slate Company Ltd., (see Part c, below), a concern having operations in several slate districts during the 1860s, and once consolidated at its main site (Talysarn Quarry, Nantlle) by the mid-1870s, it proceeded to build up a powerful local base. Commencing with the acquisition of the Ty Mawr West Quarry (in 1877) as a replacement for its failing subsidiary at the Fron & Old Braich Quarry, Robinson enlarged his business empire to included the Tanrallt group of quarries (in 1881), followed by Braich Quarry (in 1890) and the Cloddfa'r Coed Quarry (in 1896), also purchasing the freehold of the Tynyweirglodd Quarry (in 1894) and the Singrig Quarry sett (in 1896) [88].

Other quarry sites at Nantlle were in the 1890s also falling into the hands of parties already established in the district. For example, the Galltyfedw and Fron quarries were under a single proprietorship from 1896 to 1901, and Tyddyn Agnes having originally been combined with Ty'n Llwyn as the Nantlle United Quarries Ltd., was after 1897 operated in conjunction with the Ty Mawr East Quarry by the United Quarries Ltd [89]. By first decade of the present century, the trend towards multi-quarry ownership continued, the main examples of David Williams & Co., Daniel Evans & Co., and the Amalgamated Slate Association Ltd., having already been noted (see previous sub-section).

The most predatory of the Nantlle concerns was, however, the Dorothea Slate Quarry Co. Ltd. Having leased the defunct Cloddfa'r Lôn and Penybryn quarries in 1892, the Company in 1922 bought out the adjacent South Dorothea Company and a decade later obtained a lease on its other bankrupt neighbour, the Galltyfedw Quarry [90]. The Company was, however out-bid by a rival in its attempts to purchase its strategically important third neighbour, the Talysarn Quarry, in 1926, and fortuitously had second thoughts about taking over the interests of the bankrupt Amalgamated Slate Company Ltd., (see above) in 1931 [91]. Nevertheless, the Dorothea Company continued with its policy of acquisitions by purchasing its own freehold in 1932 and in the process gained ownership of the Gwernor, Ty Mawr East and Ty Mawr West quarries in addition to the land it formerly held on lease [92]. In 1942, the Company was able to purchase the grounds of Talysarn Hall so as to secure the parent quarry's north-west boundary, and in 1962 it completed its acquisitions when the then derelict Talysarn Quarry complex was bought for only £250 [93].

It remains problematic whether these amalgamations had beneficial long-term economic effects in the majority of cases. Expanding the boundaries of the existing mineral 'sett' undoubtedly extended the life of the Dorothea Quarry, but the spreading out of inadequate capital over too large an area ruined the Old Penybryn Company after its takeover of the Talysarn Quarry in 1926 [94]. Neither was the improved cost-effectiveness often associated with increased working scale achieved in the majority of quarry amalgamations at Nantlle with the exception of the reduction in production costs that was achieved by a centralisation of haulage, pneumatic and processing services in the Dorothea/Galltyfedw/South Dorothea combined quarries after 1938 [95].

The arguments against further quarry amalgamations in the Nantlle Valley were crystallised in 1948-49, when the Government insisted upon the enforced merger of the district's three largest remaining concerns (the Crown, Dorothea and Penyrorsedd companies) a pre-requiste of the granting of war reconstruction loans to the affected concerns (see below). The main thrust of the quarry proprietors' joint-objections to this proposal was that no increase in efficiency would occur because (1) most of the existing essential machinery (haulage and pumping) was not mobile, and required to be thus; (2) that the sharing of the new, modern mobile plant required by the concerns on an individual basis was not possible because of the excessive distance between the three main quarrying sites; and (3) merging the companies would only save on the cost of three sets of clerical and maintenance staff, but that reducing job opportunities was contrary to the aim of the exercise. Consequently, state aid was with-held, much to the disgust of the quarrying concerns, who considered that they deserved compensation for sacrificing the future prospects of their investments for the sake of the country during the war [96].

Notwithstanding the refusal of the main Nantlle quarries to be forced to amalgamate in 1949, the proposal re-emerged on a voluntary basis in 1965-66 as the result of the increasing difficulties experienced by the concerns. A combination of a shortage of funds for investment in modern machinery and development work was reducing production levels because of the problems of retaining skilled quarrymen and the exhaustion of available rock. Thus, none of the quarries at Nantlle could tender for large contracts, which were the only sector of the slate market that was not diminishing in free-fall. Despite operating an inter-quarry slate purchase scheme to make up for shortfalls in stocks, thus virtually sub-contracting the orders, the three main Nantlle quarries continued to suffer from individual commercial and technical problems. Each had, however, valuable assets - Dorothea had modern machinery, technological experience and a good order book (but little workable rock); Penyrorsedd had plenty of rock and skilled manpower (but little sales); and Crown potentially had vast reserves and contacts in the wholesale trade (but was an inefficient minuscule concern). Yet, after much discussion, no consensus could be reached and the result of further inter-company talks on the same subject in 1969-70 was equally fruitless (see also Chapter 1, above) [97].

External secondary funding: debenture stock and mortgages

Whereas the initial funding for any quarrying venture came from its sole-proprietor, partners or shareholders, additional funding was sometimes required during the lifetime of the concern. The circumstances that necessitated this included unexpected costs such as additional un-budgeted development work, clearing landslides, or to cover cash-flow problems arising from dips in the trade cycles. In the first instance, this extra funding would have been sought from within the concern, through the injection of additional personal capital in the case of sole-proprietorships and partnerships, or by calls on unsubscribed capital and the sale of unallotted shares in the case of joint-stock companies, the latter occasionally requiring an increase in the nominal capital [98].

However, the surviving records of a number of Nantlle concerns show alternative means of raising additional funding. This sometimes took the form of directors' loans, or overdrafts which had to be secured on personal guarantees [99]. Banks were generally wary of lending to leasehold concerns which had wasting assets (such as quarries), although the Penyrorsedd Company was able to borrow £10,000 from Lloyd's Bank in 1911 on the security of the value of its new electric plant &

machinery [100]. Mortgages were only available in general on the security of freehold interests, which was rare in the Nantlle quarries. The only recorded examples of this were the purchase of the Talysarn Quarry freehold by John Robinson in 1880, financed by means of a £30,000 personal mortgage [101], and the mortgaging of the freehold of the Dorothea Company in 1963 to raise £30,000 for development funding [102].

In the face of the virtual non-availability of unsecured bank loans to corporate bodies and the wariness of ordinary investors to extend their personal financial exposure to concerns substituting the promised annual dividend with platitudes and 'jam tomorrow' forecasts, the provision of additional finance for slate concerns at Nantlle by the early-1870s became increasingly dependent upon the sale of speculative debenture stock. These were fixed-term loan certificates carrying a redeemable face value and yielded a high annual fixed-rate interest; they were charged onto the assets of the concern for a measure of security in the case of liquidation, being equivalent to a first mortgage [103].

Whereas the issue of internally-subscribed debentures by some concerns shows that even the best companies experienced some funding shortfalls, other companies at Nantlle seem to have depended upon these loans to survive. A comparison of the value of debenture stock with the proportion of issued/nominal capital can identify the excessive borrowing requirements of several concerns which subsequently failed spectacularly. Amongst examples of these at Nantlle were the Coedmadoc Slate Co. Ltd., (£10,150 face-value of shares issued of £12,000 nominal capital) had £25,000 debentures on closure in 1909, the last figure having doubled since 1902, and the Talysarn Slate Quarries Ltd., (nominal capital £20,000, fully issued, fully paid) had £12,000 in debentures to one wealthy lady by 1910 [104].

Yet, the available data, much of it being incomplete, has to be treated with caution because the anomalies in the methods of issuing shares can lead to false conclusions. For instance, the common practice of issuing fully-paid shares to a vendor as a part of the quarry purchase price rendered a proportion of the subscribed capital to the status of 'paper value' only. In the case of the Amalgamated Slate Association Ltd., for example, a £15,000 issue of debentures from the incorporation of the concern in 1918 could easily be mistakenly interpreted as commencing on the wrong financial footing, if this figure was added to the sum of the issued capital at £43,057 of the £50,000 nominal amount. However, only £6,657 of the total share issue had been in receipt of cash, the remainder being *in lieu* for share interests in the three independent companies that were being amalgamated, and thus the concern would have been seriously under-funded without the debentures [105].

Having highlighted the necessity of debenture stock to the quarrying companies, the motive and wisdom of subscribers in such high-risk issues as those involving quarrying concerns, must be questioned. There can be little doubt that the high annual interest rate was attractive to serious speculative investors, especially those having powerful prior interests in the concern, where a privilege of inside information gave some security. Nonetheless, the surviving records suggest that slate quarry debenture issues in general failed to provide the promised returns, and the holders, despite being preferential creditors, had little option other than play a passive role because the alternative of seeking repayment through an enforced liquidation often did not even realise the full par value of the loan bonds.

External funding: Government aid

The circumstances surrounding the demise of the Amalgamated Slate Association Ltd., (see above) were especially important in the history of the Welsh slate industry during the twentieth century. This concern had employed over 500 men in three Crown quarries but had got into financial difficulties during the mid-1920s despite being partially funded by the Treasury *via* debenture stock. An application to the Treasury for a low-interest loan to finance essential overburden removal was, however, rejected, and the inevitable consequence was a massive landslide which ruined the Company in 1930, resulting in almost total unemployment in the Moeltryfan area [106].

This was the first known instance of an attempt to secure a direct government intervention in the slate industry, other than the granting of rebates on overdue payments or reduced royalty rates at the Crown quarries in the 1900s [107]. Yet, after the Amalgamated Slate Association Ltd., was forced into voluntary liquidation in 1930, its successor as lessee of these quarries was able to secure a government loan of £20,000 to finance the essential development work, a political act which still aroused bitterness in the heart of the Amalgamated's former company secretary forty years after the event [108].

This was, however, a special case arising from the social disaster that resulted from a single bad decision, and no other funding was subsequently forthcoming to any private company in the slate industry from public funds during the inter-war depression. The circumstances surrounding the with-holding of government reconstruction loans in 1948-49 has already been discussed (above). In default of Treasury assistance, the Welsh slate industry had to attempt to rescue itself from the legacy of the wartime embargo on development work during a period of restricted trade (see Chapter 1, above). The Dorothea Company, for instance, funded the overdue re-development of the quarry by eating into its £30,000 reserve fund [109] and other concerns found alternative methods of raising the necessary finance. This was, however, not a sustainable position for small private concerns in a declining market and increasing operating costs.

Nevertheless, government policies in the late 1950s appeared to provide an answer to the investment shortfall in the Welsh slate industry. At first, the omens looked good, with the Dorothea Company receiving a £4,500 loan under the Ministry of Power's Fuel Efficiency Scheme for the conversion of three steam winders to electric drive. Unfortunately, under the Treasury's perverse financial rules, this assistance prejudiced the Company's separate application for development grant aid that was available under the terms of the Rural Areas Development Act 1958. Upon the enactment of the Local Employment Act 1960, a fresh application for a development loan was made to the new Board of Trade Advisory Committee, but the quarry was again refused assistance despite the best efforts of Goronwy Roberts M.P., (Caernarfonshire) to intercede [110].

The Caernarvonshire Crown Slate Company (Cilgwyn & Alexandra/ Moeltryfan quarries, post-1932) was faced with a similar problem regarding the financing of development work in 1961-62, and its application for aid was also rejected by the Board of Trade. This concern consequently was forced to borrow £15,000 from one of its trade customers, the loan being redeemed in 1962 for a ninety-nine per cent interest in the Company. The new owner invested heavily from his private resources in new plant & machinery at the Moeltryfan site, but as in the case of Dorothea, an application for government grant aid to complete the development scheme fell on deaf ears [111].

It can be argued that the failure of the government of the day to assist the slate industry at Nantlle by providing short-term 'soft' loans was a contributory factor in the closure of both the Dorothea and Crown quarries in 1970 and 1972 respectively, although not the primary cause. The Penyrorsedd Quarry was, however, able to soldier on as the sole substantial quarry at work in this district after 1972 despite its diminishing financial and rock reserves. This concern had not pinned its faith on government assistance during the 1960s because it seemed apparent to its directors that the aid on offer was not aimed at the Welsh slate industry. Penyrorsedd was more fortunate than the Dorothea Company in the case of grants for re-equipping, gaining several thousand pounds in aid for its mill improvement scheme in 1970, whereas the latter had lost the available funding because of administrative ineptitude [112].

The situation regarding government grant aid to the slate industry post-1980 cannot readily be discussed because little information is volunteered on this subject by the potential recipients. It is, however, certain that if any assistance has been forthcoming, it has been restricted to the purchase of new plant rather than the funding of development work [113].

(b). Types of Business Organisations

The complexity of the structures of capital investment that existed in the Nantlle slate quarries can only be satisfactorily described by an individual analysis of the various forms of business units. These are (i) partnerships, (ii) sole-traders and (iii) joint-stock companies, listed in the chronological order in which they were first found in the district. Within each of these categories, examples showing variations on the general criteria have been grouped, based upon a common characteristic.

Given the constraints of unsatisfactory information and the criteria of counting each quarry in a multi-site concern as a separate entry (about a third more than the actual total number of business units), it is estimated that in the slate quarries of Nantlle from the eighteenth century to the present day there have been 81 cases of sole traders; 71 of formal partnerships; 31 of ordinary joint-stock companies; and 90 of limited liability companies (see Table 13, below). In addition to these reasonably accurate totals, there are a recorded 56 examples of concerns operating as quarrymen-partnerships which might represent around a half of the true total, plus an unestimatable number of tip contract operations [114].

(i). Partnerships

A partial chronological progression characterised the different types of partnership, derived from the extant working practices and from financial considerations. The relationship of these factors was not always clear, but general conclusions arising from known examples appear to have sufficient validity to allow some extrapolation for periods where details are more sparse.

Common partnerships

These were characterised by being low investment, low cost operations, often worked upon a subsistence scale, with accepted local practices taking the place of formal legal agreements in controlling the conduct of the concerns. This system was probably the dominant form of operation during the early period of the slate industry but became associated with small-scale working on the fringes of the industry during the nineteenth and twentieth centuries. During this later period common partnerships were usually associated with men of independent character having an aversion to being paid employees in larger concerns [115]. However, echoes

TABLE 13
TYPES OF BUSINESS UNITS

QUARRY	SOLE PROP.	QUARRY-MEN	PARTNER CO's	ORDINARY J.S. CO's	LIMITED CO's	TOTAL
Dorothea	-	-	2	1	1	4
Penyrorsedd	4	-	2	1	2	9
Alexandra	1	-	2	2	4	9
Cilgwyn	1	3	3	1	3	11
Cloddfa'r Lôn/Penybryn	3	3	1	1	2	10
Moeltryfan	2	1	3	3	3	12
Talysarn	7	3	4	3	6	23
Cloddfa'r Coed	6	2	4	1	2	15
Coedmadog	2	1	3	1	2	9
Fron & Old Braich	8	5	4	3	8	28
Fronheulog +Green Pit	4	2+	1	-	4	11+
Galltyfedw	2	3	2	-	5	12
South Dorothea	1	1	1	1	4	8
Tanrallt	3	2+	2	1	2	10+
Tynyweirglodd	3	3+	8	2	6	22+
Braich	5	?	2	-	4	11
Gwernor	3	-	3	-	3	9
Llwydcoed	4	1+	4	2	5	16+
Ty Mawr East +Green Pit	1	1+	4	3	3	12+
Ty Mawr West +Green Pit	3	1+	1	1	2	8+
Tyddyn Agnes	1	4+	3	-	3	11+
Brynfferam	5	2	3	2	2	14
Foel Clynnog	1	?	-	-	1	2+
Pwll Fanog	1	3	-	-	-	4
Singrig	-	1	-	-	1	2
Twll Coed	2	4	1	1	2	10
Twll Llwyd	3	1+	2	1	2	9+
Taldrwst Lower	2	1	2	-	1	6
Taldrwst Upper	-	1	1	-	1	3
Bryncastell	-	1	-	-	-	1
Chwarel Wm. Owen Jones	-	-	1	-	1	2
Cilcoed/St.Beuno?	-	?	-	-	1	1+
Coch-y-bîg/St.Winifred?	-	?	-	-	1	1+
Cwm Dulyn	-	2	-	-	-	2
Gelli Bach	-	1	1	-	-	2
Pretoria	-	2	-	-	1	3
Talmignedd	1	-	-	-	-	1
Ty'n Llwyn	2	1	1	-	1	5
Upper Tyddyn Agnes	-	-	-	-	1	1
	81	56+	71	31	90	329+

of this simple capital structure were also preserved in the larger quarries whereby the productive units known as 'bargains' were originally mini-quarries operated by independent gangs of skilled quarrymen employing their own additional labour when required [116].

Whereas the vast majority of these common partnerships involved groups of active quarrymen, there was no reason why non-working proprietors could not also adopt the system. It was unlikely to have been a satisfactory option in the case of a commercial enterprise involving the investment of substantial sums by unconnected individuals, but was eminently suitable within a close-knit family concern involving a high measure of bonding and trust. On this basis, it is likely that a few small concerns operated at Nantlle by such family groups come under this heading, although these would not have been typical of the main-stream of non-working proprietors [117].

Perhaps the most fascinating, yet most poorly documented period in the history of the slate industry was that of the golden age of the local quarryman-proprietor before the closing decades of the eighteenth century. Fortunately, a single list of quarrymen at Ochr-y-Cilgwyn dated 1787, survives. This document bears out the details recorded in nineteenth century secondary sources which were based either on folk-lore or directly from the recollection of elderly survivors from the previous century [118]. The sources show that the characteristic capital structure of the industry by the late eighteenth century was the common partnership, and it may be confidently surmised that this organisation was one of long standing.

The members of these partnerships at Cilgwyn were working skilled quarrymen, forming around ten self-contained productive units of two to five 'masters' per quarry, where profits arising from their combined efforts would have been shared equitably. The remainder of the workforce named in the list consisted either of 'labourers' or 'boys' (from three to ten per concern), being unskilled employed workers. Some partnerships included women too, and they most probably were in charge of the transport of the output to the coast or were widows inheriting the interest of deceased husbands according to local practices [119].

In contrast to the better-documented businessmen of the nineteenth century, little is known of the first local quarry entrepreneurs at Nantlle. Judged by the yardstick of the Calvinistic local historians of the late nineteenth century, the early quarrymen were ignorant peasants, illiterate people of low morals and ungodly ways, albeit no more so than their contemporaries elsewhere. It is not surprising that the social life of the early quarrymen must have appeared primitive to the spokesmen of a later society dominated by nonconformist religion, but the latter's biased defamation of their predecessors' craft skills and their business acumen, was indefensible. That the independent quarrymen of the eighteenth century lost control of the industry is undoubted, but this was inevitable when faced with adversaries like determined local professional men well versed in the law, and by the weight of superior financial backing flooding in from England.

Despite the increasing domination of the industry by companies (mainly English) during the nineteenth century the independent common partnership continued to exist in small-scale quarrying concerns over a considerable period, persisting at Nantlle up to the 1960s. The concentration of such operations varied from district to district, but was always at its greatest in the Nantlle area owing to the ample opportunities afforded for local quarrymen to operate independently under conditions of low investment. These opportunities came about in two main ways and resulted in one of two courses of action being undertaken by the local operators.

The large number of quarries in the Nantlle district coupled with the high failure rate of all types of companies provided a constant stream of abandoned quarries for working partnerships of quarrymen to exploit. These men commonly were allowed onto a site either by the receiver of a failed company attempting to provide some level of income for creditors, or were granted short-term tenancies by the estate agents wishing to maintain some level of revenue for the landowner in the interregnum before finding a new commercial operator. The quarrymen, in return, earned a living denied to the previous high-cost operators by being able to manufacture marketable slates from rock that would not have been cost-effective under full-scale operating conditions. However, there was a price to pay on the part of the landowner in that the financial limits of the partnerships caused a short-term working policy whereby little or no development took place and that extraction rubble was often tipped directly into the pit bottom, to the detriment of the next lessee and of the long-term future of the quarry. However, this last consideration hardly mattered after the first world war when the industry was in decline [120].

The tip-reworking contracts which characterised Nantlle to a greater degree than any other district post-*c.*1890, also allowed opportunities for common working partnerships of quarrymen to set themselves up as individual operators. Sites were available on a variety of terms, according to individual circumstances, but there were only a limited number of locations where these partnerships could truly operate independently. Despite generally having to conform to imposed restrictions upon sales on the open market or being tied to an agent, this semi-independent situation was by far the most common in terms of numbers of operating units. In such tied cases, ground rent and royalty were generally not levied, but the price paid by the site agent to the men per hundred slates made, was well below market levels to compensate for this.

On fully independent sites, higher price levels from local merchants or direct from customers could be gained, although this required merchandising on the part of the proprietors and generally needed a larger scale of working to sustain contract commitments. However, in all cases of tip re-working, the economics of the operation were virtually those of the eighteenth century. No explosives nor machinery were required and manpower costs could be reduced by using casual labour or insisting that all workers were self-employed [121].

Even during recessions there was a base demand for slates, and the low-cost partnerships were well-placed to compete with the mainstream concerns via the sales and marketing system of local slate-merchants [122]. Thus, this type of informal system of capital organisation was found in significant numbers at the very marginal concerns at Nantlle until the collapse of the dampcourse slate market in the mid-1960s. They were also to be increasingly found on the margins of other important slate-producing districts, but never in the same concentration as at Nantlle. The reasons for such a difference was probably a factor of the differing degree of availability of workable sites in various districts, notwithstanding the effect of employment opportunities of very large concerns such as Dinorwic, Penrhyn and Oakeley upon the quality of the pool of unemployed men who were the most likely to be involved in the marginal side of the industry.

Formal partnerships

The term 'formal partnership' has been coined to describe specifically the combinations of partners under formal deeds of co-partnership. These were legal documents which specified the rules for the setting up, running and dissolving of the partnership in the face of vague regulation under common law [123]. This type of concern had no fixed capital other than an initial investment from each partner, but provision was made in the vesting deed to call up additional capital when required. Interests in partnerships might be held on an equitable basis between the persons involved, but smaller or larger commitments to the concern could be provided for, by allotting unequal fractions of the concern to the individual members.

Formal partnerships were open-ended commitments to supply the required working capital for a concern on a *pro rata* basis, and consequently to benefit from a distribution of profits on a similar basis. The fractional share also specified the distribution of liabilities to meet any trading losses or winding-up settlements. Under the legislation in force from 1720 to 1825, the maximum number of partners that could combine in this manner was six in the case of banking companies and was probably the same for other branches of commerce; this was designed to limit the extent of the enterprise, but was eventually withdrawn precisely because of its efficiency in stifling business ventures [124].

Even after the authorisation of joint-stock companies anew in 1825 (see below), the formal partnership continued as a popular form of capital organisation for groups of investors restricted in number. It was convenient for small groups of people not requiring to transfer paper shares to others, to set up formal partnerships regulated by their own individual rules. It was a very simple structure and the investment could be injected into the business as and when required. However, this open-ended commitment to supply capital could be disadvantageous if some partners became unwilling or unable to supply their equitable share of the calls. In comparison, the purchasers of shares in a joint-stock concern knew exactly the extent of their investment commitment.

The first recorded formal partnership at Nantlle was the Cilgwyn & Cefn Du Slate Company (of 1800) [125], although it may have had at least one predecessor in the district [126]. It was joined at Nantlle in 1802 by the Talysarn Slate Company [127]; in 1808 by the Penybryn Slate Company [128]; and in 1812 by the Hafodlas Slate Company [129]. Each had from four to six partners, who had a majority of local connections and wealth based on land, the law, commerce or the industry itself. Unfortunately, the final total for the capitalisation of these concerns is uncertain, although it known that the initial investment of the Cilgwyn Company amounted to £100 per partner [130].

This first batch of companies at Nantlle was not particularly successful, most surviving from four to about ten years, with only that at Cilgwyn lasting as long as thirty years (albeit having been reconstructed once in the last case) [131]. Their general lack of success is not fully understood despite working sites that in subsequent years did provide good returns. Yet, their significance was that they coincided with the greatest development of individual quarry sites in the first two decades of the nineteenth century, and were also associated with the schemes for the construction of the greatly-delayed Nantlle Railway, opened in 1828 (see Chapter 5, below). Perhaps the greatest problems encountered by these concerns were caused by their ill-defined legal status and, as a result, their structure. Typical difficulties were the deaths of partners; distrust by sleeping partners of the managing partners; and insufficient investment capital by individuals (or an unwillingness to supply it). At least two partnerships ended up in litigation and/or ejectment, and another one was deeply indebted to the bank upon winding-up. Others probably had similar problems [132].

It is likely that the majority of concerns at Nantlle, pre-1855, which sported the title 'Company', were formal partnerships, although they are not easily distinguishable from concerns based upon share capital (that is, joint-stock companies). The last of the former that can be identified with any certainty was the Penyrorsedd Slate Company (of 1856) [133]. Formal partnerships in the middle decades of the nineteenth century were temporarily eclipsed by joint-stock companies, and for a number of reasons. Firstly, the latter had a superior structure to cope with raising the large sums needed to develop bigger, more expensive works, especially when greater numbers of members were involved. Secondly, joint-stock companies after 1844 were clearly defined in legal terms whereas partnerships were less so and were therefore not suitable vessels for public investments. Thirdly, the concession of limited liability for registered companies having at least seven members (granted in 1855), was a more advantageous system for those which qualified under the new rules, but which might previously have become formal partnerships.

The Partnership Act (of 1890) finally brought partnerships under strictly defined regulations [134], and was probably why the trend (described above) became reversed in their favour. At least one formal partnership at a Nantlle quarry coincided with this legislation and several others were formed in succeeding decades [135]. After this date no un-limited joint-stock companies were formed to work quarries in this district. The new rules of partnership appear to have satisfied those concerns with restricted numbers of members where limited liability was not deemed desirable and consequently they formed a discrete intermediate category between the latter system and sole proprietorship.

Little can be gleaned of the financial nature of these more recent partnerships. Secondary sources paint a picture of low-capital operations working smaller quarries or taking over larger sites from failed limited companies on a greatly reduced scale of operations. A number of these partnerships post-1946 were established builders' merchants from England diversifying into slate quarrying in order to circumvent post-war restrictions upon supplies and to by-pass local middle-men [136]. By the mid-1960s this class of concern had become extinct at Nantlle and remained thus until the early 1980s. About 1984 one new local formal partnership had been formed to operate a small quarry at Nantlle, as a family concern. Apart from the differences in legal status, this particular concern, which combines a quarry with a farm, brings the discussion round in a full circle in that it provides a direct link between the local economics of the close of the twentieth and that of the eighteenth centuries [137].

(ii). Sole Traders

This group of individuals was always in a minority within the North Wales slate industry, and their relatively low numbers in the quarries at Nantlle was no exception to this rule. Regardless of the personal ambitions of many a potential slate magnate, the onerous financial obligations involved in the development of slate quarries was too great for most individuals beyond the smallest scale working. Of the family dynasties who founded the most important slate quarries in North Wales, only the Lords Penrhyn and the Assheton Smith's had sufficient personal wealth to become large-scale sole traders [138]. Whereas a number of other individuals were able to build up sole enterprises up to a moderate scale, these 'second division' concerns generally became partnerships or companies within a few decades of their founding, commonly for financial reasons.

Below this second rank was a layer of small-scale sole traders who operated little quarries on a modest scale, employing no more than one or two dozen men. In the case of the Nantlle district, this third division of operators was the most common amongst the classification of sole traders, with only a very small number of the second rank being encountered and none of the premier class of individual quarry owners. Nonetheless, despite their modest contribution to the overall output to the industry, this lowest ranking of sole traders was economically important. They were often the precursors of larger concerns, being commonly associated with the first phase of prospecting and trial working of new sites. Furthermore, they made an important contribution to the employment and output totals of the industry by working the marginal sites that were uneconomic propositions for companies having high 'overheads'.

This three-tier classification of sole trader is, however, not a convenient system for discussing this topic within the context of the economic history of the slate industry of the Nantlle district. Because of the special circumstances acting in this district (see Chapter 1, above), it is more expedient in this discussion to sub-divide the sole traders into two groups based upon freehold or leasehold tenure respectively.

Landlord-proprietors

The relatively large number of landowners in the Nantlle district allowed the possibility of a very intensive investment of capital in the development of the slate reserves by the landed classes. However, this was a rare occurrence in this district because the estate owners in general showed little or no interest in the quarries on a commercial basis, preferring to reap the benefit of rents and royalties from the efforts of other parties. In this manner they escaped the risks and expenditure associated with slate quarrying, but shared in the profits of the successful enterprises [139].

Nevertheless, there were a number of examples of landowners actively involved in slate quarries as sole traders at Nantlle, although this was largely confined to the first three decades of the nineteenth century. The earliest example was that of a possible development by *c.*1793 of the Penybryn Quarry by the estate owner prior to the leasing of the sites to a company in 1808 [140], but this initial period of working cannot be corroborated by other evidence. The first example confirmed by extant primary documents involved the working of the Cloddfa'r Coed (or Hafodlas) Quarry by Rev R. M. Humphreys, its landlord, from 1802-12 after the financial failure of his previous lessee [141].

Subsequent recorded cases also involved landowners filling a void after the cessation of work by a lessee, being chronologically at Cloddfa'r Lôn Quarry by Richard Garnons (1818-*c.*36) [142]; Cloddfa'r Coed by the widowed Mrs. Humphreys (briefly, *c.*1820) [143]; at the Talysarn Quarry by William Jones (*c.*1810-*c.*25) [144]; and Colonel Hughes at the Penyrorsedd Quarry by 1828 [145]. In each case, the involvement of the landowner was short-term, with the quarries being subsequently let to companies.

The second phase of landowner sole-proprietorship at Nantlle was composed of a few special cases after the mid-nineteenth century. The first, at Cloddfa'r Coed Quarry, was in the mid-1860s and involved the then landowner reopening a long-abandoned site, probably so as to improve the chance of letting it. However, the operation was run on a shoe-string basis for about a decade, and the resulting air of dereliction may have been an important contributory factor in the singularly unsuccessful attempts at finding a lessee until the great slate boom was well under way [146].

The eventual lessee of Cloddfa'r Coed (in 1874) was John Robinson, managing director of the company operating the adjacent Talysarn Quarry (see part i above), although he probably did no work at the former site before its sub-letting to a Welsh concern in 1876. By 1880, Robinson had become the freehold owner of the Talysarn Quarry, although his business empire seems to have lived from hand-to-mouth for the first decade of its existence despite its outwardly prosperous appearance [147].

The change of fortune in the slate industry during the mid-1890s (see Chapter 1, above) revitalised the Talysarn Quarry, which had become the centre-piece of a local business empire encompassing several smaller satellite quarries. John Robinson's two surviving sons had joined the business in a managerial capacity by *c.*1897, and upon the father's death in 1900 the whole concern passed to Thomas (the third son), William (the heir) having died in 1898. Unfortunately, he had not long to live either, and just prior to his death in 1905 the business was converted into a limited company for the benefit of his trustees and beneficiaries [148].

Within recent years, the only freehold sole slate-proprietorships at Nantlle were very small scale concerns, both being involved in the green slate trade. Twll Llwyd was purchased freehold by a local independent (lessee) quarry proprietor in 1965, but latterly became a family partnership. The second case was of marginal interest, being the purchase of a farm for mainly agricultural purposes, albeit with some occasional working of the included Fronheulog Green Quarry [149].

Leasehold sole traders

This category of sole traders was the most common at Nantlle by virtue of the general reluctance of landowners to become involved in the operation of the quarries (see sub-section, above). As in the case of other slate districts, the leasehold sole proprietors enjoyed their greatest economic importance at Nantlle during the first half of the nineteenth century, when the capital requirements of the smaller scale of quarrying of this period was not as great as in the larger-sizes of quarries which developed in later years.

The local working of the slate quarries in the eighteenth century appears to have been largely by working partnerships of active quarrymen (see sub-section ii, above). However, there appears to have been a limited influx of external individual local capitalists into the industry at Nantlle from about the 1760s. Recorded examples included William Williams (of Tal-y-sarn) and Hugh Roberts (of Nantlle) who were credited with being the first proprietors of Cloddfa'r Coed (*c.*1760s) and Cloddfa'r Lôn (*c.*1770s) respectively [150] and by the early decades of the nineteenth century John Griffith of Tryfan Hall [151] and Capt. R. Evans of Caernarfon [152] stood out in terms of pre-eminence at Nantlle.

Yet, by *c.*1820, the majority of local sole entrepreneurs had been forced out of the premier league in the slate industry either by factors such as restrictions of personal finance or by disputes relating to tenure on the Crown lands. Their position as major individual owners within the local area was subsequently taken by others who had amassed capital from the working of slate elsewhere, of whom the most notable were William Turner (a noted entrepreneur) [153], Thomas Edwards, of Llanllyfni, Turner's former agent [154], and George Bettis, of Caernarfon, (the land agent of the Glynllifon estate) [155].

It is particularly difficult to draw conclusions concerning the business activities of these persons because of the general lack of relevant primary documents. In the case of the earliest recorded sole traders of local origin, little is known of their enterprises other than the relative small scale of their operations, which were comparable with those of contemporary quarrymen partnerships. Furthermore, in the case of the second generation of sole traders (above), their affairs were further complicated by the interweaving of many business interests within the industry. However, there was an obvious difference in the scale of these later enterprises which must have reflected the limitations of personal finances in each case. Turner was by far the wealthiest of the second wave of sole traders at Nantlle and his operations at the Penyrorsedd Quarry from *c.*1820-*c.*30 was by far the biggest and longest-lasting of this category of business, whereas Bettis' Coedmadog Quarry (*c.*1822-*c.*29) was much smaller in scale and Edwards's developments south of the Llyfni river were minuscule [156].

A third wave of sole traders at Nantlle came to the fore during the 1830s-40s in the midst of a flood of new external investors (almost entirely English). Whereas partnerships of investors were usually involved with the larger quarries in this district, the sole traders were generally associated with the smaller quarries, which suited this class of enterprise which had a restricted capital. This in turn was beneficial to the development of the slate industry in this district, because this class of proprietor, having greater funds than local quarrymen/proprietors, was an important step in the development of a significant number of the smaller sites in the era before the boom years of the 1860s-70s.

One notable (and infamous) sole trader at Nantlle during this period was G. A. Muskett, a self-styled M.P. He took a Crown lease of the derelict Cilgwyn Quarry, which was one of the largest of the Nantlle quarries, c.1834 and proceeded to lavishly develop the site, allegedly spending up to £40,000 on clearing out debris from the workings and removing old spoil heaps which hindered the further development of the pits. Unfortunately, his receipts for the decade of his occupation of the quarry were said to have only amounted to around half the outlay, leaving a deficit of around £20,000 on his estate after his death in 1844, whereupon the workforce were left with six weeks' (one contemporary pay 'month') wages unpaid [157].

There was only one significant leasehold sole trader in the Nantlle area during the second half of the nineteenth century, namely John Pearson (of Newton-le-Willows). Hardly anything is known with certainty about this entrepreneur, but the few details which have been uncovered suggest that he was involved in a major investment of personal capital which might have made a significant difference to the history of the district had it been made a decade earlier. Pearson first appeared at Nantlle when he bought the interest of the Coedmadog Quarry in 1880 and subsequently of Braich Quarry in 1881, just as the market demand for slate was diminishing. By 1886-87 he was negotiating for the purchase of the important Talysarn Quarry and also the Tanrallt Quarries, but the high asking price for the former was not acceptable at the deepest point of the depression. Before any further progress could be made, Pearson died (in 1887) and the opportunity to consolidate a strong business unit which would have been amongst the top four in the industry, was lost [158].

Persons such as John Horne, a modest entrepreneur of Dutch extraction, were more typical of the sole traders that operated slate quarries in the Nantlle district during the mid-nineteenth century. Horne's business enterprises rarely employed more than twenty quarrymen at a succession of small quarries on the south side of the valley, and the proprietor also acted as an occasionally-employed quarry agent when the opportunity arose [159]. Other persons involved in the industry at Nantlle on a small scale included local quarrymen-entrepreneurs such as William Hughes (of Tynyweirglodd Farm), prospected and developed virgin sites under a licence (or 'take note') from the landowner, in order to reap a windfall profit from the sale of the mining rights to incoming public or private companies [160].

In view of the increasing cost of operating quarries as they developed in size, particularly those with deep pits on low ground, it is not surprising that the local sole trader faded out of the picture early in the nineteenth century. The increasing sophistication of leases may have also played a part, where landowners demanded higher basic ground rents and higher thresholds into royalty payments, plus such onerous conditions as minimum employment levels and development investment. However, the twin economic forces of the failure of many quarry companies during the cycles of depressed trading periods which commenced in the 1880s (see Chapter 1) and the development of a market for dampcourse slates during the 1890s (see Chapter 3), led to the re-establishment of the local sole trader at Nantlle.

Of the many small-scale lone proprietors who took over abandoned quarries and reprocessed old waste tips, the most prominent were William John Davies [161] and Morgan Hughes [162] (both of Talysarn), operating from *c.*1919-57 and *c.*1946-*c.*60, respectively. These two entrepreneurs leased a multitude of quarries in turn, employing several hundred men during the peak years, although technically their workmen were classified as self-employed for legal and taxation purposes [163].

(iii). Joint-stock companies

Although partnerships of various descriptions and even individual bargain crews within quarries used the title 'company', the joint-stock version was the only capital organisation having the privilege of being a corporate body. Within the context of this chapter the distinctive character of a joint-stock concern which differentiated it from a partnership was the provision of a fixed notional capital divided into individual transferable shares of unit face value upon which all or part of the value could be paid-up at any one time.

The details of the organisation of such concerns was more complex than this simplistic model due to the differences arising from legislation from time to time, and both the increasing sophistication in the financial structures of businesses and any relevant significant changes are noted within the account. The variety of options available within the title 'joint-stock' is most conveniently sub-divided according to company law into ordinary companies and those with limited liability, with the distinction between private enterprises and public flotations being subsumed by that difference in legal status.

Ordinary joint-stock companies

The first important phase of British joint-stock company flotation of the late seventeenth and early eighteenth centuries was too early to affect the slate industry of North Wales, although the legislation introduced in 1720 in response to excesses such as the infamous 'South Seas Bubble' ensured that no large-scale public investment in the industry was possible in the first period of its capitalist development during the late eighteenth and very early nineteenth centuries [164].

The restrictive companies legislation of 1719, known popularly as the 'Bubble Act' remained on the statute book until 1825, at which date it was repealed due to its strangulatory effects upon business investment [165]. The immediate effect of the Repealing Act was a general investment boom in which extractive industries particularly benefited. In the case of the North Wales slate industry, the most important result was the arrival in the Ffestiniog district of two great rival concerns, both having the objective of investing in the development of mines and quarries on a very large scale. The ripple effect of their initial activities spread out to several other areas, including Nantlle.

Of these two concerns, the Royal Cambrian Company, with its Charter claim to all Crown lands within the Principality, caused great consternation and worry amongst those slate concerns leasing or occupying land or mountain 'wastes' claimed by the Crown. Had this claim been successfully prosecuted then a significant portion of the most important parts of the slate industry would have fallen into the hands of this concern, including about a third of the Nantlle slate reserves. However, it never became necessary for the operators of these Crown quarries to defend their interests owing to the Company ignominiously giving up the claims after unsuccessfully defending its first legal challenge in the Ffestiniog district [166].

The second concern, the Welsh Slate, Copper Lead and Zinc Company, commenced work with equal bluster at Ffestiniog in 1825. It became either openly expansionist in its policy of seeking to buy-out established concerns in other areas, or was the subject of opportunistic entrepreneurs attempting to off-load quarries at premium prices. It is known that this Company was in 1825 negotiating for the purchase of the bankrupt Talysarn Quarry at Nantlle, and the Royal Cambrian Company had been offered the interests of the Cilgwyn Company, but nothing came of either scheme [167].

Despite the rebuff of the first foray of large-scale investment from England into the Nantlle district, it is probable that the area came to the notice of outside investors as the direct result of this. By 1827, a London-based joint-stock company had been formed to purchase the freehold of the Talysarn estate so as to work the numerous slate quarries on this ground. This first Talysarn Slate Company was a private concern which included a number of aristocrats and members of parliament amongst its members. It had a nominal capital of £24,000 and was by far the most heavily capitalised concern ever to have worked in the Nantlle district up to that date. Yet, despite the wealth, the fate of this Company served as a foretaste of oft-repeated calamities generated by inexperience or incompetence. The concern folded, *c.*1844 and there followed an abortive attempt to rescue the enterprise by floating a public company. Eventually a core of original members were joined by new investors to form another private company which survived until 1857. Despite the large investment, this was a salutary lesson that cash alone could do little to revive the fortunes of a quarry which was potentially extremely productive but suffered from unwise management policies [168].

In the decades following the arrival of the Talysarn Slate Company (above), the number of concerns carrying the title 'company' increased steadily, accelerating after *c.*1850, although it is not certain how many had a joint-stock structure rather than being formal partnerships (see above). Despite this uncertainty, their histories gives an insight into the character of capitalism in the slate industry in the three decades post-1825. These concerns broadly fell into three categories, viz:- (1) the extravagant, flamboyant, over-confident enterprises such as the Penybryn Slate Company (of c.1836) [169] and the Carnarvonshire Slate Company (of 1853) [170], whose brash character emulated that of their upper-middle-class English shareholders, who soon discovered that their finances could not stretch beyond the preliminary stages of their grandiose development schemes; (2) more introspective concerns such as the Dorothea Slate Company (of 1849) [171], whose sombre proceedings reflected the predominantly Calvinistic Methodism religion of its members; and (3) crooked speculations such as the Mining Company of Wales (of 1850) [172], which existed solely as a vehicle for its promoters to fleece unwitting investors.

The procedures allowing the incorporation of Joint Stock Companies that were provided in an Act of 1844 [173] should have had a marked effect on the capitalist structure of the slate industry, but this was not to be the case. The best intentions of the legislators were frustrated by subsequent events which rendered the Act impotent. Yet, of the small minority of six new slate quarrying companies in Wales between 1844 and 1855 which were registered under these regulations, three were at Nantlle [174]. One significant omission from this short list was the

Dorothea Slate Company (1849), which specifically claimed not to be a joint-stock enterprise as defined by the Act of 1844 despite having shares and a nominal capital, but operated as a Cost-book Company, whereby the profits were distributed amongst the shareholders in short-term accounting periods [175]. This was a characteristic of metal mining concerns especially, whereby the risks of unlimited liability upon the members were reduced to a minimum, and in adopting this capital structure it is suggested that the new local owners of the Dorothea Quarry showed a distinct lack of faith in the long-term future of the concern.

The private ordinary joint-stock capital structure faded in importance upon the advent of limited liability (see below). However, whereas the contemporary English slate concerns wholeheartedly embraced the protection afforded by the new legislation from its inception, most of the Welsh-owned slate companies of the 1850s-1870s (see sub-section i, above) eschewed this option. The latter's preference for open-ended liability, which was maintained well into the depressed 1880s, is difficult to understand in view of the increased risks of trading in the unfavourable market conditions after 1877. However, the answer might lie in the requirement for the public disclosure of accounts in the statutory annual returns of limited liability companies, an obligation which might have been uncomfortable for the local shareholders in the period of the rise of the Quarrymen's Union.

Limited liability companies

All the capitalist structures discussed above shared a common feature of exposing the person(s) investing to the risk of unlimited liability for the debts on a *pro rata* basis related to their fractional interest "unto his last cuff-link." In the case of a large holding or of a heavy loss this personal liability might amount to a very large sum which could bring financial ruin in its wake.

After a series of financial crises in the U.K. commercial world during the first half of the nineteenth century, this major barrier to public investment was overcome by instilling new confidence in the share markets through the introduction of limited liability. The provisions of the U.K. under the Joint Stock Companies Act of 1855, initially amended by a second Act in 1856, and revised by the Joint Stock Companies (Consolidation) Act of 1862, was to restrict the excess indebtedness of a shareholder of a duly registered company, in the event of liquidation, to the amount still owing on any partly-paid-up shares. The shareholder still shouldered the ultimate responsibility not to subscribe to partly-paid shares beyond his means of furnishing the outstanding amount, but was shielded from the worst excesses of the older system [176].

The protection of limiting the liability was greatly beneficial to many industries in the U.K. after 1855, and this allowed a rapid economic expansion to occur at a period when costs such as mechanisation were beginning to tax the limits of the finances of sole traders. However, despite the new measures, shareholders in limited liability companies were not protected against fraudulent speculations, and the legislation contained a number of important loopholes which afforded the means by which unscrupulous persons could evade their creditors whilst keeping hold of their assets. A series of liquidations and asset transfers that characterised this manipulation of the law was at its most blatant in the case of the Fron and Talysarn quarries at Nantlle in the 1860s and 1870s involved John Robinson and five or six companies [177].

From 1855 to 1879 all of the limited liability companies operating at Nantlle (see Appendix 2) were registered in England and had exclusively English members as significant shareholders (of ten per cent holding or greater). The vast majority had registered offices in London, often in the City or at Westminster, with the next most popular bases being Liverpool and Manchester, with at least one Scottish company having been here, although several concerns transferred to Caernarfon at a later date. Very few were from elsewhere [178].

The first exclusively Welsh-owned limited liability concern at Nantlle was the Moel Tryfan Slate & Slab Company Limited, Caernarfon (of 1879) [179], which was joined by the Vron Old Braich Welsh Slate Quarries Co. Ltd., Caernarfon, in 1882 [180]. Despite being rarities amongst the Welsh companies of this period (see above), the adoption of limited liability amongst local concerns increased significantly after *c.*1890 [181], as the unlimited joint-stock structure gradually fell out of favour.

The first attempt at introducing limited liability (in 1855) produced a rather cumbersome system for the formation of the companies, and consequently the uptake of the system in the North Wales slate industry was initially slow. Only five limited companies were registered in the Nantlle district in 1855-62 (see Appendix 2), of which one was already trading under the provisions of the 1844 legislation (see above). The streamlined registration procedures in 1862 brought about the desired boost in investment in the country at large. Dylan Pritchard noted that the impact was more acute in the slate industry than in any other form of business [182], and at Nantlle, for example, twelve new limited companies were formed within the first six years after 1862 and there were another fourteen new registrations under this Act in the years 1872-80 [183].

In the years of major recession in the slate industry at Nantlle from 1880 to 1895, almost half of the companies that were registered in 1855-80 crashed, with the majority surviving for less than a decade (see Table 14, below). Yet, ten new limited company formations occurred during the recessionary years of the 1880s, reflecting a remarkable resilience of confidence in a future upturn. Of these new concerns, those formed during the earlier part of the decade experienced the deepest dip in demand and market prices, and it is unsurprising that their operating lives were particularly short [184].

The period 1896-1903 was the last great boom in the slate industry, but most new concerns restarted in this period were partnerships instead of joint-stock companies. Only seven limited companies were registered at Nantlle during this period (see Appendix 2), when amalgamations of formerly independent quarries into larger business units was more common than the entry of new capital into the industry. This batch of limited companies had a no better life expectancy than in the previous years (see Table 14, below) due to the deep recession in building from 1903 to 1914. Surprisingly, although two of the three concerns formed during the first four years of this slump crashed quickly, one survived and was joined by four additional new local formations after 1907, all of which did well despite the depression. They were joined from 1909 to 1914 by an extra two local concerns, both of which also survived relatively well. But, from 1918 to 1939, Nantlle saw only five new quarrying concerns registered, and only two were added after 1945 [185].

Certain anomalies distort the data for the life-span of these companies because of complications in the registration and winding-up procedures. The Dorothea Slate Quarry Company Limited, for instance, was active from 1892 to 1970, but was a registration of an existing, ordinary joint-

TABLE 14

LONGEVITY OF LIMITED COMPANIES

YEARS EXISTENCE TO RECEIVERSHIP	No. OF COMPANIES	PERCENTAGE (Rounded up)		
1 - 5	17	29	..58%	..77%
6 - 10	17	29		
11 - 15	11	19		
16 - 20	4	7		
21 - 25	3	5		
26+	7	12		

TABLE 15

PAR SHARE VALUES OF LIMITED COMPANIES

PERIOD	No. of COMPANIES IN RELATION TO SHARE VALUE ON ISSUE								
	£1	£2½	£5	£10	£20	£25	£50	£100	£500
1855-1860	2	1	-	1	-	-	-	-	-
1861-1865	1	-	4	4	-	-	-	1	1
1866-1870	-	-	1	1	-	-	-	-	-
1871-1875	-	-	2	2	1	-	2	1	-
1876-1880	-	-	2	1	1	-	1	-	-
1881-1885	1	-	1	1	-	2	1	-	-
1886-1890	1	-	-	-	-	-	1	-	-
1891-1895	2	-	1	-	-	-	1	-	-
1896-1900	2	-	-	2	-	-	-	-	-
1901-1905	3	-	-	-	-	1	-	-	-
1906-1910	2	-	2	-	-	-	-	-	-
1911-1915	None registered								
1916-1920	1	-	-	-	-	-	-	-	-
TOTALS	15	1	13	12	2	3	6	2	1

stock company dating from 1849 [186]. Furthermore, it continued to exist under receivership for a further two years after it ceased trading. Similarly, the limited companies working at the Tanrallt (1856-1880) [187], Penyrorsedd (1863-1978) [188], and the Cilgwyn quarries (1896-1917) [189], as well as those operating the Talysarn (1904-25) [190] and South Dorothea quarries (1907-22) [191], were all existing concerns under some other form of capital organisation over a period of from three to forty-seven years, and continued in non-trading receivership for up to six years after the quoted dates.

The notional (or 'nominal') capital sum for these companies was the maximum face-value of shares that could be issued, and despite not being reached in terms of subscribed share totals in most cases, it gives an idea of the envisaged scale of the concern at its incorporation. At Nantlle, in the data period of 1855-1940, the nominal capital of eighty-five per cent of limited companies (46 cases) lay in the range of £10,000 to £60,000. This was not excessive as a maximum sum in view of the high cost of developing sites and the probability of not being able to sell the full share issue. Only four companies lay below the stated range, with the lowest at only £120. Nine concerns exceed the range, with the maximum being £100,000 [192].

The thirteen limited companies lying outside the norm were either private companies at small quarries with low capital requirements at the bottom end, or were large public companies or high-capital private concerns at the higher end. On a chronological basis, the mid-nineteenth century (and earliest) limited-liability companies had a significantly higher nominal capital than those formed towards the last decades of the century. The amount decreased rapidly after 1895 when locally-based concerns increasingly registered in the form of limited liability concerns rather than as other unprotected capital structures. However, it must be stated that these figures relate only to the original registered amounts, which could be increased or decreased if required [193].

Share prices showed a wide range of face-values, with a minimum of £1 and a maximum of £500 each (see Table 15, above). Over the whole sample (1855-1940), three-quarters of the companies had share face values at the lowest end of the price range at £1 to £10. This suggests attempts at attracting mass public subscription, particularly when matched by a high nominal capital. About twenty per cent of company shares were priced from £20 to £50 at face-value, suggesting a more wealthy (middle-class) clientele, although monetary inflation reduced the real price to a small extent over the years. Only five per cent of companies had shares of over £50, and these indicated private concerns with a low number of wealthy investors, although such concerns could also be found with much smaller-value shares [194].

Chronologically, the very high value shares were issued in the period 1861-75 when the slate boom was at its greatest. The £20 to £50 value shares were found from 1871-1905, and lower value shares were uniformly distributed throughout the period 1855-1940. In the last case, the data when compared with the type of company and the geographical source of the investment correlates well with the boom years of the 1860s-70s and 1896-1903 when public interest in the industry was at its greatest, with the intervening periods being characterised most often by local company-flotations [195].

As in the case of ordinary joint-stock companies, these limited-liability concerns fell into two discrete categories of public and private companies which were only distinguishable in the first half-century by the number of subscribers involved. Public companies raised capital from members of the public at large and could have as many shareholders as did not exceed the total number of individual shares but in the case of private companies the flotation was purposely restricted to a reduced circle of investors although there could be no fewer than seven members. Public flotations in slate concerns at Nantlle were very much on the minority, and only twenty per cent of this category of limited company at Nantlle had over thirty shareholders. A third of the total concerns had less than ten members and can be definitely placed in the category of private concerns [196].

The two forms of concern were not distinguished in law until 1907, when companies wishing to be specifically registered as private ones were allowed to do so [197]. The new private limited companies had a minimum number of two members but were not to exceed a maximum of fifty shareholders. This allowed smaller partnerships to convert into corporate bodies with limited liability, but there appears not to have been any involved in the slate industry. Under a later statute there was a development known as the 'hundred pound company' which has been a popular structure in recent years. Under this legislation a private company with limited liability could be formed on a minimum nominal capital of no less than £100 with a minimum of two members holding a minimum of a £1 share each. This characterised the two most recent joint-stock limited companies formed to work quarries at Nantlle, namely the Cocklebank Conservations Ltd., (of 1972) and the Nantlle Slate Company Ltd., (of 1980). These represented a contemporary system of operating a formal partnership under the protection of limited liability, but retaining the option of taking on additional investors if desired [198].

(c). Profitability

The discussion of investment trends (Sub-section a, above) shows that despite the untimely demise of a great number of the slate concerns, a continued inward flow of funds into the industry at Nantlle (and elsewhere) was assured for most of the nineteenth century by the lure of the high profitability of a few major quarries. Subsequently, the rate of investment fell off sharply as the fortunes of the slate quarries faded in a diminishing market, until a new era of a brighter complexion unfolded in the 1980s. This concluding sub-section seeks to analyse and quantify the profitability of the Nantlle quarries during the different phases of the history of the slate industry.

(i) Factors affecting profitability

On a basic level, the working balance of slate quarries was much like any other forms of business, and the main sections of the cash balance sheets [199] could be broken down as follows:-

Debit:	Credit:
Rents & royalties (if leased)	Receipts from sales
Development costs	Receipts from tenancies
Operating costs (fuel, etc.)	Yield from investments
Wage/salaries costs	Debtors
Director's fees	
Transport costs	
Interest on loans and debenture stock	
Rates and taxes	
Insurance costs	
Creditors	

There were, however, a number of basic factors which affected the profitability of the quarrying concerns by altering the magnitude of the individual debits and credits listed above, the most important of these being:-

In the short term.... Quality of the slate quarried
Market demand, preferences and prices
Control of production costs
In the long term.... Availability of development funds
Cash-flow control
Unforeseen expenditure

The idiosyncratic nature of quarrying concerns, even in the case of successive companies on a single site, makes a comprehensive analysis of the factors affecting profitability a highly complex issue. Consequently, this matter is best resolved by recourse to a brief summary of the recommendations of Victorian handbooks on investments in slate quarries [200], which attempted to guide the unwary past the traps laid down by dishonest speculators towards the ultimate goal of a profitable venture - in the manner of a secular "Pilgrims' Progress."

The first guideline was that the site should contain slate rock in sufficient quantity and quality to repay the costs of opening and working the quarry. Adequate trial excavations were therefore required in the first instance rather than the immediate provision of grand buildings and expensive machinery. It was also essential that there was sufficient space to tip rubble, that there was an adequate water supply, and that transport arrangements were satisfactory or at least capable of improvement [201].

Secondly, the lease terms should have been favourable to the lessee, who bore the risk of investing capital, rather than towards the lessor who gained whatever the result. Particular problems could be caused by sliding scales of payments which increased the charges progressively over the lease term, although this was nominally designed to reduce the charges in the initial period of low productivity and high development costs [202].

Problems were also caused by restrictive clauses requiring set annual expenditure on development work, or minimum workforce levels. These conditions might not have been desirable under prevailing economic or financial conditions, but non-compliance rendered the lease liable to forfeiture [203]. Crown leases were particularly criticised in the early decades of the present century due to their fixed percentage royalties of five to ten per cent of market value. This rate was proportionately greater than the average 2*s*.6*d*. (12½p.) per ton of contemporary private leases [204].

Thirdly, as much as possible of the capital subscription should have been from the sale of ordinary shares rather than an excessive free allocation to the vendor and the promoters of the new concern. In the limited companies at Nantlle the usual range of the percentage subscription of ordinary shares was from twenty to eighty per cent, and only a few promotions failed to float due to an insufficient take-up of the share issue [205]. It was therefore important that accurately costed plans for both the development and for subsequent working were drawn up at the outset, and a judicious amount of the profit should have been ploughed-back into development work to ensure the long term future of the concern, if conditions warranted this commitment [206].

Fourthly, once up and running, the ordinary operating costs of the concern should have been kept as low as possible because of the relatively small profit margins of less than fifty per cent even at the height point of the 1870s boom [207]. Volume sales generated the high revenue of the best quarries, but the consequential emphasis on production should not have been at the expense of essential 'non-productive' work so as to boost short-term rates of return, as that policy inevitably resulted in disastrous landslides which disrupted production and increased operating costs [208].

(ii) The profitability of slate quarrying at Nantlle

A precise analysis of the profitability of the individual quarries cannot be undertaken because of the loss of most of the financial records. Only in certain cases, usually the most important concerns, is there any accurate data available and this is only occasionally of a long-term character. This subject is best approached from a chronological viewpoint, illustrated by examples self-selected by the chance survival of financial information.

The early era, pre-1830

None of the financial accounts of the early quarry proprietors at Nantlle during the eighteenth century have survived, assuming that this information was ever documented. Yet, some insight can be gained into the businesses of the most important group of early local quarry proprietors at Ochr-y-Cilgwyn from the scant information that has been preserved. The most striking feature of this collection of workings on the Crown 'wastes' was the apparent lack of outgoings other than wages and consumable items. No rent was payable by these concerns until a peppercorn amount was imposed about 1776 (see sub-section a, above) and no royalty was charged on their output during the era of the independent quarrymen/proprietors pre-1800 [209]. Thus, it can be concluded that the profitability of these concerns must have been extremely good and that the return on the low capital investment required was therefore likely to have been phenomenal.

A further clue suggesting that slate quarrying in the last decade of the eighteenth century at Nantlle was probably a very renumerative activity was the inflated rents asked for, and accepted by quarry operators. Even at the inflated rate of half-a-guinea a head, that is 10*s*.6*d*. (52½p.), *per annum* temporarily charged by the local Crown Agent in 1791 (being double the rate recommended by the Crown Commissioners), there were forty persons prepared to sign up for quarrying rights at Ochr-y-Cilgwyn [210]. Annual quarrying licences were even dearer on private land, with a flat-rate of two guineas (£2.2*s*., or 210p.) *per* man being asked at one site in the early nineteenth century [211], this almost surely being a charge upon the principals only. Some quarries were being let on short leases by public auction in the late eighteenth and early nineteenth centuries, also suggesting a bouyant demand for sites [212].

Whereas small-scale quarrying appears to have been profitable at Nantlle pre-1830, the extant financial records of larger concerns paint a different picture. The Penybryn Slate Company, for instance, made very little profit during its tenure of the quarry from 1808-17 and ended in 1818, owing £920. Similarly, the Llwydcoed Quarry provided an indication of its future history by running at a £319 loss over the two years 1823-25 [213].

Of greater consequence was the disappointing record of the Cilgwyn & Cefn Du Slate Company - Nantlle's premier concern during the early decades of the nineteenth century. In the six years 1806-12, this Company returned a net profit of only £2,861 because it spread its capital over too many quarrying sites in two counties. Its affairs improved somewhat after 1812 due to the sub-letting of its interests other than the main quarry at Cilgwyn (Nantlle), thus diminishing its development expenditure account. Unfortunately, false economies at the Cilgwyn Quarry resulted in a massive landslide in 1823, which reduced the net profit for the subsequent six years to a low average of £66 *per* *annum.* A court award of £1,680 in favour of the concern's bankers in settlement of overdue loans, brought the concern to an end in 1830 [214].

The middle years, 1830-1900

Little is known of the details of company profitability at Nantlle in the first three decades after 1830, although the surviving records correlate with the 'micro-economic' cycle which characterised this district (see Chapter 1, above). The main feature of this was a localised depression in the slate industry at Nantlle during the 1840s, a feature which is illustrated by the histories of individual quarries during this decade. The debacle of G.A.Muskett's alleged £20,000 adverse balance at Cilgwyn between 1835 and 1845 has already been recorded (see Part b, above) [215]. The important Talysarn Slate Company (of 1827) was also in deep financial trouble by 1844, when it was dissolved [216]. Poor returns on its investments also forced the ambitious Penybryn Slate Company to abandon its extensive development plans on the Moeltryfan common, retrenching to its parent site in order to survive the financial storm [217]. Similarly, the potential profitability of the Dorothea Quarry, revealed in the 1860s, eluded Messrs Turner & Morgan (of 1828), precipitating the closure of the quarry in 1848 and its subsequent sale [218].

The 1860s and 1870s present a more fruitful period for comparative studies because of the availability of a more comprehensive selection of documentary evidence. In order to place the Nantlle quarries within the wider context it is useful to note the estimated profits of the premier quarries. The computed annual net profit of the Welsh Slate Company (Ffestiniog) from c.1859 to 1886 was in the range of £21,000 to £93,500, which was of a similar order to the returns of the Dinorwic Quarry, while the estimated annual profit of the Penrhyn Quarry was about £100,000 in the 1860s [219].

There were no concerns at Nantlle that could match the size and profitability of the examples listed above. However, after an initially disappointing start, the judicious operations of the Dorothea Slate Company (of 1849) under new management yielded in the period 1864-82 between £2,000 and £15,000 net profit *per annum*. The issued capital of this Company was only £2,500, and the annual dividend of between £60 to £160 *per* £25-par share was a remarkable return [220].

Yet, despite the huge increase in the demand for slates after *c.*1850, the apparent prosperity of most of the Nantlle quarries during the subsequent three decades was to a large extent an illusion. The scale of quarrying had undoubtedly increased dramatically and the technology of the industry at Nantlle must have appeared very impressive (see Chapter 4). But, contemporary secondary sources suggest that most of the slate quarries in the district were afflicted by major technical problems by the 1860s and 1870s [221]. Consequently, their operating costs were inflated, thus making credible the claim made in 1873 that only three out of fifteen local concerns were profitable [222], that is definitely Dorothea and probably the Cilgwyn and the Penybryn quarries.

Of the remaining major quarries in the district, primary and secondary evidence points to poor results because a combination of high purchase prices for sites and heavy development costs dissipated the working capital and sales revenue almost at once, forcing concerns to borrow to survive. Two excellent examples of the result of entering the slate business at the height of the 1860s boom were the contemporary Penyrorsedd and Talysarn concerns. The Penyrorsedd Slate Quarry Company (of 1861) had paid a high part-cash, part-share purchase price of £31,000 for the leasehold quarry interest. A further £81,000 was invested on development during the first three years of trading, with a return on this of only £3,590, net of a redemption of a loan of £3,663. The confidence of the shareholders in the Penyrorsedd Company was fortunately high, and the concern was eventually steered to profitability, surviving for a remarkable 118 years [223].

A long operating life was certainly not the case with the second example of the perils of gambling on the profitability of the Nantlle Valley slate quarries. The Carnarvon & Bangor Slate Company Limited (of 1867) promised much in its prospectus, including a handsome return upon investments in its shares, of which a fully-paid issue to the value of £33,310 was used to pay for the lease of the Talysarn Quarry. Its available liquid capital was restricted to the subscriptions on the 937 shares that were sold, amounting to deposits of £7,826 on the £9,370 total. The financing of further land purchases created a debt of £6,690 on the books of the fledgling company, and despite the sale of preference shares to the value of £8,867, the continuing shortfall in working capital had to be financed by debenture stock to the value of £8,820 in addition to personal loans of £2,895. Against this approximate £28,000 initial investment in the quarry, the profit for the first year of operations was only £1,502, and it failed to increase sufficiently to finance the required development costs and the heavy loan interest payments. This precarious financial position was untenable, and in 1874, at the height of the market boom, the Company was compulsorily wound up on the order of the High Court in response to a creditor's petition [224].

The vast majority of the concerns which operated slate quarries in the Nantlle district had more in common with the Carnarvon & Bangor Company than with the Dorothea Company. Whereas the smaller concerns such as Cloddfa'r Coed were allegedly capable of producing a twenty per cent return on capital over short periods [225], the turnover of operators on individual sites due to financial failures was remarkably high at Nantlle even during the boom years of the 1860s and 1870s [226]. The subsequent fifteen years of depression at Nantlle, post-*c.*1880, was not surprisingly a harrowing time for many of its concerns. Many quarrying companies fell victim to cash-flow problems during this long period of reduced trade and low prices, with the majority falling foul of the legacy of ill-judged economies made in the sphere of development and safety work in earlier years.

The company failures of the 1880s and early-1890s created a vicious spiral involving a reduced investment flow into the industry [227]. This was hardly reversed by the mini-boom of 1895-1902, when high rates of profitability were restored briefly to the best quarries only.

The era of decline, post-1900

The continuing problems of the investment-starved companies led to the progressive diminishing of the importance of this district during the twentieth century. The profitability of the dwindling number of active quarries at Nantlle melted away after 1902 because of a combination of market forces described in Chapter 1, above, and technical factors discussed in Chapter 3, below. A diminishing demand for Welsh slates plus increasing production costs necessitated higher prices, which itself had a dampening effect upon sales in a highly competitive market. With hardly any investment being drawn into the industry, there was very little finance to update time-expired plant & machinery and to develop new rock reserves, two pre-requisites for the long-term survival of a significant number of the larger quarries at Nantlle [228].

The perilous position of the slate industry at Nantlle at this time is well illustrated by the evidence to the Royal Commission on Metalliferous

Mines & Quarries in 1910, of A. W. Kay Menzies, the managing director of several local quarries [229]. Menzies provided financial details of four anonymous concerns at Nantlle, which gives a valuable snapshot of the state of the core sector of middle ranking companies. Their profitability ranged from tolerable to very poor, and the cases can be summarised viz:-

'Quarry No.1,' (not positively identified, but possibly Braich Quarry) was the best performer of this group, having made a net total profit of £8,275 in the decade 1901-10 on a capital outlay of £20,000, working out at around a four per cent return annually.

'Quarry No.,2' (definitely the Alexandra Slate Quarry Co. Ltd.) had between 1900 and 1910 only produced a cumulative profit of £12,000, but this was diminished by a £5,000 trading loss to a net profit of only £7,000 on a capital of £45,000, equivalent to a 1½ per cent return.

'Quarry No.3,' (which must be the Talysarn Slate Quarries Ltd.) made £4,548 in 1905-06, but lost £7,371 in 1907-09.

'Quarry No.4,' (probably the South Dorothea Quarry or perhaps Coedmadog Quarry) in 1900-09 lost £17,005 net, having only returned a total profit of £1,250 set against £18,255 in deficits [230].

The balance sheets of the Dorothea and Penyrorsedd quarries show a similar low return during the difficult years from 1903 to the First World War [231]. After the end of the war, the slate trade picked up considerably, but crashed in the mid-1920s before being even more diminished during the Great Depression (see Chapter 1, above). The continuous era of economic gloom in the slate trade from the 1930s to the 1970s was characterised by only a low profitability of the major quarries at Nantlle in the better years, and operating losses during the remaining years, resulting in their progressive closure.

In terms of return upon capital, to continue operations even at the Dorothea and Penyrorsedd quarries after the mid-1960s was to all intents and purposes futile, and the Crown Company was in a worse financial state. Yet, there were compelling reasons why these concerns were not voluntarily wound-up on the grounds of the futility of trading at a zero return rate. On the one hand, there were maturing equity and gilt investments tied up in these companies, but other than freehold land, none of their other assets had much value on break-up. Moreover, inherited holdings of the shareholders had no market value, and consequently they were happy to continue in business for as long as possible just in case a better future lay around the corner. Also, despite the maxim concerning business and sentimentality not being compatible, these concerns in the 1960s had a genuine sense of duty towards their workers in an economically depressed area [232].

Of the three major quarrying concerns of the Nantlle district post-1945, only the Caernarvonshire Crown Slate Quarry Co. Ltd., remains in existence, although in a state of limbo, not having been involved in active quarrying in this district since 1972. The Dorothea Company suspended its quarrying operations in September 1969 and subsequently traded as a slate merchant pending a proposed merger with the Penyrorsedd Company. This was not to be, and in view of a heavy debt to the banks, Dorothea went into voluntary liquidation in March 1970. The Penyrorsedd Company also liquidated voluntarily, in 1979, after its attempt to withdraw from quarrying in favour of property development was thwarted by local planning regulations and a lack of funding [233].

The revival in the Welsh slate industry since 1980, in which the utilisation of new technology has been an important feature, has radically altered the economics of the trade. Few details are available from the private concerns currently operating in the Nantlle district (see Chapter 1, above), but it is apparent to the external observer that the scale of profit return must now be on a par with that of the mini-boom of a century earlier [234].

When all the above factors are brought together, it may be concluded that the huge investment made in the development of a large area of the Nantlle slate veins was an expensive mistake. By an accident of geology, practically all the quarries on the southern side of the valley were to all intents and purposes valueless except in the special circumstances of very small-scale, low-cost operations by working quarrymen during years of great demand. Of the remaining quarries in this district, many had potentially valuable slate reserves but uncertain profitability. Some of these quarries were expensive to work for geological reasons and their successful operation required long-term applications of capital and steady market conditions, which were rarely achieved. Other quarries at Nantlle were plagued by problems of insufficient ground for waste disposal and some suffered periodical flooding by the lower of the two natural Nantlle lakes (see Chapter 3).

The lack of co-operation between competing adjacent concerns compounded the problems as did the often awkward layout of surface boundaries based upon the pattern of landed estates. Had there been fewer, and wiser, landowners in this district, the best ground might have been developed by fewer, bigger concerns, which if adequately capitalised and competently managed might have gained a level of cost-effectiveness and profitability to rival the premier quarries in the industry [235].

NOTES: CHAPTER 2

Abbreviations

C.R.O. Caernarfon Records office, Gwynedd Archives Service
N.L.W. National Library of Wales
P.R.O. Public Records Office
Q.M.J. Quarry Managers' Journal
U.C.N.W. University College of North Wales, Bangor
(now University of Wales, Bangor).

(a). The Sources of Investment

1. Information about the organisation of the slate industry at Nantlle in the early commercial period can be gleaned from a comparison of the details provided by the agent of the Penrhyn Estate quarries in 1738, in Pritchard, D.Dylan, 'New light on the history of the Penrhyn Quarries in the eighteenth century,' Q.M.J., September 1944, pp.116-118, with the *ex.info.*, details recorded by local historians, in Ambrose, W.R. (1872), Hynafiaethau, Cofiannau a Hanes Presennol Nant Nantlle, (Pen-y-groes, re-published Llanllyfni 1985), pp.74-75; *Sylwebydd*, (John Griffiths, 1889), Chwarelau Dyffryn Nantlle a Chymdogaeth Moeltryfan, (ed. W.J.Griffiths, Conway *c.*1930); C.R.O., XM 392/1, essay by *Diwyd* (unidentified author, 1877), Chapter III, ff.5-8; C.R.O., XM 1785/Add.89, essay by Edward Williams (*c.*1875); and U.C.N.W., Nantlle Ms 1, essay by *Alaw Llyfnwy* (John Hughes, 1877), Chapter 1, ff.5-8.

2. Early incorporated concerns involved in metal mining in North Wales included the Company for the Mines Royal (in Tudor times), the Cheadle Brass Company of 1719, Messrs Roe & Co., of Macclesfield in the 1760s, the Parys Mine Company of the 1770s and the Mona Mine Company of the 1780s; see Dodd, A.H., The Industrial Revolution in North Wales, (Cardiff 1951), pp.17, 153-155, 308-309.

3. Lewis, M.J.T. & Williams, M., (1987), Pioneers of Ffestiniog Slate, pp.6-9, in their account of the background to the Nantlle quarrymen who moved to Ffestiniog in the 1760s to 1780s, point towards the pre-existence of a capitalist structure in the Ochr-y-Cilgwyn quarries. This hypothesis is supported by the subdivision of the extant list of quarrymen at Ochr-y-Cilgwyn in 1787 [N.L.W., Glynllifon 89, ff.56v-69v.], into sub-sections of Masters, Labourers and Boys.

4. A summary of the history of the rise to prominence of the family dynasties controlling the Penrhyn and Dinorwic quarries can be found in Pritchard, op.cit., 'The financial structure of the slate

industry in North Wales 1780-1830,' Q.M.J., December 1942, pp.210-211; Lindsay, Jean (1974), A History of the North Wales Slate Industry, (Newton Abbot), Chapters 2 and 3; and Richards, A.J., (1985), Slate Quarrying in Wales, (Llanrwst), Chapter 2, pp.21-38 passim.

5. These persons are named in the historical accounts of individual quarries by *Alaw Llyfnwy, Diwyd* and *Sylwebydd* op.cit., with additional notes by Dylan Pritchard in C.R.O., XM 4874/6. See also sub-section on early sole proprietors in Part (b) of this chapter.

6. Dylan Pritchard, Q.M.J., December 1942, op.cit., p.210.

7. Idem., 'Investment in the slate industry 1830-1930,' Parts I-IV, Q.M.J., January 1943. pp.377-380; ibid., February 1943, pp.297-300; ibid., March 1943, pp.318-323 and April 1943 pp.377-380; J.Lindsay (1974), op.cit., Chapters 2-9 passim; Alun Richards (1995), op.cit., Chapter 2 passim.

8. The Rt.Hon. Charles John, Earl of Shrewsbury, and the Rt.Hon. George Granville Levenson Gower (1758-1833), the Earl of Stafford and later 1st Duke of Sutherland, were shareholders in the Talysarn Slate Company (of 1827-44), which was largely made up of English M.P.'s [see C.R.O., XM 2350/1-2].

9. Maj.Gen. W. F. Scarlett, Lord Abinger (of Kensington and Inverlochy Castle), was an important shareholder and director of the Penyrorsedd Slate Quarry Co. Ltd. (of 1863), and the family interest was maintained up to the liquidation of this concern in 1979 [C.R.O., X/Penyrorsedd.addit 1853; ibid., addit 2653; C.R.O., G.P.Jones/Nantlle Mss, Penyrorsedd Quarry, uncatalogued].

10. Albert Levenson Gower (1843-74), third son of the 3rd Duke of Sutherland, was involved in the Alexandra Slate Co. Ltd., (of 1874), with other aristocrats named in Notes 11-12 infra.

11. Arthur Edwin Hill Trevor, grandson of Sir John Trevor of Brynkinallt, co.Denbigh (sometime speaker of the Commons), was also involved in the Alexandra Slate Co. Ltd., (of 1874).

12. Sir Thomas Bateson (1819-90), M.P. for Londonderry (1844-57) and for Devizes (1864-85) until created 1st Baron Deramore, was a significant shareholder in the first Alexandra Slate Co. Ltd., (1863-69), maintaining his interest *via* a succeeding private company prior to the re-forming of the limited liability concern in 1874 (see also Notes 10-11 supra). The family involvement in this quarry spanned three generations, coming to a close with Robert Wilfred de Yarburgh Bateson, the 3rd Baron, of Belvoir Park, Co.Down.

[see C.R.O., J.S.Wilkinson's abstracts of P.R.O. Files of Defunct Companies, 'Alexandra *q.v.*', BT31/762/346c and BT31/14497/8509].

13. Sir John Kennaway, Bart.,M.P. (1797-1873), of Ottery St.Mary, was a leading shareholder in the Penybryn Slate Company (of 1836-80).

14. Charles Bradlaugh, the Freethinker and controversial M.P., who refused to swear allegiance in order to take up his seat, was involved in the ephemeral Talysarn Slate Co. Ltd., of 1859-60 [Wilkinson, op.cit. P.R.O. BT31/407/1563], and was subsequently became involved in an equally unsuccessful venture of the Caerhun Slate Co. Ltd., in Cwm Eigiau, Dyffryn Conwy [Wilkinson op.cit.].

15. See C.R.O., Wilkinson P.R.O. BT31 abstracts, op.cit.

16. The Rev John Jones (1796-1857) was a quarryman of Dolwyddelan, who was invited to take a Ministry in the Nantlle district in 1821 (subsidised by working in the Talysarn Quarry), where he subsequently married a daughter of Thomas Edwards, a former quarry agent turned entrepreneur (see Note 154, infra). Jones became deeply involved in the setting up of the 'Welsh' concern which bought Turner's interest in the Dorothea Quarry in 1848-49, and briefly managed the concern in 1851-55 until an accident and increasing criticism of the incompatibility of his Ministry and his actions as quarry agent, forced his withdrawal from an active role with the concern [see G.P.Jones, 'The Dorothea Slate Quarry 1822-1970, (M.A. Thesis, Bangor 1980), Parts I (ii) and III (c),; and Thomas, Parch O. (1874), <u>Cofiant y Parch John Jones Talysarn</u>, (Wrexham), Chapter XIII, 'Blynyddoedd ei Arolygiad ar Gloddfa Dorothea,' pp.850-852].

17. John Lloyd Jones (1826-1893) of Baladeulyn and latterly Plas-y-bryn, near Caernarfon, was the eldest son of the Rev John Jones, above. J.Ll.Jones became a shareholder, salesman, transport contractor and then agent of the Dorothea Company in the 1850s, selling out in 1860. He spread his interests to the Fron Quarry (1850s), Penyrorsedd Quarry (1854-60), Ty Mawr East Quarry (by 1860-74) and Tynyweirglodd Quarry (by 1863 to about 1870) at Nantlle, also holding the water rights for the Dorothea, Penybryn and Penyrorsedd quarries. Jones' speculative interests spread to the Britannia Slab Quarry near Nefyn (1850s), to the Glyn Ceiriog district, Abergynolwyn (1862) and the Llwyngwern Quarry, near Corris (1867), and also several granite quarries in Caernarfonshire [see C.R.O., X/Dorothea 2108; ibid. G.P.Jones/Nantlle Mss, (uncatalogued), essay by Jack Ll.Jones 'A Note on the Plas-y-bryn Family;' references in local history essays Note 1 supra., and sources for histories of other slate areas].

18. G.E.Magnus (1801-1873) was involved in slate quarrying from the 1830s at Ffestiniog before becoming part of the Carnarvonshire Slate Company at Tanrallt, near Llanllyfni from 1853 [Wilkinson, op.cit., P.R.O. BT31/63/239], also at Garth Llwynog, Croesor (1862-63), at Valencia, co.Kerry and at Waldeck, Germany (from 1864). Magnus had set up the Plimlico Slate Works, London, around 1840 to exploit his patent of enamelling slabs, had a second works at Aberllefenni (Corris) by 1847, and possibly a third at Bangor (Caerns.) by the 1850s. [The author is indebted to Dr Dafydd Gwyn for this information].

19. John Robinson, J.P., (1830-1900), of Liverpool, London and latterly Tal-y-sarn Hall, sometime High Sheriff of Caernarfonshire, first became involved in slate quarrying through his association with Shallio's Bank, London, during the reconstruction of the ailing British Slate Co. Ltd., in 1864 [Wilkinson, op.cit., P.R.O. BT31/504/1993; ex.info. Dr Dafydd Gwyn]. This concern, with Robinson as managing director, took a lease on the Fron Quarry, Nantlle after 1864, and formed the Carnarvon & Bangor Slate Co. Ltd., to lease the Talysarn Quarry in 1867 [Wilkinson op.cit., P.R.O. BT31/1323/3444]. Neither concern flourished, and Robinson deftly side-stepped the creditors through the flotation of the Vron Slate Co. Ltd., in 1873 [Wilkinson, BT31/1881/7494], the Freehold Estates Co. Ltd., [BT31/1757/6550] and the Slate Co. Ltd., [BT31/1808/6946]. Robinson manoeuvred himself through the collapse of these companies around 1880, to emerge as sole proprietor of the Talysarn Quarry (see Note 148, infra).

20. William Arthur Darbishire, J.P., (1829-1915), of Plas Baladeulyn Nantlle and latterly Penbryn Seiont Caernarfon, was the son of a railway company's solicitor who had retired on health grounds to Penmaenmawr in the 1850s. Darbishire's first known involvement with slate quarrying was as managing director of the Penyrorsedd Slate Company Ltd., (1862), had shares in the family's granite quarries at Penmaenmawr and Trefor, and was briefly involved in the Cedryn Quarry, Dyffryn Conwy (1865-68) and the Penybryn Quarry, Nantlle (1882-87).

21. St.Pierre Foley was a shadowy figure involved in the fraudulent Mining Company of Wales (1850-52), which held interests in several metal mines as well as leases on the Abercorris Quarry (Corris), Cwmorthin and Wrysgan quarries (Ffestiniog), the Great Denbigh Slab Quarry (unidentified) and the Tynyweirglodd Quarry, Nantlle [refs. per Dr M.J.T.Lewis, Dr Dafydd Gwyn; see also account of Robert Williams, the manager at Tynyweirglodd, in <u>Cymru</u> XVIII, Ebrill 1900, (105), pp.226-227, and Note 172, infra].

22. Quote per Dr Dafydd Gwyn. Winfield Attenborough, of Lincoln's Inn Field was a co-promoter of the Mining Company of Wales (see Note 21, supra). He had individually bought the Tynyweirglodd lease on 24 December 1849 for £800 and sold it four days later for £14,000 [U.C.N.W., Tyngongl Ms 583].

23. Thomas Harvey (d.1875), a solicitor of Brixton and later a gent., of Llanfair, Harlech, was involved in the Talysarn Quarry in 1857-59 [John Griffiths *Sylwebydd* op.cit., p.22] and was promoter of the Llyfni Vale Harbour Bills of 1859 and 1860 (see Chapter 5, infra). After moving his activities to the Pennant Valley and to Llanfair Quarry in the early 1860s, Harvey returned to Nantlle in 1865 to be involved at the Tynyweirglodd Quarry with the Dorothea West Green Blue and Red Slate Quarry Co. Ltd., [Wilkinson, op.cit.].

24. M.J.T.Lewis (ed.), <u>The North Wales Slate Quarries in 1873</u>, (Plas Tanybwlch 1987), p.70. This ex.info. story, recounted to the Special Correspondent of the <u>Carnarvon & Denbigh Herald</u> in 1873, provides the sole reference to an early, local female quarry owner. The survival of the lore over a century from the late eighteenth century suggests it was likely to be true in substance, but that Shân [Rowland?] of Y Bontfaen (Clynnog Parish) may have been an eccentric rather than the norm in the industry.

25. Elizabeth Lydia Cane, later of Cwellyn, Llanberis Road, Caernarfon, appears to have taken over her deceased brother's sole interest in the Penyrorsedd Quarry around 1840. She presided over the quarry's operations for about 14 years, which was a longer trading period than achieved by many contemporary male-dominated concerns, this possibly being the cause of the disdain shown by the otherwise well-balanced commentator John Griffiths (*Sylwebydd*) op.cit., p.58-59, although *Diwyd* op.cit., f.32, and *Alaw Llyfnwy* op.cit., ff.22-24, were not as biased.

26. Mary Barnes, nee Darbishire (1872-1960) of Plas Celyn, Penmaenmawr, was a niece of W.A. Darbishire (Note 20, supra.), and assumed the chair of the Penyrorsedd Company in the 1920s upon the indisposition of her cousin, Prof. Otto Vernon Darbishire. She dominated the Board during the remainder of her life, and was a great restraining influence on the progressive ideas of Prof.Darbishire, who failed to regain his former position [ex.info. Mr Stephen Darbishire, son of O.V.D.].

27. John Evans (1766-1827) of Talymignedd Uchaf, Nantlle and Caernarfon, trained as a solicitor with Wright & Ellis (Bangor), who were involved in the Dinorwic Slate Company of 1787. Evan's practice at Porth yr Aur Caernarfon flourished, and he came to hold

several positions of influence. His involvement with slate quarry investments came about through a partnership with local gentry in the Cilgwyn & Cefn Du Slate Company (of 1800), in which Evans was the leading light [see C.R.O., XM 4874/6 notes; Jean Lindsay (1974). op.cit., Chapter 4 passim].

28. John Griffiths (*Sylwebydd*), op.cit., pp.67-68.

29. See Note 27, supra.

30. Dylan Pritchard, Q.M.J., December 1942, op.cit., p.214.

31. Loc.cit.

32. Loc.cit.

33. Ibid., p.213.

34. Pritchard, Q.M.J., March 1943, op.cit., pp.318-320.

35. Loc.cit; C.R.O. XM 4874 uncatalogued list, by Dylan Pritchard of registration of limited liability companies in the Welsh slate industry.

36. Pritchard, Q.M.J., January 1943, op.cit., pp.254-256.

37. E.g., Pritchard, loc.cit., p.255 stated that T.C.Smith (1860), Slate Quarries in North Wales, which showed the eligibility of the industry as an investment, sold 15,000 copies in five years

38. Pritchard, Q.M.J., February 1943, op.cit., p.297.

39. Pritchard, Q.M.J., January 1943, op.cit., p.254, quoting the editorial of the Mining Journal of 9 September 1859, which gave data for the three major concerns and claimed profits of from 50 to 100 per cent for ***most*** quarries; idem. Q.M.J., October 1946, p.227 quoted T.C.Smith, op.cit., regarding the alleged safety of financial investments in Welsh slate quarries.

40. Based on estimated profit levels due to the lack of comprehensive data, but the general conclusion extrapolated from extant records is proposed with confidence.

41. The minimum number of shareholders was seven for limited liability companies, and the Articles of Association could included a clause prohibiting the sale of shares outside the existing company without authorisation by the Board. Examples of private limited companies at Nantlle (which were indistinguishable in law from public ones until 1907) were those operating the best quarries, namely Alexandra, Cilgwyn, Dorothea and Penyrorsedd, whereas shares in speculative enterprises spanning the spectrum of scale of working were most often, but not exclusively, promoted to the general public. The details regarding the allocation of shares provided by J.S.Wilkinson

in his P.R.O. Abstracts, op.cit., allows individual companies to be categorised.

42. E.g., a prospectus for the Dorothea Quarry in the 1850s, in which the author had left gaps for the promoter to fill in production and valuation data, and these figures having been revised before circulation [C.R.O., X/Dorothea Mss 915, 916]. Other examples for the same quarry include a sales circular of 1848 [ibid., 911] and sales reports of 1864 [ibid., 934, 935].

43. See example given by Robert Williams, 'Hunangofiant Chwarelwr III,' Cymru, XVIII, Chwefror 1900 (103), pp.131-132.

44. The classic example is the Taldrwst Quarry, Llanllyfni where a glowing prospectus dated 1873 [C.R.O., G.P.Jones/Nantlle Mss, uncatalogued], containing reports by the managers of two of the leading local quarries, painted a completely false picture of the state of the quarry and its prospects.

45. U.C.N.W., Tyngongl Ms 583; see Note 22 supra.

46. Lindsay (1974), op.cit., p.76; C.R.O., XM 2350/1-2; C.R.O., X/Dorothea Ms 5, f.23; C.R.O., J.S.Wilkinson P.R.O. abstracts, op.cit., 'Vron' *q.v.*

47. C.R.O. XM 4874/47, pp.46-47.

48. Such as in the case of the British Slate Co. Ltd., and its offshoots, see Note 19 supra.

49. Dylan Pritchard, Q.M.J., March 1943, pp.321-322; idem., Q.M.J., April 1943, pp.377-380; idem., Q.M.J., October 1946, pp.227-229.

The ebb and flow of Welsh investment

50. At Nantlle, e.g., John Evans of Talmignedd Uchaf (see Note 27 supra) and John Griffith of Tryfan Hall, [see W.G.Williams, ed. G.H.Williams (1983) 'Y Tryfan,' in Moel Tryfan i'r Traeth] were of local origin, but the Rev R. M. Humphreys and G. Bettis [Lindsay (1974) op.cit., pp.76-78] were outsiders. On a more regional scale, most of the most influential of the private entrepreneurs, such as William Turner, Samuel Holland and J. W. Greaves [ibid., pp.79-87] were all incomers.

51. For instance from the law (John Evans and O. A. Poole), and landowners (John Griffith 'Tryfan' and William Jones 'Talysarn').

52. Dylan Pritchard, Q.M.J., December 1942, op.cit., pp.211-213.

53. For details of the troubles at Ochr-y-Cilgwyn see J.Lindsay (1974), op.cit., Chapter 4; C.R.O. XM 4874/6, abstracts by Dylan Pritchard of information from the U.C.N.W. Porth yr Aur Mss.

54. John Griffiths (*Sylwebydd*), op.cit., pp.29-33; Lindsay (1974), op.cit., pp.121-126; G.P.Jones (1980), 'The Dorothea Quarry...' (Thesis) op.cit., Part I (ii) passim.

55. Ibid. The family block vote of the Rev John Jones (see Note 16, supra) and his allies, feeding the ambitions of his eldest son, J.Ll.Jones (see Note 17, supra), was too powerful for the remaining minority of local shareholders to withstand, resulting in the latter selling out pre-1864 at a handsome premium of up to four times their original value.

56. J.Griffiths *Sylwebydd*, loc.cit.; G.P.Jones (1980), op.cit., Part I (ii), passim; C.R.O., X/Dorothea Ms 1, the first Minute book (from 1850) shows the declining attendance of the shareholders in the monthly company meetings and the subsequent inability of the concern to carry out its business efficiently.

57. J.Griffiths, op.cit., p.17.

58. Ibid., pp.73-74, gives the history of the working by trespassers of the Cilgwyn Quarry in 1845-*c*.47, but despite its record as a good site, no locals had the means or aspiration to work it, the next lessee being John Hayward of Oswestry.

59. E.g., Hughes & Co.; see Note 43, supra.

60. Lewis Lloyd (1989), <u>The Port of Caernarfon 1793-1900</u>, p.14.

61. The writers of late nineteenth century local essays (such as those listed in Note 1, supra., and including C.R.O., XM 4874/47, an astute appraisal by John Paull of the prospects of the district, dated 1886) were certainly awake to the speculative promotions and were capable of analysing accurately the future prospects of individual quarries. This knowledge must have been widespread through the quarrying communities.

62. See Note 59, supra; the Lists of Quarries appended to the annual reports of H.M.Inspectors of Mines & Quarries, North Wales & Isle of Man region, post-1882, are a good source for identifying the proprietors of these concerns.

63. Dylan Pritchard, <u>Q.M.J.</u>, January 1943, op.cit., p.254. The zenith of production of the Welsh slate industry was in 1876 or 1877, but no accurate data is available pre-1882 to allow the annual totals to be calculated.

64. At Ffestiniog, the Davies Bros., and others were the most important of the local entrepreneurs, working peripheral sites such as the Rhosydd and Wrysgan quarries. At Nantlle, the persons listed in Notes 66-74 infra., were able to obtain leases on several medium-sized quarries such as Cloddfa'r Coed, Fron, Moeltryfan and Tynyweirglodd because of the worse economic effect of the 1880s recession on the Nantlle district than elsewhere (see Chapter 1).

65. Griffith Williams (d.,*c*.1895) of Bryngwynedd, Caernarfon. An agent for John Robinson (see Note 19, supra.) during the 1870s, Williams was able to purchase the South Dorothea Quarry (then the 'Cornwall Pit') off Robinson in 1878 as a speculation which was quickly sold to an ill-fated English concern [J.Griffiths (1889), op.cit., p.26]. He had founded Griffith Williams & Co. Ltd., slatemerchant of Caernarfon in 1880 [C.R.O., X/Dorothea Ms 40, a concern which included several important quarry proprietors], from which base the Vron & Old Braich Welsh Slate Quarry Co. Ltd. of 1882-91, [Wilkinson, op.cit., P.R.O. BT31/3011/17003] was born. He may have been involved in the Moeltryfan Slate Company of 1875, but was definitely a shareholder in the succeeding limited company of 1879 [Wilkinson, op.cit., BT31/14632/13455].

66. Griffith Davies, M.D., of Caernarfon, shareholder in the Vron & Old Braich Welsh slate Quarry Co. Ltd. with Griffith Williams, Hugh Pugh and John Thomas [Notes 65, 68, 71; J.Griffiths (1889), op.cit., pp.82-83]. He may have been the Morris Griffith Davies (1852-1929), later of Penygroes, who married a sister of John Robinson (see Note 19 supra.).

67. Thomas Lewis of Bangor, merchant and flour miller, local politician [A.H.Dodd, 1968, <u>A History of Caernarvonshire</u>, p.360]. He was managing partner of the Tynyweirglodd Welsh Slate Co. from 1895 until its closure in 1907. Lewis was declared bankrupt in 1910 [C.R.O., X/Dorothea 1488, press cutting, 1910].

68. Hugh Pugh of Pwllheli and later Llys Meirion Caernarfon. A one-time bank clerk who bought the business, Pugh became a shipping magnate and after his move to Caernarfon in 1870, he invested heavily in slate quarries at Nantlle [see Lewis Lloyd, <u>The Port of Caernarfon</u>, op.cit., p.119, fn. 58, and p.127; idem., <u>Pwllheli, the Port and Mart of Llyn</u> (1981), pp.192-193]. His interests included the Bangor & Carnarvon Welsh Slate Company (at Cloddfa'r Coed Quarry) and the Vale Slate Company (at Tynyweirglodd Quarry) from *c*.1875 [C.R.O., X/Dorothea 903] with Morgan Richards (see Note 69, infra); a partnership with Ellis Roberts (Note 74, infra.) at the Coedmadog Quarry in 1877-81; a major holding in the Moel Tryfan Slate Co., (of 1875) and the Moel Tryfan Slate & Slab Quarry Co. Ltd,. of 1879

[Wilkinson, op.cit., P.R.O., BT31/14632/13455; J.Griffiths (1889), op.cit., p.98], and in the Vron & Old Braich Welsh Slate Quarry Co. Ltd., with G. Williams (Note 65, supra.).

69. Morgan Richards (*Morgrugun Machno*) of Penmachno and Bangor. Author of Slate Quarrying and How To Make It Profitable (London, 1877), and first president of the North Wales Quarrymen's Union. Slatemerchant and shareholder/secretary of both the Bangor & Carnarvon Welsh Slate Company (at Cloddfa'r Coed Quarry) and the Vale Slate Company (at Tynyweirglodd Quarry) from *c.*1875 [C.R.O., X/Dorothea 903].

70. John Evan Roberts of Snowdon Villa, Upper Bangor, shop owner and shipowner [C.R.O., XM 4889/250-252]. Was a director of the Moel Tryfan Slate & Slab Quarry Co. Ltd. of 1879 [Wilkinson, op.cit., BT31/14632/13455] together with Griffith Williams (Note 65, supra.) and Hugh Pugh (Note 68, supra.), succeeding the latter as chairman *c.*1890.

71. John Thomas, of Bangor St., Caernarfon, shipowner and secretary of the Arvon Shipping Company [see Lewis Lloyd, The Port of Caernarfon op.cit., p.119, fn. 58]. Shareholder and director of the Vron & Old Braich Welsh Slate Quarry Co. Ltd., with Morris Davies, Hugh Pugh and Griffith Williams (see above).

72. W. David Williams of Bryngwynedd, Caernarfon. Slate merchant, agent of the South Dorothea Quarry by 1902, partner in the Llwydcoed Quarry 1904-09, shareholder/director/secretary of the Vron Welsh Slate Quarries Ltd., in 1902-1913, when he emigrated to the U.S.A. [Wilkinson, op.cit., P.R.O. BT/31/9972/74448].

73. Thomas Charles Lewis. Partner in the Tynyweirglodd Welsh Slate Co., (see Note 66, supra.).

74. Other Caernarfon/Bangor-based middle class Welsh entrepreneurs of this period included Richard Morris Griffiths Jnr (d.1872) of Bangor, a banker involved in speculative companies throughout the county, but only known to have dabbled once at Nantlle, at Penyrorsedd in 1860-72; Thomas Owen of Caernarfon, slatemerchant and partner of John Lloyd Jones (see Note 17, supra) at Ty Mawr East and Tynyweirglodd quarries; Griffith Robert Rees (1831-1911) of Plas Brereton Caernarfon, bank manager and major shareholder/director in the Cilgwyn Slate Co. Ltd. (of 1896) and probably of the earlier unlimited concern there; Ellis Roberts, slatemerchant of Caernarfon & Portdinorwic, partner in the Coedmadog Quarry (with Hugh Pugh, Note 68, supra.), Galltyfedw (Victoria) and Nantlle Vale (Ty Mawr East) quarries in the 1870s; and Richard D. Williams, solicitor of

Caernarfon, sole proprietor of the Galltyfedw Quarry during the 1860s-early 1870s.

75. J.W.Wilkinson, op.cit., abstract of P.R.O. file BT31/18830/102802, Ty Mawr Slate Quarry Co. Ltd.

76. Wilkinson, op.cit., P.R.O. BT31/14632/13455.

77. Ibid.; op.cit., P.R.O. BT/31/9972/74448; C.R.O., X/Dorothea 903; C.R.O., XD 35, Mss 219, 447, 540; U.C.N.W., Nantlle 21.

78. C.R.O., XD 18, Mss 114, 151.

79. Abstracts from Skinner's Mining Manual 1909, per J.S.Wilkinson, to whom the author is indebted; C.R.O., X/Dorothea 1286; ex.info., former employees.

80 J.S.Wilkinson, op.cit., P.R.O., BT31/32253/150225; C.R.O., X/Dorothea 1303; ex.info., Gordon H. Richards, former company secretary.

81. Ex.info., former employees of the tip contractors.

Amalgamations and take-overs

82. The former (see U.C.N.W., Porth yr Aur Mss for a large collection of documents) was an unique concern, controlling about thirty quarries on large tracts of Crown land in two counties, whereas the latter was more typical of the district-based multi-site company (for which there are no known extant documents, but see John Griffiths (*Sylwebydd*), op.cit., pp.47-49, 80-81, 90, 93-94).

83 E.g., within the boundaries of the Cilgwyn, Taldrwst, Talysarn and the Tymawr quarries, the majority of the pits had originally been independent concerns, although the later expansion of the workings have obliterated the earlier remains.

84. Dylan Pritchard, Q.M.J., October 1946, p.227.

85. References to the localised 1880s amalgamation proposals can be found in C.R.O., X/Dorothea 5, and in C.R.O., X/Penyrorsedd.addit 1873, passim.

86. Ibid., C.R.O., X/Dorothea Ms 5, ff.35, 48. The regional amalgamation schemes of 1889 and 1899 were doomed from the start due to the high price in cash demanded by some proprietors wishing to get out of the industry with all haste, whereas others refused to consider the idea of a 'super consortium.'.

87. The first pairing were Braich/Coedmadog and Talysarn/Ty Mawr West, but by 1910 the list included Dorothea/Penybryn (since 1892), Tyddyn Agnes/Ty Mawr East, Fron/Galltyfedw/Llwydcoed/Ty Mawr West in various combinations, and Talysarn with Cloddfa'r Coed & Tanrallt including Braich, were the main groupings of quarrying sites [ref. Lists of Quarries, Appendix to Annual Report of H.M.Inspectorate of Mines & Quarries, North Wales & Isle of Man District, per J.S.Wilkinson].

88. Ibid.

89. Ibid; Wilkinson, P.R.O. abstracts, op.cit., BT/31/4019/25596 and BT31/5180/35015; C.R.O., X/Dorothea Ms 41.

90. Wilkinson, H.M. Inspectorate Lists of Quarries op.cit.; G.P.Jones (1980), 'The Dorothea Quarry...' (Thesis), op.cit., Parts I (iii), IIIA (ii).

91. C.R.O., X/Dorothea Mss 1023, 1283, 1286; documents of the Talysarn Estate per Mrs A.Breen-Turner inspected by the author in 1971, but now believed lost.

92. C.R.O., X/Dorothea Mss 1196, 1203, 1346, 1347, 1353.

93. Ibid, Mss 1283, 2074 pp.513-515.

94. C.R.O., G.P.Jones/Nantlle MSS (uncatalogued), 'Datblygiad Chwarelyddiaeth yn Nyffryn Nantlle dros y Chwarter Canrif Diwethaf,' essay by Owen Humphreys (1945), notes on the Galltyfedw and Talysarn quarries *q.v.*

95. G.P.Jones (1980), 'The Dorothea Quarry...' (Thesis) op.cit., Parts IIIA (d) and IIIB (i).

96. Dylan Pritchard, 'The Welsh Slate Committee,' Q.M.J., July 1946, pp.36-39; The Welsh Slate Industry, Report by the Committee appointed by the Minister of Works (H.M.S.O., 1947); C.R.O., XM 99/75, Prof G. Hibberd, 'A survey of the Welsh Slate Industry,' (Abridged version, privately circulated 1948); ibid, XM 99 Mss 59-61, 93-103; C.R.O., X/Dorothea 1401.

97. C.R.O., G.P.Jones/Nantlle MSS uncatalogued, Penyrorsedd Quarry File 11.1; ex.info. Mr Stephen Darbishire (Penyrorsedd Quarry), Mr Walter Riley (Crown Quarries) and Mr M. J. B. Wynne-Williams (Dorothea Quarry).

External secondary funding: debenture stock and mortgages

98. This process can be followed in the first Minute book of the Penyrorsedd Slate Quarry Co. Ltd., [from 1862; C.R.O., X/Penyrorsedd.addit 1853], when calls of cash, and sales of additional shares were made to keep the concern afloat.

99. Ibid., by the 1870s, when there was no further demand for shares.

100. Ibid., second Minute book [C.R.O., X/Penyrorsedd.addit 1875].

101. Private papers of the Talysarn Estate, seen by the author in 1971 by permission of the late Mrs Ada Breen Turner, but possibly since destroyed.

102. C.R.O., X/Dorothea Mss 20, 21, Annual Report for 1963.

103. For a comprehensive account of debenture stock, see Webster-Nunn, E., & Miles Taylor, E., The Principles of Company Law, (London 1930), Chapter VIII.

104. J.S.Wilkinson, P.R.O. abstracts, op.cit., BT31/17287/81836 (Talysarn); abstract of Skinner's Mining Manual 1909, privately supplied by J.S.Wilkinson, to whom the author is indebted. See also C.R.O., XM 4556/1-2, correspondence re. British Slate Company debenture stock.

105. Wilkinson, P.R.O., op.cit., BT31/32253/150225; C.R.O., X/Dorothea 1303.

External funding; Government aid

106. Ex.info., G.H.Richards (now deceased), slatemerchant of Caernarfon, former company secretary of the Amalgamated Slate Association Ltd.

107. Annual Reports of the Commissioners of H.M. Woods Forests and Land Revenues, Nos. 82 p.74, 93 p.111, 109 p.32, 110 p.37, 114 p.48; C.R.O., XD 35/430.

108. C.R.O., G.P.Jones/Nantlle MSS (uncatalogued), Caernarvonshire Crown Slate Quarry Co. Ltd., financial files, 1932-37.

109 G.P.Jones (1980), 'The Dorothea Quarry...' (Thesis), op.cit., Part IIIC (3).

110. Ibid., Parts I (iii) and IIIC (3); C.R.O., X/Dorothea Mss 1383, 1422, 1480. The Company went as far as to engineer a refusal by a finance company for a loan to try to meet the Treasury's criteria of eligibility, but this cut no ice with the civil servants who judged that the grant would benefit the Dorothea shareholders rather than promote increased employment opportunities in the Nantlle district.

The second application for grant aid was rejected on the grounds that the Company was accused of deliberately undervaluing potential profits and that all of its financial reserves should be used up before any assistance might be given, a completely unacceptable demand.

111. C.R.O., G.P.Jones/Nantlle MSS (uncatalogued), Caernarvonshire Crown Slate Quarry Co. Ltd., financial files, 1960s.

112. G.P.Jones/Nantlle MSS (uncatalogued), Penyrorsedd Quarry File 11.1; ex.info., Mr Stephen Darbishire, former managing director, Penyrorsedd Quarry.

113. From conversations with the directors of the Nantlle Slate Quarry Co. Ltd., (working the Penyrorsedd Quarry since 1979).

(b). Types of business organisations

Partnerships

114. Data based on author's lists of operators of individual quarries.

115. These persons are mentioned in the notes on individual quarries found in local history essays listed in Note 1, supra. The author is indebted to Mr Iorwerth Thomas, of Talysarn (a former independent quarry proprietor and tip contractor) for enlightenment upon this aspect of the industry.

116. See Chapter 3, section (c). The bargaining gangs were invariably recorded as ".....[*Principal Member's name*] & Co.," in the wage ledgers, re-inforcing the notion of independence from the proprietors.

117. Whereas there is no documentary proof of this hypothesis, this would explain the anomalous position of such concerns as Morgan Hughes' unregistered partnership with his brother (Tanrallt Quarry, 1950s).

118. See accounts of the early period in local history essays listed in Note 1, supra; N.L.W., Glynllifon Ms 84, ff.56v.-96v, list of quarrymen at Ochr-y-Cilgwyn in 1787.

119. Ibid; Robert Williams, 'Hunangofiant Chwarelwr,' <u>Cymru</u>, XVIII, (104), Mawrth 1900, p.170 recounts the special arrangements made for the continued benefit of the widow of a bargainman; <u>The Slate Quarries of North Wales in 1873</u>, (Lewis 1987), op.cit., p.70, re. 'Sian Bontfaen' (see also Note 24, supra).

120. Examples of scavenging of defunct quarries by gangs of independent quarrymen included the sub-letting of the Fron and Moeltryfan quarries during the 1840s [John Griffiths, *Sylwebydd*, op.cit., pp. 80, 96]; Ty Mawr West being let on contract for three years in the 1870s [C.R.O., XM 392/1 f.44]; the Galltyfedw concern of quarrymen-partners in the 1880s [C.R.O., X/Dorothea 963]; and a report on the Ty Mawr East Quarry in 1911 [ibid., 885, p.128] discussing the despoliation caused by sub-leasing to these zero-capital concerns.

121. Ex.info. Iorwerth Thomas (former tip contractor). See also Chapter 3, sub-section (a), tips reworking.

122. Ibid; see also Chapter 1, part (a) & Note 24.

123. H.A. Shannon (1931), 'The Coming of General Limited Liability,' Economic History Review, Vol.II, 6, in E.M.Carus-Wilson (ed.) Essays in Economic History, Vol.I, (London 1954), pp.361-364. Partnerships were governed by Common Law until 1890, and furthermore were not legally discriminated from unincorporated companies after 1720 until the former date (see Notes 134, 164, infra).

124. Ibid; Ashton, T.S., The Industrial Revolution 1760-1830, (London, reprint 1958), pp.97-98, re. restriction on the number of partners. None of the early companies at Nantlle exceeded the limit of six partners.

125. U.C.N.W., Porth yr Aur Ms 27222. The original partners of the Cilgwyn & Cefn Du Slate Company (of 1800) were John Evans (solicitor, of Caernarfon); Richard Roberts (merchant, of Caernarfon); Thomas Jones (landowner, of Bangor); and John Price (landowner, of Llandegfan); they were joined in 1807 by O.A.Poole (solicitor, of Caernarfon).

126. John Griffiths (*Sylwebydd*), op.cit., p.12 and N.L.W., Rumsey Williams Ms 1647, refer to a late-eighteenth century concern at Cloddfa'r Coed Quarry comprising of Richard Roberts (of Caeathro, Caernarfon), Hugh David and John Jones, which may have been a formal partnership because the first named was very probably a banker.

127. U.C.N.W., Porth yr Aur 30134-30148, re. the Talysarn Slate Company (1800s).

128. Ibid., 30104-30133, re. the Penybryn Slate Company (1808-17).

129. Ibid., 29479-29714; N.L.W., Rumsey Williams 2694; A.H.Dodd (1951), The Industrial Revolution in North Wales, p.310, re. the Hafodlas Slate Company (1812-16).

130. U.C.N.W., Porth yr Aur 27222; Dylan Pritchard, Q.M.J., December 1942, op.cit., pp.211-213; J.Lindsay (1974), op.cit., pp.67-78, 97-98.

131. See Notes 125-129, supra.; details of the New Cilgwyn Slate Company from U.C.N.W., Porth yr Aur 27321.

132. E.g., the ejectment of Thomas Edwards (see Note 154, infra) from the Tynyweirglodd Quarry, on the accusation of not working the quarry with sufficient dispatch and not keeping it clear of rubbish, reported in the North Wales Gazette, 24 August 1826, p.3, col.2., and of Thomas Hughes and James Knight from the Penybryn Quarry, reported in ibid., 19 April 1827, p.3., col.3. See also Note 214, infra.

133. C.R.O., X/Penyrorsedd.addit 1954, deed of co-partnership of the Penyrorsedd Slate Quarry Company, 24 June 1856.

134. Shannon (1931), op.cit., referring to the Partnership Act, 1890.

135. G.P.Jones (1987), 'The Gwernor Slate Quarry, Nantlle,' Transactions of the Caernarfonshire Historical Society, Vol.48, (1987), pp.64-65, re. the Gwernor Slate Quarry Company (of 1899). In the light of a reappraisal of the evidence, is likely that the preceding concern (of 1890) was also a partnership under the new Act (Note 134, supra), rather than a joint-stock concern.

136. Ex.info., per former employees, details of Messrs. Fyldes and then Sugden (Twll Coed Quarry), Samuel Lisman (Tanrallt and Cloddfa'r Coed Quarries), and Nicholson's Quarries Ltd (Fron and then Twll Llwyd), all in the late-1940s to the late-1950s.

137. Ex.info., Mr Alan Humphreys, co-proprietor of the Twll Llwyd Quarry, to which this refers.

Sole Traders

138. See the account of the involvement of the Penrhyn and Faenol estate owners in the development of the Penrhyn and Dinorwic quarries, respectively, in Lindsay (1974) op.cit., Chapter 3; also Dylan Pritchard, Q.M.J., December 1942, pp.210-211. Richards, R., 'Nantlle and its Slate Quarries,' in Miscellaneous Poems and Pen & Ink Sketches, (Bangor 1868), pp.132-133, in referring to the immense sums that had to be expended on development before seeing a return, pointed out that investment funding was scarce locally because the agricultural economy was too poor to provide for the accumulation of wealth.

139. This was not untypical of the situation generally regarding landowners and commercial enterprises, especially in the case of the

minor squirearchy. There were, of course, important exceptions, of which the Penrhyn Estate in the Ogwen Valley was the most prominent.

140. John Griffiths (Sylwebydd), op.cit., p.46, although the alleged leasing of this quarry to William Turner in 1793 is unlikely to be correct (see Note 153, infra).

141. Dodd (1951), op.cit., p.310; Lindsay (1974), op.cit., p.76.

142. John Griffiths (*Sylwebydd*), op.cit., p.47; U.C.N.W., Bangor Ms/1232 (ii).

143. U.C.N.W., Porth yr Aur 29582; N.L.W., Rumsey Williams 1850-1861.

144. John Griffiths (*Sylwebydd*), op.cit., p.20.

145. Pigot's Trade Directory (1828), 'Carnarvon: slate.'

146. C.R.O., X/Dorothea 941; John Griffiths (*Sylwebydd*), op.cit., pp.17-18.

147. Ibid., p.22; C.R.O., G.P.Jones/Nantlle MSS (uncatalogued), annotated map of the Talysarn estate and its leaseholds, c.1900; private papers of the Robinson family seen by the author in 1971, but now believed lost.

148. G.P.Jones/Nantlle Mss, op.cit., 'John Robinson of Tal-y-sarn Hall,' (draft essay).

149. Ex.info., Mr W. H. Humphreys (Twll Llwyd sole proprietor 1963-1980s). The concern is now a partnership with his two sons.

150. John Griffiths (*Sylwebydd*), op.cit., pp.11, 52.

151. Ibid., pp.79, 86; W.Gilbert Williams, 'Y Tryfan,' Transactions of the Caernarfonshire Historical Society, Vol.2, (1940), p.68, re. John Griffiths (of Tryfan), whose mother was Anne Price of Wern, Llandegfan, possibly connected with John Price of the Cilgwyn Company (of 1800; see Note 125, supra).

152. U.C.N.W., Porth yr Aur 27277; Lindsay (1974), op.cit., p.75. Robert Evans seems to have had early connections with the Cloddfa'r Lôn Quarry before taking on one of the quarries at Ochr-y-Cilgwyn, having to give the latter up in 1805 upon threat of trespass action by the new Crown lessees. He might have been the same Robert Evans mentioned in connection with the opening of the Dorothea Quarry in the 1820s [U.C.N.W., Nantlle 1, f.31].

153. U.C.N.W., Nantlle Ms 19 (Penyrorsedd Quarry accounts, 1820s); John Griffiths (*Sylwebydd*), op.cit., pp.28-30, 46-47, 56-57; J.Lindsay (1974) op.cit., pp.44, 63, 78-82, 97, 100-101, 105, 109, 114, 121-122, 127-128, 140-141, 170, 187, 318-319, 328; Lewis & Williams (1987),

Pioneers of Ffestiniog Slate, op.cit., pp.9-11. Despite some uncertainty of his early activities possibly including a period in Ireland just before the 1798 rebellion, William Turner (1766-1853, born at Seathwaite, Cumberland) and some friends had in 1799 purchased the important Diffwys Quarry at Ffestiniog from under the noses of the Welsh (ex-Nantlle) lessees. By 1808 he was involved with the Penybryn Company at Nantlle and was making a separate fortune as a managing partner at Dinorwic, Llanberis. After the demise of the Penybryn concern in 1818 (or possibly in advance of this), Turner had commenced working the adjacent Penyrorsedd Quarry independently. Abandoning this by the late 1820s, he embarked on his last grand development at Nantlle in 1828-29 when he took over the fledgling Cloddfa'r Llyn, which was renamed Cloddfa Turner and finally to Dorothea Quarry. He continued in business at this latter quarry up to 1848. Several of his sons and grandsons followed him into the trade, and many were involved in the Nantlle area from the mid-nineteenth century to the first decade of the present one, but none was as successful or as outstanding a character as their father.

154. Thomas Edwards (1773-1841) of Llanllyfni, Ffestiniog and latterly of Taldrwst Llanllyfni, was for many years a quarry manager for William Turner (see Note 153, supra) at Diffwys Quarry (Ffestiniog) and at the Penybryn and Penyrorsedd quarries in Dyffryn Nantlle. Edwards was also a minor entrepreneur, involved in concerns working the Ty Mawr, Tynyweirglodd and Taldrwst quarries Nantlle [see Note 132, supra., and U.C.N.W., Nantlle Ms 1, notes on these named quarries] and was probably one of the partners in the first concern on the Dorothea Quarry site (with Robert Evans and another; see Note 152, supra).

155. George Bettis (of Caernarfon) was the estate agent for Glynllifon and he managed the estate quarries at Ffestiniog and Glynrhonwy. He became a partner in the Hafodlas Slate Company in 1812 to 1816 (see Note 129, supra) and was subsequently the proprietor of the Coedmadog Slate Quarry (John Griffiths (*Sylwebydd*), p.8, and a co-promoter of the Nantlle Railway (see Chapter 5, below).

156. U.C.N.W., Nantlle Ms 1, ff.21-22, 31-32, 46-49, 50-51, 54, 61; John Griffiths (*Sylwebydd*), op.cit., pp. 8-9, 56-57.

157. Ibid., pp.70-73.

158. Ibid., pp.10, 88; Lists of Quarries, appended to the Annual Reports of H.M.Inspectorate of Mines & Quarries, North Wales & Isle of Man, 1883-87.

159. John Horne Snr., and John Horne Jnr., individually worked and sold as speculative promotions, the Gwernor, Taldrwst and Ty Mawr quarries and served as managers for new occupants (Robert Williams, 'Hunangofiant Chwarelwr,' Cymru, XVIII, (105), Ebrill 1900, p.258; Slater's Trade Directory, [1850 and 1868], 'Carnarvon: slate;' Lewis (ed.,1987), The Slate Quarries of North Wales in 1873, op.cit., p.75; C.R.O., J.S.Wilkinson abstracts of P.R.O. files of defunct companies, BT31/2171/10121; H.M.I., Lists of Quarries, op.cit., 1883-90; C.R.O., X/Dorothea Mss 5, 1253, 1347, 1349; ex.info., Mr E.W.Jones, Plas Gwernor Nantlle, a descendant of John Horne.

160. William Hughes and others, held successive leases on the Tynyweirglodd Quarry from March 1830, June 1842 and May 1861 (Schedule of Deeds of Tynyweirglodd Quarry, per Mrs.A.Breen-Turner of Menai Bridge, seen by the author in 1971, but now believed lost), each of which were assigned to other parties [based on draft list of operators of the quarry, assembled from evidence in local history essays, see Note 1, supra., and Robert Williams, Cymru, XVIII, Chwefror 1900, pp.131-132].

161. Ex.info., former employees on tip contracts operated by Davies.

162. Ex.info., former employees on tip contracts operated by Hughes.

163. Ex.info., former employees of Davies & of Hughes, above. This ruse allowed the contractors without risk to employ men who also drew the "dole".

Joint-stock Companies

164. Ashton, T.S., The Industrial Revolution, op.cit., pp.97-98; H.A.Shannon (1931) op.cit., pp.359-361. Plumb, J.H., England in the Eighteenth Century (1714-1815, (Pelican, 1950), pp.26, 58-59.

165. Shannon, loc.cit.; Redford, A., The Economic History of England, 1760-1860, (London, 2nd ed. 1960), p.182; Dodd, A.H. (1951) The Industrial Revolution in North Wales, pp.312-313.

166. Lewis & Williams (1987), op.cit., p.21; Dodd (1951), op.cit., pp.215-216; Lindsay (1974), op.cit., pp.84, 87, although there is some confusion on this matter (see Lewis, review of Dr Lindsay's book in Transactions of the Caernarfonshire Historical Society, 1974, p.242).

167. Dodd (1951), loc.cit.; Lindsay (1974) loc.cit.; Lewis & Williams (1987), op.cit., p.22.; C.R.O., XD 8/2/210, letter dated 2 June 1825 and The Memoirs of Samuel Holland, Merioneth Historical & Record Society, Extra Publications Series 1, No.1, (1952), pp.11-12, both re. the rumoured prospective sale of the Talysarn Quarry; U.C.N.W., Porth

yr Aur 27714, re. John Evans' offer of his interest in the Cilgwyn Company to Rothchilds at £14,000.

168. C.R.O., XM/2350, 1-2; John Griffiths (*Sylwebydd*), op.cit., pp.20-21; copy from unidentified publication per Mr D.Clayton, of an advert offering shares in the 'Carnarvonshire Slate Company' in 1844. This concern, which never floated under this title (but see Note 174, infra), was for the Talysarn Quarry, and should not be confused with a company formed under this name to work the Tanrallt Quarry in 1853 [ibid., and Note 170, infra].

169. John Griffiths (*Sylwebydd*), op.cit., pp.47-49; N.L.W., Rumsey Williams Ms 2705.

170. C.R.O., J.S.Wilkinson, P.R.O. Abstracts, op.cit., BT/31/63/239, Carnarvonshire Slate Company (see also Note 168, supra).

171. John Griffiths (*Sylwebydd*), op.cit., pp.31-34; G.P.Jones (1980), 'The Dorothea Slate Quarry' (Thesis) op.cit., Chapter 1, passim; C.R.O., X/Dorothea Ms/1.

172. The Mining Company of Wales was formed in 1850 with a nominal capital of £120,000 to work a variety of slate quarries and metal mines, but had disappeared into oblivion by 1852, taking with it the investments of the unsuspecting shareholders [information per Dr M.J.T.Lewis; adverts for subscriptions in the Mining Journal, No.372, 3 August 1850]. For the story of the Company's brief involvement at the Tynyweirglodd Quarry, Nantlle, see Robert Williams, 'Hunangofiant Chwarelwr,V,' Cymru, XVIII, (105), Ebrill 1900. See also Notes 21, 22, supra., re. the promoters of the concern.

173. Redford (1960), op.cit., p.183; Shannon (1931), op.cit., pp.368-372.

174. The three Nantlle concerns registered under the 1844 Companies Act were the Moel Tryfan Slate Company, the Talysarn Slate Company (both in existence by June 1845) and the Carnarvonshire Slate Company (of 1853). The author is indebted to Mr J.S.Wilkinson for this information.

175. C.R.O.,X/Dorothea 5, ff.23, 37-38; ibid., Ms 912.

176. Fay, C.R., Great Britain from Adam Smith to the Present Day, (London, 5th ed.,1950), pp.315-318; Redford (1960), op.cit., pp.183-184; Shannon (1931), op.cit., pp.372-379; Westby-Nunn, E. & Taylor, E.M., The Principles of Company Law, (London 1930), pp.2-3, and passim.

177. Shannon (1931), op.cit., pp.385-388, in which the quote from the Royal Commission on the Depression condemning "....promoters whose

interests lies [sic] rather in the creation of an industrial undertaking and the speedy sale of its shares at a premium than in its permanent prosperity," is very pertinent. See also Note 19, supra.

178. Analysis by the author of data in C.R.O., J.S.Wilkinson's abstracts of P.R.O. files of defunct companies, op.cit.

179. See Notes 68, 70, supra.

180. See Notes 65, 66, 68, 71, supra.

181. Analysis by the author of data in J.S.Wilkinson's abstracts of P.R.O. files of defunct companies, op.cit. Unlimited companies were in general going out of favour by the 1880s, especially after the spectacular crash of the unlimited City of Glasgow Bank in 1885 (see H.A.Shannon, 'The Limited Companies of 1866-83,' Economic History Review, IV, (1933), 13, in E.M.Carus-Wilson (ed.), Essays in Economic History, Vol.I, (London 1954), pp.388-390).

182. Dylan Pritchard, Q.M.J., February 1943, op.cit., p.298; idem., Q.M.J., March 1943, op.cit., pp.318-319. For an appreciation of the national context regarding limited liability companies, see H.A.Shannon (1933) in E.M.Carus-Wilson (ed.), op.cit., pp.380-405.

183. Analysis by the author of data in J.S.Wilkinson's abstracts of P.R.O. files of defunct companies, op.cit. This growth trend mirrors that nationally [see Shannon (1933), op.cit., p.380].

184. Analysis of J.S.Wilkinson, P.R.O. abstracts, op.cit.; Shannon (1933), op.cit., pp.383-388 and Tables A, B and C, pp.396-401, shows the same trend nationally for public companies, but see Note 196 infra., regarding private companies.

185. Analysis of J.S.Wilkinson, P.R.O. abstracts, op.cit.; Shannon (1933), op.cit., p.384 also noted a national trend towards company amalgamations and reconstructions in the late 1880s and the 1890s.

186. C.R.O., X/Dorothea 5, ff.37-38.

187. C.R.O., J.S.Wilkinson, P.R.O. abstracts, op.cit., BT31/63/239.

188. The Penyrorsedd Slate Quarry Co. Ltd., (of 1863-1979) was an unlimited joint-stock company for about a year before its registration under the 1862 Companies Act [C.R.O., X/Penyrorsedd.addit 1873]).

189. The Cilgwyn Slate Quarry Co. Ltd., of 1896-1918 [Wilkinson P.R.O. abstracts, op.cit., BT31/15696/50201] was a registration of an

unlimited joint-stock company having its origins in a formal partnership of 1849.

190. The Talysarn Slate Quarries Ltd., of 1904-1925 [Wilkinson, P.R.O. op.cit., BT31/17287/81836] was previously a sole proprietorship formed by John Robinson (see Note 19, supra.), and inherited in 1900 by his son, Thomas Robinson (d.1905).

191. The South Dorothea Slate Quarry Co. Ltd. of 1907-1922 [ref. Skinners's Mining Manual, 1909, per J.S.Wilkinson], was a registration of an unlimited joint-stock company dating from *c.*1880.

192. C.R.O., J.S.Wilkinson, P.R.O. abstracts, op.cit.

193. Ibid.

194. Ibid.

195. Ibid. The trend in share par-values correlates with the national trend, described by Shannon (1933), op.cit., p.389; and Jeffreys, J.B., 'The Denomination and Character of Shares 1855-1885,' Economic History Review, XVI, (1946), 1, in E.M.Carus-Wilson (ed., 1954), Essays in Economic History, Vol.I, op.cit., pp.344-357.

196. C.R.O., Wilkinson P.R.O. abstracts, op.cit. See discussion of private limited liability companies in Shannon (1933) op.cit., pp.380-382.

197. Fay (1950), op.cit., pp.315-318; Westby-Nunn & Taylor (1930), op.cit., p.9.

198. Annual Return of the Cocklebank Conservations Ltd., (Company No.409873) for 1988, per Companies House, Cardiff.

(c). Profitability

199. The samples of balance sheets for Nantlle are limited to the Crown Quarries for 1932-1963 [C.R.O., G.P.Jones/Nantlle Mss (uncatalogued) Caernarvonshire Crown Slate Quarry Co. Ltd. files]; the Dorothea Quarry for 1860-1968 [C.R.O., X/Dorothea Ms/5, ff.187-199, Mss 20, 21] and the Penyrorsedd Quarry for 1863-1978 [C.R.O., X/Penyrorsedd Addit.1873, 1875 and G.P.Jones/Nantlle Mss, Penyrorsedd Slate Quarry Co. Ltd., File 3.2] in a long term, and to the Fron Quarry in the 1880s [C.R.O., XM 1758.addit 3-19] and Talysarn Quarry in 1868-72 [C.R.O., G.P.Jones/Nantlle MSS, British Slate Co. Ltd., reports] for short runs of accounts.

200. See Bibliography.

201. See Davies, D.C., Slate and Slate Quarrying, (London 3rd ed.1887), Chapter XII; Dylan Pritchard, Q.M.J., February 1943, op.cit., p.297,

gives the example of the debacle of the enormous expenditure at the futile Gorseddau Quarry as the most prominent example of a lack of knowledge on the part of the proprietors, but many other financial disasters based on a want of basic prospecting occurred on a smaller scale throughout the industry.

202. Davies, op.cit., pp.81-84, re. leases. An example of staged terms was the lease of the Penybryn Quarry to the Dorothea Company, signed in December 1895 (C.R.O., X/Dorothea 2), which had a royalty of 2*s*.6*d*. (12½p.) per ton on best slates, 2*s*. (10p.) on seconds and inferiors, and 1*s*. (5p.) on moss slates and blocks, merging into a dead rent of zero in the first year, £100 in year 2, £200 in years 3 and 4, £300 in years 5 to 9, and £400 for the subsequent forty years. Whereas this sliding scale assisted the Company to invest in the early period on development work, the increased payments became a burden when geological problems created a continued requirement for high expenditure at a later date.

203. Ibid., Ms 1350, where the landlord threatened a forfeiture of the lease because the requirement of a minimum workforce of 50 men at Penybryn (see Note 202, supra) could not be fulfilled.

204. C.R.O., XM 669/2, table of royalties c.1907; Slate Trade Gazette, March 1930, reporting that Goronwy Owen M.P., (Caernarfonshire) had asked a Commons question regarding reducing the Crown royalties in Nantlle due to the very high unemployment caused by the closure of the Amalgamated Slate Company's quarries, but was told that this was a matter for the applicants concerned. See also Note 107, supra.

205. Analysis of C.R.O., J.S.Wilkinson P.R.O. abstracts, op.cit. The rate of 'abortive companies' in the slate trade at Nantlle was well below the national average of all registrations (Shannon, 1933, op.cit., p.382), thus illustrating the degree of popularity of the slate industry amongst investors.

206. Few development plans exist for the quarries, and it is likely that in many cases none was ever drawn up formally. An interesting case-study is the development of the New Penybryn Quarry by the Dorothea Company, post-1897, where John Evans' original estimates dated 19 January 1898 [C.R.O., X/Dorothea 1254] for a £5,000 development scheme had been increased to £22,000 by his successor, report dated 30 June 1904 [ibid., Ms 983).

207. D.C.Davies (1887), op.cit., pp.146-148, cites average figures for the nett profit per ton in the 1870s as only just over £1, a third of the market value. Thus, volume sales were required to repay the costs of developing the quarry to a state of production. In the period

after the end of the great boom in 1878, diminishing market prices squeezed profit margins in the face of increasing production costs resulting from the progressive deepening of the pits at Nantlle and the working-out of the best slate.

208. E.g., at the Dorothea Quarry, see C.R.O., X/Dorothea 5, passim for a diary of such events from the 1880s.

209. Lindsay (1974), op.cit., p.69. There is no evidence of any royalty payments for mineral extraction on the Crown lands at Nantlle pre-1800.

210. Ibid., p.68; U.C.N.W. Porth yr Aur 27208, 27264.

211. John Griffiths (*Sylwebydd*), op.cit., p.20.

212. E.g., C.R.O., X/Poole 3071, letter dated 18 July 1803, referring to the method of letting "Humphreys Quarry" (that is, Cloddfa'r Coed, Nantlle) by auction for a term of six to seven years.

213. Lindsay (1974), op.cit., p.98.

214. Dylan Pritchard, Q.M.J., December 1942, op.cit., pp.211-213; U.C.N.W., Porth yr Aur 27488, 27472.

215. John Griffiths (*Sylwebydd*), op.cit., p.73.

216. C.R.O., XM 2350/1-2.

217. John Griffiths (*Sylwebydd*), op.cit., pp.93-95.

218. Ibid., pp.29-30.

219. Dylan Pritchard, Q.M.J., December 1942, op.cit., p.210; idem., Q.M.J., January 1943, op.cit., pp.254-255.

220. C.R.O., X/Dorothea 5, ff.187-199.

221. References to the technical problems of the individual quarries can be found in local history essays [see Note 1, supra., and C.R.O., XM 4874/47], dating from the 1870s and 1880s. Although these problems were recognised, little could be done to avoid them because of financial constraints and the fixed pattern of land ownership.

222. Dylan Pritchard, Q.M.J., February 1943, op.cit., p.297. It was also noted that only four out of fifteen concerns at Ffestiniog were allegedly profitable.

223. C.R.O., Penyrorsedd.addit Mss 1873, 1875, minute books.

224. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), reports of the British Slate Company Ltd., per Dr W.Slatcher and Dr David Gwyn.

225. C.R.O., XM 4874/47, pp.9-11.

226. Local history essays, see Note 1, supra; C.R.O., J.S.Wilkinson abstracts of P.R.O. files, op.cit.

227. Dylan Pritchard, Q.M.J., March 1943, op.cit., pp.321-322.

228. This trend was also to be found across the industry, see Pritchard, Q.M.J., April 1943, op.cit., pp.377-380.

229. U.C.N.W., Arts Library, f.KF47, First Report of the Royal Commission on Metalliferous Mines and Quarries 1910, (H.M.S.O., 1912), minutes of evidence given by Arthur William Kay Menzies on 7 December 1910, pp.214-223. See also Note 188, Chapter 3, infra.

230. Ibid., Questions 7354-7404, pp.217-218.

231. C.R.O., X/Dorothea 20; C.R.O., X/Penyrorsedd.addit 1875.

232. Ibid; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Caernarvonshire Crown Slate Quarries Co. Ltd., files; ex.info., Mr Stephen Darbishire (Penyrorsedd Quarry), Mr Walter Riley (Crown Quarries), Mr M. J. B. Wynne-Williams (Dorothea Quarry).

233. Ibid.

234. This is assumed on the basis of the current price of slates, the rate of sales as witnessed by the author, and an estimate of the production costs. No official data is available because of the policy of maintaining confidentiality amongst the commercial undertakings involved.

235. This issue has been commented upon by various writers on the history of the industry in this locality since the 1870s (see Note 1, supra), but without result because of the commercial pressures maintaining the *status quo* until the decline of the quarries was too far advanced for a major revival to be possible.

CHAPTER 3

PRODUCTION METHODS

This chapter deals with the development of methods of production in the Nantlle quarries. The discussion analyses the changing working practices of the industry so as to provide an insight into the methods of quarrying at various stages in the development of the industry in this district. The first sub-section (Part a) discusses the issue of site development from the viewpoint of the quarry owners and managers, whereas the perspective of the quarrymen extracting and processing the slate is reserved for the succeeding sub-section (Part b). The third sub-section (Part c) deals with changes in pay systems and the consequential effect upon the production of slates.

(a). The whole-quarry overview

A potential quarry proprietor wishing to commence operations at any new site had to make a number of important decisions at the onset of working. Of these, the most important was an analysis of the prospects for the return of any capital expenditure, plus a working profit, within a reasonable time-scale. This was no easy matter, with several of the factors being variable or incalculable, -particularly the future demand for the product and the economic value of the slate lying in the ground. Furthermore, the likely fixed costs of operating the quarry had to be borne in mind, notwithstanding the cost of bringing a virgin site up to the initial productive stage. If a long-term view was taken, then the future increases in working costs when the quarry approached maturity, followed by the effect of the law of diminishing returns, might also be taken into consideration even at an early stage.

The synopsis above refers to an ideal and therefore theoretical situation. It seems likely that little forward planning was undertaken in the quarries of Nantlle except at a limited number of sites. In most cases, operations were undertaken on an *ad hoc* basis, particularly during the golden years of the slate trade during the middle decades of the nineteenth century. In many cases, it is almost certain that there was no clear plan of development, due to the purely speculative nature of the venture. Furthermore, it is likely that some of the less honest promotions were worked in a reckless manner with the sole purpose of diving headlong into financial disaster, so as to expedite the commencement of the next speculative cycle [1].

With hindsight it might be argued that none of the most marginal concerns in the Nantlle district (or elsewhere) should ever have been opened. Furthermore, it is certain that the hundreds of thousands of pounds wasted upon such sites would have been more productively employed in the more efficient development of the better quality sites. Unfortunately, the closed partnerships or private companies characteristic of the best quarries were not generally enthusiastic about the input of public investment due to the preference of the existing shareholders to restrict the numbers of investors, thus maximising the individual sums received upon the distribution of dividends (see Chapter 2).

The methods of acquiring a quarrying site were restricted within the conventions of the day. In general, the first stage was a geological survey of the ground. On virgin sites this was more difficult than in the case of an existing quarry where the structure of the rock was easier to determine. Often the survey was carried out by a 'knowledgeable person' of local origin; these were either one of a band of acknowledged expert quarrymen or the managers of successful quarries. The same names were commonly found on the reports accompanying the prospectuses of a number of quarries in the district, and it was an invariable expectation that such reports made on behalf of a lease-vendor were to be up-beat and highly optimistic. This was a true picture of a number of sites at Nantlle, but several extant reports by eminent local persons showed a disregard for accuracy which cannot have been accidental nor attributable to a lack of knowledge [2].

Not all optimistic reports that eventually proved inaccurate were due to fraudulent intent. In defence of these Victorian geologists, it must be noted that an understanding of earth-moving processes and structures was only developing in academic circles by the 1850s. Simultaneously there was an increasing development of understanding of the structure of the slate and mineral-bearing strata amongst the class of highly-skilled workers and the lower locally-based echelons of management. These two largely independent strands finally converged sometime around the 1870s-80s, when there was the first real understanding of the relation of the economically-important characteristics of slate to the overall geological structure and processes. Notwithstanding this progress, the exceedingly complex geological structure of the Nantlle district defied accurate description until the definitive version was produced by Morris & Fearnsides in 1927 [3].

In the earliest times, the identification of potential sites for quarrying for slate must have been solely dependent upon rock exposures. These were particularly common on the northern slopes of the valley, especially in the area which encompassed Ochr-y-Cilgwyn. Allied to the essential role of frost-weathering in the pre-splitting of sheets of slate in the 'primitive' production process, these circumstances must have been important in the establishment of the early industry that was concentrated at Ochr-y-Cilgwyn. An additional factor must have been the special characteristic of the slate in the northern of the two striped-blue slate beds to split from the sides as well as down the 'grain'; this would have made this material easier to work successfully under the constraints of the techniques available to the early quarrymen. Such a hit-or-miss system of prospecting had obvious limitations, particularly down on the valley floor where the underlying rock was often thickly covered by surface deposits. Thus these locations tended to be developed at a later date, although the correlation between early sites and the northern blue vein still held true; the purple and southern blue beds appear to have been developed later, probably when quarrying techniques had improved [4].

The first hints of slate quarrying sites being chosen at Nantlle on the basis of an evaluation of geological evidence came in the early nineteenth century. According to historical accounts related at a much later date, the opening of three major quarries between c.1810-c.1825 was based upon the theoretical projection of the course of the slate formation from contemporary workings into virgin ground [5]. This required an understanding of the concept of the slate lying in beds (or 'veins') which ran in a general fixed direction. This was not obvious from the fragmented structure of the main ground then being quarried, and it must be significant that the entrepreneurs involved both had prior experience of quarrying in the Ffestiniog district, where the stratigraphy of the rocks was clearly to be seen [6].

Assuming that the prospects for the potential site based on informal (and preferably secret) investigations was satisfactory, the next stage was to secure the working rights to the ground. If this was a virgin or dormant site, then the first stage was most commonly to obtain a short-term convertible licence (or 'take-note') from the landowner; this laid the claim to the ground with minimal risk to either party and kept competitors at bay. Take-notes were usually for terms of one to three years, returning a flat dead-rent to the landlord but reserving the option for a full lease upon pre-negotiated terms, and preferably including powers for assignment to a third party [7]. This last facility was essential for a particular class of local entrepreneurs who made a living from developing new sites under take-note powers and selling the proto-quarry either to a prospective proprietor or to a second speculator/promoter. This was a very important route for attracting capital investment into the local industry upon a scale above that possible from purely local sources, and was particularly prevalent in the century after c.1810 (see Chapter 2).

If the first stages outlined above proceeded satisfactorily, the next hurdle was the full lease. Relatively few quarries at Nantlle were ever held by proprietors on a freehold basis, and in this, the area was typical of the region as a whole. Each individual lease differed in detail, but all were based upon a number of almost standard features [8]. The lease term varied from around twenty to sixty years, and included an option of renewal within the last few years and a termination 'escape' clause after the first five or so years; powers to assign were included, but generally requiring prior permission from the lessor perhaps involving the payment of a fine for the privilege. There was nearly always a complex system of payments (see Chapter 2, sub-section c), being based upon a dead-rent which merged into a scale of royalties charged upon production or sales, with both being either fixed or increasing on a sliding scale.

Additional clauses sometimes regulated the way that the site was worked, particularly in restricting the areas to be designated as tipping sites; setting minimum annual expenditure rates on development work; and stipulating minimum workforce levels. The provision of water-rights and access way-leaves were very important, although sometimes worded ambiguously, subsequently causing difficulties with neighbouring parties. Finally, there was a miscellany of special clauses involving compensation for ground tenants, provisions for restricting the demolition of buildings or removing plant upon determining the lease, and penal clauses for transgressions on the part of the lessee [9].

Development methods

The method adopted to develop a productive quarry from virgin ground was dependent upon a number of factors, of which geology and topography were especially important.

The topography of the Nantlle exhibits classic post-glacial features (see Figure 1, p.4a). The main valley runs due east-west at an average altitude of 450 feet above sea level, and is a linear U-shaped trough bounded by relatively steep slopes cut into an older plateau rising to around the 1,000 foot contour. There are a number of foothills rising just above this plateau, of which Mynydd-y-Cilgwyn and Moel Tryfan are the most important on the north, complemented by Y Foel to the south-west. The southern boundary of the district is delineated by a range of mountains known collectively as the Nantlle Ridge, whereas Mynydd Mawr is the sole portion of ground reaching just over 2,000 feet to the north. The eastern end of the valley is a narrow, dark place occupied by copper mines; the quarries lie some two miles to the west from these upper reaches. Beyond the area of workings, which cross the valley in a band no more than one mile wide, the hills are left behind and the flat valley floor tumbles down to the narrow coastal plain in a relatively steep scarp [10].

Within this geographical area there were only three main types of topography that had a significance to slate quarrying, namely flat ground on the valley floor and on the ancient northern plateau; the north and south-facing steep valley sides; and the slopes of the three foothills named above. Each of these three topographical types imposed certain constraints upon quarry proprietors and dictated the methodology of proceeding with slate extraction. On any sloping ground, simple low-cost outcrop workings could initially be undertaken, and it is not surprising that all of the quarries claimed to have had early beginnings were located on such sites.

Conversely, on flat ground there was no option other than the excavation of open-cast pits from the outset; in general these appear to have been later workings than the previous type. However, it is important to qualify this simple categorisation by noting that this referred only to the first phase of development and that changes in the methods of working after the mid-nineteenth century complicated the pattern.

Nearly all of the slate quarries at Nantlle were opened in the Cambrian series of rocks, with only a few unsuccessful trials being conducted from time to time in the lower Ordovician slate bed found along the southern margin of the district (see Figure 5, below) [11]. The main working area constituted a four mile belt running from near Llanllyfni in a north-eastern direction across the valley and up along the flanks of Ochr-y-Cilgwyn, and towards Moel Tryfan and Cors-y-bryniau before plunging into the Gwyrfai Valley below. However, it is evident from the abandoned trial quarries at the south-western sector of the district, in the neighbourhood of the village of Clynnog, that not all of the Cambrian deposits were found to be economically workable [12].

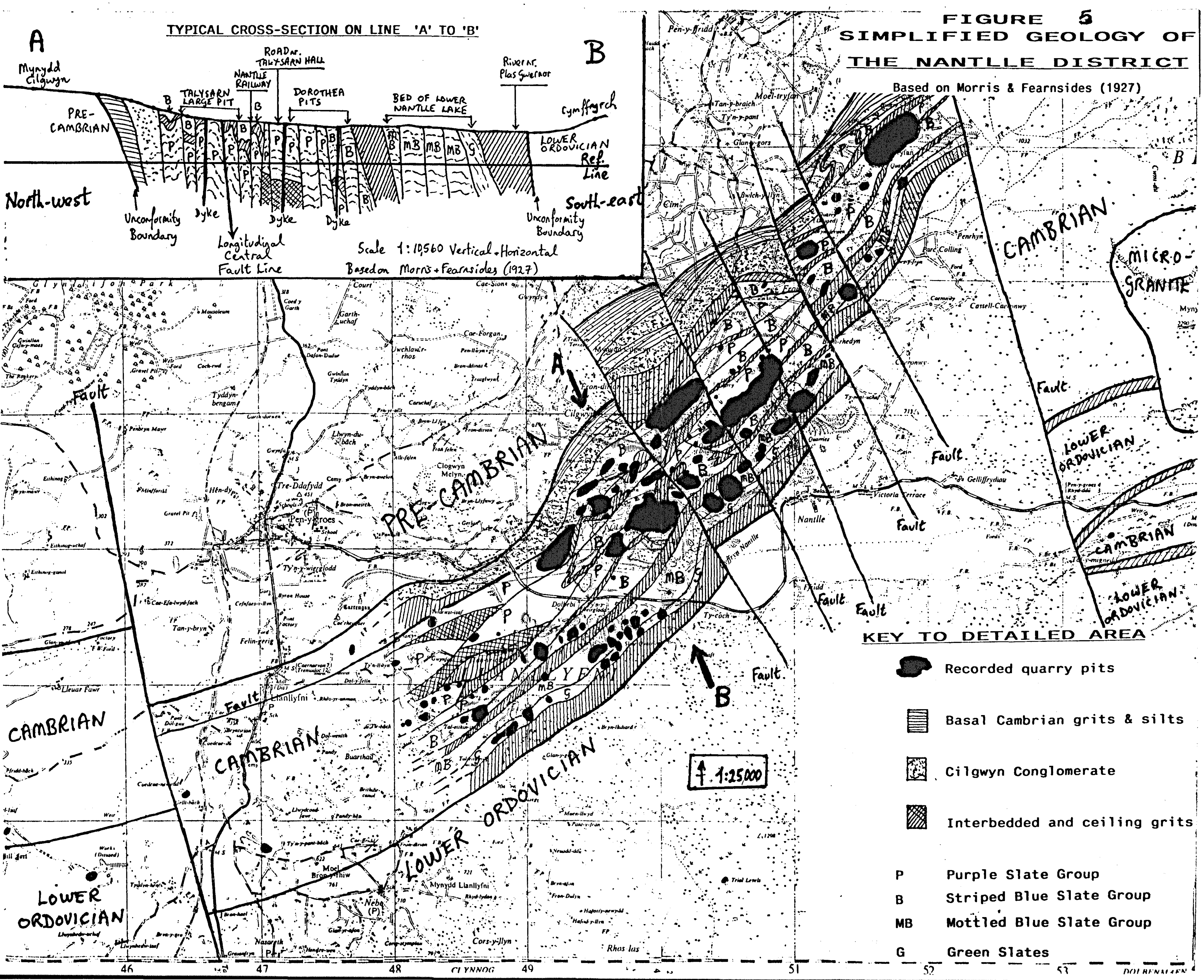


FIGURE 5
SIMPLIFIED GEOLOGY OF THE NANTLLE DISTRICT

TABLE 16

LIST OF SUB-VEINS IN THE CAMBRIAN SLATE BEDS AT NANTLLE

GROUP (Ascending Order)	THICKNESS		SUB-VEINS IN SLATE BEDS
[Base Pre-Cambrian Strata]			-
Tryfan Grit Group ...	900ft		-
Cilgwyn Conglomerate	500ft		-
Glog Grit Group ...	2,000ft		-
Purple Slates	800ft	Lower:	Green Bed (*Llwyd Garw*)
Gwely Coch			New Bed (*Llygad Newydd*)
			Lower Stripes (*Llygad Gwythiennog*)
			Slight Purple (*Glas-goch*)
		Upper:	Spotted Red (*Llygad Goch Ysmotiog*)
			Upper Stripes (a) (*Llygad Brith Goch*)
			(b) (*Llygad Brith Las*)
Dorothea Grit Group .	100ft		-
Striped Blue Slates .	600ft	Lower:	Lower Stripes (*Gwythiennog Isaf*)
Gwely Glas Gwythiennog			Greenish slate (*Llygad Llwyd*)
		Middle:	Great Bed (*Llygad Mawr*)
		Upper:	Stripes (*Llygad Gwythiennog Uchaf*)
Penybryn Grit Group .	200ft		includes *Llygad Llwyd Caled*, semi-slate
Mottled Blue Slates .	600ft	Lower:	Mottled Blue (*Glas Ysnodennog*)
Gwely Llwyd-las Ysnodennog		Middle:	Thin Green bed (*Bastard*)
		Upper:	Silky Red (*Llygad Sidan Coch*)
Green Slates	300ft	Lower:	Green (Apple green colour)
Gwely Llwyd		Middle:	Slight Green (Bluish-green colour)
		Upper:	Khaki (Brown-grey colour)
Cymffyrch Grit Group	600ft		-
Lower Ordovician beds	dark-grey slates		
	thin pale green-grey slates		

Total thickness of the slate-belt from the base of the purple slate to the base of the Cymffyrch Grits is about 2,600 ft., varying in individual beds in different locations.

Ref: Morris & Fearnsides (1927), pp.256-263.

The slate beds are at their maximum width of about a mile when crossing the valley floor, but become increasingly narrower to the north-east and south-west. The depth of the slate has never been ascertained with any degree of confidence, although it has been worked down to about five hundred feet below the valley floor at the Dorothea Quarry.

The general form of the Cambrian slate belt at Nantlle described above, belies the true complexity of the geological structure. There were four main beds generally known as the purple; striped-blue; mottled-blue; and green, which were themselves sub-divided into sub-beds (termed *llygaid*) exhibiting significant variations in colour and other physical characteristics (see Table 16, above). To further complicate matters, the character of each bed and sub-bed varied from place to place, depending upon the degree of compression suffered by individual portions during the primaeval earth-moving processes and of the precise chemical constitution of each patch of original mud [13].

Furthermore, the gross geological structure of Nantlle was highly irregular, being possibly the most disturbed of all the slate-producing areas. Originally the mud deposits had been laid in horizontal layers upon the basement of Pre-Cambrian rocks, but when under the influence of the massive earth-movements which reshaped the land some 500 million years ago, the whole mass was tipped on its side. The material metamorphosed into slate under the influence of this massive compressive force, but it was also further distorted and faulted as a result of a second set of tectonic movements [14].

The resulting structure was one of a confused fragmentation, showing the original stratigraphy only at the extreme northern and southern sectors of the district. In the centre portion, where the major slate workings were to be opened, the rock was disrupted by major and minor fault-lines, with one longitudinal fault causing the duplication of the strata over a significant length of ground. This was economically important in that it uplifted a portion of the slate that might otherwise have been too deeply buried in the ground to have been economically worked.

This doubling also increased the surface area available for opening additional quarries. The original horizontal bedding was contorted into a pattern of folds ranging from an inch tall to a hundred feet high, although the new cleavage of the slate ran nearly universally in a near-vertical direction, cutting through all the remnants of the original structures. Such was the magnitude of the earth forces that coarser inter-bedded deposits became changed into hard grits which were subsequently expelled out from below ground to overlie the surface in a massive arched configuration [15].

These convulsions in the genesis of the slate rock had immense significance for the quarry proprietors of the recent past. The fragmentation of the strata made the prospects of striking a body of slate of the best economic quality a hit-or-miss affair. There was no guarantee on the one hand, that poorer material was no further than one shot-hole away, but on the other hand, the chances of uncovering good rock was equally as high. Consequently, the early proprietors followed the visible sign-post provided by rock exposures, and worked in pockets of good rock [16]. Once these were worked out, and where the constraints of sett boundaries confined quarrying operations more closely by the mid-nineteenth century, the later generations of quarry proprietors had often to contend with the more difficult rock left behind by their more fortunate fore-fathers.

In such circumstances the empirical methods of the skilled quarrymen based on experience, were probably more reliable than the then-unsophisticated geological theories held by mining engineers. It was in this context that the local theory (paraphrased and directly translated) that "a quarry won't work in English" arose during the 1860s, due to a clash between these two differing and mutually antagonistic forms of expertise [17].

Notwithstanding the turmoil of the rock structures at Nantlle which created great difficulties in obtaining the raw slate rock, there remained the consideration of the role of the fine structure of the material in the final analysis of its economic value. The production of the standard roofing slate resulted in the wastage of ninety per cent of the total bulk of material excavated from the rock-face when the quarry was a very good one. In a poor quarry the net percentage yield decreased dramatically, with the break-even point varying depending upon a complex interplay of economic conditions [18].

The reason for this seemingly impossible figure was one of the narrow criteria surrounding the characteristics of a marketable product. By the mid-nineteenth century the roofing slate had to conform to certain specifications of thickness, colour and prescribed ratios of length-to-breadth [19]. Material not conforming to these rules was occasionally saleable, either on special applications or during the so-called "slate famine" due to over-demand in the period c.1850-1877 (see Chapter 1). During periods of great depression in the trade, the criteria frequently became more restrictive in a buyer's market, and previously useable material had to be thrown away as waste due to the presence of features such as green stripes or spots [20].

Only certain pockets of rock at Nantlle produced large-sized slates of the very highest quality. These included the famed blood-red 'veins' of Cilgwyn, Blaen Cae and the south side of Talysarn Quarry; the pale Cloddfa'r Lôn 'vein'; and the purple bed at Alexandra, Dorothea and Penyrorsedd (see Table 16, above) [21]. For the most part, the quality of the rock at the majority of less important quarries was not as good as in those named above, had these concerns had to survive on the 'bread-and-butter' grades known as 'second-best' and 'seconds' [22]. The latter's problems would have been compounded by the common problem of not being able to produce the more remunerative larger slates due to the natural joints being closer in shallower workings.

The green slate was not typical of the remainder due to phases of architectural fashions. This material could not be split as thinly as the blue or purple slates, but produced a highly attractive (albeit very heavy) roof. Unfortunately not all of the green 'veins' were resistant to weathering and some slates tended to oxidise to an unpleasant rusty-brown colour. Thus the green slates experienced occasions when it commanded a premium price, but at other times it was virtually unsaleable [23].

Quarrying systems

There is no technical description available for the earliest methods of quarrying slate at Nantlle, although it is possible to guess its probable methodology from a number of clues found in documentary evidence and from one contemporary pictorial source [24]. It is almost certain that there was a direct correlation between the earliest sites of quarrying at Nantlle and that of rock outcrops on steep slopes. This in turn points towards a simple form of quarry which involved cutting a single working face along the hillside and working progressively inwards until arrested by such factors as instability of the cliff or its excessive height for convenient working. Debris was likely to have been tipped directly over the side of the slope, being directed towards one particular location if the workings were conducted in an orderly fashion, or deposited randomly if this was not the case [25].

Deeper rock was most easily removed by means of a second cut commenced below the floor of the original quarry, with these successive floors being opened until some limit was reached. Such limits may have included the reaching of a flat area of ground, debris recklessly deposited over the ground from higher workings in earlier years, or the uncovering a fore-breast of hard gritty rock interbedded with the slate. When the last circumstance (above) was the case, there were a number of options available to the early quarry operators. The driving of an open cutting through such a fore-breast was a likely choice in the first instance, with the new floor of the quarry being opened out in the form of an enclosed bowl. By this method, direct haulage (by men or animals) was maintained to the working face and any water inflow could be directed out of the workings by gravity [26].

The limit to the situation discussed above, came about due to the general rule that the grit fore-breasts tended to increase in thickness with increasing depth, and it was therefore almost inevitable that access to a second depth had to be by tunnel rather than a cutting, with each successive tunnel being longer and more expensive to excavate [27]. In general, the accessing of deeper rock reserves by means of long tunnels, which served both as haulage routes and for drainage purpose, was only feasible where the operator had sufficient funds to cover the costs of the mining work. The implications of heavy and unrecoverable capital expenditure and the length of time required to drive the tunnels for reducing the profitability of concerns in the short term were therefore limiting factors on the use of tunnels to develop the quarries at Nantlle [28].

Only in the case of the more prosperous proprietors on a number of sites having suitable topography was this trend reversed, albeit with variable results. In the case of the Penyrorsedd Quarry in the 1860s, the carefully-planned driving of a series of tunnels at successive depths greatly enhanced the cost-effective development of the site. This was in direct contrast to the reckless tunnelling on the Moeltryfan Crown sett in the 1830s, which resulted in the loss of a large investment with virtually no returns [29].

The cost implications of tunnelling to gain access to the deeper rock were therefore likely to promote the adoption of alternative strategies involving the development of up-haulage and pumping systems, described in Chapter 4. This in turn determined the way in which the quarries were subsequently worked, namely the quarrying method known as "sinking". This entailed in the first instance, the digging of a shaft near the centre of the first working floor of the quarry, then opening the former out radially into a mini-pit (or 'sink') after attaining a convenient depth of around sixty or seventy feet. The new 'sink' then became a new quarry within the original workings, and once sufficiently large in its surface area it could itself give birth to a second sinking, whereby a deep open-cast quarry eventually developed [30].

The most productive quarries at Nantlle had developed into pits of sufficient depth to impress the visitor even by the dawn of the nineteenth century. The Cilgwyn Quarry was described in 1798 and 1801, for instance, as being of a significant scale on a regional basis [31] and it was claimed (tongue-in-cheek) that Cloddfa'r Coed Quarry was sufficiently deep by the 1820s to allow an observer standing on its lowest floor to see the stars at mid-day ! [32]

By the last quarter of the nineteenth century, the frenzied quarrying during the 'golden era' of the 1860s and 1870s had resulted in the largest of the opencast pits achieving depths of nearly four hundred feet, and the removal of the maximum amount of workable slate had resulted in these workings having sheer cliff sides. This transformation was severely criticized by one contemporary analyst of the industry [33] on the dual grounds of the damage caused to the workable blocks prised from a high rock face falling a considerable distance to the bottom, and that material originating from perhaps just below the quarry lip had by this method of working to be raised the full height from the pit bottom, at the cost of additional fuel and wasted time.

A spate of serious landslides during the 1890s and early 1900s from unsupported, unstable rock faces in the major workings at Nantlle (see below) heralded the introduction of gallery working in this district, in the pattern of the Penrhyn Quarry. In the case of existing pits, it was often not possible to revert from the discredited full-face system for practical reasons, but galleries could be conveniently created in the most recent workings, served by the new blondin cableway haulage system, which better matched the different technological requirements than did the existing chain-inclines (see Chapter 4) [34].

The progressive introduction of heavy excavating plant into the quarries after the 1960s (see Chapter 4) had also an impact upon the organisation of the pits. The use of 'back-acting' hydraulic shovels dictated the maximum height of working faces to a limit not exceeding the reach of the machine's boom, thus creating a system of shallow benches reminiscent of the working systems used in the eighteenth century [35].

Whereas the open-cast quarry was the characteristic type of slate working found at Nantlle, there is also evidence of attempts at underground mining in this district. The main reason leading to the adoption of this method appears to have been the presence of massive grit bodies overlaying slate of excellent quality, although the wish to exploit reserves buried under huge waste tips may have been important in some locations.

The problems encountered when folded gritstone was uncovered bore heavily on the resources and ingenuity of the quarry proprietors. The structure of these deposits was usually massive, with a thick 'head' of contorted strata capping a section of purple slate before plunging vertically with decreasing thickness before pet ering out completely several hundred feet below [36]. This was a very awkward structure to deal with, entailing the removal of a very large quantity of material near the surface so as to unlock the slate deposit beneath. It was therefore not surprising to find that several proprietors had initiated the practice of a controlled undermining of these grit bodies through semi-underground working as early as the 1860s, a method which persisted in the case of the Blaen Cae Quarry until its closure in 1924 [37].

The practice of undercutting this grit was not unreasonable assuming that sufficient support was left to hold up the very thick and heavy roof, but the likely lack of experience at Nantlle of underground techniques was probably the reason for a number of landslides which took place in several quarries where semi-underground working is thought to have taken place. The most spectacular examples of the wholesale collapse of weakened grit bodies occurred thrice at the Faengoch pit, Cilgwyn Quarry between 1863 and 1878, and once on an enormous scale at the Talysarn Quarry in 1894 [38].

Documented references to the classic Ffestiniog-style underground working at Nantlle are rare, but there are records of three schemes, none of which were implemented, to undertake full-scale sub-terranean exploitation. This was considered as an option to access important slate reserves which were considered unprofitable to exploit by conventional open-cast methods at the Penyrorsedd green pit in the 1870s and at the Cilgwyn and Alexandra quarries in 1920 and 1931 respectively [39]. There were also a number of individual (and now-inaccessible) underground chambers of unknown vintage referred to in documentation or recalled by former quarrymen. However, it appears that none was particularly large and all were probably abandoned in the trial stage [40].

Quarrying problems

Each individual site in the Nantlle district had a number of advantages and disadvantages associated with its location; the extent of its leasehold boundaries; or with its geology. It is not possible to engage in a detailed appraisal of each site, but the difficulties encountered were probably more significant than the less numerous advantages of the majority of sites, and the former can conveniently be summarised in four main groups for individual discussion.

(i). Economics

D.C.Davies produced in 1878 a series of costings for developing a productive slate quarry in a variety of differing locations corresponding to the four main types of working methods [41]. The data conclusively showed that the Nantlle-type open-cast pit was significantly more expensive to set up from virgin ground to a base production level than the other types of quarries. This could be attributed to the higher costs of uncovering workable slate over an area of level ground compared with opening galleries on slopes or mining. This conclusion is based on the overall costings of both the initial development period plus the standard fixed costs of production. Whereas both deep pits and mines were more expensive to operate than the hillside gallery workings as exemplified at Dinorwic and Penrhyn, the deep-pit quarry was the most costly to develop due to the combination of haulage and pumping costs combining with the greatest volume of waste rock to be removed prior to commencing production [42].

It must, however, be recognised that Davies' data was only a generalised viewpoint, and that individual cases varied considerably from this mean. In particular it must be pointed out that his fixed production costs were based upon pumping using steam power and that some sites exceeded the average in the costs of running very large (or multiple) steam pumps, whereas virtually cost-less water-wheels could be used for pumping elsewhere (discussed in Chapter 4). Also, whereas a number of the most important quarries in the Nantlle district had hardly any overburden requiring removal before productive slate rock was uncovered, others had to bear very high costs in clearing thick top-rock or surface deposits of gravel or compacted clay from the deeply buried slate rock [43].

A serious problem encountered with these fixed costs was that their effect upon the profitability of deep-pit workings increased by the end of the life of a quarry, when pumping and haulage costs were greater in proportion to the depth of the pit. Thus, concerns operating old and nearly worked-out pits tended to exhibit signs of cost-cutting economies, particularly involving the deposition of rubble in the lower workings or some abandoned corners, if this was sanctioned by the lessor or if the site was freehold property [44].

In most recorded cases, such actions heralded the approach of the demise of the concern, but this was not an universal rule. There were some notable exceptions where an integrated long-term development scheme envisaged the staged exploitation of the quarry involving back-filling old workings, albeit only after they had been thoroughly exploited. For instance, the policy commenced at the Penyrorsedd Quarry in the 1860s was continued well into the 1930s by the descendants of the original proprietors, although economic circumstances unfortunately curtailed the scheme prematurely [45]. However, such fore-sight seems to have been a rare commodity due to the short-term profit-driven strategies commonly encountered in the industry, and in particular in the Nantlle valley.

(ii). Landslides

Quarries have always been susceptible to landslides due to the instability of their sides due to natural factors or by injudicious working. Slate quarries (and mines) were particularly prone to collapses of rock faces due to the high concentration of intersecting joints and planes of weakness in the slate. Of all the possible methods of working slate deposits, the deep open-cast pit was the least stable due to the penchant of operators to work the faces as vertical as possible to the greatest depth that could be tolerated. This provided ample opportunities for frost-action to detach large sections of these unsupported faces, particularly where a major fault-line existed in close proximity to the quarry face and ran parallel to it [46].

Of additional significance was the greater effect of landslides upon deep pits than on any other form of slate quarrying. Whereas a 'fall' might disrupt a number of galleries in a hillside operation or only one part of a mine, there was always a section of the workings unaffected and capable of normal production. In the case of deep pits, the debris of a large landslide would completely bury the whole of the productive faces located at the bottom of the quarry. This would halt production unless there were other separate unaffected pits on the site or minimal working could commence on a stable face or if slabs could be salvaged from the fallen debris if this was composed of slate rock [47].

In partial defence of the operators, they usually had no means of knowing of the presence of these major faults (or *slonts*), and the local agents often faced pressures from the head office to maximise the extraction of rock from the workings. Nevertheless, this cannot excuse recklessness on the part of management as the risks associated with this methodology were well known as far back as the 1820s but were constantly disregarded [48].

Consequently, nearly every quarry in the district was afflicted by 'falls' at one time or another, and a number of pits experienced a series of collapses [49]. Each case caused some degree of disruption and added expenditure and even loss of life, and a number had catastrophic consequences to the financial viability of the operators. Yet it can be (and was) argued that landslides which involved the collapse of bodies of grit overburden covering productive slate could be considered beneficial. Such so-called "development falls" certainly saved the expense of blasting down this grit and possibly caused less damage to the underlying slate than would have been received from the shock-waves of explosive detonations, though their timing might not always have been convenient and their effects were unpredictable [50].

(iii). Flooding

Ground water was found at all of the Nantlle quarries within a relatively short distance of the surface, regardless of the altitude of the site [51] although pits located on the valley floor suffered more from the ingress of ground water than those on upland sites due the effects of the hydrological gradient. In addition the over-spilling of water from the Lower Nantlle lake and the Llyfni river into the adjacent quarries caused catastrophic flooding which exceeded the capacity of the standard pumping systems designed to cope only with ground-water. The presence of the large body of water in the lake basin plus the liability of the river flood-plain to flooding also served to limit the exploitation of potentially highly valuable slate deposits over a wide area of the valley floor [52].

The main cause of the problems on the valley floor was the authorised use of the lake basin as tipping ground by the Cloddfa'r Lôn, Dorothea and Gwernor quarries [53]. This had reduced the capacity of the basin to store abnormal inflows of water from its mountain feeder-streams during exceptionally wet weather. The lake overflow consequently over-spilled into the first two named quarries on occasions, with Dorothea being particularly hard-hit. The floodwater in the lake also affected quarries downstream of its outlet due to the inability of the shallow and meandering river to cope with the extra volume.

The end-result cannot have been envisaged when tipping into the lake was first sanctioned by the riparian landowner in the early decades of the nineteenth century, and it is unlikely that any hint of trouble was experienced for some considerable time. However, the great expansion in output after 1850 created a vast increase in the volume of debris to be disposed of, and by the 1870s a critical point had been passed [54].

The first recorded incidents of flooding involved the inflow of water from the lake into the adjacent Cloddfa'r Lôn Quarry in 1873 [55], and of the contemporaneous alleged destruction of a water-wheel sluice-gate at the lake outlet by an abnormal discharge rate of water [56]. Over the succeeding three decades the problem became much more pronounced, and threatened to curtail the quarrying activities on the valley floor. One radical plan put forward in 1879 by an enterprising party with no known connections with the area, was that of a statutory drainage company which was to pipe the lake water clear of the workings, thereafter levying a rate upon every beneficiary in perpetuity; it was also proposed to undertake all pumping duties at the quarries at a fixed charge [57].

The scheme itself was technically feasible and had commendable attributes, but was commercially unacceptable, which ensured that it received no local support. Despite being modified after the intervention of the Standing Orders Committee, the Nantlle Vale Drainage and Tramway Bill was defeated in Parliament in 1881 by the objections of powerful local landowning interests [58].

This episode may be explained in terms of an opportunistic gambit but it illustrates the existence of a vacuum caused by a lack of collective will to tackle the problem locally. Nothing was achieved for nearly a decade due to the impossibility of bringing the various interested parties to any consensus. Nevertheless, in the aftermath of the drowning of the Dorothea pits in 1884-85 [59], and of the inundation of both Coedmadog and Cloddfa'r Coed in 1890-91 [60], several schemes were mooted to solve the problem. Some were promoted by individual quarries and others by a combination of concerns, and comprised various ideas ranging from short diversions of the river away from individual quarries to the complete drainage of the lake itself [61]. The offending concerns, despite having suffered themselves, had no choice other than to continue tipping into the lake, there being no alternative tipping ground available to them [62].

Eventually the impasse of mutual distrust and commercial rivalry was broken by the intercession of local commercial interests. Local shop-keepers were by c.1892 being severely affected by the closures of quarries due to the problems of flooding. Consequently, this influential faction of the community created an organisation to mediate between the factions and to co-ordinate a plan that finally met approval from all sides [63].

The result of the intervention of the local commercial interests was the Nantlle Vale Drainage Scheme (of 1893). This involved the cutting of a new direct, deep river channel to drain the lake and to alleviate the flooding downstream. Yet, despite the initial optimism, the project, not finally completed until 1896 due to unforeseen difficulties, was only partially successful. Although the drainage of the Llyfni flood-plain was significantly improved, a remnant of the lake remained due to an error in the gradient of the new river channel [64]. As a result of this failing the heavy costs of pumping had contributed significantly to the closure of all of the low-lying quarries with the exception of Dorothea, which itself had to instigate additional protective works over the subsequent three decades and had also to safeguard the property of other parties downstream to stave off the threat of legal action for damages [65].

(iv). Landowning

The fragmented pattern of landowning at Nantlle prevented the integrated development of the area's slate reserves in the same manner as achieved on the Penrhyn and Faenol lands at Bethesda and Llanberis, respectively. None of the Nantlle quarries was able to benefit from the economic advantages of large scale working, although a number reached the medium sector on an industry-wide perspective.

TABLE 17

QUARRY OWNERSHIP BY LANDED ESTATES

ESTATE	QUARRY	CATEGORY	ESTATE	QUARRY	CATEGORY
Bryncir...	Cwm Dulyn	F	Hafodlas..	Cloddfa'r Coed	C
Coedmadog.	Coedmadog	C		Pwll Fanog	E
Crown.....	Alexandra	B	Kinmel....	Penyrorsedd	A
	Braich	D	Madryn....	Ty'n Llwyn	F
	Brynfferam	E	Pant-du...	Bryncastell	F
	Cilgwyn	B		Cloddfa'r Lôn	B
	Crown New	E		Dorothea	A
	Fron	C		Galltyfedw	C
	Moeltryfan	B		Penybryn	C
	Old Braich	D		Old Penybryn	E
	Pretoria	F		Taldrwst Lower	E
Faenol....	Talmignedd	F		Taldrwst Upper	E
Glynllifon	Llwydcoed	D		Ty Mawr East	D
Gwernor...	Gwernor	D		Ty Mawr East Green ...	E
	Tyddyn Agnes	D		Ty Mawr West	D
	Tynyweirglodd	C		Ty Mawr West Green ...	E
	Upper Tyddyn Agnes	F	Tal-y-sarn	Blaen Cae & Talysarn .	B
Gwynfryn..	Cilcoed	F		South Dorothea	C
	Coch-y-bîg	F	Tanrallt..	Chwarel W.O.Jones	F
	Foel Clynnog	F		Fronheulog	C
	Fronheulog Green .	D		Tanrallt	C
	Gelli Bach	F		Twll Llwyd	E
	Singrig	E		Twll Coed	E

*CATEGORY refers to grouping of quarries by scale criteria; see p.3, supra.
Listing of ownership refers to original owners, prior to later sales.

Chapter 3: Production Methods

Most of the quarrying land at Nantlle was owned by a number of private estates and was further sub-divided into a number of leasehold 'setts' which verged on a standard size of around sixty acres (see Table 17, above). The remainder of the slate reserves in the district was found on the extensive Crown lands of Ochr-y-Cilgwyn, Moel Tryfan and Nantlle Common. The mineral leases on these Crown lands tended to encompass a larger acreage than on private lands, although the frequent boundary changes in the grants to successive quarrying companies greatly complicates any discussion of this topic with regards to these concerns [66].

In a climate of a quickening in the pace of the development of the industry during the first half of the nineteenth century, it was to be expected that these landowners took steps to maximise the revenue from their properties. The greatest returns were to be made from royalty payments rather than the rent on the land, so that it was advantageous for the lessor to restrict the area leased to a party so as to maximise the latter's investment per acre. Any adjacent surplus land could then be leased to a second party, again at a maximum return [67].

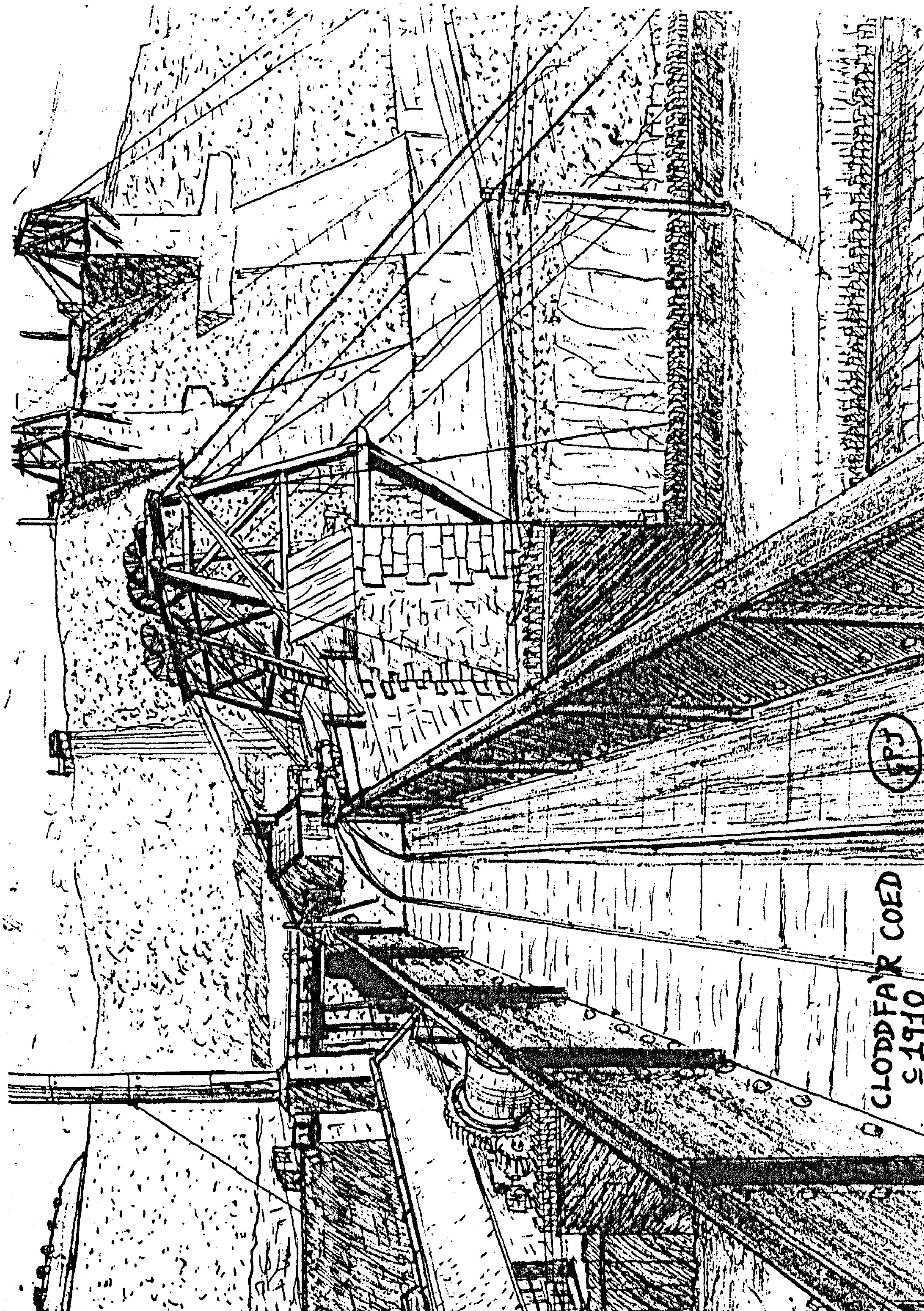
These advantages to the lessor in maximising his short-term revenue had disastrous consequences for the long-term future of the quarries in the Nantlle district. The restricted surface area available for working was hardly a problem at first, but with the rapid expansion of the industry after *c.*1850 the flaws in the system were exposed. On some sites there was a mis-match between geology and topography, where the slate beds were either located in an inconvenient relationship to the ground layout, or where the bulk of the best material passed under the leasehold boundary into an adjoining property.

This made the quarrying process awkward to carry out, particularly when a landslide from under the boundary line impinged onto the adjoining land and precipitated a claim for trespass and compensation from the neighbouring landowner. In a number of quarries it was necessary to obtain a separate lease of adjoining land to enable the site to be worked effectively, but this brought added complications and costs arising both from the complex calculation of the proportion of royalty due to the separate lessors and from the dual payments of rents and charges [68].

The vast volume of waste ultimately generated by the quarrying and processing was usually greater than the individual space reserved for it on each 'sett'. Furthermore, it was not unusual for the chosen tipping space to have contained workable slate reserves which had to be sacrificed in order to work the remainder of the site [69]. One answer was to pile the waste in multi-layered tips, with each new layer over-lying the previous waste heaps, and this became a characteristic hall-mark of the slate quarries of the Nantlle district. A typical multi-layer tip landscape with its complementary winding-gear structures and tramway bridges is illustrated in the present author's reconstruction of part of the Cloddfa'r Coed Quarry in *c.*1910, Figure 6, below. This solution brought forth its own costs and problems, particularly the requirement for additional powered haulage up inclines to the tip levels, although high 'galleys' for cableways were sometimes constructed for direct haulage from the pit to the high tips (see Chapter 4) [70].

In a number of cases, of which the Coedmadog, Dorothea and Fronheulog and South Dorothea quarries are documented examples, proprietors were forced to lease additional land so as to extend their waste tips. This commonly proved very expensive, with lessors taking advantage of the

FIGURE 6



predicament of the lessees by charging exorbitant rents for this privilege [71]. In comparison, the Talysarn Quarry was fortunate in being able to purchase the freehold of some adjacent mountain pasture, whereupon a new centralised tip was established [72]. Occasionally there were significant civil engineering costs associated with gaining access to new tipping ground. Perhaps the prime example was the high timber viaduct constructed by the South Dorothea Company in 1900 to span a deep cutting on the diverted channel of the river Llyfni [73], but the double-reverse curve tipping tramway climbing over the shoulder of Mynydd-y-Cilgwyn also ranks high in the list [74].

The disposal of quarrying waste at Nantlle did not appear critical in the view of one commentator in 1868 [75], but over the next decade, local experts had recognised the blight on future prospects that was to emanate from indiscriminate tipping [76]. A scheme which would have alleviated this problem had been promoted by Thomas Harvey, proprietor of the Talysarn Quarry, in 1858-59, whereby all of the debris would have been carried by rail from the quarries, to be tipped into the sea [77], but this was defeated by the objections from vested commercial interests (see also further discussion of this scheme in Chapter 5, infra). Despite an awareness of the ultimate implications of the mounting debris problem in certain quarters, resulting in an occasional call to resurrect the Harvey plan, nothing was achieved because of the self-centred attitude of the individual quarry proprietors [78].

However, the local circumstances of leaseholding and the mutual animosity of most producers provided no options other than to continue the process thus begun. It was only after the closure of the majority of the valley-floor quarries in the period *c.*1908-*c.*32 and the commencement of back-filling old workings by the Dorothea Company prevented the total clogging of the valley floor with debris [79].

Tip re-working

This activity deserves a separate sub-section due to its great significance in the economic history of the slate industry in the Nantlle district. The sorting and re-working of blocks and slabs of slate thrown away in previous eras became both an important source of employment for men who could not find work in the conventional quarries and was also a very remunerative source of profit for the main contractors leasing of the tips. This lucrative business existed because the waste tips of slate quarries were not necessarily totally composed of economically-worthless material. It was true that the bulk of the material found in the majority of waste tips had been justly consigned, but a significant proportion of the waste generated in certain eras had been thrown away either because of its unsuitable dimensions or colour in the contemporary market, or as a result of the maladministration of production systems whereby the wastage of workable rock had become a legitimate means of earning a living wage [80].

Despite the emulation of this practice in other slate-quarrying areas, none approached Nantlle in terms of the scale of tip re-working operations undertaken (see Tables 11 & 12, pp.60, 70a, above). It is unlikely that the waste heaps of Nantlle contained more re-workable material than in comparable heaps in other areas but local conditions were probably more favourable in this locality towards the establishment of this sub-branch of the industry. There were more suitable abandoned sites for the independent local tip re-working concerns to rent at Nantlle than elsewhere and a number of the conventional quarrying concerns were prepared to enter into agreements to allow contractors access onto old tipping grounds [81].

The first known reference to tip re-working at Nantlle was at the Cilgwyn Quarry in 1822 [82]. No further reference has been uncovered until 1868, when an offer had been made from an un-named local party to the proprietor of the Talysarn Quarry, whereby the former requested a lease of the old waste heaps, from which workable material thrown away in previous years of bad management was to have been extracted on a royalty basis [83]. It is not known whether this was sanctioned, but it is certain that tip-working on a massive scale was undertaken at the Dorothea Quarry in the first months of 1885 as an emergency measure designed to keep the whole of workforce in employment in the aftermath of the great landslide and flooding which devastated this concern [84].

Up to the 1890s, tip re-working was concentrated on the production of roofing slates, which limited the choice of salvageable material to sizes greater than the ten by six inches 'singles' that were the smallest size of slate marketed at that time. A limited market had developed for twelve and ten inch long slates by eight and six inches wide for roofs exposed to heavy storms, such as the west coasts of Ireland and Scotland, but it was the introduction of slate damp-proof courses into brick-built houses during the 1890s that provided a huge new outlet for tip-products. The latter provided a market for relatively thick slates in random lengths, but of both nine and four-and-a-half inches width, matching the width of double-brick walls and the top-face area of single standard bricks, respectively [85].

The local tip-working concerns were very numerous in the period c.1890-1939, and worked under two different systems of tenure. The original system comprised an annual tenancy for specific areas of a tipping ground from an operating conventional quarry concern. The individual contractor, or partnership, was bound to grant the landlord the first refusal on any manufactured slates, paid for on a list price in a similar fashion to that used for valuing slates made at the quarries. The contractors were free to organise their mini-concerns as they wished, within the parameters of restrictive clauses in the contract. Some worked on a small scale with one or more partners, but others employed additional slate-makers and labourers in a fashion reminiscent of the pre-1800 industry at Ochr-y-Cilgwyn (see Chapter 1, supra) [86].

After the First World War, some contractors were able to gain leases of abandoned quarries because the landowners were increasingly giving up hope of ever leasing the sites to conventional quarry operators, and were desirous of gaining some income from their properties. This class of contractor generally set themselves up as tip-working agents or factors rather than working the site on their own account, taking on teams of scavenging production gangs on a self-employed basis. These gangs were set to work at specific locations on the tips (corresponding to 'bargains' in the quarries) and were remunerated for their produce delivered to a central stock-yard, on a conventional list price system. The agents usually dealt with local slate-merchants for the sale of the produce, but one set up himself as a merchant to maximise the available profit by reducing the number of middle-men in the chain [87].

The slate waste tips of quarries after the the first decades of the nineteenth century were not the simple heaps of debris found in earlier periods of working. The adoption of rail transport bestowed a certain discipline and order imposed on the waste-disposal process such that it could be argued that the tips were constructed rather than deposited.

Each tip had to be carefully planned to make the full use of the available ground, and consequently the debris was laid down in an orderly fashion, with a fair degree of sorting between waste derived from different sections of the workings and from different stages in the production process [88].

The method used by the tip contractors at Nantlle depended upon the circumstances at the site to be worked. The favoured tactic was to attack a tip from the side, once a promising patch of suitable material had been identified. Cuttings of up to twenty foot deep were driven in at right angles to the side of the tip, so as to gain access to the damp (and more easily cleaved) slate within its body. Using wheelbarrows, or sometimes railways, the cutting progressed inwards with the sides being supported by retaining walls constructed of larger blocks, until a body of suitable material was uncovered, with the rejected waste being tipped for a second time from the cutting mouth. Working of the raw material was carried out in individual slate-making huts (termed *gwaliau*) located on the secondary tip outside the cutting. The finished slates were carried daily along a network of rough paths to a central yard, where the stock of each gang was counted and examined by the tip agent's clerk, prior to calculating the reward due [89].

Eventually, when it became no longer cost-effective to proceed any further inwards, the excavation was abandoned in favour of a new one at an adjacent site. Some contractors preferred the margins of tips and the valleys between the separate 'fingers' of waste, where the larger slabs were to be found. These required very careful working but could yield, with care, very remunerative roofing-slate quality produce. Other contractors preferred to excavate shallow pits into the top surface of the tip, especially under the former tramway site, where good slabs were to be found in the old tip-head embankments. These holes were often not particularly large, and always had a spoil heap adjacent, reminiscent of an ancient cratered mining landscape. Sometimes, quite large excavations were undertaken by a gang of men, and one at the Talysarn Quarry was alleged to have required a portable steam winding to haul truck-loads of material out of it [90].

On abandoned sites, it was usual in the nineteenth century for the landowner to protect the integrity of any structures in preparation for an eventual re-opening within a short period of years. However, after 1918 it became increasingly common for quarries to be stripped of all reclaimable material soon after closure if no new operator was forthcoming. A contractor was usually responsible for the recovery and sale of the roofing slates (often cut-down to remove the nail holes) and roof timbers. Once reduced to a ruinous state, the walls of the buildings became quarries of slate blocks to provide the raw material for the production of dampcourse slates by the contractors.

Despite having dried out, a high proportion of the walling blocks were useable due to the acceptability of slates of up to a quarter of an inch in thickness, and the large foundation slabs of mill walls were particularly sought-after [91]. Thus, a significant number of quarry sites in the Nantlle district were in the half-century after *c.*1920, reduced to an almost featureless state comprising only of highly-cratered tips with only scant remains of any buildings or other structures; this has presented many problems of interpretation to the industrial archaeologists of the present day.

(b). Developments in quarrying and processing methods

After being extracted from the rock-face, and transported away from the working face, the slate blocks and slabs entered the production phase. Their fate was dependent on several factors, in particular their quality and also the range of products being marketed at that period of time.

For geological reasons, the main product of the Nantlle quarries was roofing slates, supplemented by 'damp-proof slates' from the 1890s (see above), although a limited output of dressed slabs was maintained when suitable raw material was available (discussed in Chapter 4) [92]. However, the criteria determining the commercial value of slate rock for roofing 'tile' manufacture and dressed slab products were very tight, and consequently a minimum of ninety per cent of all of the material excavated in a quarry found its way to the waste tips [93].

One possible avenue for improving the profitability of the quarries, which was only partially exploited, was to diversify the product range, especially with regards to the utilisation of the reject slabs and waste rock. Some use was made of offcuts to construct houses in the immediate neighbourhood of the quarries, and slate lintels, gateposts and steps were sold further afield. Flooring slabs, tiles, 'crazy-paving' and craftwork were also popular products in different eras, but the sales volume was never sufficient to make a significant impact upon the production economics of the quarries.

Neither was the promotion of 'non-slate' activities such as brickmaking, gravel aggregate, general construction and tourist ventures a panacea for the general decline in the core trade of the concerns. Of the various offshoots of the slate industry in the valley, the only one that tasted any measure of success was the production of writing slates. This flourished from the 1860s to its gradual decline during the first decades of the present century as a result of the huge demand from the introduction of elementary education (see Chapter 4).

Regardless of the attempted diversification outlined above, the main thrust of the battle for commercial viability at the quarries was fought in the twin spheres of improving the rock-extraction methods so as to maximise the yield of the pits, allied to developing better techniques of processing the slabs on the quarry bank. This sub-section seeks to identify the main developments in the manual processes of slate working, with the subsequent mechanisation of the production system being discussed in Chapter 4 (below).

Extraction methods

This sub-section deals with the changing techniques of extracting raw slabs or blocks of slate from the rock-face in preparation for the final processes of product manufacture. It also, *inter alia*, involves a brief discussion of the development of the role of the 'rock-man' [94] from its origins to its peak as a specialised craft skill by the second half of the nineteenth century, together with developments in hand-tools and rock-extraction technology.

Slate quarrying was one of a minority of extractive industries where it was vital that the useful portions of the rock were detached with the minimum of fragmentation. The success of this process depended upon the skilful exploitation both of the inbuilt crystalline planes of weakness within the material and of the secondary shrinkage joints within the rock body [95].

Initially, it seems likely that slate extraction was carried out in a crude manner, using the traditional techniques of quarrying for building stone to exploit the frost-shattered exposures of slate rock found on mountain slopes such as at Ochr-y-Cilgwyn (see Chapter 1, supra., and Figure 3, p.16a) [96]. However, the relatively poor quality of these ready-cleaved surface exposures, in addition to the limit of supply of the material, must have provided an incentive for the early quarrymen to develop the means of dealing with more 'solid' rock beneath the immediate surface. However, the natural jointing present in much of the deeper bodies of slate rock was not amenable to be freed by these manual methods. Therefore, before the exploitation of the deeper rock could be achieved, new techniques of quarrying were required.

The most important breakthrough in the development of extraction methods for slate rock, was the introduction of gunpowder for shot-blasting, a technique which was almost certainly introduced into north-west Wales in the early eighteenth century by itinerant Cornish miners. Cornishmen were reputedly working at the Drws-y-coed copper mine at Nantlle by the 1730s, lending weight to the folk lore that the slate quarries of this district were the first in the industry to introduce shot-blasting [97]. If this tradition is true, then both the pre-eminence of the produce of the Nantlle quarries over that of their great rivals on the Penrhyn estate by 1738, and the very early use of large slate-slabs as gravestones at Llanllyfni (see Chapter 4) can be explained in terms of this technological advance. Gunpowder (or 'black powder'), the earliest commercial explosive substance, was ideal for slate extraction because of its relative mildness. Thus, slabs of slate could be gently detached from the rock body for a maximum yield, and once this was achieved, manual methods were then used to prise them free with the minimum of damage and wastage [98].

The development of a variety of new hand tools by the early decades of the nineteenth century, such as improved designs of chisels, crowbars, hammers and wedges, was also an ongoing important factor in the advancement of techniques of detaching slabs from the rock-body, with the aim of increasing the yield [99]. In some cases, this was achieved by simple modifications to existing tools, for example the introduction of a double-ended crow-bar, having at one end a point for digging and at the opposite end a blade for forcing open cracks in the rock. Some new tools were also developed, for example a very heavy iron percussive chisel (named *y trosol mawr*), used to fracture slate-rock which exhibited distinct jointing [100]. None of the claims and counter-claims made for the development of particular tools or techniques in individual districts, can now be corroborated. Nevertheless, it appears that none of the individual slate-producing district enjoyed a long-term advantage from a monopoly of new techniques because of the rapid dissemination of knowledge throughout the industry as the result of the high mobility of skilled quarrymen [101].

Regardless of the effectiveness of new tools and quarrying techniques, the irregular geological structure of the slate beds at Nantlle must have made the working of the quarries a difficult proposition from an early date. That these difficulties were largely overcome, can be attributed to the development of the craft-skill of the specialist quarryman, often known as the 'rock-man'. The physical prowess of this class of workman is well recorded [102]. However, the athleticism displayed on the rock-face, frequently in situations of danger, has to some extent concealed the equally important intellectual aspect of the work.

The crucial stage in the extraction process, when at its peak of development during the century after *c.*1830, was the evaluation by the whole team of 'bargain-takers' (see part c., below) of the fine structure of the rock to be worked, leading to a plan of action, having the aim of converting the maximum amount of the extracted material into finished slates. This specialised body of knowledge accumulated from one generation of quarrymen to the next, and it ultimately developed to a high degree of specialisation [103].

Whereas the skill of the production rockmen developed in the direction of the conservation of the quarried material, the techniques involved in the removal of unworkable rock (that is, 'development work'), took a different course. The aim in this latter case was of achieving maximum fragmentation of the material so as to expedite its removal, although the rock face would be let as a 'bad-rock bargain' where there was an opportunity to salvage some workable material, often worked by less-skilled men or persons serving a penance for some misdemeanour [104].

Within the sphere of development work, the removal of large bodies of hard gritstone and dolerite dykes (termed 'posts') presented special difficulties. The piece-meal removal of these major geological impediments to the successful development of several quarries, was not a satisfactory option because of the huge volume of rock involved. Furthermore, this material required the deployment of a greater explosive force for its successful removal than could be provided by gunpowder. The invention of the high-explosive nitro-glycerine in 1860 provided an answer to this problem by providing an opportunity for large sections of rock-face to be brought down in a multiple-blast. Unfortunately, the early 'nitro' was a very unstable liquid which appears to have been unpredictable in action [105]. A poorly judged 'bulk-blast' at the Talysarn Quarry in 1864 was probably the cause of the death of a young mother, who was struck by flying debris at a distance of over a quarter of a mile from the site [106].

After further development by the manufacturers, the nitro-glycerine was subsequently stabilised, making its effects calculable, and by the turn of the present century it was the standard high-explosives in regular use for development work at the Welsh slate quarries [107]. Bulk-blasting became more common as better mechanical rock-drills became available (see Chapter 4), and some of these explosions were very spectacular spectator events, such as those at the Dinorwic and Penrhyn quarries during the 1890s. The most celebrated 'big blasts' at Nantlle were two at the Faengoch pit, Cilgwyn Quarry, in 1896 and 1901, respectively, followed by one at the Talysarn Quarry *c.*1902 [108]. So successful were these blasts at Nantlle, that the amount of waste material brought down frequently exceeded the wildest dreams of the proprietors, although in the case of the Faengoch blast (above), the pit had to be consequently abandoned because the cost of removing this excess of rubble was excessive. A similar fate befell the Blaen Cae Quarry in 1927 [109].

Bulk-blasting was adopted in the extraction process for workable rock during the mid-1960s, as one facet of the mechanisation of pit work (see Chapter 4). In the van of this movement was the Dorothea Quarry (Nantlle), which attempted to adapt the extraction system used in granite and limestone quarries [110]. Having invested in heavy earth-moving machinery for mechanical loading, this concern found that traditional rock-extraction techniques, matched to a shortage of skilled rock-men, provided insufficient work for the new high-capacity plant. Bulk-blasting appeared to solve both of these problems in one stroke. Using a specially formulated milder high-explosive, complete faces of slate rock, amounting to several thousand tons of rock, were blasted and useable slate blocks were subsequently extracted from the rubble by the few skilled quarrymen remaining in the employment of the concern [111].

Whereas the theory involved in this new practice was logical, in practice the loss of productive rock through excessive fragmentation was greater than expected, due to both a lack of expertise with the new explosives and to the excessive height of the faces. One particularly disastrous mis -fire *c.*1967 at the Dorothea Quarry rendered a complete production face unsafe and unworkable, and this was an important contributory factor to the demise of this concern in 1970 [112].

Other major operators of open-cast Welsh slate quarries also followed Dorothea's lead, but with mixed results. In the case of the Dinorwic and Penrhyn quarries, the high rate of wastage was apparently not considered a problem because of the huge reserves of available workable rock at these sites. On the other hand, the Crown Quarry (that is, Alexandra/Moeltryfan) at Nantlle shared with the Dorothea Quarry the problems of working within a confined deep pit, where a high yield was essential because of the limited amount of accessible workable rock. Thus, after a brief flirtation with bulk-blasting in the mid-1960s, the Crown Company reverted to more traditional techniques for its production work. However, bulk-blasting remained standard practice for large-scale untopping work in the Nantlle quarries, such as in the development work at the Penyrorsedd Quarry in 1979, a role in which the system was eminently suitable [113].

Improvements in the slatemaking process

The object of the process of manufacturing roofing slates was the production from slabs of slate-rock, of the maximum number of thin tile-like sheets within a controlled range of dimensions. During this process, economic and geological factors interplayed with the skill of the slate-maker, the level of technology available, wage incentives or dis-incentives, and managerial directives regarding production.

Details of the slate-making process can be found in a variety of sources and need not be reiterated here except in summary. The production of the various grades and sizes of roofing slate 'tiles' was accomplished by a sequential series of events, summarised into four main steps. These were **(a).** the primary sub-division of the large quarried slabs into 'blocks' or 'pillars' of manageable size; **(b).** the secondary preparation and further sub-division of blocks prior to splitting; **(c).** the splitting the prepared blocks into thin sheets; and **(d).** the cutting (or 'dressing') of these irregular sheets to a regular shape within a range of standard dimensions.

The processing methods used in the Nantlle were not generally different from those in the remainder of the industry. Furthermore, any differences that can be identified were often due to individual circumstances, and were more important in the earliest period of working rather than after the first quarter of the nineteenth century. The main improvements that can be identified in the manual processes of slatemaking were in the development of better hand-tools and techniques for the various stages identified above, in which the well-developed early slate industry at Nantlle is likely to have led the way [114]. As in the case of rock-extraction, tools and techniques became rapidly standardised throughout the region due to the migration of workers and entrepreneurs from one district to contiguous ones. This ensured that the best practices and technological solutions to problems were popularised, and were soon adopted in all areas [115].

In the case of the initial subdivision of the quarried slabs (step a., above), different techniques and tools had to be developed to allow for differences in the splitting characteristic of the rock in the three dimensions of length, breadth and width. Of the three dimensions, the splitting of slabs lengthwise to obtain the thinner ones required for the final splitting stage, was the easiest to achieve because of the lamination of the natural crystaline structure along its plane of cleavage. Thus, the main development in tools for this purpose was in various types of hammers, heavy chisels, gouges, wedges and light crowbars [116].

The plane of pillaring, at right angles to the cleavage, but running lengthwise, was less pronounced, especially in the purple and red slates. Consequently, there was a tendency for this cut to 'run out', spoiling one portion of the slab which was being subdivided. The earliest recorded method of 'pillaring' was very crude and must have created a considerable amount of wastage. It consisted of weakening the slab by splitting it to about 1½ inches thickness, and subsequently cutting a shallow guide channel along the required line of breakage. The slab was then rested on a large spherical granite stone, whereupon it was struck a hefty blow aimed at its point of contact with the stone, using either a substantial tapered wooden club with an eight-inch diameter head, or with a heavy iron hammer. After the development of means to create a smooth cross-cut face (see below), this method was abandoned in favour of using a broad-headed, medium weight iron chisel, struck with a four-pound iron hammer, acting upon the upper face of the slab [117].

Cross-cutting, at right angles to both the cleavage and pillaring planes, so as to reduce the length of a slab, presented a greater challenge than the other methods (above) because of the lack of a plane of weakness in the crystal structure in this direction. However, it was very important that this should be achievable because of (1)., the requirement for the final splitting of a prepared block of slate into the wafer-thin roofing sheets, that the uppermost surface for the splitting-chisel was smooth, so as to distribute the applied force evenly, and (2)., that slabs longer than the maximum length of slate produced could be cut into two, so as to make the greatest use of the workable material [118].

Natural horizontal cracks in the rock-body, termed 'foot-joints', provided the sole means of obtaining such smooth surfaces in the earliest days of the industry [119]. However, the randomness of the jointing, allied to the unevenness of a high proportion of the natural joint surfaces, resulted in a high wastage rate of workable slate during the early era, before the development of better manual methods of cross-cutting, a situation not finally resolved until the introduction of mechanised sawing (see Chapter 4) [120].

The first recorded method of cross-cutting involved a one-foot long tool, similar to a butcher's cleaver, but having a rounded cutting edge turned up into a point at the outermost end. This point was used to cut a guide-notch in a thin slab before resting it upon a spherical stone, whereupon a cross-cut was hacked across from the notch using the curved blade of the knife [121]. This was, however, unsatisfactory because of the significant proportion of spoilt material coming from either breakages or uneven surfaces. The answer to the problem is alleged to have came from the Nantlle area, c.1835, when a blacksmith named Rhys was said to have invented a new tool, which bore his name [122].

The *rhys* consisted of a large, heavy, double-handed wooden mallet having novel design features. The leg was of ash, being strong but springy, and measured about three feet by two inches diameter; the head was of heavy African Oak six inches in diameter by eighteen inches long, bound on the two striking ends by twin iron hoops [123]. This combination of the strengthened, but soft wooden striking face on a shock-absorbing handle was the secret behind its success. With this tool it was possible to strike a hefty blow that provided a sufficient shock force to break the prepared thin slate-slab cleanly without shattering at the point of impact.

Despite its effectiveness, the twin disadvantages of the *rhys* were the high degree of skill required to obtain consistent results and the time taken to carry out the procedure. However, despite the introduction of mechanical sawing into the larger Nantlle quarries in the late nineteenth century, the *rhys* continued to be used in smaller non-mechanised quarries and by tip-contractors. It is still in occasional use at one Nantlle quarry, albeit for 'pillaring' slabs rather than for cross-cutting [124].

Slatemaking and dressing

Specialised chisels for use in the slate-making process probably developed from wedges and bladed crowbars used in the extraction process at an early date. However, the thin-bladed splitting-chisel (or '*cŷn manhollt*') must have been developed prior to 1738, a date at which the Ochr-y-Cilgwyn quarrymen at Nantlle were already producing thinner slates than at the rival Penrhyn estate quarries [125].

The original type of splitting chisel was said to have been similar to that still in use today, but was probably shorter and less broad, proportionally matching the smaller size of the slate blocks worked in the earliest periods. Thus, it must have resembled the narrow chisel used in later eras by apprentices and contractors for splitting the blocks destined to produce dampcourse slates [126]. With the improvement of extraction techniques, the increased size of slate blocks delivered to the slatemakers created a requirement for wider and longer splitting chisels, so as both to spread the percussive force across a greater width of the slate, and to enable the tool to be driven a sufficient distance into the longer blocks.

With the exception of the development of variants of the standard splitting chisels such as the 'driver', which was a heavier version which differed in its shape and dimensions, the basic design changed very little because it served its purpose adequately. Thus, a late-nineteenth century splitting-chisel recently discovered during an archaeological excavation at a Nantlle quarry was identical to the modern design of the tool [127]. The only major modification that has been uncovered was a special version manufactured by the Dorothea Quarry blacksmith in the 1950s-60s. This had a composite structure, consisting of a central strip of hard steel sandwiched between a folded outer sheath of iron or mild steel, and was so designed to maintain a sharp blade without periodically returning the tool to the smithy for re-steeling the leading edge [128].

Other slatemaking tools were developed over the years for specific applications. These were generally varieties of chisels such as the '*stolper*' and the '*cŷn mesur*' (measuring chisel) [129]. One major advance was the substitution of the original light iron slatemaking-hammer by a wooden mallet (or '*gordd wal*') bound with iron hoops, which was in effect a mini-*rhys* (see above). This mallet had the dual advantage of not damaging the head of the splitting chisel, and of absorbing much of the percussive shock that was transmitted to the slate-maker's hand when splitting the harder types of Cambrian slates such as the blue varieties [130].

The 'dressing' of the split sheets of slate was the final stage in the production process. This involved trimming the sides and ends of the split thin sheets into straight edges, with right-angled corners, having the characteristic bevelled edges on one face [131]. The traditional method of cutting was undertaken by resting the edge of the slate on one fixed knife-edge, then using a mobile knife-edge to shear the overhanging edge, with the size marked out using a gauge [132].

Originally, the cutting equipment used was a trowel-like iron knife, seven-and-a-half inches long by four inches wide, cutting onto a triangular-shaped stone (termed a *maen nâdd*) as the fixed edge. These stones were probably of Pre-Cambrian rock found adjacent to the slate at the early quarrying sites on Ochr-y-Cilgwyn. This material shows partial cleavage and breaks easily into a wedge-shape having a razor-sharp edge. When using these tools, the dresser sat on a pile of stones covered with straw [133].

At an unrecorded later date the fixed blade became one of iron with a steeled cutting edge; this was known as the *trafal*. Most were of one piece construction, with the ends bent over and shaped into a point which secured the blade into a sloping wooden bench having a seat for the dresser at the upper end. At least one example of a *trafal* dating to the 1890s was constructed in three pieces, having two separate legs which could be adjusted to a number of positions to suit individual dressers. The cutting tool (termed a *cyllell naddu* or *cyllell fâch*) was also re-designed into the form of a knife of various lengths to suit the type of slate being worked; it had a cranked handle near one end to give a better control on the slicing action, and could also be made to suit left-handed working if required [134].

The manual dressing of slates was only superseded gradually by mechanical dressing at Nantlle because of the unsuitability of much of the rock to the new method (see Chapter 4). Furthermore, the preponderance of small unmechanised quarries and tip reworking in this district during much of the present century, ensured the continuation of hand-dressing together with many of the other pre-mechanised techniques of preparing the material described above. However, as a consequence of the closure of these small concerns due to the general contraction of the industry and of the cessation of the market for dampcourse slates during the 1960s, these skills were not passed down and are now being gradually lost with the passing of the older generation of quarrymen.

(c). Wage Systems and their effects

Within an economic analysis of any industry, wages represent an important component in the costs of production. Despite the attractions of following a statistical approach, the insufficient local data outside three major concerns and a surfeit of general published works on this topic [135], has steered this sub-section towards a discussion of the evolution of wage systems within the slate quarries, and of the consequential effects of these systems upon production and processing methods.

(i). Flat-rate pay systems

The standard method of payment associated with slate quarrying was that of the 'bargain system' (discussed in part ii, below). This was not, however, the original system employed in the industry, nor was it universal even in its heyday during the nineteenth century. Moreover, it seems likely that there was a greater variation in wage systems than has previously been recognised, with the diversity being particularly marked amongst the numerous Nantlle concerns.

The early era

It is highly likely that the labour systems used in the Nantlle district during the eighteenth century were similar, if not identical to those practised at the Penrhyn estate quarries pre-1782 [136]. None of the individual concerns at work at Nantlle before 1800 are thought to have employed significant numbers of men, and of those persons involved in the proprietorship of the quarries a high proportion were almost certainly profit-sharing working partners (see Chapter 2). A list of workmen at the Ochr-y-Cilgwyn quarries in 1787 shows that only a small proportion of the concerns employed more than three or four labourers and/or boys, whereas the majority of workmen came under the classification of 'masters' [137]. Unfortunately, it is not possible to determine whether the additional labourers were employed on a day-rate or whether a crude calculated tonnage or yardage rate for the waste removal and development work was used by these early concerns [138]. It is unlikely that the wage system was sophisticated due to the restricted scale of working encouraging a simplicity into any systems of payment.

Evidence for the likely means of renumerating the various classes of worker found in these early quarries might come from more recent sources concerning the smallest workings in the valley, which provided a direct link with the practices of the eighteenth century. In the case of working partnerships of quarrymen during the twentieth century, the provision of additional labour was often an irregular practice. There was often a core of skilled men employed on a piece-work system alongside the working proprietors as additional slate-makers, but there were also other men employed as occasional labour on a day-rate basis, when additional assistance was required for specific tasks such as development work or clearing landslides [139]. In the special case of the Ochr-y-Cilgwyn pits from 1745 to c.1800, the requirement of paying a fixed annual fine per man employed [140], probably stabilised the variations in employment, although additional short-term labour was possibly exempt from this charge and if not, was probably not declared.

Later fixed-rate systems

Despite the early introduction of a complex piece-work system known as 'bargaining' into the larger concerns during the early nineteenth century (see below), this was not universally adopted in the Nantlle district, where a number of examples of fixed-rate wage systems were to be found at various dates, spanning the whole spectrum of quarry size.

In the earliest known cases of fixed-rate wage systems at Nantlle during the nineteenth century, very few details are available. Yet, a record of the payment of a standard day-wage rate for all classes of workmen other than boys, both at the Coedmadog and the Talysarn quarries during the late 1820s [141] shows that these concerns were not operating a piece-work system. Both were amongst the largest concerns in the district at this date, and their fixed-rate wage system must have been more complex that recorded at the small Tynyweirglodd Quarry in the 1840s, where a single gang of rock-getters and slatemakers were paid on a direct day-rate [142].

The most important example at Nantlle of fixed-rate wages was the case of the British Slate Co. Ltd., which operated a mixed system at its Fron and Talysarn quarries during the 1860s-70s.[143] This comprised features of both piece-work and flat-rate payments, with the rock-getters and slatemakers working independently of each other, and where sections of the quarry were sub-let to a number of contractors [144].

This was probably a precursor of the so-called 'big-contact' system which was to become a contentious issue in the Welsh slate industry during the last quarter of the nineteenth century because of the intrinsic loss of independence of the quarrymen [145]. Yet, in the sociological melting pot of the Talysarn Quarry in the early-1870s, where a high percentage of the employees were said to have been men blacklisted by other neighbouring concerns, the big contracts were apparently accepted because no-one was in a position to complain even if they had wanted to [146].

(ii). Bargaining systems

Regardless of the perceived advantages of the variations on fixed-rate payments (see above), the standard 'bargaining system,' whereby gangs of men sub-contracted to produce roofing slates from strictly defined areas of the quarry for a period of four calendar weeks, had become universal in nearly all of the larger Nantlle quarries by the middle decades of the nineteenth century, and had also been introduced into the Fron and Talysarn quarries by the 1880s. It may be hypothesised that this latter event occurred because the early fixed-rate wage systems, devoid of incentive payments, could only have proved effective in the exceptional boom period of the 1860s and 1870s, when earnings were generally high. With the breaking of the boom in 1878 and the subsequent headlong descent into recession (see Chapter 1), a flexibility in wage rates was required [147].

Despite the prominence given to the sociological aspects of the 'bargaining system' in the Welsh slate quarries, its economic significance in terms of its effects upon production systems has largely been subsumed. In particular, the role of the larger quarries of the Nantlle district in the development of this system during the early decades of the nineteenth century must be re-examined, and both the benefits and failings of 'bargaining' need to be discussed.

The 'bargain system' of the slate industry appears to have its roots in the changes introduced to the working practices of the quarries on the Penrhyn Estate from the 1760s to the 1790s [148]. Commencing with the imposition of a code of conduct for the mini-companies of quarrymen who operated individual pits on a tenancy basis, the existing quarrymen became reorganised as gangs of semi-independent contractors when the whole site came under the direct control of the landowner. The majority of the rules imposed were designed to co-ordinate the development of the site, but others were designed to regulate the organisation of the workforce.

A simple piece-work system of payment based upon that used in the metal mining industry, was then imposed, involving gangs of from two to twelve contractors (averaging four per gang) operating sections of the quarries for periods varying from six weeks to several months. They were paid according to a graduated 'list price' per *mille* of 1,260 slates for ordinary thin (or 'talley') roofing slates produced, and on a tonnage (of 21 *cwt*) for thick, heavy slates (termed 'rags'); the larger sizes of slates in each case were proportionately more valuable [149].

The Penrhyn system of organisation appears to have spread at only a slow pace through the Welsh slate industry at first, probably reflecting the scarcity of large concerns in which it would have proved more advantageous than existing systems. Significant capitalist investments were rare before 1800, with only the Dinorwic Slate Company (of 1788) at Llanberis; the Cilgwyn and Cefn Du Slate Company (of 1800) at Nantlle and elsewhere; and possibly Turner & Co., (of 1799) at Ffestiniog, being likely candidates. However, during the first decades of the nineteenth century, increasing numbers of the larger examples of commercial partnerships that were established within the industry appear to have adopted the new system of organisation and payment.

This simple piece-work system, which was similar to that operated at tip re-working sites at Nantlle up to the early 1960s [150], was too crude to compensate for the huge variations in the individual characteristics of each rock-face over a period of time. Consequently, individual skill and effort were not always rewarded when the quality of the slate was poor and the consequent production of the gang (its 'make') was low, resulting in huge fluctuations in the wages of individual groups of men over consecutive contract periods. Also, some form of compensation had to be paid for unremunerative work such as removing all the debris from the working area to the tip - a contractual obligation persisting into the 1830s, - lest the cumulative effects of not doing so either rendered future working unprofitable, or resulted in a serious landslide [151].

The first surviving record of added payments to supplement the basic 'make' rates is found in the extant pay-sheets of the Cloddfa'r Coed Quarry, Nantlle (of 1809-19). These showed that the majority of bargain crews were by that period being paid a standard rate of 3*d.* (1½p.) per kibble for debris removed [152]. In the same era, a more complex system was used at the Cilgwyn Quarry, where kibble-loads of debris were remunerated by the score and there were either lump-sum payments or yardage rates for the 'dead-work' of pulling down the bad rock [153].

The Cloddfa'r Coed Quarry may also have led the field in the 1810s by applying variable list-prices from gang to gang, whereby those undertaking development work (and consequently producing fewer slates) were paid at a higher price for the 'make' that they produced [154]. However, this was a complex system, and data analysed by Dylan Pritchard showed that it was not very effective. In a typical year (1814) there was a large range of from £26 to £68 in the total wage payments paid out to gangs during comparable contract periods, showing that the theoretical equalisation was not being achieved. One reason for this must have been the relatively long term of the contracts, commonly lasting from six to eight weeks.[155] Consequently, it was almost impossible to predict the future trend of each working face until the introduction of the four-week contract as the standard practice in the industry (with certain exceptions) by the 1830s made the forecasts more accurate.

In the Cloddfa'r Coed system (described above), there was an opportunity for negotiation between the crews and the management (or 'bargaining'), albeit on a limited basis. This relatively simple answer to the practical problems of equating labour and reward in respect of a slate working-face, seems to have been adopted by a number of quarries in the early nineteenth century. Yet, it is unlikely that it was sufficiently sensitive to respond to the wider variation in circumstances in those quarries which had grown to a larger scale of working.

Consequently, as a result of the increased complexity of its operations as the concern expanded in scale, the Cilgwyn Quarry was by the 1820s experimenting with more advanced wage systems. One important concession granted to bargain crews at Cilgwyn was that of an 'advance' granted when there was a large amount of bad-rock clearance to be undertaken. This was a *pro rata* addition at a negotiated rate on every £1 value of slates made (as calculated by the standard list price) and was designed to compensate for lost production caused by the diversion of labour into beneficial development work. This was originally very much a special payment for difficult circumstances only, but had by the 1830s spread and developed into the standard, and ultimately contentious component of the pay-system known as the 'poundage' [156].

The modification of the Cilgwyn special 'advance' into a general compensatory and negotiable 'poundage' based upon a single standard list price, allowed a general regulation of the wage levels of all of the production gangs in a quarry. It was this, according to Dylan Pritchard (1944), that finally crystallised the structure of the bargain system into its recognisable classic form [157]. The range of the original poundage rate was only of the order of a few shillings in the pound, but as time passed, this standard price list became increasingly unrealistic in monetary terms, and merely represented a fixed base-scale upon which larger poundages were applied [158].

Additional components were added to the bargaining wage system from time to time. These included payments on a standard tonnage rate for all debris cleared and loaded by the production gang at the rock face. There was also a yardage rate for ensuring that the gallery floor was rendered level for the laying of access tramways, which were periodically moved to keep pace with the developing workings. From the total earnings. deductions were then made for the cost of tool sharpening, and for explosives and other consumable items supplied by the quarry proprietor to the bargain crews [159].

Although there is evidence of exploitation of the men in the early period when several quarry companies operated truck (or 'tommy') shops, this does not appear to have been the case in more recent times [160]. Furthermore, despite the assertions from some quarters that the bargaining system represented a tangible act of oppression of the quarrymen, it must be noted that their Union (of 1874) strongly supported the piece-work sub-contracting, with its perceived independence of the crew, although the way that it was operated in some quarries was much criticised [161].

The experience of a team of rockmen at the Cloddfa'r Lôn Quarry in the 1840s illustrates the commercial relationship between the proprietors and the contracting skilled quarrymen. Here, two men paid the management £1.16*s.* (£1.80) for the privilege of sinking a seven yards deep shaft in the quarry floor, so as to claim the sole rights on the undeveloped rock thus uncovered [162].

In parallel to the production teams and the bargaining system, there developed a hierarchy of different classes of workmen in the quarries, both casual and full-time employees retained on a variety of contracts, day-rates, tonnage-rates and salaries. With the exception of the self-employed blacksmiths, other tradesmen (for instance carpenters, fitters, masons and platelayers), machine attendants (such as engine drivers, saw-sharpeners, and weigh-bridge clerks), and general labourers were paid on a day-rate basis according to the grading of the job. Men employed on development work and pit labourers were usually paid on a tonnage rate to provide an incentive to complete the required clearing work, although some labourers and semi-skilled men were also employed directly by production teams on a day-rate. Management grades (including clerks and inspectors) were retained on a salary, although there was one recorded profit-related bonus scheme for senior management in operation by 1907 [163].

The decline of the bargaining system

The bargaining system was designed to reward skill and effort in the face of geological variations within the slate strata, and when operated correctly it was capable of doing so successfully to the mutual benefit of the men and masters. Its great virtue was the incentive to attain the maximum yield from the quarried rock, promoting the development of a highly advanced craft-skill.

The bargaining system appears to have worked well in the period of the great slate boom in the 1860s and early 1870s, when labour relations appeared amicable throughout the industry except for the flash-point of the Penrhyn Quarry, Bethesda (see below). With soaring sales, the quarries could not keep up with the demand for slates and skilled men were at a premium. Average wage rates advanced about 12½ per cent between 1865 and 1874, when the average per day for quarrymen at Nantlle was around 5*s.* (25p.), and 3*s.*10*d.* (19p.) for labourers, although such average day-rate comparisons are a most unsatisfactory form of data [164].

On the other hand, bargaining had many flaws, of which its greatest was a dependence upon the integrity of all participants. It was therefore particularly unfortunate for the industry that the bargain system was mis-used by owners and managers. The injustices handed out to the quarrymen at the Penrhyn Quarry in particular, by corrupt management, and the general practice of 'offering' the bargain terms as an ultimatum as an alternative to unemployment, had totally debased the system by the 1870s [165]. On the other hand, it was counter-claimed that during periods of skill shortages during the 1860s, certain elements within the workforce also abused the system by demanding cash payments as an inducement to take bargains, and that some men held options on bargains in several quarries simultaneously, thus disrupting the working of the concerns [166].

The gradual downturn in demand for slates post-1878 turned into a headlong rush into depression by the mid-1880s (see Chapter 1), causing financial chaos throughout the industry. The matching of quarry output to the market demand could have been achieved by reducing the number of bargains at work in a quarry, but had the disadvantage of risking the permanent loss of the skilled men discharged from the industry [167]. There was little choice in the first instance other than to maintain current production levels and place the unsold slates in a stockpile. Yet, to do so required a reduction in the production-based wage rates to compensate for the default of sales revenue, or an inability (or refusal) to dip into reserve capital, if this existed.

In reducing wages *via* a depression of poundage rates, the quarry concerns evoked an unwritten rule in the industry regarding the linking of prices and wages, a relationship which was supported by the workforce during the market spiral pre-1877, but dis-owned when this trend was reversed (see subsequent sub-section) [168].

The key to regulating the wages of the production gangs was a tighter control by management of the setting of bargain terms, based on the utilisation of statistical analyses of the piecework rates. The most useful accounting indicator was the computation of average day earnings, from which a 'letting standard' (that is a controlled poundage) was derived so as to set a common ceiling for the wage of the production gangs [169]. Thus, the incentive element of the piecework system was gradually eroded and the poundage rate became an instrument of control rather than one of compensation, whence the term 'bargaining' became certainly a misnomer, albeit remaining in common usage.

One particularly pernicious result of the accountancy-based management of slate production was the use of the previous month's earnings to set the level of the succeeding month's poundage. Thus, a breach of the nominal maximum wage would be clawed back by the 'bargain setter' through the reduction of the subsequent month's poundage, but the converse was only grudgingly conceded [170].

This was an unsatisfactory method on many counts. The outcome of any month's work depended upon a number of incalculable factors, and the penalty of a cut in the poundage for successful working was a disincentive which forced the gangs into adopting ruses to circumvent the financial indicators which triggered these reductions.

The most obvious means was to reduce the number of slates made. The balance in earnings was made up by boosting the payment for the removal of debris on a standard tonnage rate, by throwing away workable slabs. The malicious wastage of a finite reserve of raw material had grave consequences for the future prospects of a business, and there were consequently severe penalties for any proven cases; however, the skill of the rockman could equally be channelled into disguising malpractice as it could for working conscientiously [171].

Some rock-men could not bear to desecrate the quarry in this manner, and used other tactics to beat the 'bargain-setter'. This official was not always a proficient quarryman, and it was often possible to disguise the true nature of the rock face so as to obtain a slightly higher poundage within the discretionary range within which he was allowed to operate [172]. It was in these situations that bribery became endemic, with the cottager-quarrymen having the advantage over his terraced-house colleagues in terms of the agricultural produce that could be used to tempt the quarry officials into compliance [173]. None of these tactics were good for the proprietor, who lost production; nor for the quarryman who was forced into cheating so as to beat the system.

Wage disputes and the role of the Quarrymen's Union in bargaining

The response of the workforce to wage reductions varied from era to era, and at times this followed a predictable pattern. The slate industry at Nantlle had experienced many cycles of activity before the 1870s, each being marked by fluctuations of wages. Dylan Pritchard noted that under the piece-rate system it was practically impossible for the quarrymen to calculate the average rate in their own quarry, and a district average could not be estimated at all. Pritchard further recognised that the fragmentation of the workforce into small self-interest groups made up of crews made up of family members or close friends, together with the absence of a trade union, accounted for the general absence of strikes in the slate industry before the last quarter of the nineteenth century [174].

At Nantlle, the mobility of a significant fraction of the workforce from one quarry presented a further factor, allowing persons harbouring grudges to start anew elsewhere and providing some measure of pressure on management to retain skilled workmen by fixing competitive piece-rates [175]. This was probably the reason why there had been only one strike at Nantlle pre-1878 despite the reduction in wage levels consistently applied in the industry on the downturn side of each trade cycle. This single incident was at the Dorothea Quarry in 1857, when the men became particularly disenchanted by the reduction in wages implemented by this company because almost half of the shares were owned by local persons, many of whom were quarrymen [176]. However, the despoiling of the Cilgwyn Quarry during the bleak Christmas of 1845 and the subsequent unofficial (and illegal) working of that site for two years showed that the potential for industrial unrest was ever present [177].

Yet, after the 1850s, the great expansion of the industry ushered in a new era where the outlook of the inhabitants, both in industrial practices and culturally, was radically altered by an influx of new blood into the quarrying districts. Furthermore, the enlarged workforce after the great expansion of the industry during the 1860 had a high proportion of urban dwellers amongst the men compared with formerly, and thus the effects of any reversal to the constant wage increases of the 'golden years' upon those who were not self-sufficient in basic food-stuffs would have been more pronounced and less tolerable [178]. However, the difficulties of labour relations encountered at the Penrhyn Quarry during the 1860s, leading to the traumatic birth of the Quarrymen's Union in 1874 [179], had no parallels in the Nantlle district, where the atmosphere was calm at first.

Nevertheless, it is significant that the first mass wave of industrial unrest amongst the quarrymen at Nantlle coincided with the downturn in the slate trade in 1878. When wages were reduced to shadow the downward trend in slate prices in that year, there was an immediate series of strikes affecting several slate-producing areas. The quarries of the Nantlle district were affected by a greater degree of unrest than elsewhere, with production being halted in at least six concerns for several weeks [180]. However, in each case the men were forced to capitulate probably because of a lack of co-ordination in the action and due to the low number of Union members in the district.

Ironically, the Union was particularly careful to distance itself from one faction of Nantlle men who were very likely to have been rare examples of fervent activists in this district; they had formed the mob which assaulted the management of the Hafodywern Quarry (Betws Garmon) in 1879 and driven off the 'blackleg' Cornish workers employed there [181].

The Quarrymen's Union never gained a great deal of support in the urbanised portions of the Nantlle valley before the 1900s, despite the founding of a local lodge during its first year of existence and evidence that several important quarry proprietors were in sympathy with its cause [182]. Consequently its members were permanently in the minority for decades.

This phenomenon has been explained by Dr Merfyn Jones in terms of the fragmented organisation of the industry in the Nantlle district, making the functioning of an Union lodge extremely difficult, and of the lack of cohesion of a relatively mobile workforce being not conducive to the development of an awareness of unity [183]. Furthermore, the high rate of unemployment at Nantlle during the deep trade recession of the 1880s, dissuaded strikes to protect wage levels, and the Union dues were consequently considered an unnecessary expense. A general increase in wage rates granted unilaterally by the quarry proprietors in response to rapidly improving trade after 1896, marginalised the Union even further, relegating it at Nantlle to a small, yet particularly vociferous rump of activists [184].

It was only in the Crown quarries of the northern plateau of the Nantlle district that there was to be found a strong Union lodge, serving a close-knit and rather insular upland community inhabited by many descendants of the old independent local quarrymen of the eighteenth century. This lodge (the No.9, Moel Tryfan District) was amongst the most militant in the Union and the only one not to lose members in the late 1890s when morale plummeted after the defeat at Penrhyn in 1897. From 1878 to 1914, the Moel Tryfan lodge was involved in ten strikes with the proprietors of the Crown quarries, which included both the Welsh, Liberal proprietors of the Moeltryfan Quarry and the English, Tory owners of the Alexandra and Braich companies [185].

The harsh wage reductions following the reversal of the 1896-1903 mini-boom into a decade of deep recession in the slate industry, awakened even the less militant workers of the valley floor. Although only small in number, it is likely that the highly socialist Nantlle lodge of the Quarrymen's Union had an important role in the unsuccessful strikes which affected the Alexandra, Braich, Coedmadog, Penyrorsedd, Talysarn, and South Dorothea quarries, variously in 1905 and 1911-12 [186]. This can be contrasted with the contemporaneous acceptance of wage reductions at the Dorothea Quarry, where industrial relations were more amicable and where the enlightened management briefed representatives of the workers' committee on the financial necessity of reducing costs [187].

It was significant that all of the quarries involved in the 1905 dispute (above) were managed by A. W. Kay Menzies (of Caernarfon), who had an autocratic attitude with regard to his workforce [188]. Fresh from his victory over the strikers, Menzies continued to practice a Penrhyn-like approach which involved such practices as summarily reducing poundage rates from the terms agreed (termed *torri gosodiad*). In so doing, he was breaking the unwritten code which expected all participants in a bargain-setting to honour the verbal contract, a situation which was an anathema to the quarrymen. It was therefore inevitable that a further clash would take place at Menzies' quarries, the eventual flashpoint being at the Alexandra Quarry in 1914, a battle ground chosen by the Union. This strike was a significant event for the Quarrymen's Union in that it was the first victory in an official dispute under the inspired leadership of the new general secretary, R. T. Jones [189].

Changes to the organisation of working were only slowly instituted and were generally localised until the setting up of an official Union/employers negotiating structure in 1917 (see below). For example, as a result of pressure from the production gangs following precedents in other districts, weekly payments were gradually introduced by the larger Nantlle concerns during the first decades of the present century. This involved paying the individual members of the production gangs a standard 'subsistence' sum in four or five payments, with the balance being accounted in the final instalment when making up the monthly pay 'bill' following the end of the contract period [190].

This was almost an unofficial minimum wage system, but despite pressure from the Quarrymen's Union an official industry-wide minimum wage was not brought in until external circumstances forced the turn of events in 1918 [191]. The corresponding granting of the concession of a 'closed shop' to the Union in quarries operated by the Owners Association members brought the negotiation of wages for the majority of workers in the industry under central control after the end of the First World War [192].

The success of the Union in the collective pay-bargaining was variable. Large pay increases were obtained for those men remaining in the industry during the First World War, although much of this was merely a reflection of the depreciation of money during a period of high inflation. Average wages consequently rose in face value from an average

£1.10*s.* (£1.50) per week in 1914 to a maximum of £5 from July 1920 to December 1921, although the increase in real terms was not very great [193]. The reversal in average wage after January 1922 during the first phase of the inter-war slump in the slate trade precipitated the first and last official general strike in the industry, but this proved futile. Thereafter, the Union was unable to resist further reductions in wages as the decline of the industry deepened during the 1929-1932 Great Depression, and the modest restoration of earnings achieved during the 1930s, and almost all increases thereafter were dictated by the employers [194].

(iii). Mass-production and bonus systems

As a result of the changes outlined above, the bargain system had lost its original characteristics, and the creation of a 'letting standard' or standard poundage practically converted this component of the piece-work system into a fixed bonus system. Furthermore, there were several features of bargaining which were answers to the problems of the 1830s but were damaging to the industry a century later.

Dylan Pritchard argued that the worst aspect of the system in economic terms was the sub-division of the workings into a mass of almost individual little quarries, even when making up a large unit. Not only did this encourage a stubborn frame of mind on the part of the workforce, but the persistence of perceived ownership (albeit only in an abstract sense) proved a hindrance to the adoption of flexible systems of working, except in the case of emergencies such as major landslides [195].

Furthermore, Pritchard maintained that the strict demarcation of work also blocked the introduction of improved mechanised methods of production which proved deleterious to the long-term future of the industry [196]. The potential for abuses of the short-term contract basis of employment was condemned even during the heyday of the bargain system in the 1870s, when endemic bribery for favours on the one hand was equally countered at Nantlle by a lack of commitment towards individual employers as a result of the high resultant mobility of labour between the various quarries, thereby disrupting management development plans [197].

In view of the economic arguments presented above, plus the degradation of the system from one of individual compensation to collective wage standardisation, the ultimate demise of the bargaining system in the early twentieth century was both predictable and decades overdue. Thus it was only a matter of time before the old system was usurped by another based on that developed at the Parc Quarry (Croesor) by the idiosyncratic Moses Kellow *c.*1900, but adopted for the first time on a large scale at the Penrhyn Quarry by c.1920 [198].

This new 'mass-production' system, described and discussed below, was a more benign derivative of the contentious 'big contract' system of the 1870s-90s (see above), and was accepted by the Quarrymen's Union without reservation. Consequently, a number of the smaller quarries at Nantlle were enabled to introduce their own tailor-made versions of 'mass-production' upon reopening after 1918 [199]. In the case of the surviving larger Nantlle quarries the changeover from the old bargaining system took place progressively after 1930, with each case correlating with the introduction of new management. For example, in 1930-31 the influx of Bethesda men into the management of the Penyrorsedd Quarry instigated the first major restructuring of wage and work systems in a main employer in this district, followed by the Dorothea Quarry in 1935, and by the Crown Company in 1940 [200].

In the new 'mass-production' system, the rock-getter and the slatemaker were considered as being entirely independent entities unconnected by any ties of partnership. The extracted slate slabs were immediately the 'property' of the management, to be distributed amongst the slatemakers as deemed appropriate [201]. In the quarry pit, the rockmen were still organised in teams, but these were allocated by management on a more flexible basis than previously. They were still served by assistants, albeit now employees of the concern rather than casual labour or journeymen apprentices reimbursed by the production teams. The rockmen and rock-labourers (formerly bad-rock men) were paid on a flat tonnage rate for rock extracted, although workable slabs and rubble were differentiated on a scale which could be changed according to the circumstances. At the Penyrorsedd Quarry (Nantlle), if not elsewhere, this involved the setting of pseudo-bargains for teams of rockmen on specific rock faces with each having differing block- and waste-rates set according to the estimated commercial value of the face [202].

Slatemakers were at first paid according a piece-work rate similar to that which had previously been in force, that is, a sum per long-hundred according to a list price depending upon sizes and grades. The greatest change in this part of the system was in the allotting of slabs from the 'pool' of the produce of the pit. Several different ideas were implemented over the years, each attempting to overcome charges of inequitable distribution of the best grades of slab, sometimes put down to bribery or favouritism. The equitable distribution was largely dependent upon the skill of the 'grader' who had to place each slab into one of three categories, and had to chart the order of slabs supplied to each slatemaker [203].

This system was not altogether successful, and had an overall bad effect upon craft-skills, especially at the rock face. In addition to the lack of care taken with the productive rock due to the removal of the incentive to maximise the slatemaking yield, there remained an incentive to earn a wage by converting workable slabs into rubble. To overcome this, a system based on bonus payments was introduced by the 1950s by the North Wales Slate Quarry Owner's Association, although details varied from quarry to quarry. The most common was the payment of a standard basic weekly wage to pit production workers, with the bonus being based upon the highest earnings attained by a slate-maker (termed *bonus wal uchaf*) [204].

This pooling of all the output of the pit and the random distribution of the slabs amongst the slate-makers, provided an incentive for all production rockmen to ensure the highest quality of all slabs extracted. However, there was a tendency in this system to send all manner of borderline material to the mill, thus actually reducing the total slates made, although this situation was improved when centralised sawing systems were introduced in the 1960s. Furthermore, the level of bonus rates was a common bone of contention between the workers and management, precipitating an unsuccessful strike at the Dorothea Quarry in 1949 and a more effective "go slow" at the Penyrorsedd Quarry *c.*1957 [205].

The change-over to centralised sawing released the slate-makers from a time-consuming task, although some of the gains was lost by the new requirement of dressing the slates, a task which had formerly been performed by day-men or apprentices. The maximum produce per slate-maker thus increased and therefore the list prices had to be reduced to maintain the average wage rate. This slate-making list could then be used to compensate for changing values of individual types and grades of slates by varying the prices to provide incentives for the production of the more popular sizes. It was also possible to restrict the manufacture of certain slates that were not selling well, by simply instructing slate-makers that these were not be be made [206].

During the 1980s there was a further change at the Penyrorsedd Quarry, whereby a minimum production quota per slate-maker was set before any bonus was payable to top-up the standard basic wage. This was calculated upon a list-price, but still suffered from the penchant of the men to concentrate upon the larger sizes and to throw away the smaller material. To prevent this waste, the bonus was changed to one calculated on the basis of the total value of the mill production per week. Under this system, the sawn blocks of slate could be distributed randomly to the slate-makers due to their dependency on the collective effort to reach a bonus, although this still has the flaw of not adequately encouraging a sufficient degree of care on behalf of the pit workers when extracting slabs from the rock-face [207].

NOTES

CHAPTER 3

Abbreviations

C.R.O.	Caernarfon Records Office (Gwynedd Archives Service)
P.R.O.	Public Record Office, Chancery Lane
Q.M.J.	Quarry Managers' Journal
T.C.H.S.	Transactions of the Caernarfonshire Historical Society
U.C.N.W.	University College of North Wales, Bangor, now University of Wales, Bangor.

(a) The whole-quarry overview

1. This has been discussed in Chapter 2 (a) i and (b) iii, with regards to the implications for finance and investment. The importance of pre-planning the development of sites was constantly stressed in contemporary handbooks such as Davies, D.C., Slate and Slate Quarrying, (1887, 3rd ed.), pp.79-160 passim. Examples of pre-purchase inspection reports for quarries at Nantlle are rare, but that for the Gwernor Quarry in 1889 [C.R.O., X/Dorothea 1253] makes an interesting comparison with sales-inspired reports of 1920 [ibid., 1278]. See also the comments of Morgan Richards *Morgrugun Machno*, in Slate Quarrying and How To Make It Profitable, (London, *c.*1877), pp.4-7, on this topic.

2. Davies (1887), op.cit., pp.79-81. With regards to the provision of expert reports for dubious undertakings, good examples were those furnished by Owen T.Owen (manager of the Dorothea Quarry, 1875-93) and William Davies (manager of the Penybryn Quarry, the Talysarn Quarry and the South Dorothea Quarry (1864-75, 1875-*c.*80 and by 1881 respectively), both extolling the apparent virtues of the worthless Taldrwst Quarry in a prospectus of 1881 [C.R.O., G.P.Jones/Nantlle Mss [uncatalogued], Taldrwst Quarry]. Davies' grandson, Mr Bleddyn Davies of Talysarn, recalls seeing many such reports amongst the effects of his deceased grandfather, although none of these now survive. See also Richards, A.J. (1995), Slate Quarrying in Wales, (Llanrwst), pp.45-46; and Thomas, J.E., A Geographical and Geological Description of Carnarvonshire, (1874), p.75, which commented on the:-
   "...vast sums ...ruthlessly thrown away ...upon mining operations for a want of that particular scientific as well as general knowledge of the rock structure," and of the deficiencies in knowledge of "...many of the so-called practical men ...of the ordinary rules and principles of geological and its allied sciences."

3. Prior to the definitive study by Morris, T.O., & Fearnsides, W.G., (1927), 'The Stratigraphy and Structure of the Cambrian Slate Belt of Nantlle, Carnarvonshire,' Quarterly Journal of the Geological Society, Vol.lxxxvii (2), pp.250-303, the rocks of Nantlle had been the subject of several investigations following the early work of Ramsey (1840s) and Sedgewick (1850s) - see Morris & Fearnsides, pp.252-255. Although the general descriptions by J.O.Griffiths (*Ioan Arfon*), 1863, Llechfeini Sir Gaernarfon, (Tremadog 3rd ed., 1882); J.E.Thomas (1874), op.cit., Part IV, and by D.C.Davies op.cit., Chapters I - XI, show an increasing understanding of the regional geological structure, the localised complications of the fine geology of Nantlle defied analysis (e.g., see the local surveys C.R.O., X/Dorothea 1552 and U.C.N.W., Bangor 16536) prior to Morris & Fearnsides, op.cit.

4. Griffiths, J., *Sylwebydd*, (1889), ed. W.J.Griffiths, Chwarelau Dyffryn Nantlle a Chymdogaeth Moeltryfan (Conway *c.*1930), p.69. There is a strong correlation between evidence of early quarrying with hillside locations and the striped blue vein at Cilgwyn, Cloddfa'r Coed, Galltyfedw, Old Braich and Talysarn, and of the mottled blue vein at Ty Mawr and Tynyweirglodd.

5. The projection of the course of the slate beds into adjacent properties is alleged to have resulted in the opening of the Coedmadog and Penyrorsedd quarries [see J.Griffiths *Sylwebydd*, (1889), op.cit., pp.8, 56] and to the opening of Pit No.3 at Dorothea [ibid., pp.39-40].

6. I.e., William Turner (Diffwys Quarry, Ffestiniog) and George Bettis (Lord Newborough's agent at Lord Quarry, ditto.); see Chapter 2 supra., and Lewis, M.J.T. & Williams, M.C. (1987), Pioneers of Ffestiniog Slate, (Plas Tanybwlch), pp.9-15.

7. Davies (1887), op.cit., p.80; A.J.Richards (1995), op.cit., p.16. The sole extant take note relating to Nantlle found by the author to date was for Allt Goediog Field, Ty Mawr Farm, Llanllyfni Parish, to J.S.Smith in 1837 [N.L.W., Rumsey Williams 2703], with only a plan surviving of the Foel Uchaf take-note of 1878 [C.R.O., X/JW/Maps/10].

8. Davies (1887), op.cit., pp.80-84, discusses lease clauses in some detail. Whereas much information regarding the financial terms of a large number of quarry leases at Nantlle can be found in a multitude of abstracts and schedules incorporated into sales prospectuses and property deeds, examples of complete quarry lease agreements are rarer. Outside the comprehensive C.R.O., Dorothea (post-1849) and Penyrorsedd (post-1862) Mss, and the large collection of Crown mineral leases [P.R.O., L.R.R.O.16/-], examples are limited to the Alexandra Quarry 1863, 1864 and 1893 [C.R.O.,

XM 6703/10, 11, 17]; Dorothea Quarry 1839 [N.L.W., Rumsey Williams 2709], Fronheulog Quarry 1865-94 [C.R.O., XM 2344/1, 5, 7, 9, 10]; Llwydcoed Quarry 1862/77 and 1884 [C.R.O., XD 2/6769-6770]; Penybryn Quarry [Rumsey Williams op.cit., Ms 2705], Taldrwst Quarry 1833 [ibid., Ms 2702], Talysarn Quarry 1813 [ibid., Ms 1693]; Penyrorsedd 1853 [C.R.O., XM 55/23]; and Tynyweirglodd 1813 and 1847 [Rumsey Williams op.cit., Ms 2695; U.C.N.W., Tyngongl 583].

9. Ibid.

Development methods

10. The topography of the district can be seen in the contoured 1:25,000 O.S. (2½-inch) maps Nos., SH 45, 55. For greater detail of the slate workings, see the 1:10,560 O.S. (6-inch) maps Carnarvonshire XXI, N.W., and XXI, S.W., of 1889, 1899 and 1913 and also the complementary 1:2,500 O.S. (25-inch) maps.

11. Morris & Fearnsides (1927) op.cit., p.261; U.C.N.W., Nantlle 1, f.90 and C.R.O. XM 392/1, f.51, re. trials in Cwm Dulyn; H.M.Inspectorate 'Lists of Quarries' (appendix to annual reports) in the late 1890s records Talymignedd Quarry working briefly. These quarries worked what was termed 'black slate' which was light blue when first extracted from the rock body, but whose high hydrated iron content soon oxidised upon contact with the air.

12. Little is known of the quarries in and around Clynnog, other than their failure to develop, probably because of the poor quality of the rock. They are briefly mentioned in U.C.N.W., Nantlle 1, ff.90, 92 (Cilcoed and Foel Uchaf quarries); Carnarvon & Denbigh Herald, 24 January 1863, p.4, sale advert of Coch-y-Big, possibly unidentified "St.Winifred Quarry," apparently in Caernarfonshire and associated with the speculative Great Welsh Union Slate Co. [see Richards (1995) op.cit., p.46], having been named after St.Beuno's alleged sister (see below); and ibid., 17 September 1864, p.4, advert for workmen for the "St.Beuno's Quarry" (unidentified, but possibly Cilcoed).

13. Details of the individual sub-strata within the slate beds at Nantlle can be found in C.R.O., X/Dorothea 1211, geological sections; C.R.O., XM 4771 geological essay by O.J.Hughes. Details of the rocks in the individual quarries feature prominently in the local history essays C.R.O., XM 392/1 passim; U.C.N.W., Nantlle 1, passim; and J.Griffiths *Sylwebydd* (1889), passim.

14. North, F.J., (1925), The Slates of Wales, (National Museum of Wales), pp.5-23, 30-39. A general account of the tectonic structure of this

region can be found in Smith, B. & George, T.N., British Regional Geology: North Wales, (H.M.S.O., 1961, 3rd ed.), Chapter III, 'The Cambrian System'.

15. Morris & Fearnsides (1927), op.cit., pp.264-285, plus plan and sections appended to this source.

16. This suggestion from local history essays (see Note 13, supra.) correlates with the visible geology of those early sites that have survived later developments relatively unscathed.

17. The phrase, "*Nid yw chwarel yn gweithio yn Saesneg*" ("A quarry cannot work in English", - see J.Griffiths *Sylwebydd* (1889), op.cit., p.48; alternatively phrased, 'A slate quarry must be worked in Welsh,' - see Lewis, M.J.T. (ed., 1987), The Slate Quarries of North Wales in 1873, (Plas Tanybwlch), p.11, remained in folk memory from the mid-nineteenth century until very recently. It was an expression of the confidence of the quarrymen in their judgement of the best means of working the quarries, based on craft skills, against the perceived ignorance of the English company agents. This can be seen in Robert Williams' invective against English quarry agents in 'Hunangofiant Chwarelwr VI, Cymru, XVIII, (106), 15 Mai 1900, p276; and ibid., VII, (107), 15 Mehefin 1900, p.332. On the other hand, John Robinson, managing director of the Talysarn Quarry, dismissed this 'Welsh Management' hypothesis out of hand in his report to a company E.G.M., in 1872, pointing out that the most profitable concerns were managed by Englishmen [C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Talysarn Quarry]. The role of the manager, and of his character, is discussed at length by Morgan Richards, *Morgrugyn Machno* (1877), and by *Dewi Peris*, 'Chwarelyddiaeth, II,', Y Genhinen, XIV (1), Ionawr 1896, pp.52-54.

18. Detailed analyses of production figures for the individual Nantlle quarries are rare, but those for the Dorothea Quarry [C.R.O., X/Dorothea Mss 560-563, 1052, 1422, 1480, 1484, 2119] give a representative sample. Whereas the average make/total excavated tonnage for this concern varied from 1:14 to 1:25 over the six decades pre-1939, and had deteriorated to a range from 1:40 to 1:70 during the 1950s, the data for the four individual pits within the quarry complex varied considerably. For example, in 1898, the best mature workings in the purple slate provided a 1:10 make/total rock quarries (a 10% yield), whereas one blue slate pit nearing the end of its working life gave only 1:99 (slightly over a 1% yield), with the yield of the sawn blocks being 31% and 7% respectively. However, financial break-even points also depended on additional factors outlined in Chapter 2, Part (c), supra. The radical changes in technology and manning levels in the modern slate industry has

led to previously unsustainable low yields of 1:300 or less, becoming the norm because break-even points have moved commensurately.

19. Dylan Pritchard, 'Our Quarry Aristocracy,' Q.M.J., November 1942, pp.185-187; idem., 'Aspects of the Slate Industry: The Expansionist Period (1790-1877), VI,' Q.M.J., August 1944, pp.71-72; idem., 'Random *v* Talley Slates,' Q.M.J., August 1946, pp.103-105, discuss the criteria of grades and sizes of roofing slates. See also Note 93, infra.

20. For example, the Dorothea Company closed their Quarry 'B' in 1908 with the loss of some 250 jobs because the striped blue slate from that pit was becoming unmarketable despite heavy discounting [C.R.O., X/Dorothea 5, f.93]. Contemporaneously, thousands of tons of workable spotted red slates were dumped over the tips at the Penyrorsedd Quarry because of a market resistance to the coloration [ex.info., former employees].

21. Morris & Fearnsides (1927) op.cit., pp.255-260; C.R.O., XM 4771; discussion on individual quarries in C.R.O., XM 392/1 passim; ibid., XM 4874/47 passim; U.C.N.W., Nantlle 1, passim; J.Griffiths *Sylwebydd,* (1889), passim; ex.info., former quarrymen.

22. Ibid.

23. Reports on the Gwernor Green Slate Quarry, C.R.O., X/Dorothea 1253; C.R.O., XM 4874/47, ff.37-38.

Quarrying systems

24. The accounts of early quarrying techniques in local history essays [C.R.O., XM 392/1; ibid., XM 1758.addit 89; U.C.N.W., Nantlle 1; and J.Griffiths, *Sylwebydd* (1889), op.cit., pp.13, 66-67, 69-70, 79], are somewhat contradictory and are all second or third hand. The aquatint 'The Slate Mine' by J.C.Stadler after P.J. de Loutherbourg (1800), reproduced on the front cover of Lewis & Williams (1987), Pioneers of Ffestiniog Slate, op.cit., gives a good impression of the likely appearance of a quarry in the Nantlle district in the early years of the nineteenth century.

25. J.Griffiths *Sylwebydd,* (1889), pp.68, 71; M.J.T. Lewis (1987), The Slate quarries of North Wales in 1873, op.cit., p.63; Dylan Pritchard, 'The financial Structure of the Slate Industry of North Wales, 1788-1830,' Q.M.J., December 1942, p.213; idem., 'Aspects of the Slate Industry: The Expansionist Period (1790-1877), V,' Q.M.J., July 1944, pp.17-18; U.C.N.W., Porth yr Aur 27216. This appears to have been a particular problem at the Cilgwyn Quarry in the early years of the nineteenth century, when both the Cilgwyn &

Cefn Du Company and its successor, Muskett & Co., had to contend with the costs of removing debris tipped recklessly by their predecessors.

26. See Morris & Fearnsides (1927), op.cit., pp.264-285 and appended plans for cross-sections illustrating gritty forebreasts. The working method described is based on that described for the development of the Moeltryfan Quarry by J.Griffiths *Sylwebydd*, (1889), op.cit., pp.92-93.

27. Loc.cit.

28. Tunnelling costs varied according to the type of rock and the date in question. Costings for tunnelling at Nantlle are rare, but those extant for the Penybryn New Quarry development of 1898 [C.R.O., X/Dorothea 1254] quoted a rate of £5 per yard progressed, compared to a rate of 1*s.* (5p.) per cubic yard for removing top-rock.

29. A.J.Richards (1995), op.cit., pp.49-50; J.Griffiths, *Sylwebydd* (1889), op.cit., pp.93-95, re. Moeltryfan Quarry development scheme, 1830s. There were only a few deep adits at Nantlle because of a combination of costs, the financial insecurity of many concerns and also the question of suitable topography. The only examples of deep drainage tunnels of any significant length at Nantlle were at the Alexandra, Cilgwyn, Fronheulog, Llwydcoed, Moeltryfan, Penybryn and Penyrorsedd quarries.

30. This process of 'sinking' can be followed from the entries in the Dorothea Quarry Journal [C.R.O., X/Dorothea 5, passim.] and a cost analysis of developing one 'sinc' [ibid., Ms 562, p.233]. In the case of their main workings, new floors were opened on average once a decade before the Second World War, although this process was severely disrupted on several occasions by rockfalls.

31. The quarries at Ochr-y-Cilgwyn were described in early tourbooks thus:-

"...In the Schistose rocks are several slate quarries, very considerable ones near Dolbadarn, some in Llanberis, a few in Llan Michael [sic; Llanrug Parish], and very large ones at Kilgwyr [sic], the products of all which are brought to Carnarvon, and there shipped to market." [Evans, Rev J.; <u>A Tour Through Part Of North Wales In The Year 1798 And At Other Times</u>, (London, 1800), p.138];

and "...I walked up to them [the slate quarries], and found a chasm formed in the rocks that, from its peculiar appearance, surprised me almost as much as the excavations in the mountains of Nant Francon [sic], belonging to Lord Penrhyn. This is very narrow, long, and deep, its sides being nearly all perpendicular, and to a stranger, unaccustomed to sights of this nature, it will be found very interesting." [Bingley, Rev W.; North Wales, including its scenery, antiquities, customs, and some sketches of its Natural History (excursions of 1798 and 1801), (London, 1804), p.393].

32. J.Griffiths *Sylwebydd*, (1889), op.cit., p.12.

33. Morgan Richards *Morgrugyn Machno* (*c.*1877), op.cit., pp.36-47; evidence of R.O.Owen, Questions 2072-2076, in the Report of the Home Office Quarry Committee of Enquiry, 1893, (H.M.S.O., 1894) [U.C.N.W., Welsh Library KF 165], p.63; evidence of A.W.K.Menzies, Questions 7,465-7,467, in the First Report of the Royal Commission on Metalliferous Mines and Quarries, 1910-11, Vol.I, (H.M.S.O., 1912) [U.C.N.W., Welsh Library XF 47], p.220; and W.J.Griffiths, Question 11,175, in the First Report of the Royal Commission on Metalliferous Mines and Quarries, 1910-11, Vol.II, (H.M.S.O., 1912) [U.C.N.W., Welsh Library XF 47], p.36, regarding the mode of development of the deep-pit workings at the Dorothea Quarry.

34. The newer pits opened after the 1880s at Alexandra, Cilgwyn, Penybryn and Penyrorsedd, together with the new development at Dorothea Pit 'D' post-1930, were worked in internal galleries, but it was not feasible to install gallery systems within the existing old deep pits such as Cloddfa'r Lôn, Dorothea Pits 'B' & 'C', Faengoch Pit (Cilgwyn) or Talysarn. Whereas this issue, which had great implications for safety, had been addressed in part by the Home Office Quarry Committee of Enquiry, 1893, (Report, H.M.S.O., (1894), U.C.N.W., Welsh Library KF 165], e.g. in evidence of T.H.Griffiths and R.O.Owen [ibid., pp.37-38, 63], the advantages of working on the gallery system was more thoroughly investigated by the Royal Commission on Metalliferous Mines and Quarries of 1910-11, [First Report, H.M.S.O., (1912), U.C.N.W., Welsh Library XF 47], e.g. in the evidence of G.J.Williams (Mines Inspector), Questions 1,285-1,310, [ibid., pp.44-45], W.R.Williams & W.Jones, Questions 3,185-3,224 [ibid., pp.102-103], A.W.K.Menzies, Questions 7,269-7,279, 7,440-7,444 re. Alexandra Quarry [ibid., pp.215, 219], and J.E.Roberts, Questions 8,490-8,513 re. Moeltryfan Quarry [ibid., pp.246-247].

35. This is the contemporary quarrying system used at the Penyrorsedd Quarry.

36. See Morris & Fearnsides (1927), op.cit. pp.164-285, for cross sections and an account of grit bodies.

37. C.R.O., X/Dorothea 1023, report on the Talysarn & Blaen Cae Quarry, 1925; ex.info., former employees at Blaen Cae, 1918-30.

38. P.R.O. CRES/2/1578, report of Warrington Smyth, Crown agent (1853-63), per Dr Dafydd Gwyn, to whom the author is indebted; M.J.T.Lewis (1987), The Slate Quarries of North Wales in 1873, op.cit., p.67; U.C.N.W., Bangor 1384, letter from Commissioners of Woods & Forests, dated 2 January 1880; C.R.O., X/Dorothea 1488, newspaper cutting of 1894 Talysarn Quarry landslide. See also Notes 49, 50 infra.

39. C.R.O., X/Penyrorsedd.addit 1873, managing director's report, 14 August 1874, regarding the unprofitability of continuing the underground development of the green vein; C.R.O., X/Dorothea 1286, report on the Crown Quarries, 1931; C.R.O., Rev. Stanley Williams Mss (uncatalogued), papers of Ellis Williams, Meillionydd, Y Fron, former manager of Cilgwyn Quarry.

40. C.R.O., XD 18/114, report *c.*1909 on unamed quarry, almost certainly Ty Mawr East, or Llwydcoed if not; ex.info., Mr Lefi Jones (former employee at Fronheulog) and Mr Iorwerth Thomas (former employee at Tanrallt). These chambers were off the deep drainage adits at the Fronheulog and Tanrallt Quarries, and that possibly at Ty Mawr East Quarry may have been unroofed during the 1920s to form the present small lower west pit.

Quarrying problems

41. D.C.Davies (1887), op.cit., pp.93-116. The four methods compared were hill-gallery workings, deep pits, chambered hillside mines, and underground workings served by a shaft.

42. Loc.cit. Whereas the both the typical open hillside galleries and the chambered hillside mine cost an estimated £11,639 and £11,231 respectively for a development up to a certain defined scale of operations, and the rarer shaft-worked mine cost £17,763, the Nantlle-style deep opencast pit of equal production capacity at £14,266 was significantly more expensive than the more common first two options.

43. There was hardly any overburden at Cloddfa'r Coed, Cloddfa'r Lôn, Dorothea Pits 'A', 'B' & 'C', compared to over 60 feet of clay covering the slate at Coedmadog, and thick sand & gravel overlaying the purple rock at Alexandra and Penyrorsedd.

44. This occurred with the sanction of the Crown lessors at Fron in the 1910s, Cilgwyn in the 1920s, Moeltryfan in the 1930s and Alexandra in the 1940s, at Talysarn in the 1920s because the great landslide was too great to remove, and at Dorothea Pit 'B' after 1918 by agreement with the landlord, the bottom third of Pit 'C' being

subsequently infilled. The lower portion of the Penyrorsedd New Pit was infilled by agreement as a result of the disastrous fall of 1963, and the current freehold operators have used three disused pits as tipping ground so as to reduce haulage costs and to provide for new access roads to deeper parts of the newer workings.

45. The development of the lower purple vein at Penyrorsedd, post-1862, was a logical progression uphill, involving the infilling of the old mottled-blue pits down-slope, as these became progressively worked out. Had the development plan continued as originally conceived, then the author believes that the upper purple vein would have been similarly developed, using the present pits as tipping space.

46. Although falls of rock were common in slate quarries throughout the region, their consequences were generally more disastrous at Nantlle. Because of the concentration of working in the bottom of pits, a significant portion of the quarrying faces was always affected.

47. The account in the Dorothea Quarry Journal [C.R.O., X/Dorothea 5, passim] contains many references to landslides and of their effects on the productivity of the workings over a period of from weeks to several months.

48. J.Griffiths *Sylwebydd*, (1889), op.cit., pp.15-16, 70; Morgan Richards *Morgrugyn Machno*, (1877), op.cit., pp.36-47, 56-63. The closure of the Cloddfa'r Coed Quarry in 1828 and of the Cilgwyn Quarry in 1830 was directly attributed to a rock-fall from granite which had been recklessly left *in situ* as a cost-cutting exercise.

49. Examples of major landslides involving hundreds of thousands of tons of rock were at the Talysarn Quarry *c.*1870, 1895 and 1923; at the Cilgwyn Quarry in 1863, 1869 and 1878; and at the Dorothea Quarry in 1857, 1884, 1891, 1924, and 1926. See evidence of W.Thomas, Question 1,617, Report of the Home Office Quarry Committee of Enquiry, 1893, (H.M.S.O., 1894) [U.C.N.W., Welsh Library KF 165], p.42, re. the Cilgwyn Quarry prior to the great 'fall,' where the sides of the pit were:-
"... hanging over so much that the drops [of water?] on the top were dropping on the other side of the quarry;" and also the evidence of T.H.Griffiths, Questions 1359-1371, [ibid., pp.37-38], re. accidents due to sheer sides in pits.

50. This was true of the fall at the Talysarn Quarry in 1895 [C.R.O., X/Dorothea 1488, cutting from Y Genedl, 15 January 1895], which uncovered a valuable vein of purple-red rock behind the grit

body which had collapsed [ex.info., the late J.M.Hughes, former quarryman at Talysarn Quarry from 1894 to *c.*1898].

51. For example, water lies within 60 feet of the surface in the Braich Quarry, which is at an altitude of around 1,000 feet above sea level. This hydrological profile of the 'water table' roughly follows the topographical profile, although it diverges progressively with increased height from a common level at low altitudes.

52. This situation was also found in the adjacent Gwyrfai Valley, although the quality of the slate in the latter did not warrant the canalisation and diversion of the river as at Nantlle.

53. See Dorothea Quarry lease of 1862 [C.R.O., X/Dorothea 932], and documents re. tipping dispute [ibid., Mss 1273, 1284, 1350].

54. The critical point must have been reached by the early 1870s because there are no reports of problems being experienced before this time, whereas a spate of difficulties were encountered in rapid succession after the mid-1870s. John Hughes *Alaw Llyfnwy*, recorded in 1877 that water from the lake when in flood was finding its way into the Dorothea pits by that date [U.C.N.W., Nantlle 1, f.77].

55. M.J.T.Lewis (1987), The Slate Quarries of North Wales in 1873, op.cit., p.69.

56. C.R.O., X/Dorothea 5, f.62. This issue was tied up with a dispute about a proposed standard-gauge railway extension to the Talysarn Quarry [C.R.O., X/Plans/R/70], and was an excuse to pressurise the Dorothea Company into withdrawing its objections to the line.

57. C.R.O., X/Plans/G/13, Nantlle Vale Drainage and Tramway Bill, 1879.

58. The Standing order Committee allowed the Bill to proceed in the 1880 Parliamentary Session only after the withdrawal of the clause granting powers to erect pumping machinery in the quarries [L.N.W.R. Epitome of Bills, via Mr Geoff Jenkins, to whom the author is indebted]. The Bill was ultimately thrown out as a result of the objections of Mr Assheton Smith, of the Vaynol Estate, who was an interested party by virtue of owning a portion of the Upper Nantlle Lake [Boyd, J.I.C., (1981), Narrow Gauge Railways in North Caernarvonshire, Vol.1 - The West, (Oakwood Press), p.67].

59. C.R.O., X/Dorothea 5, ff.28-32; ibid., X/Dorothea Mss 614, 1234 give graphic descriptions of the landslide at Dorothea of 29 December 1884 and of its consequences. The whole of the low-lying quarries were constantly under threat from inundation, see C.R.O., XM 4874/47, ff.5-24, passim.

60. C.R.O., X/Dorothea 5, f.38; J.Griffiths *Sylwebydd* (1889), op.cit., p.10; C.R.O., XM 669/2*v.*, newspaper cutting containing part of an article 'Chwarelau Gogledd Cymru: (I) Dyffryn Nantlle, Gloddfa Glai a Chloddfa'r Coed,' from Y Genedl, 1891.

61. The first suggestion for draining the lake had been made in 1862, but had come to nothing [C.R.O., X/Dorothea 903, letter 11 July 1862]. In the aftermath of the 1884 landslide, the Dorothea Company hired an engineer to draw up a number of schemes to alleviate the floods, although none were acceptable to landowners and quarry lessees downstream [loc.cit., letters dated 7 May 1885, 8 June 1885 and 11 September 1885]. A scheme promoted by several quarry companies in 1889 fell through because of disagreements [ibid., Ms 907, letter 25 May 1889].

62. See details in lake tip correspondence files, C.R.O., X/Dorothea Mss 1273, 1284, 1350.

63. Details of the Nantlle Vale Drainage Scheme of 1893-1900 can be found in C.R.O., X/Dorothea 5, ff.38-40; ibid., Ms 1284; C.R.O, XM 5974/47; ibid., XD 35/ Mss 561, 567, 571, 620; XM/Maps/ Mss 555 and 755/2.

64. C.R.O., X/Dorothea 982. The Dorothea Company had to excavate a second diversion of the river through the Gwernor tips in 1897 at their own cost, because of the constriction of the drainage in the old lake bed caused by continued tipping.

65. Problems with the new canalised river channel resulting from continued tipping into the old lake bed resulted in the Dorothea Company being threatened with legal action for damages in 1903 by other parties downstream, this being resolved by a further diversion and widening of the channel [C.R.O., X/Dorothea Mss 811, 814, 816, 994, and 882 pp.138, 142]. Dorothea's difficulties with water ingress into the pits were far from over despite the large expenditure on preventative measures, and the river broke into the quarry a second time in November 1910, although without creating as much damage as in 1884 [C.R.O., X/Dorothea 1235 chronicles the events of the 1910-11 floods].

66. From leases; see Note 8, supra.

67. For example, three independent quarries (Dorothea, Galltyfedw and Penybryn) straddled Penybryn Farm and Tal-y-sarn Uchaf Farms (Pant Du estate), transcending the agricultural boundaries. References to the process of sub-division of leasehold setts are rare, but in a report to the Kinmel estate agent dated 6 June 1857 [C.R.O., X/Dorothea 928], Owen Pritchard, a quarry manager at

Ffestiniog, stated:-

"As there is an inexhaustible slate vein in that property, I would strongly urge upon the proprietors and the leasors [sic] to meet each other mutually in order to increase their present capital to divide the surface of Penyrorsedd into two separate quarries."

68. The best example of the problems of boundaries at Nantlle concerns the Tanrallt Quarry (the Carnarvonshire Slate Co. Ltd.), which suffered a landslide in 1879 which impinged upon the adjacent property. The resulting lawsuit resulted in the closure of the concern, which was only able to reopen after its new proprietor (John Robinson) came to terms with the neighbouring landlord for a parallel lease [C.R.O., XM 4874/47 pp.43-44; ibid., XD 35/78/11].

69. This can be ascertained from fieldwork, comparing the location of tips with the geology of the site from Morris & Fearnsides (1927), op.cit. The increasing problems caused by tipping can also be followed from written sources. For example, the Llanllyfni Parish Vestry, following several appeals against rate demands, had to draw up a new valuation list in 1868 so as to take account of:-

"...[the] lands rendered useless to the tenants by the slate quarries" [Richards, Rt.Rev. Gwynfryn, 'Chwareli Dyffryn Nantlle,' T.C.H.S., Vol.29, p.13].

By 1877, the Cloddfa'r Coed Quarry was reported to be tipping over workable rock in 1877, because it had no other space for depositing the debris from its current workings [U.C.N.W., Nantlle 1, f.81], and the general position re. tipping space in the vale was worse by 1886 [C.R.O., XM 4874/47, ff.2-6, 10].

70. Multi-layering of tips is a feature which is very apparent at Nantlle. Details of the tipping arrangements at the Dorothea Quarry are described in G.P.Jones, 'The Dorothea Quarry *c.*1820-1970,' (M.A. Thesis, Bangor 1980), Part II.

71. C.R.O., X/Dorothea 1273, 1284, 1350; ibid., XM/Maps 555 (Coedmadog leases); ibid., XM 2344/1-10 (Fronheulog leases).

72. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), map of the Talysarn Quarry land-holdings, *c.*1900.

73. C.R.O., XD 35 Ms 207/26; ibid., Ms 518; specifications, plans and tenders for a timber viaduct at the South Dorothea Quarry, 1899.

74. This long, winding causeway was constructed to obviate the need for a powered incline, this quarry fortunately having sufficient surface area to allow this option to be chosen. The gradient on the line was quite severe in places, and required the services of a

larger than normal 2-ft. gauge locomotive (*Jubilee 1897*, from Manning Wardle Ltd., now at Tywyn Station Museum, Gwynedd).

75. Richards, R., 'Nantlle and Its Slate Quarries,' in Miscellaneous Poems, (Bangor 1868), p.135.

76. M.J.T.Lewis (1987), The Slate quarries of North Wales in 1873, op.cit., p.63; C.R.O., XM 392/1, ff.56-57.

77. C.R.O., X/Plans/R/64; ibid., X/JW/Maps/9, Nantlle Vale Harbour & Tramway Bills, 1858, 1859.

78. C.R.O., XM 392/1, ff.56-57; ibid., XM 4874/47, f.3.

79. Comparison of the O.S. 1913 ed., 1:2,500 maps with aerial photographs taken in 1949 (University of Cambridge, Aerial Photographs E.I.S. 5-9, by J.K.St.Joseph) shows hardly any increase in the area of the tips at Nantlle with the exception of overlaying old debris at south-west corner of the Dorothea site, and the substantial progress of the Floor 'N 8' tip at Penyrorsedd.

80. See sub-section (c), infra. The very first extant reference to the reworking of slate tips was that at Lord Quarry (Ffestiniog) in 1799 [Lewis & Williams, 1987, Pioneers of Ffestiniog Slate, op.cit., p.12].

81. The preponderance of multi-site quarries and speculative closures led landlords to allow sub-contracts as a means of gaining some revenue on idle sites.

82. It was reported that a few workmen were illegally working slate from the Cilgwyn Quarry tips in February 1822, a "...scandalous theft and robbery," according to Thomas Jones, one of the proprietors [U.C.N.W., Porth yr Aur 27645]. Neither this nor the example in Note 80, supra., was comparable in scale to the intensive tip working that was encountered at Nantlle from the 1890s to the 1950s.

83. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), annual report of the Carnarvon & Bangor Slate Co. Ltd., (1868); Morgan Richards *Morgrugyn Machno* (1877), op.cit., p.41, referred to the large amount of workable blocks found in the waste tips at Nantlle, a product of earlier decades where the quality of the quarry management had been allegedly poor in general.

84. C.R.O., X/Dorothea Mss 614, 1234; C.R.O., XM 4874/47, f.19.

85. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), essay by Owen Humphreys (Tal-y-sarn), 'Tipyn o Hanes Blynyddoedd y Dirwasgiad Rhwng y Ddau Ryfel Byd,' (Hydref 1975), specially written for, and

presented to, the present author in response to a request for information on tip-contracting at Nantlle during the inter-war years.

86. Diary of Dafydd Jones, Talysarn Uchaf Farm, tip contractor in 1890s (in private hands); H.M.Inspectorate of Mines & Quarries, 'List of Quarries' appended to the Annual Reports records tip contracting operations only in 1895, when there were three contractors at Coedmadog Quarry, one at New Vronheulog and seven at Penybryn, employing a declared total of 52 men.

87. O.Humphreys op.cit.; ex.info., Mr Iorwerth Thomas (Tal-y-sarn), former tip contractor.

88. Ibid.

89. Ibid.; many examples of the remains of tip contracting operations can still be examined in the Nantlle district.

90. Ex.info. the late William Roberts (Llety Fadog, Tal-y-sarn), regarding the excavation of a 'quarry' on the Talysarn main tip in the 1930s; ex.info., I.Thomas, op.cit.

91. Thomas op.cit., relating to the author the processes and strategies involved in tip contracting, using as an example his demolishing of the buildings and structures at the Cilgwyn Quarry in 1963-65.

(b). Developments in quarrying and processing methods

92. See Note 19, supra.

93. Ibid.; additionally, the general rule governing dimensions of roofing slates generated a waste of material in that the breadth of a slate would only vary from half the length, plus/minus one or two inches. Each imperial size was originally assigned a name based on the hierarchy of female royal and aristocratic titles, originating in the 1790s, replacing the colloquial system based on multiples of a standard size (i.e., Singles, Doubles, Double-doubles etc.,), which had itself replaced at least one Tudor nomenclature. See C.R.O., XM 392/1, f.16; M.J.T.Lewis (1987), The Slate Quarries of North Wales in 1873, op.cit., p.64; Lindsay, J. (1974), A History of the North Wales Slate Industry, (Newton Abbot), pp.36-38.

Extraction methods

94. The 'rock-man' was a specialised worker who extracted slate rock for production. For descriptions of the work of the rockman, see Jones, Emyr, (1963), Canrif y Chwarelwr, (Gwasg Gee), pp.15-16;

Dewi Peris, 'Chwarelyddiaeth III & IV,' Y Genhinen XIV (3, 4), Gorffennaf 1896 pp.212-214, Hydref 1896 pp.267-268; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), essay 'Chwarelyddiaeth' (1944) by the late Owen Humphreys (of Tal-y-sarn).

95. See F.J.North (1925), op.cit., pp.7-15, for an explanation of the correlation of mineralogical content and crystaline structure of slate, with regards to its properties of cleavage and pillaring.

96. Examples of similar rock-bodies are still to be found, and the ready-split weathered sheets of slate can be prised out using a crow-bar in the same manner as carried out by the earliest quarrymen, as described in local history essays, e.g. John Griffiths *Sylwebydd* (1889), op.cit., p.66.

97. Dylan Pritchard, 'Aspects of the Slate Industry; The Expansionist Period (1790-1877), XI,' Q.M.J., February 1945, p.358; A.J.Richards (1995), op.cit., p.47, re. early rock-blasting; Williams, W. (1892), Hynafiaethau a Thraddodiadau Plwyf Llanberis â'r Amgylchoedd, (Llanberis), p.110 re. pre-eminence of the Cilgwyn quarrymen in rock-blasting. The copper mines at Drws-y-Coed, to the east of the quarrying belt at Nantlle, employed Cornish miners by the middle of the eighteenth century [Dodd, A.H., (1951), The Industrial Revolution in North Wales, (Cardiff), p.154]. These men almost certainly introduced rock-blasting using gunpowder (or 'black-powder') to the Nantlle district, a process which liberated the slate quarrymen of the Ochr-y-Cilgwyn quarries from their former restriction to frost-shattered top-rock during the first half of that century.

98. It is hypothesised by the author that the alleged marketing lead of the Ochr-y-Cilgwyn Quarries (Nantlle) over the Penrhyn estate quarries, reported in a letter from the Penrhyn estate agent to Sir William Younge, dated 25 October 1738, and quoted at length in Lindsay, J., (1974), op.cit., pp.30-35, was to a great extent the result of geological advantages coupled to a superior extraction and slatemaking technology. See also A.J.Richards (1995), op.cit., p.47; and *Dewi Peris* (1896), op.cit., Y Genhinen, XIV, (4), p.267, re. blasting techniques.

99. For descriptions and accounts of the development of rockmen's tools and techniques, see D.C.Davies (1887), op.cit., pp.119-121; J.Griffiths (*Sylwebydd*) (1889), op.cit., p.13; Owen Humphreys (1944), 'Chwarelyddiaeth,' op.cit., 'Arfau Chwarelwr', ff.25-35, 'Arfau Creigiwr,' ff.35-44; C.R.O., XM 392/1, f.13; E.Jones (1963), Canrif y Chwarelwr, op.cit., pp.123-162, passim; *Dewi Peris* (1896), 'Chwarelyddiaeth, III, IV,' op.cit., passim; Dylan Pritchard, 'Aspects of the Slate Industry; The Expansionist Period (1790-1877), V,'

Q.M.J., July 1944, p.17; Robert Williams, 'Hunangofiant Chwarelwr, VIII,' Cymru, XIX, (109), Awst 1900, p.89; Richards (1995), op.cit., p.15.

100. John Griffiths *Sylwebydd* (1889), op.cit., p.13. Owen Humphreys (1944), 'Chwarelyddiaeth' op.cit., ff.42-43; Robert Williams, 'Hunangofiant Chwarelwr, VIII,' loc.cit. At least one variant of the *trosol mawr* had a squared upper end (that is, the 'handle'), which was probably shaped to a rectangular longitudinal section; this could be used as a type of double-handed hammer to strike a conventional heavy-duty chisel.

101. See Dylan Pritchard, 'Aspects of the Slate Industry: The Expansionist Period (1790-1877), VII,' Q.M.J., September 1944, pp.117-118. The mobility of labour and the consequential spread of tools and techniques is also referred to in local history essays covering the major slate-producing districts of North Wales. None, however, agree on any one point, and each tends to exalt the virtue of the superiority of its own neighbourhood within this context, e.g. the 'jumper' drill is vaguely credited to "...a man from Llanberis" [M.J.T.Lewis, (ed., 1987), The Slate Quarries of North Wales in 1873, op.cit., p.64].

102. Owen Humphreys (1944), 'Chwarelyddiaeth' op.cit., ff.11-12; *Dewi Peris*, 'Chwarelyddiaeth, III,' Y Genhinen, XIV, (3), Gorffennaf 1896, pp.212-214; idem., 'Chwarelyddiaeth, IV;' ibid., XIV, (4), Hydref 1896, pp.267-268. The rockmen, the so-called "*Gwŷr glêw y garreg lâs*" (Bold men of the blue rock) feature prominently in the literature and lore of the quarrying communities, and came to epitomise the image of the slate quarrymen as a whole, e.g. in W.J.Gruffydd's melodramatic poem "*Cerdd yr Hen Chwarelwr*" ('Ode to the Old Quarryman'); see also Notes 94, 99 supra.

103. Ibid. The author was fortunate to interview the late John Morris Hughes (1880-1971), a rockman at Nantlle from the early years of the present century. Mr Hughes described in detail how the utmost care was taken in his day when extracting rock for production. A minimum of black powder explosive was used to crack large blocks of slate, which were then gently levered free, so as to fall precisely onto a prepared 'mattress' of timber and earth sods.

104. Ex.info., former quarrymen, explaining the term bad-rock men (rather than 'bad rock-men'), which features in wage ledgers and other miscellaneous sources.

105. Emyr Jones (1963), Canrif y Chwarelwr op.cit., p.14; Hughes, T.M., (1995) Helynt y Powdr Oel, (Author), passim.

106. The author is indebted to Mr Harold Morris (Porthmadog) for validating this local lore from his files of abstracts from the Carnarvon & Denbigh Herald.

107. Ex.info., former rockmen. It is ideal for blasting hard rock, but its explosive action is too strong for use on slate earmarked for production.

108. Cilgwyn big blasts of 1896/1901-02 [C.R.O., XM 669/66, cutting from Y Genedl, 10 January 1896; XM 923/76, cutting from The North Wales Observer, 10 January 1896; X/Dorothea 880, letter September 1901; X/Dorothea 1488, newspaper cuttings 1902]; and the Talysarn blasts [C.R.O., X/Dorothea 880, letters dated August-September 1901, 20 November 1901; The Manchester Guardian, 25 February 1902].

109. Ex.info., former quarrymen at Blaen Cae and Cilgwyn quarries.

110. Houston, W.J., 'New Developments at Dorothea Slate Quarry,' Q.M.J., February 1964, p.69; A.J.Richards (1995), op.cit., p.168.

111. Ex.info., Mr Michael Wynne-Williams, former managing director of the Dorothea Quarry.

112. Ibid.

113. Ex.info., the late Mr Walter Riley, former director of the Crown Quarries; ex.info., Mr Peredur Hughes, works manager of the Penyrorsedd Quarry.

Improvements in the slatemaking process

114. See Note 98, supra., for references to the development of tools and to the author's hypothesis of the early technological lead of the Nantlle quarries.

115. See Note 101, supra.

116. See Note 99 supra., and Lewis (ed. 1987), The Slate Quarries of North Wales in 1873, op.cit., p.15, for references to tools used at the rock face for block-extraction and primary dressing (termed "*brâs-hollti*"). In the case of large virgin slabs, these were split lengthwise along the cleavage to about 4-inches thick, and subsequently split lengthways along the pillaring plane to a maximum of about 4-feet wide, thus providing 'pillars' (*pileri*) which could be conveniently winched out of the pit for secondary preparation by the slatemakers into slatemaking blocks. Smaller pieces of rock were often dressed into prepared slatemaking blocks in the pit for convenience.

117. Ambrose, W.R., (1872), Hynafiaethau, Cofiannau, a Hanes Presennol Nant Nantlle, (Penygroes), p.75; John Griffiths *Sylwebydd,* (1889), op.cit., p.67; Robert Williams, 'Hunangofiant Chwarelwr, VIII,' Cymru, XIX (109), op.cit., p.89; C.R.O., XM 392/1, f.14; C.R.O., XM 1758.addit 89, from which an estimated date of *c*.1740 can be ascertained for the alleged introduction of this method; U.C.N.W., Nantlle 1, ff.100-101. The account in Ambrose op.cit., appears to have set a pattern for the later local writers, although the former account is itself based on the history of slate quarrying in the Bethesda district, in H.Derfel Hughes (1866), Hynafiaethau Llandegai a Llanllechid (Author, Bethesda). Nevertheless, the present author has recently acquired a rounded granite stone [a gift from Mr Wyn Jones, G & W Autos, Pen-y-groes], which was latterly serving as a door stop. This stone, originally a 9-inch sphere but now partly flattened by wear, has a shallow peg-hole, possibly designed to prevent rolling in use. An experiment, following the procedures outlined in the above references proved relatively satisfactory in view of the lack of practical experience of the present author, who is nevertheless confident that this stone is a genuine 'pillaring stone' of the eighteenth or early nineteenth centuries.

118. Ex.info., Mr Iorwerth Thomas (of Tal-y-sarn), an expert in non-mechanised slatemaking by virtue of over thirty years' experience as a tip contractor.

119. See John Griffiths *Sylwebydd,* (1889), op.cit., pp.13-14. The regularity and adequate vertical spacing of 'foot-joints' was often noted in quarry promotions at Nantlle, e.g. in the prospectus of the Upper Tyddyn Agnes Slate Quarry Co. Ltd., of 1873 [Mss collection of public company prospectuses, Guildhall Library, London, per Dr Dafydd Gwyn, to whom the author is indebted]. These joints could cause problems as well as having beneficial attributes. The vertical spacing of these foot-joints pre-determined the maximum size of any slates made from that rock, and if spaced too close together then the quarry was unable to produce other than the less-profitable smaller size range.

120. M.J.T.Lewis (1987), The Slate Quarries of North Wales in 1873, op.cit., p.63. One method sometimes resorted to, when the 'foot-joints' were too close together to allow the production of long slates, or where the unevenness of the joints was disadvantageous for splitting in the normal fashion, was to produce 'cross slates' (*llechi traws*). These were split from the sides, thus the cleavage 'grain' ran across the length rather than along it. Although 'cross-slates' were virtually undistinguishable from the normal variety to the untrained

eye, they were a sub-standard product born out of devious necessity, and were prone to break when the holes for the fixing nails were punched because both holes would have been on the same 'grain' [ref. to producing 'cross-slates' at Ty Mawr East Quarry in C.R.O., XM 4847/47, f.40; ex.info., Mr Iorwerth Thomas, op.cit.].

121. Robert Williams, 'Hunangofiant Chwarelwr, VIII,' Cymru, XIX (109), op.cit., p.89, refers to cross-cutting slates with a cleaver-like tool.

122. John Griffiths *Sylwebydd,* (1889), op.cit., p.67; Owen Humphreys (1944), 'Chwarelyddiaeth,' op.cit., ff.28-29. It is alleged, in folk-lore, that the tool was named in honour of its inventor.

123. The basic design of the *rhys* appears to have remained unchanged from the start, with an example in the possession of the author, formerly used at the Cloddfa'r Coed Quarry pre-1913 (presented by the family of the late J.M.Hughes, op.cit.), being identical to that described by John Griffiths *Sylwebydd,* (1889), loc.cit. The method of using the *rhys,* described by Morgan Richards *Morgrugyn Machno,* (1877), op.cit., pp.78-79, 82 with Figures II and III on facing pages; and in Lewis (1987)., The Slate Quarries of North Wales in 1873, op.cit., p.63, is identical to that described to the author by Mr Iorwerth Thomas, op.cit., who used this tool in his tip-contracting enterprises up to *c.*1967. Mr Thomas insisted that the secret of using the *rhys* successfully was in the preparation of the notch (*bwlch*) marking the desired point of cross-cutting. This had to be in the shape of a dove-tail, tapering inwards, with the v-end cleanly cut using an old saw-blade or scythe to ensure a clean cross-cut on the required line, free from roughness like a cockerel's comb (*torriad crib ceiliog*), which made the subsequent accurate positioning of the splitting chisel virtually impossible.

124. The only remaining commercial use of the *rhys* is at the Twll Llwyd Quarry, Nantlle.

Slatemaking and dressing

125. The market advantage enjoyed by the Ochr-y-Cilgwyn quarries by 1738, by virtue of the thinness of their slates in comparison with the produce of the Penrhyn Quarries (see Note 114, supra.), is very likely to have been the result of a technological lead in splitting chisel design, as even the well-developed cleavage of the blue slate at Cilgwyn cannot be satisfactorily exploited using traditional stone mason's tools (author's experiment).

126. the original type of splitting chisel was most likely to have been small because the original type of roofing slates were only 10-inches

by 6-inches (see Note 93, supra), which verged on the sizes commonly worked by apprentice rubblers and tip-contractors. The author possesses a small splitting chisel used for small slates, although this example is likely to be the worn-down stump of a former full-size version rather than being specially made for this purpose.

127. Emyr Jones (1963), Canrif y Chwarelwr, op.cit., pp.17, 123-162 passim; Owen Humphreys (1944), 'Chwarelyddiaeth,' op.cit., ff.14-18, 30-31; Robert Williams, 'Hunangofiant Chwarelwr, VIII,' Cymru, XIX, (109) op.cit., p.89. The 'driver,' seen by the author in use at Nantlle in the 1960s and 1970s, was a slightly larger version of the standard splitting chisel, and was used to force a split in a large block with an unresponsive cleavage. Another version of a much larger size, currently kept at the Half Way Inn, Tal-y-sarn, was used for primary sub-division of large prepared blocks, and had to be wielded from a standing position. The "small-finds" chisel, now in the possession of the author, was discovered under the foundations of the old mill (of 1887) at the Alexandra Quarry by Brinley S.Jones, the author's colleague on field surveys.

128. Ex.info., the late Gwilym Roberts, the blacksmith at the Dorothea Quarry (from 1932 until closure in 1969), who developed the design.

129. Owen Humphreys 'Chwarelyddiaeth,' op.cit., ff.29-32

130. See Emyr Jones (1963), Canrif y Chwarelwr, op.cit., p.139; and Owen Humphreys (1944), 'Chwarelyddiaeth,' op.cit., f.31, for a description of the slatemaking mallet. The basic design used at Nantlle today is virtually unchanged from the original, although iron hammers have been substituted at Ffestiniog for over twenty years.

131. The many attempts to promote roofing slates with 'square' (unbevelled) edges have been fruitless from the 1810s up to the present day because of market resistance.

132 See D.C.Davies (1887), op.cit., p.123; Emyr Jones (1963), Canrif y Chwarelwr op.cit., p.153; and Owen Humphreys (1944), 'Chwarelyddiaeth,' op.cit., f.35, for descriptions of the slate gauge. Part of the duties of the author's grandfather as a slate inspector at the Penybryn Quarry (1927-32) and subsequently at the Dorothea Quarry prior to the introduction of mechanical dressing in 1940, was to check the accuracy of the slatemakers' gauges, which were subject to frictional wear which ultimately made the marker notches over-size. Furthermore, because of the importance of accuracy in the sizes of the finished slates, only gauges bought from the

proprietors were allowed, and the provision of home-made ones was expressly forbidden [ex.info., the late Evan Williams (1892-1964)].

133. W.R.Ambrose (1872), op.cit., p.75. The author has experimented with stone knife-edges with favourable results, although a satisfactory cutting edge is difficult to produce and seems not to be long-lasting.

134. See D.C.Davies (1887), op.cit., pp.123-124; Emyr Jones (1963), Canrif y Chwarelwr, op.cit., pp.17, 136, 159; Owen Humphreys (1944), 'Chwarelyddiaeth,' op.cit., ff.33-34, for descriptions of how to use a *trafael* and trimming knife. The author possesses a three-piece adjustable *trafael* that had previously belonged to the late J. M. Hughes, and had been used at the Cloddfa'r Coed Quarry pre-1913. The author has also seen a left-handed trimming knife. The only commercial quarry in North Wales which still uses this hand-trimming method is Twll Llwyd, Nantlle, where the relatively thick green slate is not suitable for mechanical dressing. Hand-dressing is also demonstrated at the Welsh Slate Museum, Gilfach Ddu, Llanberis, this method having remained in use at the Dinorwic Quarry for certain types of slates (e.g. from Sinc Hafod Owen) until the 1960s.

(c). Wage systems and their effects

Flat-rate pay

135. This topic forms an important part of most of the standard books on the slate industry.

136. J.Lindsay (1974), op.cit., pp.29-30, 36, 38-40; Pritchard, D.Dylan, 'New Light on the History of the Penrhyn Quarries in the Eighteenth Century,' Q.M.J., September 1942, pp.119-120. The quarrymen on the Penrhyn estate pre-1782 were independent workmen, paying an *ad valorem* royalty to the landowner, although the sales system was organised *via* an agent.

137. N.L.W., Glynllifon 84, ff.56*v.*-69*v.*

138. No financial records from this period appear to have survived, assuming that the accounts were committed to paper.

139. Ex.info., former employees of the small concerns at Nantlle, post-1918.

140. Lindsay (1974), op.cit., p.69.

Later fixed-rate systems

141. Robert Williams, 'Hunangofiant Chwarelwr, I,' Cymru, XVII, (1899), p.57; C.R.O., XM 1758.addit 89, 'Coedmadog, q.v.'

142. Robert Williams, 'Hunangofiant Chwarelwr, II,' Cymru, XVIII, (102), 15 Ionawr 1900, p.75.

143. John Griffiths *Sylwebydd*, op.cit., p.82.

144. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), essay 'Hunangofiant Chwarelwr,' by *Ab Owain* (unidentified author, 1926), chapter 'Yn Nyffryn Nantlle,' ff.27-28.

145. R.M.Jones (1982), The North Wales Quarrymen (University of Wales Press), pp.84-86, 112, 117, 133, 216-218, 304. The Rhos Quarry stoppage of 1877 was the only 'official' strike of the Quarrymen's Union during the nineteenth century, where the men had been called out by the Executive.

146. *Ab Owain*, loc.cit. With regards to the idiosyncrasies of its workforce, the Talysarn Quarry had similarities with the Cwmorthin Quarry at Ffestiniog. Morgan Richards *Morgrugyn Machno* (1877), Slate Quarrying and How To Make It Profitable, pp.106, 111, quoted Robert Parry of Llanrug, a Quarrymen's Union leader, who claimed that quarrymen discharged with the Union's blessing from the Penrhyn Quarry for habitual drunkenness, were "...harboured at Nantlle quarries, to the disgrace of all concerned."

Bargaining systems

147. This is hypothesised from the lack of any references to alternative pay systems in contemporary documents.

148. J.Lindsay (1974), op.cit., pp.41-44; Dylan Pritchard, Q.M.J., September 1942, op.cit., pp.119-122; idem., 'Aspects of the Slate Industry: The Expansionist Phase (1790-1877), VIII,' Q.M.J., October 1944, p.173.

149. Loc.cit.

150. Ex.info., former tip-contractors and workmen. However, operating under a modern taxation regime, the Nantlle tip system obviously varied from the early simple piece-work, the men working under a tip-agent being nominally self-employed for the purposes of income tax and national insurance contributions.

151. Dylan Pritchard, Q.M.J., October 1944 op.cit., pp.174-175; idem., 'Aspects of the Slate Industry: The Expansionist Phase (1790-1877),

VIII,' Q.M.J., November 1944, p.203; Robert Williams, 'Hunangofiant Chwarelwr, I,' Cymru, XVII, (1899), p.58.

152. Dylan Pritchard, Q.M.J., October 1944, op.cit., p.175.

153. Ibid., pp.175-176.

154. Loc.cit.

155. Loc.cit; idem., 'Aspects of the Slate Industry: The Expansionist Phase (1790-1877), VII,' Q.M.J., September 1944, p.120, referred to the frequency of wage settlements at the Cilgwyn Quarry during the 1820s being 16 weeks, although payment in full was at this period delayed for up to eight months, a situation also found in other quarries contemporaneously.

156. Pritchard, Q.M.J., October 1944, loc.cit.

157. Pritchard, Q.M.J., November 1944, op.cit., p.203.

158. See ibid., pp.203-207 for a discussion of the economics and functioning of the bargaining system. For contemporary discussions and examples of poundage rates, see D.C.Davies (1887), Slate and Slate Quarrying, op.cit., pp.138-144; and Morgan Richards, *Morgrugyn Machno* (1877), op.cit., pp.18-23.

159. Emyr Jones (1963), Canrif y Chwarelwr, op.cit., pp.21-26. The payment by the crews for materials supplied by the quarry owner had early origins. Pritchard, Q.M.J., October 1944, op.cit., p.176, refers to a standard 1/20th deduction being made in the wage bill of the crews at the Cilgwyn Quarry in the 1820s for the use of ropes, whimseys, waggons and tools supplied by the Company. W.J.Griffiths, manager of the Dorothea Quarry, made an interesting assertion to the Royal Commission on Metalliferous Mines and Quarries of 1910-11, that one benefit of the management supplying the explosives to the men was that of the regulation of its use [Report, Vol.2, H.M.S.O., (1914), U.C.N.W., Welsh Library XF 47, questions 11,192-11,194, p.38].

160. Dylan Pritchard, 'Aspects of the Slate Industry: The Expansionist Phase (1790-1877), VII,' Q.M.J., September 1944, pp.117-120.

161. R.M.Jones (1982), passim. The initial cause of the 1900-03 Penrhyn dispute was the attempt to replace bargain crews by contractors employing the quarrymen as waged employees. The majority of the trade disputes in the quarries concerned the working of the bargaining system, rather than its replacement.

162. Robert Williams, 'Hunangofiant Chwarelwr, III,' Cymru, XVIII, (103), Chwefror 1900, p.131.

163. The reader is referred to extant wage ledgers, of which few exist for the Nantlle quarries other than the Crown Group [C.R.O., G.P.Jones/Nantlle Mss (uncatalogued)] and the Dorothea Quarry [C.R.O., X/Dorothea Mss]. With regards to the example of a profit-sharing element in the salaries of quarry management, the sole example recorded involved William Morris Jones, sub-manager at Dorothea since 1901, who was offered (and accepted) the managership of the Alexandra Quarry in 1907 at a salary of £12 per month plus 5% commission on profits [C.R.O., X/Dorothea 880, letter dated 18 March 1907]. This was not, however, a good career move on Jones' part, leaving a secure post for one which came to a premature end in March 1914 [ibid., 2108], and despite retaining an involvement on the margins of the industry at Nantlle, he never regained his former status [ex.info., the late Ellis Williams, Ty Cerrig, Y Fron (1907-1995)].

The decline of the bargaining system

164. Dylan Pritchard, 'Aspects of the Slate Industry: The Expansionist Phase (1790-1877), X,' Q.M.J., January 1945, p.307. These figures were the average for the county except for Penrhyn, where a real ceiling of 4*s.* (20p.) per day was imposed on the skilled men before the 1874 strike; the Caernarfonshire average was 10*d.* and 4*d.* (approximately 4p. and 2p. repectively) per day less than the Ffestiniog average for quarrymen and labourers, respectively.

165. Loc.cit.; R.M.Jones (1982), op.cit., pp.91-94; J.Lindsay (1974), op.cit., pp.209-210, 213-218.

166. Morgan Richards *Morgrugyn Machno* (1877), op.cit., pp.106-108.

167. For example, the author was informed by an former employee of the Talysarn Quarry that John Robinson, its proprietor, built up large stocks of slates in preference to discharging skilled men during the leaner years despite its implications for his cash-flow, because he believed that risking bankruptcy in the short term was preferable to being unable to supply his customers on a longer term after the restoration of normal trading conditions [ex.info., the late J.M.Hughes, op.cit.].

168. The linking of prices and wages was an example of an effemeral 'unwritten rule', which tended to be invoked by management when market prices decreased, whereupon it was subject to resistance from sections of the workforce, and where the significant increases in wages during the 'golden years' of the 1860s-70s was likely to have been the result of market forces in attracting and retaining

skilled men rather than altruism on the part of the owners. See sub-section on trade disputes, infra.

169. With regards the statistical 'letting standard', this calculated average did not really exist because of the variations in earnings under the piece-work system. It served however, both the management's requirements for controlling the wage bill and also the Quarrymen's Union's needs within the purposes of identifying average wage rates. This emphasis on more stringent financial controls on the part of the proprietors was inherent in the factory-based man-management philosophy introduced by the incoming large English concerns of the 1860s-70s, a process which culminated at Nantlle with an unofficial network between the managers of the most important concerns standardising working hours, rules & penalties, holiday arrangements and wage-rates in the face of the increasing organisation of the quarrymen, whose local committee had successfully applied for reduced hours of working in 1872.

170. Emyr Jones (1963), Canrif y Chwarelwr, op.cit., p.22; R.M.Jones (1982), op.cit., pp.81-85, 119; *Dewi Peris*, 'Chwarelyddiaeth, III,' Y Genhinen XIV (3), Gorffennaf 1896, pp.211-212; M.J.T.Lewis (1987), The Slate Quarries of North Wales in 1873, p.29; A.J.Richards (1995), op.cit., pp.24-25; Richards, Rt.Rev Gwynfryn (1968), 'Chwareli Dyffryn Nantlle,' T.C.H.S., Vol.29., p.18, quoting W.R.Williams, Y Ford Gron, Gorffennaf 1934, p.200, regarding the automatic reduction of poundage rates following a month of above-average earnings.

171. Emyr Jones (1963), op.cit., p.23; Morgan Richards *Morgrugyn Machno* (1877), op.cit., p.28, but also see ibid., pp.19-24, re. the pitfalls facing inexperienced letting agents faced with canny bargain crews.

172. Ibid. Such practices have also been described to the author by the participants.

173. Ibid., pp.14-15, 74; Dylan Pritchard, Q.M.J., November 1944, op.cit., p.206, recognised that "... the workmen were placed in an unduly subservient position by putting them at the complete mercy of the letting steward".

Trade disputes and the role of the Quarrymen's Union in bargaining

174. Dylan Pritchard, 'Aspects of the Slate Industry: The Expansionist Phase (1790-1877), IX,' Q.M.J., November 1944, p.206.

175. Morgan Richards *Morgrugyn Machno* (1877), op.cit., pp.106-108.

176. C.R.O., X/Dorothea 926. J.Lloyd Jones (the agent) had cut the day-rates and halved the poundage rates because of bad trade. The men were on strike for a week before accepting the new terms.

177. John Griffiths, *Sylwebydd*, (1889), op.cit., pp.72-74.

178. R.M.Jones (1982), op.cit., pp.17-25, but see also counter-argument in pp.117-118; Rt.Rev. Gwynfryn Richards (1968), T.C.H.S., (29), op.cit., p.19.

179. See R.M.Jones (1982), op.cit., Chapter V, passim; J.Lindsay (1974), op.cit., Chapter 10, passim; idem., (1987), The Great Strike, 1900-1903, (Newton Abbot), Chapter 1, passim.

180. R.M.Jones (1982), op.cit., p.113.

181. Ibid., p.84.

182. See R.M.Jones (1982), op.cit., pp.114; 159-160; the first officials of the Union were middle-class professional Welsh Liberals such as Morgan Richards *Morgrugyn Machno* (op.cit., slatemerchant and quarry investor), Hugh Pugh (banker, ship-owner and quarry investor), and John Lloyd Jones (quarry speculator). John Robinson (owner of the Talysarn Quarry) and W.A.Darbishire (managing director of the Penyrorsedd Quarry) actively sympathised with the Union. See Notes, Chapter 2, supra., for personal details of these men.

183. R.M.Jones (1982), op.cit., pp.110-111; 114; 132; 125. The Nantlle (No.4 Lodge) and Moeltryfan (No.9 Lodge) were both set up in time for the first A.G.M. of the Union in May 1875 but had few members, Unionists still being outnumbered by 4:1 two years later. The Union's structure as a loose collection of lodges with a weak central control pre-1908, its conciliatory stance during disputes and its failure to differentiate between members and non-members were the main factors identified by Dr Jones [ibid., pp.123-127, 140-141] as reducing its appeal to the quarrymen, who at Nantlle (as at Corris and Ffestiniog) were spread out between many employers.

184. Ibid., The Nantlle lodge had only 56 members out of the estimated 1,500 workforce of the district in 1887-91, a similar percentage to the Corris area, but three times better than at Ffestiniog in the same period.

185. R.M.Jones (1982), op.cit., pp.117-8, 297 +Fn. 8; 300; 304; Parry, O., (1930), Undeb y Chwarelwyr, (Caernarfon), pp6-8. This lodge was involved in two strikes at Braich and four each at Alexandra and Moeltryfan. The strength of commitment of this lodge can be gauged from the condemnation by the Alexandra Quarry delegate to the 1892

Annual General Meeting of the executive over its inactivity over a wage claim and threatened the resignation of the whole quarry membership [ibid., p.129].

186. Ibid., pp.226-227, 297, 318. Owen Parry (1930), op.cit., pp.6-8; ex.info., Dr R.M.Jones. The Nantlle-based Union President *c.*1900 was W.W.Jones *Cyrus* (1837-1903), who expressed a strong outspoken socialist view and the Nantlle lodge had proposed an affiliation with the Independent Labour Party in the 1911 and 1912 Annual General Meetings, but was defeated on both occasions.

187. Whilst not being totally free from strikes (e.g., involving labourers in 1913 [C.R.O., X/Dorothea 5, f.]), the Dorothea Quarry escaped serious disruption in 1902, 1903 and 1905 [ibid., ff.72-73, 75-76, 88] because of the wisdom of W.J.Griffiths, the well-respected works manager.

188. Arthur William Kay Menzies (d.1940s), was the son of John Menzies, C.E., managing director of the Alexandra Slate Quarry Co. Ltd., the Llanberis Slate Co. Ltd., the Talysarn Slate Quarries Ltd., and the South Dorothea Slate Co. Ltd. A. W. Kay Menzies followed an engineering apprenticeship at De Winton & Co., (Caernarfon) and Sandycroft Ltd., (near Chester), becoming an assistant to his father. Upon J. Menzies' death in 1907, A. W. Kay Menzies was appointed his successor in the above quarrying concerns, and also secured the same position in the New Braich Slate Co. Ltd., (of 1908). He was thwarted in his attempt to buy a majority holding in the Dorothea Slate Quarry Co. Ltd., in 1911, and in the aftermath of the First World War, A. W. Kay Menzies sold out his slate quarrying interests, but continued to reside in Caernarfon until his death.

189. R.M.Jones (1982), op.cit., pp.304-305; Owen Parry (1930), op.cit., p.8; C.R.O., X/NWQU Mss 189, 191.

190. C.R.O., X/Dorothea 5, f.103; ibid., Ms 1488, cutting from Yr Herald Gymraeg, 14 November 1901, recorded the payment of weekly wages at the Dorothea Quarry from 1911. The majority of the industry did not follow suit until required to do so during the First World War [Rt.Rev.Gwynfryn Richards (1968), T.C.H.S., (29), op.cit., p.19.

191. J.Lindsay (1974), op.cit., p.284; Lewis, E.Ll., (1927), The Slate Industry of North Wales, (Denver, Colorado), p.32; Owen Parry (1930), op.cit., p.30.

192. R.M.Jones (1982), op.cit., pp.308-310.

193. E.Ll.Lewis (1927), loc.cit.; Joint Research Dept. of the T.U.C. and the Labour Party (1923), The Slate Quarrying Industry of North Wales, (North Wales Quarrymen's Union, Caernarfon), p.26; N.L.W., HD 9621,

copies of the Slate Trade Gazette, 1914-1921, transcribed into research notes by Dr Dafydd Roberts, to whom the author is indebted for access to this material; Owen Parry (1930), op.cit., pp.35-37. Quarrymen's wages increased from an average £1½ in 1914 to £5 in July 1920.

194. Dr D. Roberts, N.L.W., HD 9621 notes, op.cit., Slate Trade Gazette, 1921-1939, passim; R.M.Jones (1982), op.cit., p.311; Owen Parry (1930), op.cit., pp.37-40. As a result of wage reductions, the Union called a strike in 1922. This strike, the first and last general stoppage called by the Union Executive, lasted for only two weeks, whence the matter went to arbitration, which resulted in even greater wage cuts being deemed necessary.

Mass-production and bonus systems

195. Dylan Pritchard, Q.M.J., November 1944, op.cit., pp.206-207.

196. Loc.cit.

197. Morgan Richards *Morgrugyn Machno* (1877), op.cit., pp.14-15, 71-75, 102-103 and especially 106-108.

198. Roberts, Dafydd G., (1982), 'Moses Kellow a Chwareli Cwm Croesor,' Journal of the Merioneth Historical and Record Society, Vol.IX, Part II, pp.231-232.

199. E.g., at the Fronheulog Green Quarry (ex.info., the late Ifor Hughes, former employee, 1922-*c*.38).

200. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), wage ledgers of the Caernarvonshire Crown Slate Quarries Co. Ltd., directors' reports of the Penyrorsedd Quarry, 1930s, and essay by Owen Humphreys, (1945), 'Datblygiad Chwarelyddiaeth Dyffryn Nantlle yn y Chwarter Canrif Diwethaf: Chwarel Dorothea q.v.'

201. The mass-production system, and particularly its perceived faults, is discussed at length in essays by Owen Humphreys (1944), 'Chwarelyddiaeth,' ff.2-8; idem. (1944), 'Sut Bu I'r Diwydiant Llechi Edwino,' ff.16-17; idem. (1945), 'Datblygiad Chwarelyddiaeth Dyffryn Nantlle yn y Chwarter Canrif Diwethaf: Chwarel Dorothea q.v.' [all in C.R.O., G.P.Jones/Nantlle Mss (uncatalogued)].

202. Loc.cit; ex.info., former employees of the Penyrorsedd Quarry during the 1930s.

203. Owen Humphreys, loc.cit.

204. Ex.info., Mr Michael Wynne-Williams, former managing director of the Dorothea Quarry; ex.info., Mr Stanley Owen and Mr Glyn Tomlinson, former wage clerks; ex.info., former quarrymen.

205. Ex.info., former Penyrorsedd quarrymen of the 1950s.

206. Owen Humphreys, loc.cit.; ex.info., M.Wynne Williams, op.cit; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry file 12.2, report on the wage system at the quarry by Annan, Impey, Morris & Partners, 1965.

207. Ex.info., Mr Peredur Hughes, current works manager at Penyrorsedd. It should be noted that the comments on the perceived flaws in the wage system used at this quarry are the personal opinion of the present author.

CHAPTER 4

THE MECHANISATION OF QUARRYING

Slate quarrying was an industry which depended to a high degree upon the acquisition of craft skills for the attainment of its position of economic importance in North Wales. However, in common with the majority of industries, human skills were progressively replaced by machines as the result of the inevitable drive within capitalist concerns towards greater cost-efficiency, with this trend being more marked during the present century in response to the increasing cost of labour. Notwithstanding the eventual successful application of technology to most of the processes involved in slate quarrying, the industry did not totally lose its reliance upon human craft-skills. Furthermore, the various sub-processes of both the quarrying and manufacturing aspects were mechanised at different rates in different areas in a totally unco-ordinated fashion, under the influence of factors such as the availability and suitability of new technology under localised conditions, and the financial circumstances of the individual quarrying concerns.

The slate industry itself was the cradle for the development of some of the specialised new technology that progressively replaced human skills and sweat, and the expertise of local iron foundries in manufacturing all manner of plant & machinery for the quarries deserves recognition [1]. Other machines and techniques were brought into the slate industry from outside, particularly from the mining of metal ores and the processing of building stone.

The individuality of the Nantlle slate quarries in terms of their technology was at its most marked during the nineteenth century, with the trend during the twentieth century being towards the uniformity which now characterises the industry. However, new technology rarely completely replaced its predecessors, and there was a great overlap of the old and the new in use throughout the Nantlle district until as recently as the 1970s. The complexity of this process of change precludes a generalised chronological approach, and consequently this chapter is organised under sub-sections discussing individual aspects of the quarrying and processing activities, preceded by an account of the various power sources that were utilised in this district.

(a). Power sources

The development of the Nantlle slate quarries, individually and *en masse*, was closely tied to the progressive utilisation of technology, using a range of power sources. This process, which commenced in the late seventeenth century, was not a homogenous one because it depended both on the individual economic circumstance of the quarrying concerns, and on their technological requirements during different eras. Consequently, almost every form of power source developed during the early period of the industrial revolution and thereafter, had been adopted in at least one slate quarry at Nantlle.

The introduction of new sources of power tended to be driven by a requirement for either increased performance or in pursual of improved cost-efficiency, depending on the circumstances. This dichotomy is well-illustrated in the comparison of haulage and pumping machinery, for example. In the former, the increasing of winding speeds and load capacity by substituting costly steam engines for water-powered plant, was more important than economising on running costs during the heyday of the industry, because the capacity to transport the raw material from the quarry face to the processing site was one of the greatest limiting factors on the production process in that era. On the other hand, it was common for water-wheels to be retained for as long as was possible to power a battery of simple pumping machinery in preference to installing sophisticated steam-powered pumping plant, because the existing technology was more cost-effective as long as its working capacity remained sufficient for the job.

In general, the quarries progressed through a range of power sources, which correlated with the order of general technological developments. This account is organised for convenience according to increasing technological complexity, which almost matches the general chronology, consisting of **(i)** manual power; **(ii)** animal power; **(iii)** wind; **(iv)** water; **(v)** steam; **(vi)** internal combustion; and **(vii)** electric power. It is not implied, however, that all of the above power sources were used in every slate concern in this district, and it is important to note that there was often a considerable overlap of both the old and the new in terms of technology even within individual sites. This was illustrated, for instance, by the utilisation of manual power, which reigned supreme in the very small scale quarries at Nantlle from the earliest phase of working up to the 1970s, and whereas electric plant first appeared in a number of the quarries in the first decade of this century, steam winders continued to be used in adjacent workings until the close of the 1950s.

(i) Manual Power

The use of human power in the quarrying and manufacturing of slate products can be divided into two distinct types of activity, that is, (1) the physical effort involved with the skilled tasks of extracting slate slabs on the rock face, their subsequent sub-division into blocks of manageable size, and the handling of the raw material during the final processing stage; and (2) the non-skilled tasks carried out by labourers, such as the loading and tipping of debris that resulted from the various process carried out in a quarry, and the physical tasks associated with the transport of materials within the site.

Slate quarrying was a labour-intensive industry from its earliest origin, whereby all of the stages involved in the extraction of raw material, and the whole of the subsequent processing, were carried out exclusively by manual methods until the first application of mechanisation to these tasks during the second half of the nineteenth century (see below). The demand for manual labour also continued to swell with the increasing scale of quarrying during the nineteenth century. As the quarries became larger and more complex organisations, additional manual tasks were created, such as the requirement for cableway banksmen, platelayers, tippers and weigh-bridge attendants [2].

The slate industry remained highly labour-intensive up to the 1960s because of financial constraints that prevented the mechanisation of earthmoving and loading work in the quarry pits. The increasing proportion of wages within the production costs after the first world war had made the mechanisation of the maximum amount of non-skilled tasks imperative, but it was not until the 1940s that the first general utilisation of motorised earthmoving plant started to make an impact in the larger concerns. Further increases in wage rates during the 1960s accelerated this process. However, the smaller quarries and tip-contracting enterprises at Nantlle remained in a nineteenth century time-warp until the dawn of the 1970s, when the increasing availability of cheap second-hand plant finally enabled the surviving small concerns to reduce their dependency upon manpower in favour of machinery [3].

The traditional quarry labourer only finally disappeared from the scene at Nantlle and elsewhere, during the early 1970s as the result of the radical changes that took place in the slate industry during that decade (see Chapter 1). However, despite the banishment of most of the physical excertion from the rock-face by the adoption of earthmoving machinery, the craft skill of the slatemaker remains paramount in the splitting process, where a combination of trained eyes and finely-attuned dexterity is superior to the best pneumatic chisel mechanisms of a slate-splitting machine.

(ii) Animal Power

The first recorded utilisation of animal power in the North Wales slate industry was for the carriage of manufactured slates from the quarries to the coast, for further shipment by sea (see Chapter 5). There are several references to the use of mules and horses for this task in the Nantlle district during the eighteenth and the first half of the nineteenth centuries for both road and railway transport systems, but the use of oxen for pulling carts serving the Penrhyn Quarry (Bethesda) did not appear to have a parallel at Nantlle or elsewhere [4].

Within the quarries, the first use of horses was probably to power winding machinery known as the 'whimsey' (see sub-section c, below), that was introduced into the Nantlle quarries by the 1820s. It is uncertain whether horses were utilised for surface haulage during the initial stage of the introduction of tramways in the quarries at Nantlle after *c.*1805 (see Chapter 5), but they were probably being used in this capacity by the 1820s-30s, when the volume of loads and the distances from the pit to the working banks and tips had increased.

Whereas horse-powered winding had been superseded in the Nantlle quarries for technological reasons by the 1850s, the animals continued to enjoy an important role in surface haulage despite the adoption of steam locomotives by the larger concerns after the 1870s. Horses were economically and practically superior to locomotives on short haulage routes involving tight curves in crowded stockyards or inside sawing mills [5]. Despite their continued use in the medium-sized concerns at Nantlle, where steam locomotives were barely a cost-effective option, the number of horses in the industry diminished after the first world war because of the twin forces of quarry closures and the introduction of small internal-combustion locomotives. Yet, horses did not disappear from the slate industry until 1963, when their use at the Aberllefenni Quarry (Corris), the Dorothea Quarry (Nantlle) and on the Nantlle Tramway was discontinued [6].

(iii) Wind power

North-west Wales is a relatively windy location. It is open to the cyclones which roll in from the Atlantic Ocean, which provide a predominantly south-westerly airflow. Substantial use was made of this as a power source for industrial machinery in North Wales in general. This was especially the case in Anglesey, which was noted for its abundance of windmills for grinding corn.

As far as evidence is available, it seems likely that there were only two windmills ever erected in the Nantlle Valley, both at slate quarries. These were installed to power pumps at the Braich-rhydd and Cilgwyn quarries by the Cilgwyn & Cefn Du Slate Company around 1810. The two quarries were the most important workings of the Company, which was itself the leading local concern of this period and were sufficiently developed to require mechanised pumping at this date. However, the unusual choice of wind as a power source was a direct result of the location of the quarries, which made the provision of a full flowing water supply difficult [7].

Occupying exposed high ground bordering 1,000 feet above sea level, the Braich-rhydd and Cilgwyn quarries were ideal locations for wind-powered pumps similar to the late-eighteenth century plant at the Parys Mountain Copper Mines, Anglesey. It is very likely, however, that the Nantlle windmills were built of timber, rather than stone, although the machinery was probably identical to that found at Parys Mountain [8].

Windmills were efficient in suitable wind conditions, but their dependence on unregulated natural forces created limitations to their usefulness. This accounts for the abandonment of wind power in this district after the experience gained from these first two installations. On still days, windmills were useless, but this was also true in a very strong wind, when the sails could 'run away' and self-destruct. There was a narrowly-defined ideal condition of wind strength for optimum performance, and many days in a year when these conditions could not be met [9]. Therefore, it is likely that this pair of windmill pumps at the Cilgwyn Company's quarries were either backed-up by a water-powered pumping system, or were only an auxiliary system to the latter.

(iv) Water power

Water-engines can be divided into several main types, the most important categories being gravity, impulse and pressure engines. Water-balance engines (working on inclines, or in shafts), were simple gravity machines (see sub-section c (iii) and (iv), below). The varieties of water-wheels known as breast-, overshot- and pitchback wheels used a combination of the impulse force of the impinging water flow with the gravity effect of filling the buckets, whereas undershot water-wheels and water-turbines were low-head impulse engines, which depended solely on the flow of water. Reciprocating water-pressure engines resembled steam engines in many ways, whereas a pelton-wheel used a high head of water to generate a high velocity jet which impinged on its rotor spoons [10].

The most numerous type of water-engine used at Nantlle was the water-wheel, which had a variety of applications (see Table 18, below), although the most popular use was for operating pumping gear. The utilisation of water-wheels for haulage gear and sawing mills was not very common at Nantlle because steam power was preferred for the former by the 1840s (see sub-section *b* (iv) and (v), below) and the sites of most Nantlle mills precluded the use of water-power (see pp.391-392, below). This contrasted strongly with the popularity of water power in the Merionethshire quarries, where the topography lent itself to providing ample water supplies to most quarry sites, and where sophisticated distribution systems had evolved contemporaneously with the introduction of processing and haulage machinery [11].

Archaeological evidence from surviving sites at Nantlle shows that the predominant type of water-wheel used in this district was the pitchback type, often fed from a storage tank set on top of tall wing walls. A wheel incorporating all of these features was the most efficient type for utilising the low-velocity of the water feed encountered at the majority of sites locally. It was also better sheltered from strong winds, which tended to blow water out of the buckets [12].

The sole recorded use of an impulse turbine and pelton wheels at Nantlle was at the Gwernor Quarry, because of an unusual combination by local standards of a plentiful supply of water at a high head [13]. Similarly, there was only known local example of the use of a reciprocating water pressure-engine, namely a machine described as a 'hydraulic ram-pump,' installed at the Tynyweirglodd Quarry in 1905 [14].

TABLE 18

DISTRIBUTION OF RECORDED WATER-POWERED PLANT AT NANTLLE

QUARRY	WATER-WHEELS				WATER	PELTON/
	Pumping	Sawing	Haulage	Other	BALANCES	TURBINE
Northern Plateau						
Alexandra	2	-	-	-	1 shaft	-
Braich	1	-	?	-	?	-
Brynfferam	-	-	-	-	-	-
Cilgwyn	5	?	?	-	?	-
Fron & Old Braich	1+	-	?	-	?	-
Moeltryfan	?	1	-	-	-	-
Pretoria	-	-	-	-	-	-
Central Area, north						
Cloddfa'r Coed	3-connected		?	-	-	-
Cloddfa'r Lôn &Penybryn	4	-	1	-	1 incline+?	-
Dorothea	2	1	1+	-	1 incline+?	1
Galltyfedw	1	-	?	-	-	-
Penyrorsedd	4	1	[2]	2	1 shaft+?	-
Pwll Fanog	?	-	?	-	?	-
South Dorothea	1	-	-	-	-	-
Talysarn & Blaen Cae ..	2	1?	?	-	1 shaft+?	-
Central Area, south						
Gwernor	1	-	-	-	-	3
Fronheulog	2	1?	-	1	2 inclines	-
Singrig	-	-	-	-	-	-
Taldrwst	2	-	?	-	?	-
Tanrallt	4	-	?	-	?	-
Tyddyn Agnes	-	-	-	-	-	-
Ty Mawr East	?	-	?	-	?	-
Ty Mawr West	-	-	-	-	-	-
Ty'n Llwyn	1	-	-	-	-	-
Tynyweirglodd	?	-	?	-	?	-
South-west						
Cilcoed	?	-	?	-	?	-
Coch-y-bîg	?	-	?	-	?	-
Foel Clynnog	1	[1]	[1]	-	?	-
Gelli Bach	1	-	-	-	?	-
Llwydcoed	1	-	-	-	?	-

Key: - relatively-certain zero entry
? unknown/uncertain information
[ ] dual/multiple use of plant

The quality of water supply on the opposing sides of the valley, determined by geography, unfortunately did not correlate with the industrial requirements. There was plenty of water available on the southern side of the vale, where the quality of the slate generally of poor quality, but the northern side with its better slate suffered from a severe shortage of usable water. This was especially true of the northern plateau-land, where rain falling on the thin soil was quickly lost by surface run-off [15].

Despite the unpromising conditions on the plateaux, the Alexandra, Braich-rhydd and Cilgwyn quarries were able to make a limited use of water power for pumping, but only because of elegant engineering. In each location, the water-wheel(s) was located downhill of the drainage outflow adit so that the water discharged from the pumps could be fed over the wheel. Consequently, only a small additional volume of collected water was then required to supplement the system [16].

Because the only lake on the plateaux (Llyn-y-Ffynhonnau) was reserved for the Cilgwyn Quarry during the first three of four decades of the nineteenth century, the quarries on the northern valley slopes and floor had to make do with whatever water that could be obtained from other sources, for example, the shared use of the outflow from the Cilgwyn Quarry drainage adit by the Galltyfedw, Penybryn/Cloddfa'r Lôn and Dorothea quarries [17].

By the second half of that century, the increased demands on the water supply due to the greater scale of working at most of the quarries resulted in a need to change and upgrade the system. By virtue of his independently leasing the water rights on the Kinmel Estate lands, John Lloyd Jones (the Dorothea Company's chairman). Jones, *via* a personal involvement in the Penyrorsedd Company, arranged that quarry's water system in such a way as to direct all of the outflow to a single leat joining onto the Penybryn Quarry system, which was already the main feed for the Dorothea Quarry. A complex water-leasing system was set up, whereby Jones received an annual rent for this supply from all of the users, with a tramway wayleave being appended [18].

This complex arrangement could not possibly survive without a descent into disharmony and dispute, a situation which had reared its head amongst several of the parties by the 1880s. At one stage during that decade, the Dorothea Quarry was being denied its supply because a dispute between the Penyrorsedd and Penybryn quarries resulted in the water being stopped at source. In another chapter in the saga, J. Lloyd Jones conducted an unsuccessful action against his own close relatives, the proprietors of Dorothea, in a dispute about an increase in the water rent [19].

To escape the possibility of being held to ransom by being dependent on only one water source, the Dorothea Company in the late 1880s and early 1890s took desperate measures. It obtained water leases on the Cwm Silyn lakes, on the southern flanks of the valley, purchased many acres of the contiguous mountain grazing to secure further rights, and attempted to buy out the interests of the Gwernor Slate Company completely, so as to control its water rights. Unfortunately for the Dorothea Company, it had jumped straight into another hornets' nest, and it found its ambitions thwarted by the diminutive Gwernor concern [20]

Furthermore, a detailed investigation of the Cwm Silyn water rights found that the Tynyweirglodd Quarry had been illegally tapping one stream for years, and this concern was forced in 1899 to make other arrangements forthwith. By 1905, the proprietor of Tynyweirglodd had reconsidered its previous capitulation and had resumed its use of the Cwm Silyn stream. This provoked the Gwernor Company into instigating a long-drawn and bitter action for trespass, and it eventually won on a technical point, bankrupting its adversary in the process [21].

This was probably the most highly publicised of all the water disputes at Nantlle. Others were more private, but equally vindictive. For example, in the early 1800s, the Cloddfa'r Coed Quarry had its water supply cut off by John Evans (of the Cilgwyn Company). He had specifically taken a lease of the source of that quarry's water, and used this as a threat to strengthen his bargaining position in an attempted purchase of the quarry. When this fell through, he cut off the supply and the quarry was drowned out because the pumping water-wheels were put out of action [22].

Even after water-wheels and water-balances went out of favour, there was always a demand for water, be it for generating steam, for cooling internal combustion engines, air compressors, and sawing machinery, or for more mundane purposes such as flushing latrines. It was only when some rationalisation of land ownership occurred during the present century, and the freeholds were purchased by the surviving quarry companies, that the problem of maintaining adequate water supplies was eventually resolved. With less demand, the limited water was adequate for the few quarries still working at Nantlle, and the ownership of those sources was finally safeguarded [23].

(v) Steam power

The unreliability of water supplies for working water-wheels and the need to increase winding speeds on haulage systems were the two crucial factors which led to the adoption of steam as a power source in the Nantlle slate quarries. The obstruction by a rival concern of a vital watercourse feeding the quarry's water-wheels was probably the spur for the installation of the first steam pumping engine in this district by the owner of the Cloddfa'r Coed Quarry, allegedly in 1807 or thereabouts, this being only the second of its type in a British slate quarry [24].

The steam-powered pump at Cloddfa'r Coed (above) was apparently a solution to an individual problem, and as such it did not set an immediate precedent for the industry in North Wales. Apart from this first engine, and its replacement of 1817 [25], there were no further steam-powered installations in the Nantlle area until c.1841, when a winding engine was erected at the Cloddfa'r Lôn Quarry; this early period is summarised in Table 19, below [26]. By c.1845 there were only about four stationary steam engines at quarries in Nantlle [27], but half a century later the number had increased by more than twenty-fold [28].

TABLE 19
EARLY NANTLLE STEAM INSTALLATIONS

Quarry	Date	Engine type	Function	Notes
Cloddfa'r Coed	1807?	Vertical, beam engine	Pumping	Unknown type; destroyed by rockfall, 1817.
Cloddfa'r Coed	c1817	Vertical, beam engine	Pumping	Unknown type; replacement for above; 8 h.p.
Talysarn	c1829	ditto.	ditto.	New location for 1817 engine (above)
Cloddfa'r Lôn	c1841	Vertical beam engine with integral frame?	Winding +pumping	Large+two flywheels; first chain incline erected at Nantlle.
Dorothea	c1843	Vertical, beam engine with integral frame	Winding +pumping	2nd chain incline in valley; 50 h.p.
Cilgwyn	c1844	Horizontal?	Winding	Small & low power

Refs: J.Griffiths (1889), pp.12, 14, 16, 41, 52, 71; CRO/Dorothea 612; N.W.Chronicle 12.6.1828 & 8.1.29; R.Williams (1899) p.55, (1900) pp.131-2

TABLE 20

DISTRIBUTION OF RECORDED STATIC STEAM PLANT SITES AT NANTLLE

QUARRY	Haulage	Pumping	Sawing	Compressor
Northern Plateau				
Alexandra	8	1	1	1
Braich	3	[1]	1	?
Brynfferam	-	-	-	-
Cilgwyn	16	[1]	2	(1)
Fron & Old Braich	3	[1]	1	?
Moeltryfan	4	1	2	1
Pretoria	-	-	-	-
Central Area, north				
Cloddfa'r Coed	5	[1]	-	1
Cloddfa'r Lôn & Penybryn	11	[4]	3	1
Dorothea	19	[2]+2	3	1
Galltyfedw	6	[1]+1	2	2
Penyrorsedd	8	-	3	2+(1)
Pwll Fanog	-	-	-	-
South Dorothea	4	[1]	2	1
Talysarn & Blaen Cae	26	3	4	1
Central Area, south				
Gwernor	-	-	-	-
Fronheulog	6	[1]	2	-
Singrig	-	-	-	-
Taldrwst	5	[2]	?	-
Tanrallt	5	[1]	1	1
Tyddyn Agnes	1	-	-	-
Ty Mawr East	5	[1]	-	-
Ty Mawr West	2	-	1	(1)
Ty'n Llwyn	1	-	-	-
Tynyweirglodd	7	[3]	1	-
South-west				
Cilcoed	?	?	-	-
Coch-y-bîg	?	?	-	-
Foel Clynnog	?	?	?	-
Gelli Bach	?	[?]	-	-
Llwydcoed	1	[?]	-	-

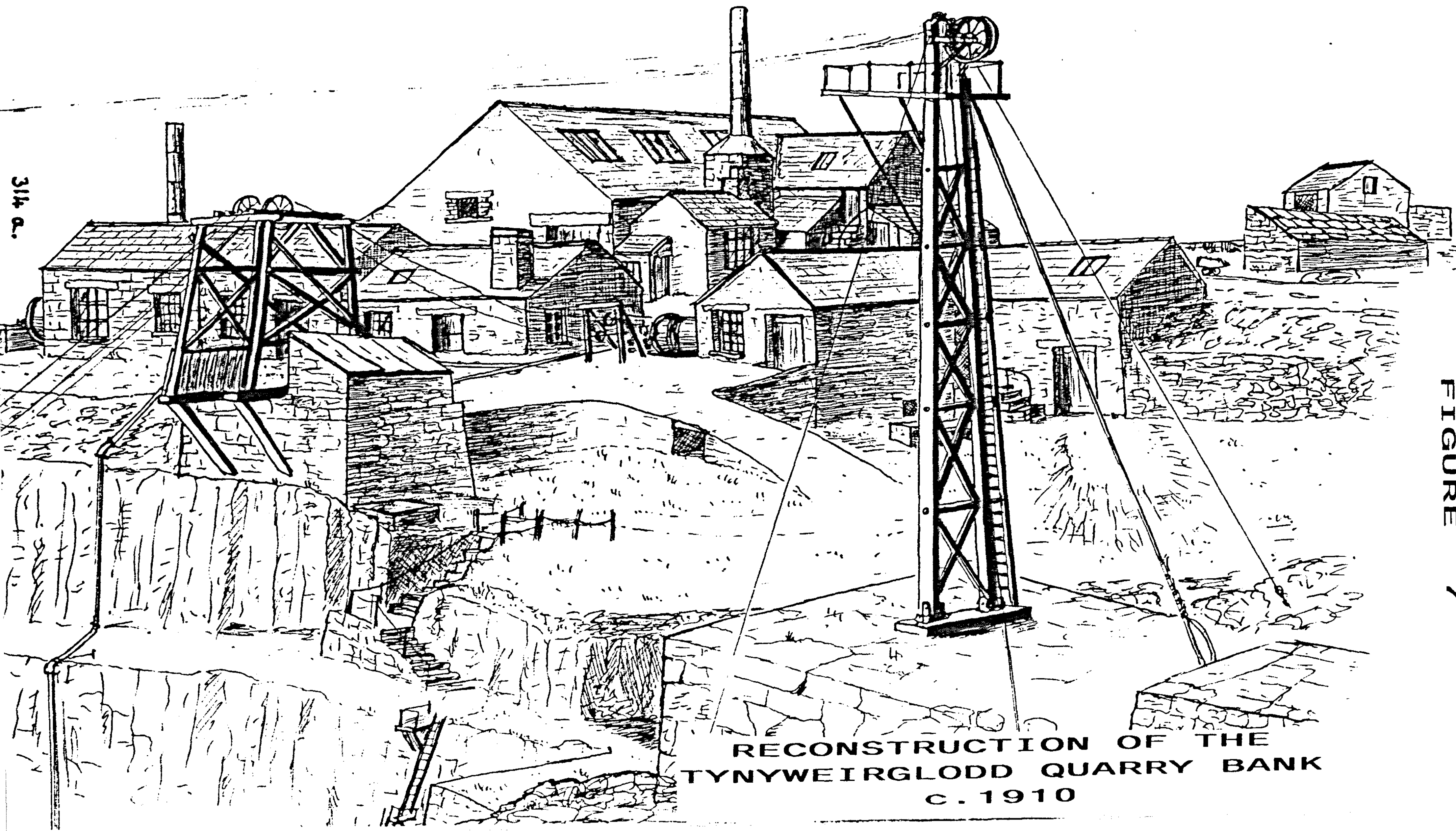
Key: - relatively-certain zero entry ? unknown/uncertain information
[ ] dual/multiple use of plant ( ) with secondary (belt) drive

By the turn of the present century, almost all the Nantlle quarries had at least one stationary steam engine; most had from two to six; and the four largest concerns had between ten and twenty each (see Table 20, above) [29]. In the boom of the 1860s-70s, the practice of using steam engines with winding machinery in place of water-powered plant spread rapidly because of the advantages to the production process derived from the higher winding speeds giving a more rapid turnover of loaded waggons. The increasing use of mechanical sawing, rock-drilling and haulage machinery (see Table 20 above, and Parts b, c and d, below) in the last quarter of the nineteenth century provided even a greater demand for steam power. A typical scene in a mechanised quarry at Nantlle is illustrated in Figure 7, below.

An important contribution to the uptake of steam power, especially in the small quarries, was the development of a market for second-hand engines, with specialist dealers and dispersal sales of failed concerns providing a cheap source of machinery [30]. There was also a high incidence of re-location and re-use of old plant at the Nantlle quarries, due to the longevity of engines, their relatively small size, and a penchant for saving money. The invention of semi-portable engines by the 1860s was also important for the Nantlle quarries because they allowed the ready re-location of the winding plant at low cost, although their multi-tube boilers were more susceptible to corrosion from acidic mountain water than were the older cylindrical horizontal Cornish boilers [31].

In default of comprehensive technical information for the Nantlle quarries, a combined survey of extant inventories and site remains has been carried out by the author with the aim of attempting a typology of the steam plant used in this district. It can be concluded from the results that the most common type of static steam engine had been the simple

FIGURE 7



RECONSTRUCTION OF THE TYNYWEIRGLODD QUARRY BANK c.1910

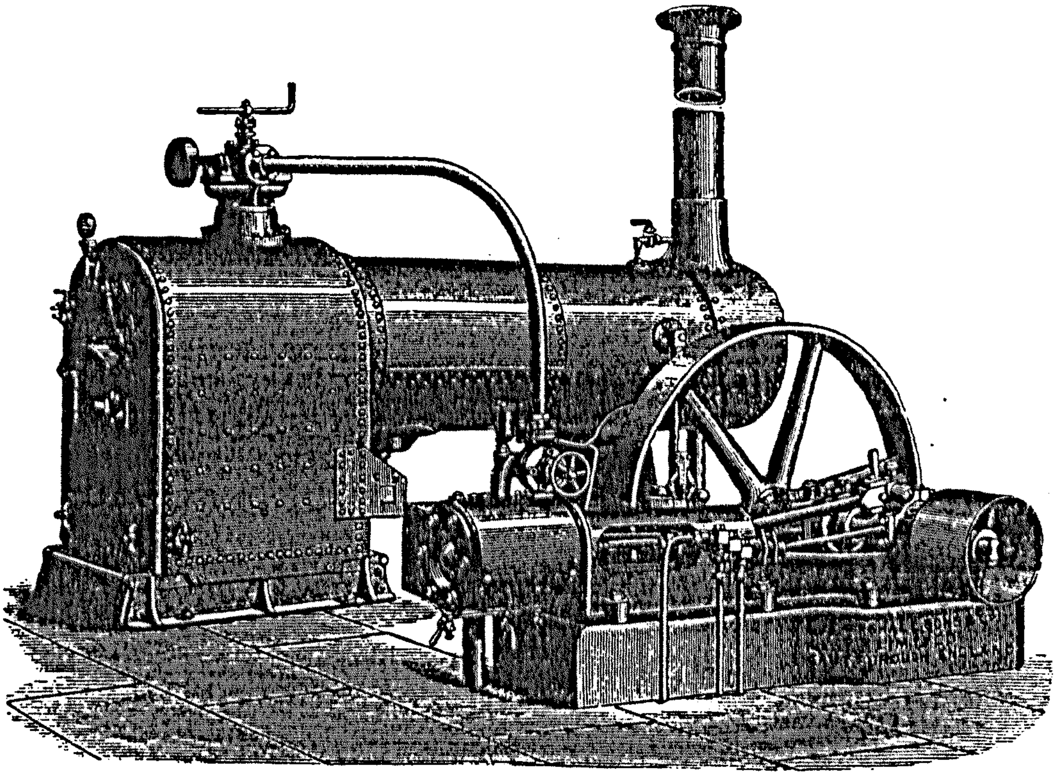
FIGURE 8

HORIZONTAL FIXED STEAM ENGINE

(Class A)

AND

LOCOMOTIVE MULTITUBULAR BOILER



Above illustration represents a Class A Horizontal Engine with a separate Locomotive Multitubular Boiler connected together and in position for work.

It will be seen from pages 37 to 45 that we manufacture Horizontal Engines of **Four Classes** and a variety of sizes, any of these are suitable for application to this type of Boiler, and the latter is specially adapted for use where only a limited space is available, and for generating steam with coal, coke, or wood and refuse as fuel; straw, cotton stalks, jungle grass or other vegetable matter may also be consumed in them by the application of a special apparatus as embodied in Engine illustrated on pages 20 and 21. They have further the advantage of requiring only a slight foundation and in a one storey building the wrought-iron chimney may be carried through the roof; when the building is more than one storey high a metal elbow pipe or underneath flue is employed to turn into an ordinary brick chimney.

These Boilers may be lagged as in our Portable Engines, and also an efficient Feed Water Heater arranged in connection with the exhaust steam from the Engine for heating the feed water to a high temperature on its passage to the boiler.

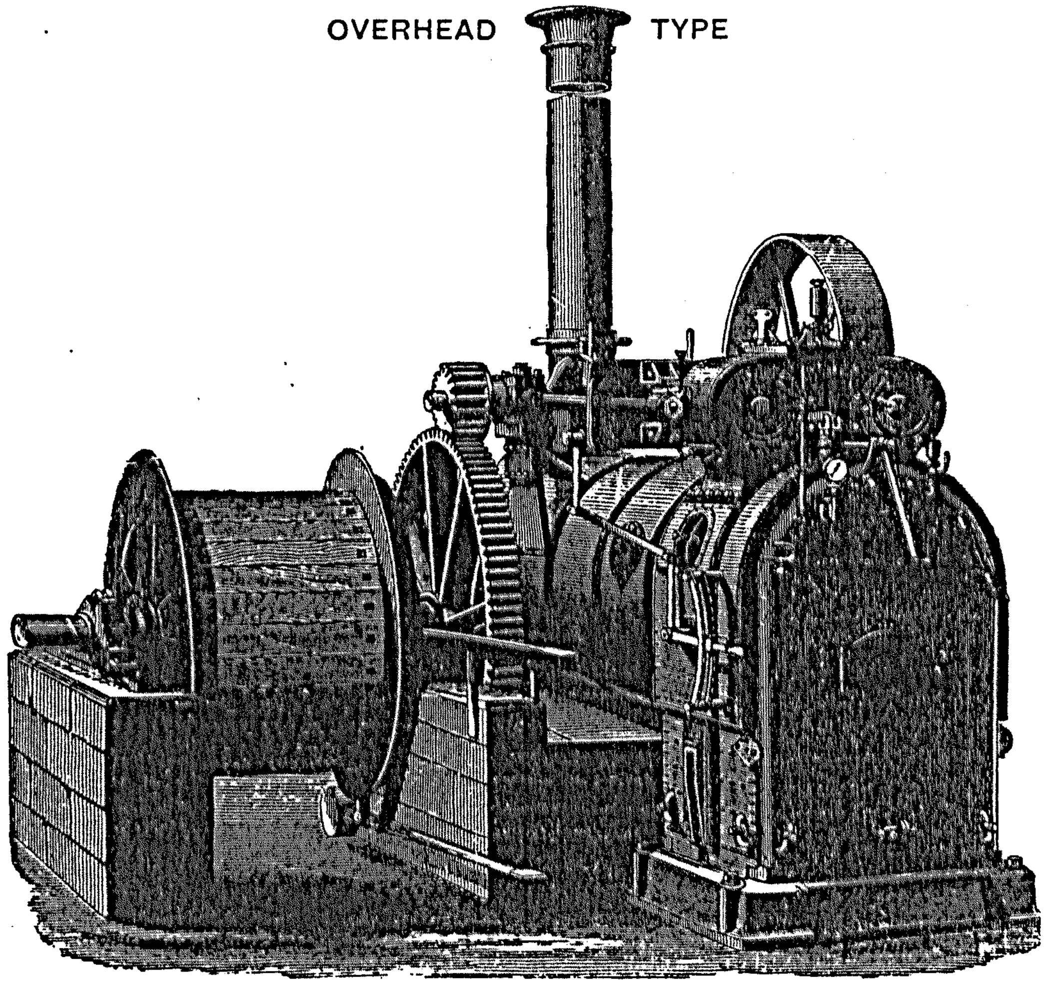
Prices and further Particulars on application.

FIGURE 9

IMPROVED SEMI-PORTABLE

STEAM WINDING ENGINE

OVERHEAD TYPE



The above Illustration represents a Stationary Steam Engine and Locomotive Multitubular Boiler combined, of our patent construction, (see page 23) in connection with a Winding Drum, mounted on masonry by the side of the Engine, as used by Contractors and others for hauling and winding. The Drum is arranged loose on the Shaft, and is fitted with Clutch and Lever for throwing it in and out of work, as also a powerful Strap Brake and Lever for lowering. Motion is imparted to the Drum through strong spur gearing direct from the Crank-shaft of the Engine, and Link Motion is also applied, so that the Engine may be run in either direction to suit the work.

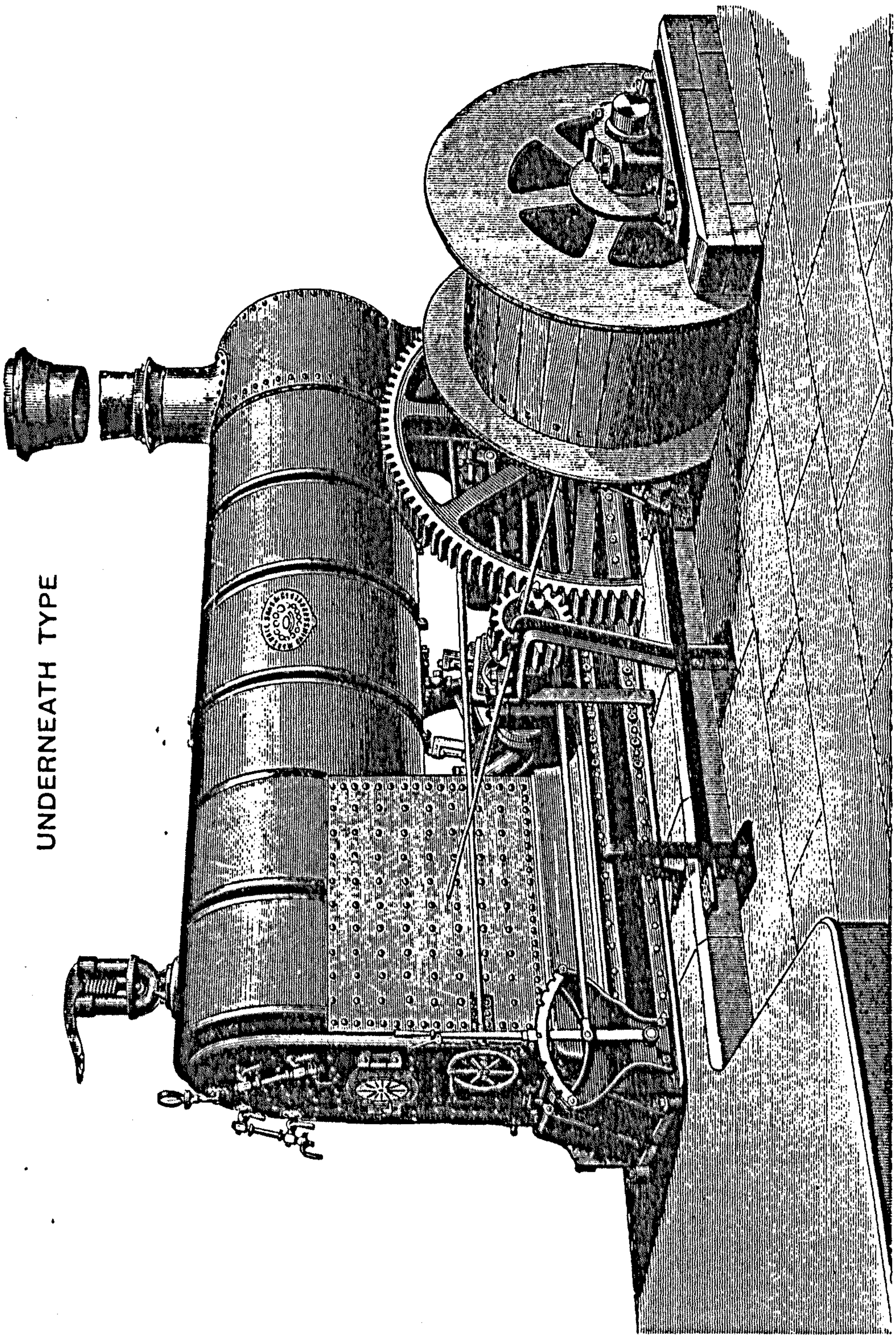
We make these Engines of various powers, and with one or two Drums of such sizes as may be required; and in addition to this particular class of Engine above illustrated, we apply Winding Drums and Gearing to our Vertical and Portable Engines for hauling and winding when necessary.

SPECIFICATIONS and PRICES will be given on receipt of information as to the work to be performed and the class of Engine preferred.

FIGURE 10

IMPROVED STATIONARY STEAM WINDING ENGINE

UNDERNEATH TYPE



For particulars of the above Engines, see pages 24 and 25. Particulars of Winding Drums and Gearing on Application.

single cylinder horizontal, commonly less than two-foot bore and no more than a three foot stroke, up to a maximum of around 25 to 30 horse power (see Figure 8, above). There were only a limited number of duplex or two-cylinder horizontal engines here, although the semi-portable engine with duplex cylinders on top of the boiler were quite popular after the 1870s (see Figures 9 & 10, below). Only a small number of compact rotary beam-engines existed in the area, dating from the 1850s-60s, and of the esoteric machines, the magnificent inverted "wall-engine" formerly located at the Penybryn Quarry, deserves to be individually noted. After 1899 the new self-contained two-cylinder blondin winches appeared in the district for the first time (see Part c, below), and a significant number of this type was purchased in the years before the First World War [32].

There were apparently few complex and expensive static steam engines at Nantlle. Of those which have been identified, it is not surprising that the majority were pumping engines. Almost nothing is known of the Cloddfa'r Coed 'No.1' beam engine of 1807 or of its replacement of 1817, other than the alleged relocation of the latter at the Talysarn Quarry in 1828 and its survival until at least the late-1890s (see above) [33]. The Cornish beam-engines at the Coedmadog Quarry (a whim-engine of c.1863, scrapped *c.*1917), the majestic Dorothea Quarry "Injian Fawr" (of 1904, *in situ*) and also the tandem-compound horizontal pumping engine (of c.1880, scrapped 1917) at Coedmadog Quarry, represented costly technology which was specifically obtained to overcome very heavy inflows of water into the deepest of the low-lying workings [34].

Very few large engines were employed in working the quarry mills due to the relatively small scale of the majority of these buildings. However, there was a small number of very sophisticated mill engines in the district, used in the largest of the mills, of which the Robinson two-cylinder engine at Dorothea (of 1887), the De Winton tandem compound at Penyrorsedd (of 1898), and the 120 horse power Buckley & Taylor (Oldham) cross-compound at Cilgwyn (of 1900) were the most impressive of those on record [35].

Little can be found about the running costs of quarry steam engines at Nantlle before the turn of the present century. Neither data of coal consumption nor details of the purchasing of fuel stocks are generally available. However, the cost of transporting coal to the Cloddfa'r Coed Quarry from the coast must have been high in the early nineteenth century, but was significantly reduced with the construction of the railway from Caernarfon in 1828 (see Chapter 5) [36]. It was only with the increasing availability of alternative power sources by the end of the nineteenth century that the issues of power costs and fuel efficiency became important. At the Dorothea Quarry by the 1890s, coal was supplied from a single source on an yearly contract, let by tender. The records showed a the steep increase in the price of coal due to the Boer War, continuing as a steady rise up to 1914, when its price on delivery at Talysarn was thirty-seven per cent more than in 1896 [37].

The continued increase in coal prices after 1914 correlates with the introduction of alternative power sources into the Nantlle quarries, although it must be pointed out that in terms of numbers, more steam plant was scrapped due to the closure of quarries than was replaced by internal combustion engines and electric motors. Only the Penyrorsedd, Llwydcoed, Alexandra, Moeltryfan and Tynyweirglodd quarries (in 1906, 1910, 1912, 1935 and 1940 respectively) totally abandoned static steam plant overnight, in favour of alternative power sources, whereas twelve steam-powered quarries closed between 1908 and 1938 [38].

The only concern which progressively converted from steam was the Dorothea Quarry, whose many statistical analyses of power costs provide a rare insight into this field. Dorothea was almost totally run on steam power in 1938, when its annual coal consumption at 1,898 tons (costing about £2,600) was half the amount formerly used in this quarry at the turn of the century. However, the installation in that year of diesel/electric generators to run the mills and auxiliary pumps led to a significant drop in coal consumption to 961 tons in 1946, although price increases after the war had cancelled out any economy gained by increasing the annual spending on coal to £3,289 in 1949 despite a further decrease in the number of steam winders by two.

The consumption of forty-eight tons of coal per month by the Dorothea Quarry's Cornish pumping engine amounted to about three-quarters of this fuel bill, and this precipitated its replacement in 1952 by electric pumps. The three remaining steam winders at Dorothea claimed the title of the last of their type in the district and in the slate industry by outlasting their counterparts at the defunct Cilgwyn Quarry by a few months. Using only eighteen tons of coal per month, the relative cost-efficiency of the Dorothea winders justified their retention until government grant-aid was made available for their conversion to electric drive in 1959 [39].

(vi) Internal combustion engines

There were three main types of internal combustion engines used in the Nantlle district, namely **gas engines, petrol engines** and **oil engines** (or 'diesels'). Their common main advantages over steam engines in the quarries were: **(a)** greater fuel-efficiency, giving better cost-effectiveness; **(b)** cheaper fuel; **(c)** immediate starting on petrol and oil engines, with no need to 'raise steam'; **(d)** no steam boiler (with its attendant costs of insurance, inspections, stoking, cleaning, water-supply, etc); and **(e)** a smaller size of machine per horse-power produced. The disadvantages of internal combustion engines in the quarries were: **(a)** the maximum torque was produced over a smaller range of rotational velocities; **(b)** their inability to start under load; **(c)** cold starting could be difficult to accomplish; and **(d)** higher maintenance costs due to their greater complexity.

Gas engines.

The gas engine became popular in the 1880s for powering small factories in towns, where the advantage of being connected to a mains gas supply gave the edge on steam installations [40]. Despite the availability of "Town Gas" in Nantlle area from 1873 [41], only a handful of quarries were in close proximity to a gas main, and consequently, the gas engines installed locally required independent gas-producing plant in the form of a retort to burn coal in a reduced air flow so as to generate carbon monoxide for use as a fuel [42].

The suction gas engines which were used at Nantlle were typical of small or medium sized units, having a single cylinder and one or two flywheels and magneto-powered spark plugs. The gas engine was a very efficient machine designed for constant running applications, such as for powering mill or workshop lineshafts, air compressors or electrical generators. It was particularly economical in that it altered its speed according to the load, and the self-suction priming of the engine regulated the combustion of the coal in the retort [43]. Extant comparative data of their performance relative to steam engines in the quarry environment appears to be limited to an analysis of cost-effectiveness of mill power plant at Dorothea in 1933-34, which showed that the two steam-powered mills were from thirty-six to forty-one per cent more expensive to run than the mill powered by a gas engine [44].

The first gas engine installation at Nantlle was probably that at the small Llwydcoed Quarry, near Llanllyfni (see Figure 11, below). Near the close of the nineteenth century, the quarry was leased to a London-based company, which equipped the site with modern plant *c.*1900. The main power house was provided with a large 'National' suction gas engine which drove a sawing mill and an air-compressor *via* belt-drives, and the engine also generated electricity for winding, pumping, surface haulage and lighting (see sub-section a.vii, below) [45].

Four other producer gas engines were subsequently erected at Nantlle, driving mills in the Alexandra Quarry (*c.*1906), Coedmadog Quarry (*c.*1907), South Dorothea Quarry (by 1909) and Tynyweirglodd Quarry (probably pre-1910), with the second listed being moved to the Blaen Cae Quarry in 1909 [46]. However, no further examples were installed in the local quarries, although one was purchased second-hand by the Galltyfedw concern in the 1920s but never used [47]. This low number raises the question of why this was so, in view of the apparent economy afforded by this power source. The answer is probably twofold. In the first instance, most of the steam mill-engines in the Nantlle quarries were relatively new at the turn of the present century, and those concerns which installed gas plant were probably special cases, where a new facility was being provided, or where an existing steam engine was due for replacement by a more powerful unit as the result of the addition of extra machinery in the mills.

Secondly, the generally bad reputation gained by this first batch of gas engines probably blighted any further purchases. Starting problems were frequent, with hours of production being lost per day on a frequent basis. Lack of proper maintenance over two decades was probably to blame, with drivers and fitters being largely ignorant of the workings of this type of plant, and with concerns economising by not calling in specialists until total breakdown occurred [48].

Petrol engines

Because of its use of liquid fuel and its small size, the petrol engine was ideal for powering small mobile or portable plant. Thus petrol engines began to occupy a niche in agriculture, light industrial applications and motoring by the turn of the present century. It was the First World War that provided the impetus for the improvement of the petrol engine for military use, and subsequent automotive and industrial variants were significantly more reliable and cost-effective in use [49].

Whereas the first petrol-powered plant to appear in the Welsh slate quarries appear to have been light rail-tractors (see Chapter 5), the first 'static' petrol engines were employed post-1918 to power portable air-compressors. In this application, the utilisation of a light power unit was highly desirable because these compressors needed to be sufficiently compact to descend the aerial cableways to the bottom of quarries, so as to work drills at faces not reached by the mains air-pipes. Furthermore, their low purchase and running costs made petrol portable compressors the first drilling plant that could be afforded by the smaller quarrying concerns, to the great benefit of their productivity [50].

The same was true of pumps. The petrol-powered pump was a godsend to small scale concerns, which previously had to rely on expensive steam engines, obsolete water-wheels or inefficient hand-bailing in default of having access to electric power. Petrol-powered pumps were ideal for small-scale applications, being small, compact and cheap, and the availability during the 1950s of war surplus high-capacity 'N.F.S.' (fire-engine) pumps resulted in the speculative unwatering of several small flooded pits at Nantlle [51].

Perhaps the most interesting adaptations of petrol-powered machinery at Nantlle were found in the realms of winding machinery. By the 1930s, motor vehicles became increasingly common, and it was quickly realised that they represented a cheap and convenient source of hauling power. In its crudest form, a motor vehicle winch simply towed the cableway winding cable along a convenient length of quarry bank, this being the system used at Fronheulog Quarry in the 1930s and at Cilgwyn New Pit in the late-1950s. At most locations, however, a hoisting track was not available, and in this case a static vehicle was used, either winding directly off a modified rear wheel as at Cloddfa'r Coed in the 1930s and at Singrig in the 1950s, or with the engine and gearbox only being retained as a power unit for a conventional small geared winch [52]. The Tynyweirglodd Quarry was unique at Nantlle in possessing, after 1940, a large industrial petrol-winch, rather than adopting the 'Heath Robinson' policies of the majority of its local competitors [53].

Oil engines

The special characteristic that made oil engines very suitable for driving constant-running machinery under a heavy load (such as large compressors, or several saws) was the production of maximum power at a lower crankshaft speed than a comparable petrol engine, and the compensatory effect of the compression-ignition system in response to changes in the load. The fuel consumption figures of oil engines were also significantly better than those using petrol or Producer Gas. The total running costs of diesel engines were less than half that of a steam engine, and was marginally cheaper per horse-power than electricity prior to the Second World War [54].

The first known use of an oil engine at Nantlle, and possibly amongst the earliest application in the Welsh slate industry, was at the Penyrorsedd Quarry, where a 12 horse power 'Hornsby Ackroyd' engine was installed in 1900-01 to turn the machinery in the new fitting shop [55]. The second installation on record at Nantlle was the 'Tangye' heavy-oil engine that powered the new air compressor at the Gwernor Quarry, purchased just before the terminal closure of the works in 1913 [56]. thirdly, a 'Crossley' vertical crude-oil engine was installed at the Fronheulog Green Quarry *c.*1920, driving a pair of air compressors *via* a flat-belt line-shaft [57].

In the 1920s and 1930s, the design of oil engines developed rapidly and they increasingly replaced gas and steam engines for heavy industrial work. The first displacement of existing plant by oil engines at Nantlle occurred in 1933, when the Dorothea Company replaced the gas engine at the South Dorothea Quarry mill with a single-cylinder 40 horse power horizontal 'National' oil engine. Following the success of this unit, the quarry company within two years had erected a 120 horse power, two-cylinder horizontal 'National' oil engine at the Dorothea Small Mill. In addition to powering the saws, the engine also drove a new set of air-compressors, replacing several individual steam-powered units. In 1938, a second, identical engine was installed in an adjacent bay to drive an electric generator (see sub-section a.vii below). Their demise and replacement by mains electricity after two decades of almost constant use came about by the changes in the power demand of more modern electrical plant at the quarry, the inevitable change-over being precipitated by a catastrophic fracture of the crankshaft of the No.1 engine [58].

Possibly as a result of the success of the Dorothea oil engines, some of the remaining Nantlle concerns began to replace their old constant-running steam plant with oil engines *in lieu* of the greater capital expenditure required for electrification. Thus, the Cilgwyn Quarry proprietors retired their very large steam cross-compound mill engine in 1941, running a reduced number of saw tables more economically by means of a small horizontal single-cylinder 'Crossley' oil engine. In the same year the Tynyweirglodd mill gas-engine was replaced by a small horizontal single-cylinder 'National' oil engine in order to reduce production costs [59].

Post-1945, small vertical single-cylinder engines, often taken out of scrapped front-end dumpers, became popular with the small concerns needing only to power one saw-table. These were a very economical option for concerns with insufficient capital for plant purchase. Other small oil engines for winding and pumping are known to have been used by them during the late 1940s to late 1950s, and are likely to have been commercially-produced machines [60].

(vii) Electricity

Dynamos capable of generating useful electric currents, and electric motors producing sufficient power to drive other machines, were developed in the 1860s and 1870s. However, electricity did not become a commercially viable form of power for industrial use until further development work had taken place in the 1880s and 1890s. The first commercial electrical plant utilised a direct current (D.C.) system, which was robust and was of relatively simple construction, although it suffered from a voltage drop over distance. By the 1900s, a more efficient, albeit more complicated and consequently expensive three-phase alternating current (A.C.) system had been introduced, which did not suffer in the same way and could be transmitted overland over great distances [61].

As a power source, electricity had several advantages over conventional steam plant. A stationary motor consumed no power, whereas a steam boiler had to be continuously fired during the working day, regardless of whether the engine was working or at rest. The inherent additional costs of steam were also absent, with the maintenance, inspection and insurance of steam boilers being done away with. However, the initial relatively high expense of the new plant, the lack of expertise in the new technology on the part of engineering staff, and the conservatism of management and owners, in general held back the inevitable replacement of steam by electricity. Nonetheless, some of the North Wales slate quarry concerns were very progressive in their adoption of this new technology, which was eminently suited to the technical requirements of this industry.

Self-generated electricity

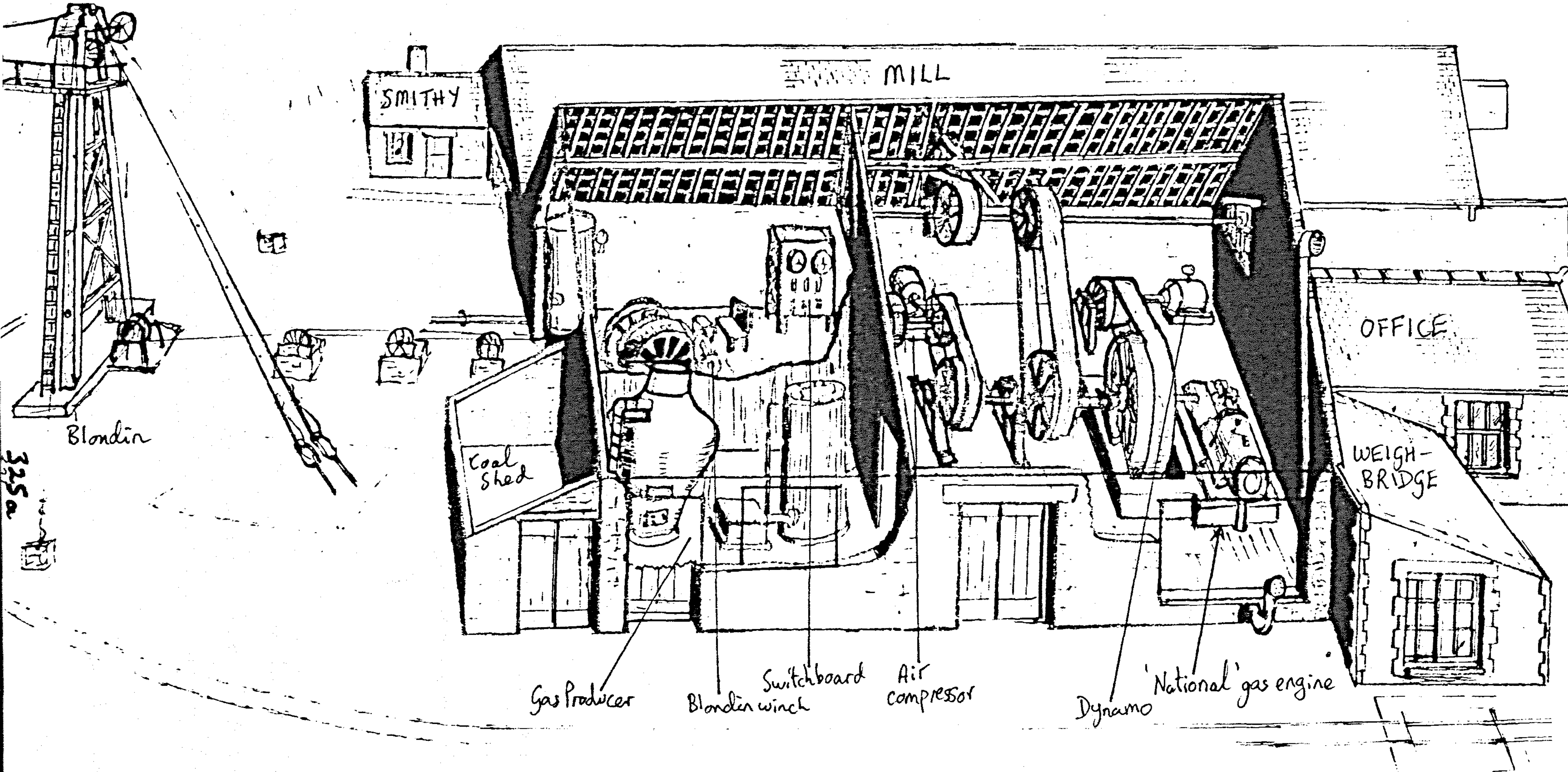
The first known electrical installation in a North Wales slate quarry was a small-scale hydro-electric, direct current generating station that was erected at the Llechwedd Quarry (Ffestiniog) in 1892, with Moses Kellow at Croesor being a pioneer of the three-phase A.C. system in 1904 [62].

The larger slate quarries at Nantlle had become heavy users of coal by the 1890s (see above) and their financial viability was increasingly being threatened by the rising cost of this fuel during the 1900s. Thus, home-produced electric power appeared to provide an escape route from this problem, although limited headway was made in this direction for a variety of reasons.

The Dorothea Quarry was the most heavily-dependent on steam power of all the Nantlle concerns, and it was the first to plan a total electrification, which was a very bold step in 1896. The scheme involved a private hydro-electric station (on a D.C. system), and was calculated that it would save £1,100 per annum in fuel costs on an initial total capital outlay of £16,453. However, on both the first attempt and a revival in 1900, the proposal was thwarted by a dispute concerning water rights [63]. A final attempt to resurrect the lapsed private hydro-electric scheme in the late 1930s after the rights had been secured, was abandoned in view of the perilous financial position of the Dorothea Company and the revised estimated cost of setting up the generating station alone being £11,450, notwithstanding the additional expense of converting the quarry steam plant [64]. Similarly, a complete conversion of the fixed steam plant at the Penyrorsedd Quarry in 1902, together with a private steam-powered generating station (D.C. system), was costed at £5,300, but was not implemented because of the declining state of the slate market [65].

The increasingly unfavourable economics of slate quarrying after *c.*1900 dictated that private single-quarry electricity generating schemes could in most cases only be implemented on a small-scale. This dictum is illustrated by the first operational use of electrical plant at Nantlle in 1900-01, where a dynamo was belt-driven from the Cilgwyn Quarry mill engine so as to power a 110 volt (D.C.) lighting circuit, some auxiliary quarry-pumps and an experimental electric rock-drill [66]. Concurrently, the Talysarn Quarry appears to have undertaken a trial of an electric (D.C.) winding motor, using power generated by a dynamo that was belt-driven from a static steam engine [67]. It is also recorded that the unsuccessful attempt to reopen the Braich Quarry in 1913 involved the

FIGURE 11



RECONSTRUCTION OF THE
LLWYDCOED QUARRY POWER HOUSE
c.1920

installation of an electric pump, which appears to have been powered from a generator worked by the mill steam engine [68].

The results of these early 'in-house' trials was, however, mixed. Whereas the installation of electric lights and pumps posed no great difficulties, the application of electricity to winding plant was not accomplished with any great measure of success. The Talysarn Quarry experiment, for instance, was a complete fiasco because of technical problems which had not been foreseen by the quarry engineering staff, who were inexperienced in this new technology [69]. Similarly, the conversion of a steam winder at Cilgwyn following the installation of a new three-phase (A.C.) generator in 1906, was dogged by technical problems. Consequently, the whole of the electric system at this quarry gradually fell into disuse, and was dismantled during the 1920s [70].

However, the private electrical installation at the small Llwydcoed Quarry, near Llanllyfni, was the most successful of its type in the Nantlle area (see Figure 11, above). It appears to have been installed in the early 1900s, during the tenure of a company whose directors had interests in the electric street-tramways in several English cities [71]. The Llwydcoed plant consisted of a 'Crompton Parkinson' 80 amp, 500 volts (D.C.) dynamo which was belt-driven from the large producer-gas mill engine (see sub-section v, above), supplying power to a blondin winder, a cable-operated tramway haulage system, a smithy fan, a pump in the pit, and a 110 volt lighting system via 'Westinghouse' controllers and switch-gear [72].

In order to reduce the running costs of its mills and auxiliary pumps, the Dorothea Quarry installed in 1938 a similar private generating set, consisting of an 80 kW alternator (A.C.), powered by a two-cylinder horizontal 'National' diesel-oil engine (see sub-section v, above). This partial electrification was a more cost-effective alternative to the complete conversion of the quarry plant, which would have required mains-power or the implementation of the recurring proposals for a private hydro-electric scheme (see above). The Dorothea power station originally generated 900,000 units per annum at a cost of £2,810 in fuel, equivalent to 0.75*d.* (about 0.3p.) per unit [73], but after 1952 its output was doubled at night to supply the additional power required by the new main pumps. This boosting was achieved by transferring the air-compressor drive-belt on the second existing oil engine to a second alternator. Synchronising the voltage phases of the two individual generator sets into a single output proved difficult using the original stroboscopic light indicators, but this was overcome by their replacement in favour of 'Ferranti' phase-synchrometers [74].

Mains electricity

The biggest drawback of the first direct current systems was the voltage drop during its transmission in a metal-wire conductor. Whereas this was of little consequence when the transmission line was less than about a quarter of a mile, the problem represented a restraint on the generation of power at a convenient location for consumption at a distance. The capability of altering the voltage of alternating currents by means of an inductive transformer overcame this problem, and after its general adoption in Britain from the 1890s, the A.C. system allowed the transmission of electric power over long distances via high-voltage overhead power lines [75].

This technological improvement was instrumental in the formation of regional independent electricity generating and supply companies, of which the North Wales Power & Traction Company Limited, set up in 1904 (and hereafter referred to as the 'Power Company'), was one such concern. This company sought to capitalise upon the high rainfall and suitable topography of Snowdonia to generate hydro-electricity for the potential industrial customers, which were conveniently concentrated in pockets for ease of supply. Its first hydro-electric station, at Cwm Dyli (near Beddgelert), began generating three-phase alternating current in 1906, delivered *via* overhead transmission lines at 11,000 volts to Blaenau Ffestiniog, Llanberis and Nantlle (Lines Nos.1-3, respectively) [76].

The Power Company, displaying a keen commercial sense, had ensured that it had one industrial customer in each of these districts from the start, having granted contracts which involved preferential discount rates and special considerations to its first consumers. At Nantlle, the initial customer was the Penyrorsedd Quarry, which had accepted the electric supply for a trial term of two years at a twenty five per cent tariff discount, with the Power Company supplying and installing the necessary plant and switchgear on approval. At the end of the trial period, the quarry held the option to purchase the existing electrical plant, substitute plant of its own choice, or ask the Power Company to remove its property and re-instate the original steam engines, of which the first option was taken [77].

The tariff of the electrical supply from the Power Company varied on a sliding scale according to the power consumption of the customer, ranging from a discounted 7/8*d.* (about 0.4p.) per unit for the high-consumption at the Oakeley Quarry, to a premium 1½*d.* (about 0.75p.) per unit for a light user such as the Dinorwic Quarry. The cost for a medium-level user such as the Penyrorsedd Quarry was 1*d.* (0.5p.) per unit, which was contracted to be held steady for fifteen years from 1908. Nevertheless, the expected reduction in fuel costs was, in this case, not as significant as had been calculated, probably because of the mechanical inefficiency of the early electric motors [78].

Unexpected problems however arose with the mains power supply system during its first two decades, which arose from the technical limitations of running only a single generating station with an enlarging supply network. These difficulties included **(a)** the imposition of a maximum annual power consumption on its industrial customers; **(b)** the difficulties of matching the hydro-electric station output to the fluctuations in demand, necessitating a prior notice of the working overtime so as to enable sufficient water to be conserved as supply for the extended period of high load; and **(c)** the effects of a breakdown in the supply, through technical faults were only compensated up to a maximum of £50 on each occasion after a minimum of three hours had elapsed [79].

In view of the high capital costs of conversion and the relatively small margin of economy gained in the early years of mains supply, it is not surprising that its uptake by the Nantlle slate quarries proceeded at a very slow rate. Apart from the Penyrorsedd Quarry, only the Alexandra and the later co-owned Moeltryfan quarries became linked, in 1912 and 1935 respectively, to the mains power supply in the pre-nationalisation era [80]. Despite long negotiations with the Power Company, the Dorothea Company felt unable to undertake such a substantial capital investment during a bleak period in its history, and moreover harboured a fear of relinquishing its independence in a vital service to an outside body [81]. Mains power was not supplied to the Dorothea Quarry until 1956, when the catastrophic breakdown of an item of plant in its own private generating station almost caused the closure of the concern by temporarily rendering the vital main electric pumps inoperative (see above and sub-section a.vi, above) [82].

The most recent electric installations at the Nantlle quarries came about as the result of an ill-fated development of the tiny Twll Coed Quarry during the early 1970s. A three-phase electricity supply was installed here in 1974-75 to work a large air compressor, an electric high-speed saw and a dressing machine. This provision of electric power was expensive because of the distance of the quarry from the nearest 'high tension' grid mains, but the expenditure was hardly justified by the low output and poor productivity of this short-lived enterprise [83]. There was, however, one beneficiary of this unhappy episode, namely the adjacent Twll Llwyd Quarry, which was able in 1989 to inexpensively obtain electric power through a short spur from the new transmission line leading to the then-defunct Twll Coed Quarry [84].

(b). The extraction process

This sub-section describes the mechanisation of the processes carried out at the rock face, both in the extraction of workable slate and the removal of waste material of various descriptions. The themes covered here are those of rock-drilling (for shot-firing); rock-cutting (mechanical extraction); excavating and loading plant; and pumping machinery.

(i) Rock-boring and drilling plant

The introduction to the slate industry at Nantlle in the eighteenth century of the technique of utilising explosives for releasing individual slabs from the solid rock-body, has already been described (see Chapter 3). However, despite the advantages gained from the use of explosives, the drilling of the shot-holes remained a slow, laborious process as long as the the only available option was the use of hand-tools. Originally, shot-hole drilling involved two men, one holding and rotating a chisel-tipped bit (or *ebill*) which was struck repeatedly by his partner wielding a double-handed heavy sledge-hammer. Whereas this method remained as the initial step in starting a hole, its subsequent completion was later achieved by one man using a form of percussion drill (or 'jumper'), incorporating a heavy weight asymmetrically located between the chisel tips at either end, thus providing two tools of unequal length in one [85].

Despite the advantage of allowing shot-holes to be drilled in confined or awkward positions as dictated by the requirements of geology, the manual method was both arduous and time consuming, a standard six-foot deep hole taking about seven hours of drilling time [86]. The early developments in mechanical rock-drilling did not, however, offer a viable alternative in terms of the production work in the quarries (see below), and thus the old methods continued to be used until the introduction of pneumatic drills in the 1890s (below) provided a practical technological answer to the specialised requirements of this aspect of the industry.

The technology of mechanical rock-drilling and core-cutting was initially developed as the result of the demand of the railway construction industry around the middle of the nineteenth century, particularly in the U.S.A., with the technology being subsequently adapted for use in the mining industries [87]. Amongst the first patented inventions in this context which related to the Welsh slate industry was one of 1852 by Edwin J. J. Dixon (of Bangor) for a machine for sinking pit shafts, incorporating a mechanical 'jumper' drill attached to a revolving platform [88]. It is not known whether this machine, or any of the most practicable of Dixon's other idiosyncratic inventions, found any practical use, but his ideas were illustrative of the contemporaneous interest shown within the slate industry and other comparable works in searching for means to maximise the mechanisation of their activities.

Chapter 4: The mechanisation of quarrying

The first known application of mechanical rock-drilling in the Welsh slate industry was in the early 1860s, when Captain Beaumont used a steam-powered drilling rig incorporating diamond bits during a contract to develop the Croesor Quarry (near Llanfrothen) [89], and when the 'Hunter' core-cutting tunnelling machine was tested at several quarries at Ffestiniog and Corris, but not at Nantlle [90]. Whereas the former method did not find great favour in Britain until the introduction of improved plant during the present century, and the latter did not prove a great success, the use of other machines for the drilling of shot-holes in the quarries became increasingly commonplace during the last quarter of the nineteenth century. However, because of expense and the organisational difficulties inherent in the application of these machines within the 'bargaining system' of slate production (see Chapter 3), their role remained in general confined to development work carried out by quarrying concerns, such as tunnelling and the 'bulk-blasting' of unproductive rock [91].

Two main types of mechanical drills, with a rotary or percussive action respectively, appear to have been used in the slate quarries by the 1870s, representing the main contending technologies of the day [92]. The rotary drill was based on the carpenter's auger, and used a revolving cutter acting under a mechanical feed. One example of this type of machine recorded in connection with the slate quarries of the Nantlle valley was apparently the product of the inventive mind of E. J. J. Dixon (see above), although his 1870s version was not related to his earlier patented machine, already described. The later 'Dixon' drill was designed for preparing large shot-holes for 'big-blasts', having a rotary bit of up to four inches in diameter on a shank which must have been hollow so as to allow for the flow of water to the cutting head from the water pump that was bolted to its frame, thus preventing clogging by flushing out the slate shards and dust. The drill could be actuated either manually by a team of three men (as at the Braich Quarry in 1873) or by a rope-drive from a portable steam engine, as in the case of the 'De Winton' drill-set purchased by the Dorothea Quarry in 1875 [93].

The percussion drill introduced to the quarries in 1872, was represented initially by the American 'Burleigh' type [94] and the later 'Ingersoll Sergent' drill [95]. They mimicked the old hand drill and 'jumper' in that the hole was cut by a steel chisel-bit which was propelled against the rock percussively with a slow turning motion. The drill-bit was moved by the action of a directly-connected piston in a cylinder, actuated by steam that was usually supplied by a portable boiler *via* a flexible reinforced hose [96].

Although the 'Burleigh' machine drilled slate at a rate of about two feet per minute in comparison with one foot per hour for manual drilling, organisational and technological problems precluded its use for slate extraction in the industry in general. Despite the claimed success of the 'Burleigh' drill used in the production process at the Cambrian Quarry (Llanberis) in 1872-73 [97], it is likely that this was due to (a) the substitution of steam by compressed air; (b) the convenience of the cast-iron air-mains supply around the small-scale quarry workings; and (c) the possibility of the existence of a 'non-bargaining' pay system in this works (see Chapter 3, part c). Yet, physical factors such as the necessity in terms of fuel economy to use portable boilers in the larger-sized workings and the question of accessibility to high rock-faces in deep pits, and the restrictive practices of the "bargaining system" ensured that manual drilling remained the norm in the vast majority of Welsh slate quarries for production work until the introduction of pneumatic drills (see below).

Furthermore, the price of drilling plant precluded its adoption by the smaller concerns. Even larger concerns, if cost-conscious, baulked at the expense, an example being the rejection of mechanical drilling for financial reasons in the deep drainage adit project at the Penyrorsedd Quarry in the 1870s [98]. Although the two small 'Allwood' drills bought by the Dorothea Quarry in 1890-91 cost only £50.16*s.* each (they used a pre-existing boiler), a large 'Schram' drill purchased by the same concern in 1902 cost £175.10*s.* plus £101.10*s.* for a new portable boiler [99]. Consequently, only the largest and most financially secure slate quarries at Nantlle could have afforded such plant, and the remainder probably resorted to hiring a drill set for development work, if and when one was required.

Electric, hydraulic and pneumatic drilling plant

The application by the 1860s of compressed air to the powering of remote machinery, overcame a number of technological problems associated with the supplying of steam over a distance, of which the pressure-losses due to condensation was the most important [100]. Yet, despite the capability of steam drills to operate using compressed air, their limited use in the quarries during the 1870s-80s (see above) restricted the adoption of the contemporary low-pressure pneumatic systems to one or two examples only [101]. Nevertheless, within a short period of time after the first introduction of high-pressure air compressors from the U.S.A., during the 1890s, the technology of rock-drilling in the Welsh slate quarries was rapidly transformed.

The first application of this American high-pressure pneumatic drilling plant, at the Oakeley slate mine (Ffestiniog) *c.*1895, was an indirect result of the Committee of Enquiry on Mines and Quarries (of 1894) [102], and in 1897 the Penyrorsedd Quarry (Nantlle) became the first open-cast slate quarry to install this plant [103]. By 1914, the majority of large and middle-sized quarries in the industry had purchased air-compressors and pneumatic drills, with the Nantlle district reflecting the general trend [104].

However, the rush to adopt high-pressure pneumatic drilling was tempered by the parallel development of a number of competing drilling systems, which were evaluated in several quarries with variable results. The electric rotary rock-drill was one contender which had important technological advantages in terms of power transmission. This machine was on trial at the Cilgwyn Quarry (Nantlle) by 1902, but its general adoption presupposed the availability of electric power, which was not common in the industry at that time (see above) [105]. Another remarkable invention, which featured a phenomenal rate of drilling, was the 'Kellow' hydraulic rotary drill. Whereas this was never used at Nantlle, its adoption was considered by the Dorothea Company, but technical problems eventually consigned this innovative machine to oblivion [106].

Of the high-pressure pneumatic systems installed in the Nantlle slate quarries, the most common early installations incorporated air-compressors manufactured by 'Ingersoll Rand', although the first compressor at Penyrorsedd Quarry (in 1897) was by the precursor 'Ingersoll Sergent' company [107]. The 'Ingersoll' plant excelled on its competitors in that it combined a robust design incorporating a single or multiple air-cylinder(s) according to the required output, with a capability of being supplied with a variety of drive systems ranging from steam (opposed or tandem cylinder configuration) to belt-driven from a variety of power sources, with the capability of subsequent conversion, if required.

The Ingersoll drills were of the small, lightweight 'jack-hammer' variety after 1912, connected to the fixed iron air mains by flexible hoses, and because they did not need cumbersome stands, they were consequently ideal for use on high rock faces. They were also relatively cheap machines, and were affordable in multiple numbers, with their rate of drilling in slate at around twelve foot per hour being comparable to the performance of the older steam drills (see above) [108].

Whereas the biggest quarries at Nantlle rapidly adopted pneumatic drilling, the majority of the installations tended to be of relatively small-capacity units, capable of operating only four or five drills simultaneously. This was a deliberate under-provision, reflecting a cost-effective approach to the necessity of running the compressors constantly during working hours, and the consequential requirement of sharing the drills on a rota seems not to have caused serious production problems [109]. Neither was the charge imposed for drilling, on a footage basis, a bone of contention because of the saving in time and physical effort over the manual method [110]. With the gradual abandonment of the bargain system during the first decades of the present century, the system of drill hire was consequently abolished, with the proprietor absorbing the whole of the cost [111].

The Dorothea Quarry approached the problem of the cost-effectiveness of its pneumatic system from a different viewpoint to its competitors. Having inherited a battery of small, remote steam-powered air compressors as the result of the takeover of its three neighbours, the Company installed in 1935 a centralised pair of 'Holman' air-compressors to supply all the air required in the four complexes of quarry pits [112]. Yet, within two decades of their installation, this plant was redundant because the rapid reduction of the scale of quarrying at Dorothea had overturned the original economic parameters. Consequently, the original system of individual, remote compressors was re-introduced, albeit using new electrically-powered 'Holman' units located close to individual production faces, but retaining the capability of being inter-connected into a grid air-main system if required [113].

The very small concerns at Nantlle were initially unable to gain the advantages offered by the high-pressure pneumatic rock-drilling, due to the high costs of purchasing and running the steam-powered compressors. However, by the 1920s, smaller portable units (commonly by 'Ingersoll Rand') powered by either petrol or diesel engines were commonly available. These were equally ideal both as main units for the more marginal slate concerns, and as auxiliary plant serving transient workings beyond the reach of the fixed air mains system in the larger slate concerns [114]. Direct-acting petrol-powered jack-hammers were also used in a number of small quarries by the 1950s-60s [115]. Furthermore, the reduced scale of quarrying in several of the surviving larger quarries at Nantlle after the 1940s, promoted the replacement of the old fixed units by small, mobile compressors (such as by 'Broome & Wade'), which were more economic to run. However, for individual reasons, the brace of old 'Ingersoll' compressors (of 1897 and 1911 respectively) at the Penyrorsedd Quarry remained in use up to 1978 [116].

Drilling Rigs

The introduction of bulk blasting into the slate industry in the 1960s (see Chapter 3), created the requirement for a portable heavy-duty drilling machine, capable of cutting shot-holes of up to four inches diameter and up to about eighty feet deep. The self-propelling compressed-air drilling rig, which had been developed for other branches of rock quarrying provided the requisite answer to the problem. The type most commonly used in the quarries harked back to Captain Beaumont's original plant at the Croesor Quarry contract in the 1860s (see above). The rig consisted of a tracked chassis carrying a single adjustable boom which guided a rotary drill, having a complex diamond-tipped head mounted on a leading section of a drill-tube that could be progressively lengthened by adding extension pieces as drilling progressed [117].

The first recorded use of the modern version of the drilling rig in the Welsh slate industry was at the Dorothea Quarry (Nantlle) *c.*1962, during its experiments with a production method termed 'bulk-blasting' (see Chapter 3) [118]. Subsequently, similar rigs were utilised in several of the largest slate quarries in North Wales, of which those at Nantlle included the Moeltryfan Quarry (in the late-1960s) and at Penyrorsedd (from 1979 to date) [119]. Although 'bulk-blasting' remains the favoured rock-extraction method at the Penrhyn Quarry, rigs have been almost exclusively used at the remaining active quarries for development work because of the high wastage rate of valuable rock caused by this method of working [120].

(ii) Rock-cutting machinery

As the result of the increases in the price of industrial explosives by the late 1980s, and the high wastage resulting from 'bulk-blasting' (see above, and Chapter 3), the technology of rock extraction came under one of its periodic reviews in the North Wales slate industry. Previous experiments with hydraulic chisels (at Penrhyn Quarry in the 1820s [121]) and with wire-saws (at Penrhyn in 1857-58 and at Ffestiniog, on various occasions in the 1900s-20s) had come to nothing [122], although some headway had been made by foreign slate producers between the two world wars [123]. This reflected problems in the application of the technology to the specialised circumstances in the North Wales slate industry. The substitution of blasting by chain-sawing at the slate-slab Aberllefenni Quarry (Corris) by the 1970s was the sole successful example of the mechanisation of rock-cutting in the Welsh quarries prior to the current phase of experimentation [124].

There is no reference to any experimentation with rock-cutting machinery in the Nantlle slate quarries prior to the late-1980s, when the proprietors of Penyrorsedd, the sole remaining large quarry in the district, undertook an attempt to introduce this new technology. The directors of the quarry became influenced by the working practices of the Italian marble quarries and German slate mines as the result of a fact-finding visit *c.*1990, and resolved to introduce similar methods to their Nantlle and Ffestiniog quarries [125].

The first trial was of the improved wire-rope saw, which used impregnated diamond dust. Good results were obtained at the group's Oakeley Quarry (Ffestiniog), where the physical characteristics of the rock were amenable to this technology. However, the high frequency of natural jointing in the rock at the Penyrorsedd Quarry reduced the usefulness of this method, and hard cross-veins of white spar tended to snap the expensive wire, which was not repairable [126].

Consequently, rock-sawing using a large chain-saw having tungsten carbide teeth was tried at Penyrorsedd as an alternative to wire-sawing. The saw was used to cut a horizontal channel along a rock face to a maximum depth of cut limited by the size of the blade of the mill primary saw (then approximately thirteen inches). This rock, unsupported except along the cleavage plane, could subsequently be easily broken off using heavy chisels, and the face could thus be conveniently worked in a series of orderly steps, with minimum wastage. Unfortunately, the irregular nature of the geological structure of the Cambrian slate, and the white spar again damaged the plant. Yet, an improved Italian chain-saw was purchased in September 1994 for use on the better rock which had been uncovered in the lower portion of the Penyrorsedd pit, but continued technical problems robbed this method of its advantages over blasting, and the trial was abandoned for the time being [127].

Despite the early disappointments with mechanised rock-cutting, the Penyrorsedd Company continued its attempts to improve the working practices in the quarry pit by designing its own hydraulic chisel, reminiscent of 'Bramah's Engine' of the 1820s at the Penrhyn Quarry (above). The bucket teeth of back-acting excavators had already been used at Penyrorsedd as percussive chisels to open up the cleavage plane, thus detaching the blocks from the rock face, from the introduction of these machines in 1979.

This rather imprecise method was, however, rather destructive. As an improvement, a specially modified hydraulic rock-breaker (or 'pecker') of Swedish manufacture, was fitted onto the boom arm of an excavator, in place of the bucket. This 'pecker' was fitted with a chisel-tool, and the control valve was modified in order to reduce its speed of action. Thus, it was possible to impart slow, accurate, single blows along the the top of a quarry gallery, following the plane of cleavage, thus releasing a series of slabs of slate. It was originally hoped that this method would replace blasting as the main method of extracting blocks, but technical problems with the 'pecker' resulted in an excessive wastage of the rock, and the machine was consequently relegated to secondary rock-breaking duties [128].

(iii) Excavating and loading machinery

Although the common tripod crane had been in use for loading large blocks onto tramway trolleys at the rock face since sometime in the nineteenth century, mechanised loaders and excavators were not utilised in the Welsh slate industry until the dawn of the third decade of the present century. The very first reference to the intended mechanisation of bulk loading at a Nantlle quarry was a proposal by the Penyrorsedd Company to purchase a 'grab crane' in November 1908, as a means of accelerating the development of a new quarry pit [129]. The purchase was delayed until 1920, when the quarry obtained a standard-gauge rail-mounted 'Ruston' steam face-shovel (or 'navvy'), which was used to remove a thick bed of sand and gravel overburden on an accessible hillside gallery. Working in conjunction with a steam locomotive, 'runs' of up to forty loaded standard quarry waggons were conveyed to the adjacent tipping ground. The excavator enjoyed a twenty-nine year service life, but towards the end of this period its boiler, a replacement for the worn-out original, became unsafe and the decision was taken to cease using the machine [130].

The Dorothea Quarry had a similar bed of sand and gravel overburden at its Pit 'D', and in the June 1936 the use of a dragline was considered to aid in its removal [131]. The idea was not pursued further, due to the likelihood that the machine would have been of no further use after this task was completed. However, by 1942, the Company had purchased the land on the west side of Pit 'D', and needed to remove up to sixty feet of gravel from the surface of the slate rock to enable the quarry to be expanded. This was a much more accessible location than on the opposite side of the quarry that was worked in the 1930s, and therefore a tracked, second-hand steam face-shovel was purchased for this untopping work, in conjunction with petrol-engined front-dumper trucks [132].

A similar untopping scheme was instigated in the late 1940s at the Moeltryfan Quarry, where the gravel overburden on a surface gallery at the old Alexandra pits was tipped into the lower workings as a foundation for a roadway down to the bottom. This road was then used to allow access for the earthmoving plant into the quarry pit, where loose rock on a high, unstable face was brought down using a home-designed dragline, made out of parts of an old blondin cableway and a large ship's anchor. A diesel-powered 'Osgood' face-shovel, later joined by a second machine was then able, in combination with front-end dumpers, to clear away some of the old landslides which prevented the development of the working faces. At the very close of working at Moeltryfan, in the early 1970s, a 'Caterpillar' loader had been purchased to replace the worn-out excavators, with the original front-dumpers having also been substituted by a pair of forty-ton dumper trucks *c.*1966 [133].

These excavators at the Moeltryfan Quarry were also capable of travelling under their own power to the Company's Cilgwyn Quarry, about a mile away. However, due to the greatly reduced scale of working at that site after 1952, this was not done very often. Consequently, other than excavating a roadway down an old tip to a rock-face at the Faengoch Pit, little clearing work was done on this site. The result of limiting the removal of the very heavy overburden at Cilgwyn New Pit was the closure of the quarry after a massive landslide in 1958 [134].

Neither the Dorothea nor the Penyrorsedd quarries were able to take their excavators down to the working faces at the bottom of their deep pits for decades after the mechanisation of their upper galleries. The only means of access to the quarry bottoms was by means of aerial cableway, which had a maximum payload of two tons, thus requiring the complete dismantling of any heavy machinery, which was not feasible in the case of the steam 'navvys'. Consequently, the loading of blocks and rubble had to continue by manual means, although the reduced scale of quarrying allowed the blondin cableways to be used as cranes during the long gaps in between raising loads to the surface [135].

The disposal of debris from the working face at Dorothea by the early-1950s was a prime example of inefficiency that could not be avoided without radically changing the system of working. Hand-filled waggon-loads of rubble were hoisted by cableway to the gallery above, to be subsequently propelled by labourers through a tunnel prior to being manually tipped into an adjacent abandoned pit [136]. In 1951, two light, rail-mounted 'EIMCO' pneumatic bucket-loaders were purchased to ease the loading, although the unfavourable transport system remained unchanged until the purchase of two small petrol-engined front-end dumpers in 1956 overcame the problem [137].

No further improvement could be made at Dorothea until a road was constructed to the pit bottom, this being unexpectedly achieved in 1963-64 through the skill of a contract-driver engaged on an un-related job at the site [138]. It was then feasible to employ a large motorised loader serving heavy dump-trucks at the rock-face, whereby the volume of material handled could then be substantially increased by the new rock-extraction method of bulk-blasting (see Chapter 3). The first mechanical loader (a 'Chaside') proved to be unsuitable because its pneumatic tyres provided insufficient grip when loading heavy slabs, and it was replaced by a tracked vehicle. The new machine was a 'Caterpillar 955' loader, which was one of the largest in the range at that time. This was ideal for the task and performed satisfactorily during the last five years of working at the quarry [139].

At Penyrorsedd, all of the rubble was raised up out of the pit via cableways until the abandonment of the bottom floors of the New Quarry as the result of a major landslide in the late 1960s provided a space for tipping debris from the remaining productive floor above. A half-hearted attempt was made in 1969 to construct a road from the surface to the pit bottom, but this was quickly abandoned because the cost of the hired excavator was excessive [140]. However, two small front-end dumpers and a small 'David Brown' tracked loader were lowered to the pit bottom by means of one of the blondin cableways, a process which necessitated the partial dismantling of the excavator. This plant worked quite successfully in clearing away the rubble generated by the rockmen, but was under-powered to cope with clearing away larger material [141].

The pair of Italian loaders, which replaced the worn-out 'David Brown' *c.*1972, similarly suffered from the unavoidable mis-match of the machine size to the task that resulted from the problems of access to the pit. The result of constantly struggling to move heavy slabs was an accelerated wear on the hydraulic and transmission systems of the loaders, resulting in the quarry fitters having to repair broken or worn out components frequently. This had to be carried out *in situ* whenever possible, due to the difficulties of dismantling the plant for its journey by cableway to and from the surface, and because of the serious disruption of slate production which resulted from every lost hour of loading [142].

Upon the take-over of the Penyrorsedd Quarry by the Nantlle Slate Company in 1979, the overdue re-development of the workings was instigated in a cost-effective manner through the use of heavy earthmoving machinery owned by an associated plant hire business. The modern type of excavators used by this concern at Penyrorsedd had a back-acting bucket on a boom arm, a type of machine which had many more uses in a quarry than a face shovel. A 'Caterpillar 694' tracked loader complemented the excavators, being used mainly for tip-end working and preparing roadways [143].

The price of even modest excavators was beyond the financial means of most of the operators of the small Nantlle quarries until an increased availability of second-hand plant by the 1970s made the machines more affordable. The mould was broken by the Twll Coed Quarry, which purchased a second-hand 'Case' tracked loader in the early 1970s. This was soon replaced by a new 'J.C.B.' front-loader, with the 'Case' being sold cheaply to the adjacent Twll Llwyd Quarry. The latter had some service out of the loader before it expired due to extreme wear of vital components, whereupon a second-hand back-acting excavator was bought from a scrap-dealer. This proved a great improvement as a multi-purpose machine, as already outlined above [144].

(iv) Pumping machinery

Slate quarries were free-draining only when worked by an open cutting, when drained by a tunnel to the lowest floor, or when an enclosed pit was sunk no lower than the natural level of ground-water (known as the water-table). The level of the water-table varied from place to place, even at corresponding altitudes, being dependent on the drainage characteristics of the surrounding topography and the geological structure.

On the southern slopes of the vale, and on the flood-plains of the Llyfni river, ground-water was encountered within about two to five feet of the surface. Yet, on the northern plateau, it appears that the water-level was substantially lower, perhaps as much as forty feet down [145]. This would have been a major advantage in the early non-mechanised era of the slate industry, and perhaps was the main reason for the success of the local entrepreneurs of Ochr-y-Cilgwyn in the eighteenth century. Not having to contend with floodwater, the Cilgwyn quarries could have reached a greater depth (and consequently better rock) with greater ease than their local competitors [146].

Relatively advanced pumping machinery had been developed on the Continent by the sixteenth century and this technology had spread to England by the succeeding century [147]. To what extent this influence might have reached Snowdonia at that time *via* the copper mining industry is uncertain, but there can be little doubt that the local developments in that industry by the eighteenth century involved external influences [148]. Sophistication was, however, equated with cost and a requirement for a power source, and it was not surprising that simpler methods seem to have been initially employed for draining shallow workings experiencing limited water-inflows.

The siphon was one very simple device used from at least the 1820s until the 1920s in shallow hillside pits, where pumping depths did not exceed about twenty-five feet [149]. Similarly, an old beer barrel connected by a wire-rope to a hand-winch could raise water as effectively for a cash-starved small concern in the 1930s as could similar crude pumps a century earlier. On a higher technological plane, a number of such barrels attached to an endless chain, powered by a portable steam engine, was sufficient to allow one local Company to maintain a sixty foot pumping level in a large, recently-abandoned deep pit [150].

Regardless of the simplicity of such devices as those described above, slate quarries required pumping apparatus of greater capacity once deep pits were opened. The rag-and-chain pump was definitely used in one location [151], possibly manually or even animal powered, but the ubiquitous mining bucket-pump became the standard plant for almost all applications during the nineteenth century.

In its simplest form, the bucket-pump consisted of an accurately bored iron cylinder (the 'working barrel') having a perforated extension pipe dipping (the 'wind bore') into the water sump below, all of which was attached to a vertical iron discharge pipe-line (the 'rising main') leading to the surface outflow. Within the working barrel was a piston moved up and down under the control of a long actuating iron rod housed inside the rising main. The upper end of the pump-rod was connected to the actuating engine by further reciprocating rods or wires, via a rocking mechanism (called a T-bob), located at the lip of the quarry. On each successive stroke, water was transferred from the suction chamber of the working barrel into the 'rising main' above the piston, via the action of a pair of simple non-return valve (or 'clacks'). When fully primed, water would overflow out of the open upper end of the rising main into a discharge launder, at the same rate as it was being sucked into the bottom end of the pump pipe [152].

For any appreciable height of lift, the technical limitations of the earliest versions of these pumps required the use of a number of shorter 'lifts' arranged in a series of individual pumps, each one feeding the one above it. Individual multi-stage lifts of bucket-pumps were found in pits having several internal galleries, such as at the Gwernor and South Dorothea quarries [153], but most applications had multiple lifts piped directly in tandem [154]. Simple modifications allowed the lift-pump to be utilised in almost any situation, and its simplicity of action and reliability were additional important factors in its almost universal application in the deep open-cast slate quarries at Nantlle.

Whereas the lift-pump required only a simple reciprocating motion to complete its working cycle, the variety of the physical forces which came into play at the different stages of its operating cycle affected the design of the power transmission system. The main problem was that of a sudden coming on, and release of load at the beginning of successive up and down strokes respectively, transmitting a destructive shock to the machinery. In consequence to this, several methods were developed of reducing these shock stresses. The most popular method in very wet quarries was to double the number of pumps, with the provision of parallel sets working on the opposite strokes. Thus, when one lift was engaged on the load (upwards) stroke, the second piston was descending on no-load; this balanced the forces on the actuating engine and helped maintain a constant speed. On single pump installations, a balance box working in opposition to the pump was used to achieve the same result [155].

The majority of pumping plant was remote from the water-wheel or rotary steam engine power source, and there was a requirement for a power-transmission system between the pumps and the power-source. In view of the type of forces involved, one to two inches diameter iron rods, supported within grooved pulley guides and joined intermittently by vertical rocker guides were ideal for the surface reciprocating connection pieces in the majority of installations. In certain cases wire rope was used in place of a rigid connection. This worked well, being in tension on the load-stroke, but required sufficiently heavy vertical components to ensure efficient downwards motion when the rope was slack on the return stroke. However, in very deep quarries, where the load was especially heavy, a more rigid transmission system was required. In such cases, the horizontal rods would have been of solid twelve inches square timber, bound in iron hoops and plates for added strength, with frequent joints consisting of pendulum rockers [156].

Water-wheels were ideal sources of power for lift-pumps. The rotational speed of this power-source was well matched to the optimum stroke rate of the pump, allowing a direct connection to the transmission rods via a sweep crank. The high torque characteristics of the water-wheel also matched the requirements of the pumping gear, when starting each up-stroke. A large diameter wheel was also advantageous to provide a flywheel effect, required to equalise the stresses of motion reversal. Assuming that a sufficient water supply was available, the pumps could be operated constantly at no cost other than water easements (if applicable), lubricants, general maintenance and the wage of a pump attendant [157].

In comparison with water-power, steam-powered pumping plant was not an economic proposition in normal circumstances for the Nantlle slate quarries in the era of low-capital companies and poor transport system, that is, prior to the late 1820s. Nevertheless, the purchase in 1807 of a steam pumping-engine for the Cloddfa'r Coed Quarry at Nantlle (see sub-section a.iv, above) represented a first in the Welsh slate industry and only the second in a British slate quarry. Whereas the quarry had previously relied on a complicated triple inter-connected water-wheel 'engine' to power its pumps in the deepest contemporary pit in the district, the loss of the water supply due to a feud with an adjoining (and competing) quarry proprietor threatened the future of the concern [158].

The use of steam power for pumping duties was confined to this single quarry until 1828, when the replacement engine (of 1817) was moved from the closed Cloddfa'r Coed Quarry to the nearby Talysarn Quarry. However, despite a reduction in the price of coal at Nantlle as a result of better transport by rail after 1828 (see Chapter 5), steam-power remained too expensive for continuous pumping duties as long as water-wheels were capable of coping with the water inflow into the early shallow pits. Thus, no further steam pumps were installed at Nantlle until the 1840s, when the first dual-purpose steam haulage engines were erected in the larger concerns. As a consequence of having steam power available, these latter quarries were able to supplement their water-wheels with auxiliary pumps during periods of heavy rainfall, or in times of drought or freezing weather, in a cost-effective manner [159].

By the late nineteenth century, the pumping loads in the major quarries located on the valley floor had increased to such a degree that water-wheels were no longer suitable power sources. This was due both to the increased depth of the pits, and by the frequent influx of surface flood-water into quarries bordering the lower Nantlle lake and the river Llyfni during very wet weather. Thus, the most severely affected concerns, namely the Cloddfa'r Coed, Coedmadog, South Dorothea and Talysarn quarries had converted totally to steam-powered pumping by the late 1880s, and half of the pumping system at the Dorothea Quarry was steam-worked by that time [160].

The rate of water inflow was so great in the deepest of the above quarries, namely Coedmadog, Talysarn and Dorothea, that these concerns installed Cornish deep-mine pumping gear, *c.*1873, *c.*1870 and in 1904 respectively. This technology used 'force-pumps' in connection with large steam 'beam-engines', and was an expensive system to purchase and maintain. Consequently, the adoption of Cornish pumps was confined to applications where they were really necessary, and no others are known to have been used in the Welsh slate industry [161].

By the last decades of the nineteenth century, two new avenues of pumping systems were being developed, namely the centrifugal rotating impellor-type machines, and ones operating on the steam-injector principle. These were eminently suitable for shallow pumping depths and provided advantages of size and portability over the old-style lift-pumps. There had been a variety of designs of small portable steam-powered pumps on the market since the 1860s (including the later 'Cameron', 'Pulsometer' and 'Worthington' pumps), but these had found little favour in the area on the grounds of running costs, except in special circumstances such as in shaft-sinking contracts. Yet, the designs known as semi-portable 'donkey pumps' with either force or centrifugal pumps, proved economical in use and were commonly found thereafter in pits of up to about 150-foot depth having low inflow rates and were also found in water distribution systems for stationary steam engines on the quarry bank [162].

The advent of electric power to several of the local concerns during the present century (see Sub-section a.vii, above), allowed the efficient use of rotary impellor (centrifugal) pumps. The Cilgwyn Quarry had by 1901 at least one unit of this type, worked by an electric motor [163], and the Llwydcoed Quarry had another around the same time [164]. Some of the small reciprocating portable steam pumps, notably the 'Worthington Duplex', were capable of being operated by compressed air, and this was tried out at Cilgwyn in 1909. Unfortunately, the plant suffered from "icing", and was not sufficiently dependable to be entrusted solely with the pumping duties [165]. However, a similar machine worked well at Penyrorsedd in the 1950s and 1960s, although it was only raising water a short distance [166]. There was one recorded use of a water pressure-engine, pumping one shallow lift within the Tynyweirglodd Quarry from 1905 to 1907. Its installation precipitated a law suit concerning rights to the water feeding the machine, a case lost by the Tynyweirglodd Company, which subsequently folded [167].

A well-marketed product of the 1900s was the 'Rees Roturbo' pump. This claimed to be the ultimate impellor-type plant, having a specially-designed internal shape and a matched advanced blade design. Alexandra Quarry replaced its water-wheel pumps and standby 'Tangye' steam pumps *c.*1912-13 in favour of this new product, installing one unit in each of its three pits. Their maximum output varied from 12,000 to 22,000 gallons per hour, and they were powered from directly coupled electric motors of twelve to twenty-six horse power, running at 1,450 r.p.m. The 'Rees' pumps gave good service at Alexandra because the pumping depths here, at a maximum of 192 feet to the drainage adit, hardly changed after the plant was installed. This was crucial because the 'Rees' pumps were supplied in a range of capacities to suit the particular depth being pumped, because the machines only maintained peak efficiency within a narrow margin around an optimum operating speed [168].

The Dorothea Quarry was the last deep pit to turn to electric pumping. The company had installed a pair of electric pumps, one in each of two subsidiary pits, in the 1940s, but the output of its single generator was not sufficient to allow the electrification of the main quarry pumps prior to the provision of a second alternator set (see sub-section a (vii), above). Subsequently, a pair of submersible screw-type 'Mono' pumps, placed at the bottom of the existing pumping shaft, took over from the Cornish Engine in 1951. Unfortunately, because of the ineptitude of the ineptitude of the contractors, the new pumps were not erected as specified in the design. Neither pump could be brought up to the surface for maintenance, and an unprotected electrical junction box just above the units rendered their submersability useless. Fortunately, no disaster occurred which might have threatened the functioning of the units, otherwise the quarry Company would have been in considerable difficulties [169].

After the First World War, compact internal combustion engines were matched to centrifugal pumps for industrial use to replace water and steam power, where no electricity was available. Several types and sizes of both petrol and diesel-powered pumps have been recorded at Nantlle after c.1920. Most were used in the small scale concerns, especially those reopened by English builders' merchants after the second world war [170]. Larger concerns also found use for internal combustion pumps, a pair of 'Winget' petrol units being the main pumping gear at Cilgwyn by 1946 [171], and two 'Ransome' portables being used at Penyrorsedd to supplement the pneumatic pump in the lower 'sink' of the New Pit. However, the driving of a short drainage tunnel *c.*1962 released the water from the Penyrorsedd 'sink', restoring the free-drainage [172]. Consequently, no further pumping will be required in this quarry until the present workings are driven deeper than the drainage level, if this is ever contemplated.

(c). Winding Machinery

Winding machinery was required in a slate quarry when material was to be raised up from deep pits or lowered from higher workings. The high concentration in the Nantlle district of the deepest open-pit workings in North Wales resulted in its haulage technology being in the forefront of new developments and innovations.

Chapter 4: The mechanisation of quarrying

(i) Paths and steps

The earliest methods of haulage at the Nantlle quarries appears to have been similar to those found in slate quarries elsewhere in Britain, and probably had their origin in metal mining [173]. At first, the haulage of all the extracted material from the working-face was totally by manual labour. Well-broken debris was removed using box-barrows and wheel-barrows up steep paths or gang planks respectively, to the surface tips, but the valuable pre-prepared slate blocks were carried to the slatemakers by labourers, who wore special leather jerkins having a carrying shelf built into the back panel [174].

The method of haulage described above was adequate in the earliest period of development of a quarry, when the workings were not very deep. However, in response to advancing development of the workings, mechanical haulage would have become necessary (see below). Yet, manual haulage did not completely disappear at Nantlle until the early-1960s. Small-scale two-man concerns and some contractors scavenging workable material in old abandoned workings, continued to rely on human strength and wheel-barrows to carry slate to the dressing area, and to carry finished slates up ladders and rough paths to surface stock-yards [175].

(ii) Unguided vertical hoisting

When the scale of quarrying reached a significant level, the original methods of haulage described above, would have placed a constraint on the efficient working of the concern. The obvious technological advance in this case was to adopt the contemporary standard metal and coal mining winding gear, that is, manual windlasses, termed 'turntrees.' These must have been already in use at the Drws y Coed and Gwernor copper mines at Nantlle in the early decades of the eighteenth century, thus suggesting a route by which this technology was introduced into the slate quarries locally, as a response to the necessity of sinking pits to exploit the better rock below the surface (see Chapter 3) [176].

The original design of slate-quarry turntrees was probably similar to those used at the opencast pits of the Mona and Parys copper mines (at Amlwch, Anglesey). The windlass consisted of a long small-diameter winding drum having an un-geared cranked handle at either end of the axle, one for each of the pair of operators. The apparatus, mounted on a four-legged frame was possibly erected on a cantilevered platform overhanging the quarry pit, through which the vertically-hoisted loads passed *via* a trap-door, as was the case at the Parys mine. However, the only description extant of a turntree at a slate quarry was of a version in use in the 1820s, and this had a special head-gear incorporating swinging derrick-arms *in lieu* of an overhanging platform [177].

The slate blocks were raised using slings attached to the hemp winding rope, whereas fragmented rubble was raised in standard mine kibbles, discharging into wheel-barrows at the pit-head. Although the load capacity of this type of winch was limited to seven or eight hundredweight because a non-geared windlass was used to possibly achieve a maximum winding speed, this capacity was probably adequate for the circumstances [178].

The turntree vertical winder would have served adequately and cheaply at the smaller quarries well into the early decades of the nineteenth century, and an item of plant carrying this name (possibly a hand-windlass only) was lent by the Dorothea Company to the diminutive Taldrwst concern as recently as 1922 [179]. Hand-winches, albeit geared and linked to guided cableways, were definitely used up to the 1950s by slatemaking contractors at the Faengoch pit, Cilgwyn Quarry, and several others are likely to have existed contemporaneously elsewhere in the district. However, returning to the 1810-20s, manual-powered haulage systems would have proved a limiting factor at concerns such as the Cilgwyn, Cloddfa'r Coed, Penybryn and Talysarn quarries, where the scale of working was expanding significantly.

The initial answer to the requirement for uprating the pit haulage systems of the larger Nantlle quarries in the 1800s was to substitute a more powerful power source onto the existing equipment. This came in the form of the horse whim (or 'whimsey'), which had already usurped the turntree in the larger metal and coal mines [180]. The horse whims used in the Nantlle quarries were almost identical to the standard mining version, differing only in the head-gear, which was specialised to take account of the special requirements of the quarries. This equipment used either one or two horses harnessed to a mounting on the underside of a high winding drum on a vertical axle, supported by a timber framework. The horses actuated the counterbalanced winding sequence by walking in a circular path in an alternating clockwise and anticlockwise direction. The method of attaching the loads was identical to that for the turntree (above), but the maximum payload of this equipment was increased to about one ton [181].

The horse-whims probably persisted in the smaller concerns at Nantlle until the 1850s and 1860s or even later, but increased demands for a greater payload and a faster winding speed led to the progressive adoption of more sophisticated guided haulage systems (see below) throughout the industry locally. Vertical unguided haulage systems did not however die out completely, this forming an element of the various types of aerial cableways that were in use up to 1978. Furthermore, at least one light derrick crane incorporating unguided vertical hoisting was installed at a Nantlle quarry in the 1930s [182] and the utilisation of 'Scotch derricks [sic],' in the pattern of the Scottish granite quarries, had been proposed and may have been implemented at the Fron Quarry in the 1860s in anticipation of its working as a slab works [183].

(iii) Guided vertical haulage

Although some form of guided haulage was possibly employed in conjunction with the whimseys at the Cloddfa'r Coed Quarry by the late 1820s, the first application of the colliery guided-cage vertical shaft-haulage system in the Welsh slate industry was in 1829, at the Talysarn Quarry (Nantlle). The plant was a single-acting vertical water-balance, incorporating a descending water-filled tank to counterbalance an ascending cage carrying loaded tramway waggons, having a load capacity of about four tons per lift [184]. Subsequent versions of this plant at the North Wales slate quarries were double-acting, whereby a pair of combined cage and water tank units worked in opposition, thereby doubling the rate of waggon movements.

The first batch of this later type appears to have been the shaft-balances installed at the Penrhyn Quarry in the 1850s. Only two installations of this type of plant are recorded at Nantlle (with the same number at Ffestiniog), these being the shaft-balances erected at the Penyrorsedd Quarry in 1867 and a contemporary one at Alexandra Quarry. Whereas the former enjoyed only a limited period in use, having been part of a misjudged development of barren ground, the Alexandra balance had also been sunk in the wrong location, lying in excellent slate which was ultimately exploited by the development of a new pit on its site [185].

The remaining three examples at Nantlle of vertical guided haulage systems were steam-operated, and represented a concentration of a rare form of haulage in the slate industry of North Wales. The earliest probably being the colliery-type plant at the Ty Mawr East Quarry, erected in the 1870s during its occupation by a Scottish concern having connections with coal-mining [186]. A variation of this haulage system was a part-shaft, part external lift at the adjacent Ty Mawr West Quarry, dating from the 1890s [187]. The third example was, however, an unique local design comprising of an external vertical lift at the Faengoch pit, Cilgwyn Quarry, where a pair of counterworking platforms, running on three tensioned steel guide cables, ferried tramway waggons between the quarry bottom and a timber head-gear at the pit bank without recourse to the expense of sinking a shaft [188].

(iv) Inclined planes

Following the introduction of surface tramways into the local quarries after *c.*1805 (see Chapter 5), it became desirable to enable the waggons to reach the rock face so as to expedite the removal of slatemaking slabs and debris out of the pits. The use of vertical guided haulage systems (described above) was one answer, albeit an expensive one. A cheaper answer was to partially circumvent the restricted payload of the old horse whims by using a detachable body on the waggons and having one running chassis on the bank and a duplicate permanently in the pit. A better solution was to adopt existing railway and canal engineering practice for raising and lowering heavy loads over steep ground, namely to connect the pit bottoms and the quarry banks by inclined planes carrying tramways [189].

The earliest record of an inclined plane in connection with the North Wales slate industry is of a proposal to construct one at the Dinorwic Quarry in 1788, although the first use which can be traced with certainty was on the exit railway of 1801 from the Penrhyn Quarry, where there may also have been a contemporaneous powered inclined plane hauling out of a pit [190].

The date of the introduction of haulage inclines into the quarries at Nantlle has not been recorded, but the requisite economic and technological conditions for their adoption were in place by the 1820s. Almost nothing is known of the earliest installations in the district, although some details can be surmised from later ones that have been recorded by, or described to the author. From a technical viewpoint, it is likely that the first pit haulage inclines were relatively shallow and probably single-acting that is, one traffic movement at a time on a single track. In terms of sources of power, manual geared winches were used on short haulage inclines in shallow workings during the present century, their usefulness would have been very limited in deeper quarries, and there is one reference to the use of a horse whim to power a pit-haulage incline at Nantlle [191].

The exploitation of the greater loading capacity of haulage inclines over the older types of lifts required, however, a greater amount of power than could be supplied by humans or horses, and it was only after the application of superior sources of power to this task that the benefits of the new could be fully exploited. The first non-biological source of power used on haulage inclines in the Welsh slate industry was almost certainly water, which was used in one of two contrasting ways of almost equal popularity. The earliest was likely to have been the use of a water-wheel to power a geared, reversible winding drum, which could have worked a counterbalanced (that is, 'double-acting') system of haulage, or powered several parallel and independent single-acting tracks [192].

The water-balance system was also adapted from shaft haulage (described above), in either a single- or double-acting configuration, favouring steeper gradients for the more efficient working of the system which utilised combined water tank/transporter cars to keep the loads level [193]. The first recorded example of both types of water-powered haulage incline at Nantlle was at the Dorothea Quarry in the 1850s, but this date merely represents the lottery of the survival of relevant documents. Both examples were almost certainly pre-dated by earlier unrecorded inclines such as the one that gave its name to 'Twll Ballast [sic]' at the Cloddfa'r Lôn Quarry, which probably dated from the 1830s, but which is first represented on an extant plan of the 1860s [194].

Whereas the utilisation of a water-wheel to power a haulage incline circumvented the inherent delay in water-balances during the filling and emptying of the tanks, the former was less economical in its use of water and its use was restricted where this resource was in short supply. In view of the scarcity of available water for the use of the quarries at Nantlle and the perpetual requirement for faster winding operations, it is not surprising that the majority of the later haulage inclines in this district were powered by steam engines. Notwithstanding their more efficient use of water, the latter had also the advantages of a faster winding speed and shorter delays inbetween loads than both types of water haulage systems, although their purchase price and running costs precluded their general use here before the boom of the 1860s [195].

Simple steam-powered haulage inclines were similar to those utilising water power, either being single or double-acting, and using transporter cars on steep gradients [196]. Several steam-powered pit haulage inclines were recorded on the first two editions of the 1:2,500 Ordnance maps of the Nantlle Valley, of 1889, 1900 respectively, with concentrations being found in the New Pit, Cilgwyn Quarry, at Coedmadog Quarry and at the South Dorothea Quarry [197]. Despite the early concentration of haulage inclines in the quarry pits at Nantlle, they latterly featured more prominently on the surface, lifting debris up to high-level tips (see Chapter 3). Their designs followed the general pattern already discussed for pit inclines, but their distribution was restricted to those concerns which experienced severe lack of space to deposit debris at ground level [198].

Comparison of the earlier 1:2,500 maps (above) with the 1913-15 Third Edition shows, however, a decrease in the number of the pit haulage inclines and their replacement by aerial inclines, with the exception of Coedmadog Quarry, which had closed in 1908 [199]. This is attributable to the single great problem that was encountered with pit haulage inclines at Nantlle, this being the difficulty of extending the system downwards to match the progressive deepening of the workings where the lateral expansion of a pit had been halted by the restrictions of land boundaries (see Chapter 3). In such circumstances, the only options were to steepen the incline gradient at great expense, or provide a secondary deeper incline with its implications for available space and added operational costs. The most common answer was to replace the incline with a cableway system (see below), this being a better haulage system for very deep sheer-sided quarries.

On the other hand, when pits were worked on an internal gallery system not accessed by tunnels, and where the layout was suitable, haulage inclines were preferred to inclined cableways and blondins (see below) because of the former's greater daily winding capacity and lower total operating costs. This appears to have been the reason why a number of quarries reversed the trend outlined above. The best example of this is the Delabole Quarry (Cornwall), which had replaced its aerial cableways with a multi-tracked fixed steam haulage incline by the end of the nineteenth century [200]. At Nantlle, the Penyrorsedd Company installed a short electric incline in 1935 as a prelude to an uncompleted scheme to replace its blondin cableways [201]. Two pit haulage inclines dating from the 1930s and 1940s, respectively, were still operating up to the 1950s at the Tynyweirglodd Quarry, although only one was steam powered [202].

For the sake of completeness, the gravity-operated inclines at Nantlle must also be described. The majority of identified examples were so-called 'exit inclines', being part of the access link from the quarry stock yard to an external transport system, be it railway or road. Only a limited number were involved with the downhill transport of slate slabs from the workings to mills, due to the common practice of establishing the working banks at the highest level relative to the uppermost workings as the result of a need to maximise the volume of space to deposit rubble (see Chapter 3) [203].

The majority of gravity inclines identified by the author's fieldwork at Nantlle were comparatively short to medium length by slate industry standards, and not particularly steep. The short inclines were normally of constant gradient, but those over a hundred yards or more often had the more advantageous profile of a catenary curve. No alternative design has been recorded for the machinery on these inclines other than horizontal cast-iron drums consisting of an axle, two outer and one inner drum 'spider' casting, with timber planks making up the barrel of the drum [204].

Typologically, of the 44 known examples of gravity incline sites locally, nothing is known of the layout on six sites shown on old plans, but now buried by later tips. Of the remainder where some remains exist, 33 were conventional dual track inclines, running from one floor to another with no intermediate turnoffs, all having 'run through' drum houses, with the exception of one positive identification of an underfloor drum and one 'remote' drumhouse. The remaining minority were a mixed bag. One had transporter cars on an otherwise conventional setup. Another was the only local example having a connection to an intermediate floor. The remaining two inclines had lengths of single track at the upper and lower portions, with a passing loop at the mid-point, representing a significant reduction in construction costs on long formations [205].

The cessation of use of the majority of gravity inclines at Nantlle was the result of the progressive closure of the quarries, although the former were retained by tip contractors in a number of locations for decades after the remainder of the site had been scrapped (see Chapter 3) [206]. The very last set of gravity inclines operating in the area was that connecting the hillside working area of the Penyrorsedd Quarry with the lorry loading bay at the lowest floor of the site (formerly joining onto the Nantlle Railway, see Chapter 5), a system which was finally abandoned about 1968.

(v) Aerial cableways

Of all the technologies used in the industry, it was the aerial inclined and horizontal cableways which became the hallmark of the Nantlle slate quarries because of their particularly high concentration in this district. Yet, despite the recording by the author of the reminiscences of former plant fitters and drivers of the location and technical details of the different variations of many of these cableways at Nantlle, there remain gaps in the understanding of the development of the various designs in both the local context and in terms of the importing of ideas from external sources.

The type of aerial haulage system known as the 'chain incline' was one of the most important technical innovations adopted by the slate industry at Nantlle, where the first installation was made at the Cloddfa'r Lôn Quarry *c.*1841 [207]. Although not confined solely to this district, it was at the quarries of Nantlle that the chain incline made its greatest impression, being virtually essential for the development of the deep-pit workings that was to characterise the area.

Developed at the Delabole Quarry in Cornwall during the 1830s by that concern's proprietor, Thomas Avery, the chain incline can be described in simple terms as the substitution of rails on a terrestrial double-acting powered inclined plane by a pair of aerial chains running from a pair of anchorages at the pit bottom to another pair on the quarry bank above, *via* a timber headgear (or 'papote head') located at the lip of the pit. The fixed chains provided a track for a pair of simple load-carriages running in opposition, each supporting a load-block controlled by individual winding chains counter-wound on a powered winding drum [208].

The advantages of the chain incline over vertical and fixed incline haulage (see previous sub-sections) were the combination of **(a)** a relative low cost of installation (and relocation if required); **(b)** the ability to raise material from any chosen point along the path of the aerial chains rather than from one fixed point on the edge of the pit, **(c)** a capability of coping with the increasing depth of the workings without the requirement for expensive modifications or rebuilding of the haulage system; and **(d)** it was less severely disrupted by rockfalls than would a fixed incline [209].

The chain incline did, however, suffer from the disadvantages of (i) requiring greater maintenance than fixed inclines because of the problem of wear and metal fatigue failures on the chains; (ii) being in practice unable to serve more than two loading points, compared to the multi-turnouts possible on a fixed incline; and (iii) having a practical slower winding speed than fixed inclines because of safety considerations for the workmen in the depths below the aerial chains [210].

In practice, the advantages of the chain incline far outweighed the disadvantages, the latter having been minimalised by a number of innovations. For example, at the Dorothea Quarry by the end of the nineteenth century, the substitution of chains by steel wire ropes and the use of improved steam winders raised the average winding speed to about 300 feet-per-minute, giving a complete winding cycle of about five minutes on a 350 foot depth, and thus maximised the capacity of a double-acting unit to a very adequate eighty counterbalanced loads per day. In very busy locations, or where multiple floors were to be served by a single winder, the plant was simple doubled, the engine simultaneously working two double-acting aerial inclines in parallel. Triple units were also occasionally used, and one quadruple is known to have existed, but these were rare for technical reasons [211].

Despite its potential, the recorded uptake of the chain incline in the Nantlle quarries after its first application at Cloddfa'r Lôn Quarry (see above) was nevertheless not one of an uniform increase. Their rate of installation was probably initially constrained by the sluggish development of the local quarries in the 1840s-50s (see Chapter 1, above) allied to the slow adoption of steam winders because of their relatively-high running costs due to geographical reasons [212]. However, in the boom years of the 1860s-70s, the numbers of chain inclines grew to match the increasing haulage demands of the blossoming industry, and this was repeated during the 1895-1902 mini-boom [213]. Additionally, the deep pits on the hillsides that were initially served by tunnels, became increasingly dependent upon chain inclines towards the end of the nineteenth century, when modifications to their haulage facilities were required for technical reasons [214].

Operating details and typology

Whereas the basic design features of the chain incline are described with confidence, the same cannot be claimed for operating details of all of its variants, and neither is its typology complete. Sources on this topic are woefully scarce and contradictory, but what information there is suggests that there were three main sub-types of chain incline, listed below in their assumed typological chronology. For ease of discussion, they are termed (1) 'simple,' (2) 'intermediate,' and (3) 'late,' and each are discussed separately.

(1) Simple type. It is assumed that in this probable earliest version of the chain incline, the loads were raised directly from, and empties delivered to the base of the inclined running chains, with no provision being made for vertical hoisting from some intermittent point as in the later versions. Several hoists incorporating these features (although using wire-ropes, *in lieu* of chains) were in use at the slate quarries in the Angers district of France in the 1890s and, on a smaller scale, the surface double-acting aerial units used in several quarries at Nantlle to lower loads *in lieu* of conventional terrestrial inclines were on a similar principle, albeit powered by gravity [215].

(2) Intermediate type. An illustration of the plant at an Irish slate quarry, dated 1845, together with another undated, but undoubtedly

contemporaneous view of the Glynrhonwy Quarry (Llanberis) [216], show what must be an intermediate stage between the simple and later design of chain incline haulage systems (see Figure 12a, below), whereby an unfavourably excessive gradient could be avoided in the case of a deep, narrow quarry. Within the constraints of "artistic licence," the mechanisms recorded by the artists had a pair of fixed running chains (or perhaps hemp ropes) arranged in a shallow catenary from a surface headgear to an anchorage located somewhere above the pit bottom, thus requiring a secondary vertical hoisting/dropping phase for the load from/to the quarry floor at some intermittent point along the span.

The probable mode of operation of this 'intermediate' design, best illustrated by the Irish example, is most simply described in reverse, concentrating only on the returning 'empty' side of the two counter-acting halves of the system, *viz:-* The returning empty load-box, kibble or chain sling, waiting at the headgear, was firstly attached to a load-block which ran freely on the winding rope, the attachment probably incorporating a block and tackle to hoist the load clear of the ground. Once clear, the actuating engine (a horse-whim in this case) was started and the winding chain or rope was paid out, allowing the simple load-carriage attached to its free outer end to run down the fixed catenary guide rope until its motion stopped naturally at the base of the curvature. The now stationary load-carriage then provided a fixed point from which the uncoiling winding rope dropped the free load-block vertically to the quarry floor. The details of the corresponding load ascending under the actuation of the second counter-wound winding rope, are the reverse of the above account [217].

(3) Later type. One reason for modifying the intermediate design (above) could have been the requirement for greater robustness due to the

FIGURE 12a

INTERMEDIATE TYPE
INCLINED CABLEWAY

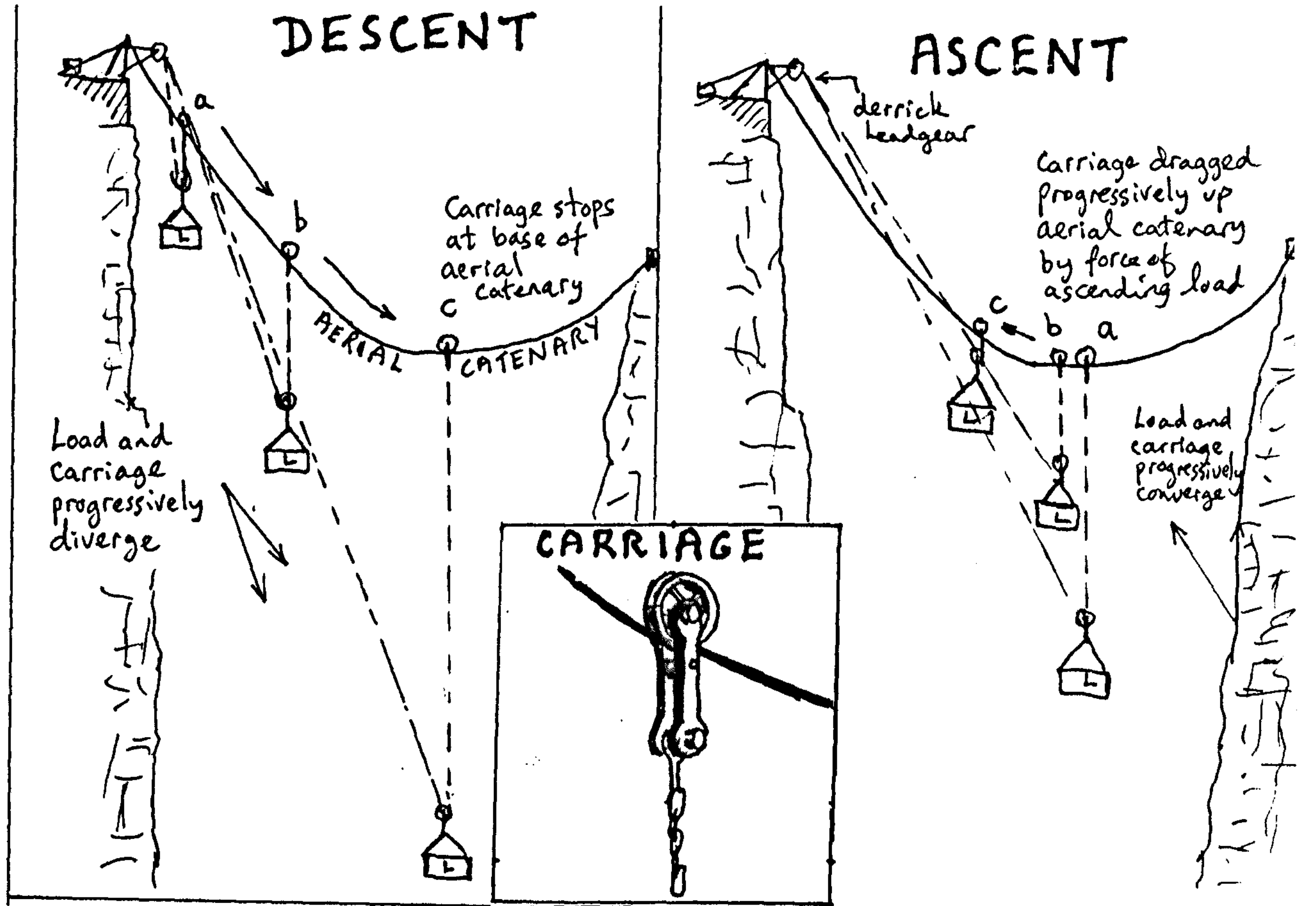


FIGURE 12b

LATER TYPE
INCLINED CABLEWAY

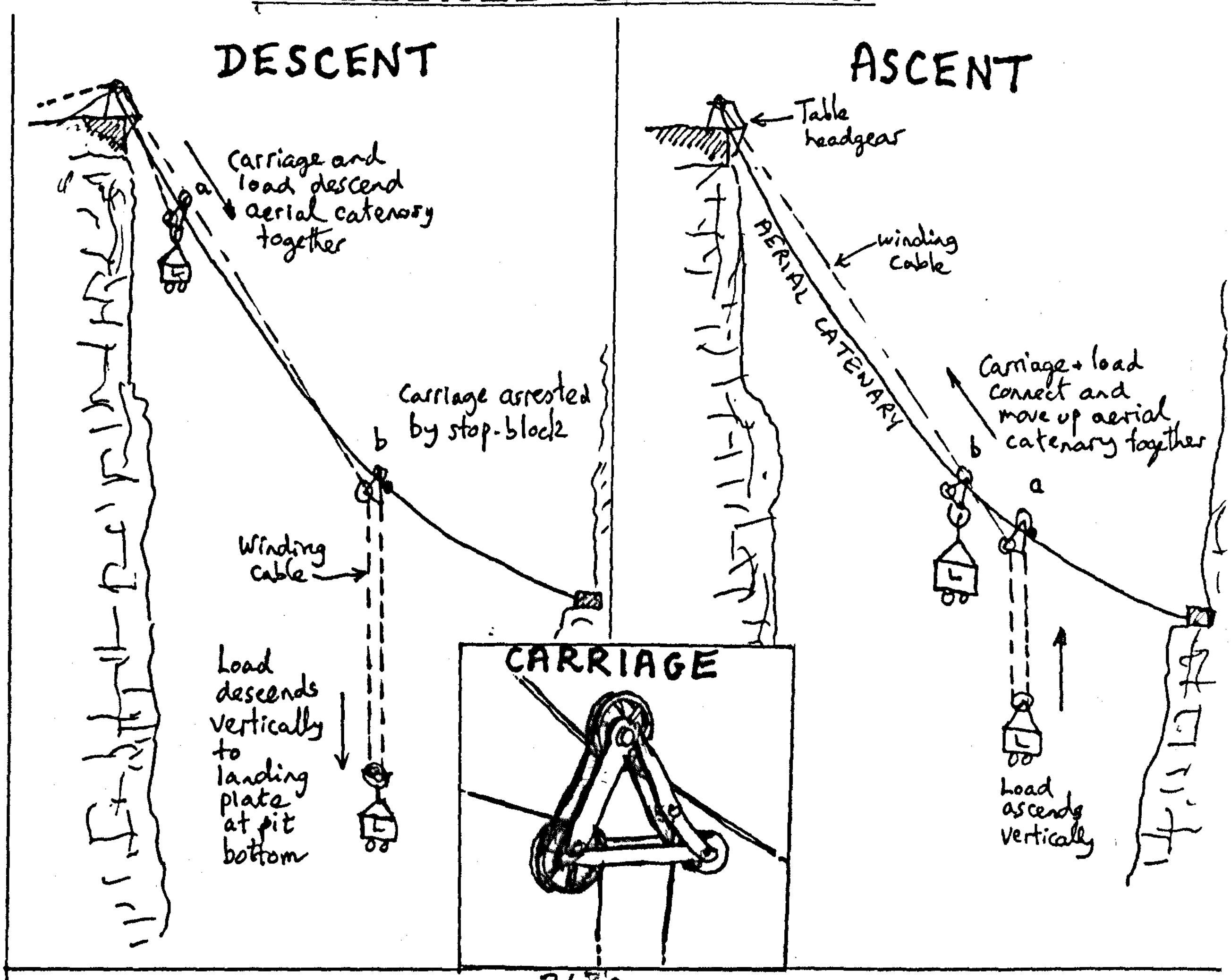
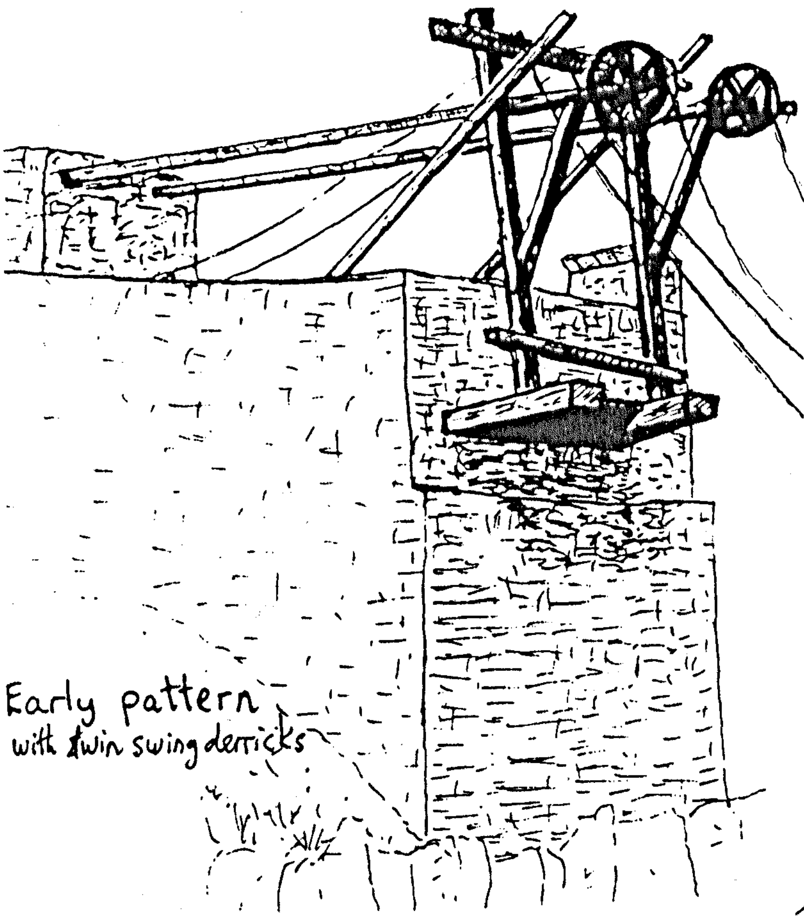
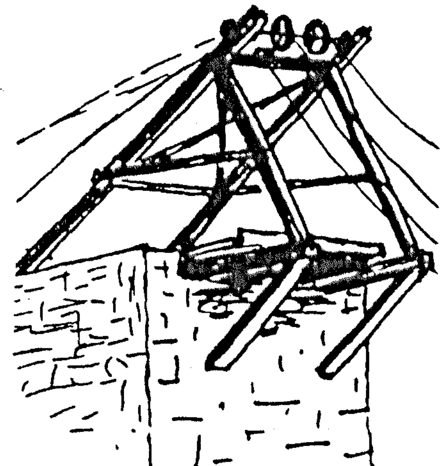


FIGURE 13

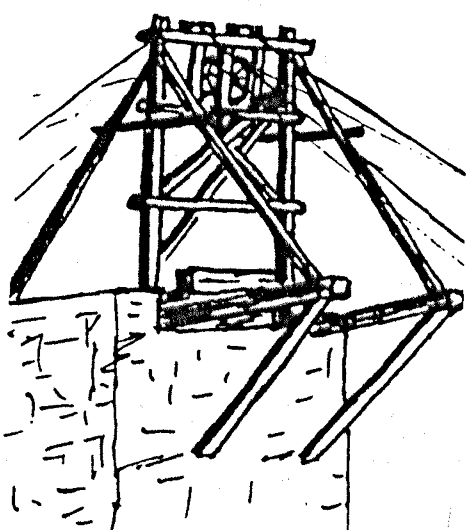
EVOLUTION OF INCLINED CABLEWAY HEADGEAR



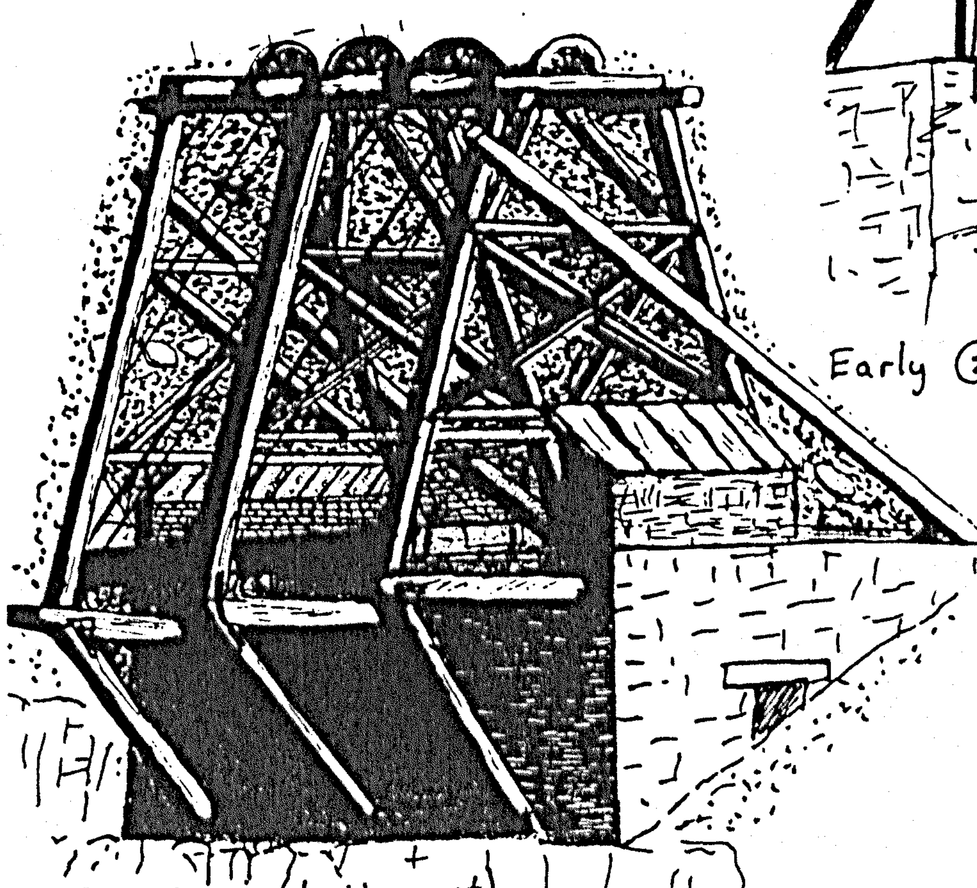
Early pattern
with twin swing derricks



Mid c19th pattern



Early c20th pattern



c19th pattern (double unit)

substitution of tramway waggons for the kibbles and chain slings that originally carried the load, this being the result of the increased power available from the introduction of steam winding engines. Another reason might have been the tendency for the load to oscillate excessive in the 'intermediate' design, thus negating the advantage of increased winding speeds provided by steam power [218].

The main improvements in the design of the chain incline in its later guise (see Figure 12b, above) was to determine the position of the vertical phase of lifting by means of an arrestor 'stop-block' (or *clan*), thus **(i)** allowing an optimum degree of steepness in the fixed chains for maximum efficiency, **(ii)** increasing in the stability of the load during the lift by running the winding chain <u>through</u> the freely moving load carriage, locking both together on the inclined phase of the hoist, and **(iii)** allowing the hoist-block to have a velocity ratio of two or even three, on the vertical phase, to optimise the efficiency of the winch [219].

Other improvements made to the system by *c*.1900 were concentrated on the design of the headgear (see Figure 13, above). The sliding landing platform seems to have been incorporated from the earliest installation at Nantlle, but the simple strutted timber framework of the 1840s headgear was largely superseded in this district during the 1860s by a heavier design apparently based on colliery timber headstocks, this being probably better suited for the steeper aerial inclines in very deep quarries. This latter type was itself superseded in the 1900s by a lighter design of headgear, again in timber, which incorporated the economy in material of the 1840s version with the technical features of the colliery-type units [220].

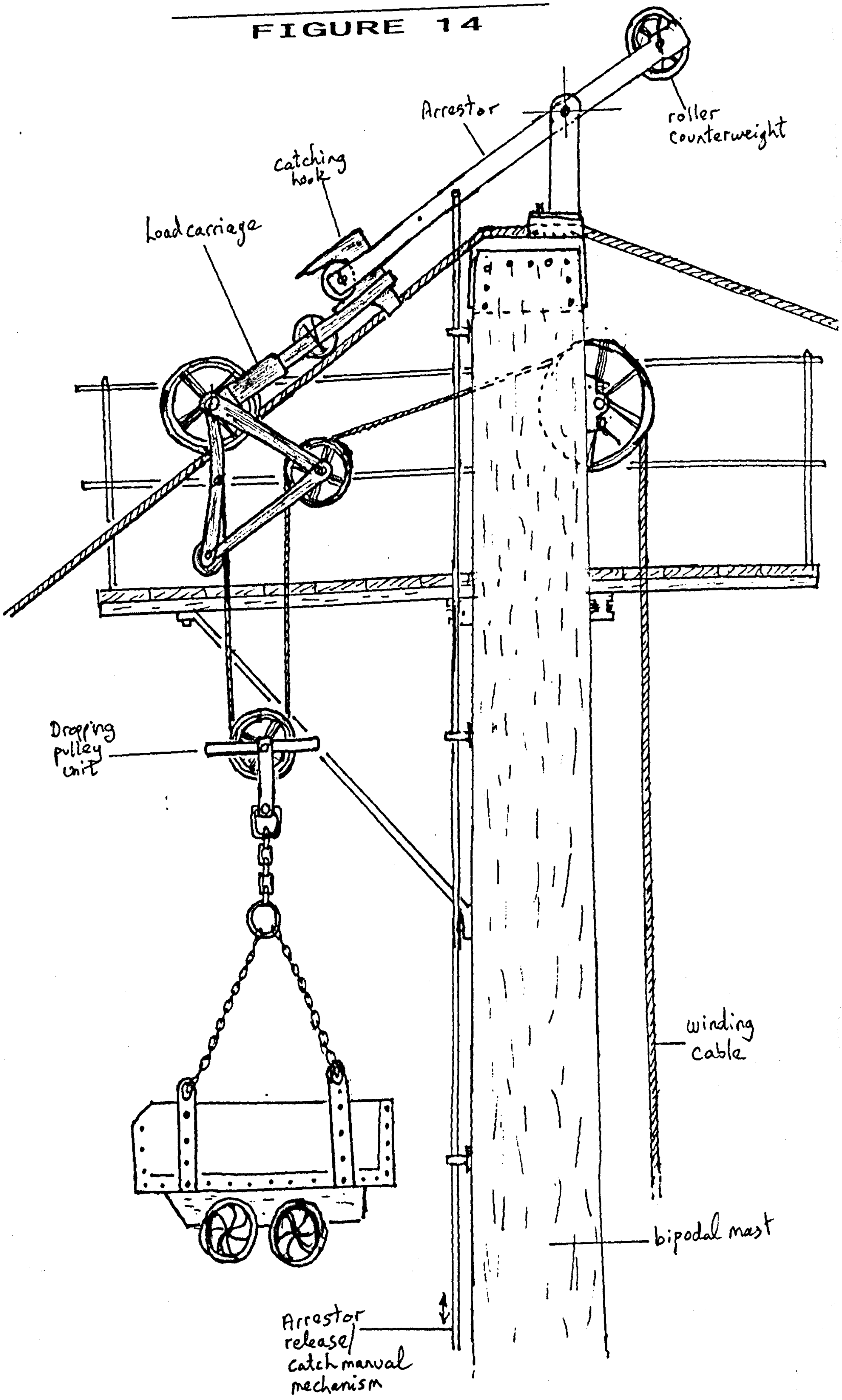
Concurrently, individual localised modifications appeared to the winding gear, particularly the use of arrestor gear in place of the more complex cantilevered landing table (see Figure 14, below). In very small concerns and on some tip-scavenging contracts, cheap light-weight single-acting units were often erected, using slender 'blondin'-type bi-podal masts (see below) in place of the traditional headgear [221].

Blondins

Whereas a single chain incline was a very efficient haulage system for traditional deep pits having just one working floor, the newer multi-floor quarries of the 1890s (see Chapter 3) needed one unit to serve each gallery, a requirement which remained cost-effective when limited to two or possibly three per pit. A solution to this increased need for additional chain inclines was provided by the introduction of the 'Blondin Cableway' (see below), which was first utilised in the Nantlle district at the Penyrorsedd and Alexandra quarries after 1898, correlating with the rapid development of gallery working in the newer parts of these two concerns [222].

The 'blondin' consisted of a single-acting cableway which had separate controllable hoisting and travelling functions (see Figure 15, below) [223]. The single main aerial guide-cable, raised clear of the ground by a pair of bi-podal timber or lattice steel 'masts', was either arranged horizontally between two anchorages astride the pit or, less often, on a catenary gradient like a chain incline (see above). The load-carriage (the *carfil*) running along this cable, was actuated by an 'endless' traversing rope from the winding engine in the horizontal system, but was an unpowered, braked unit in the inclined version [224]. The load-carriage carried the pulley system for operating the vertical lift of the load block on the winding rope, which was separately powered, allowing loads to be

FIGURE 14



INCLINED CABLEWAY
CATCHER GEAR

SKETCH SHOWING THE ARRANGEMENTS OF VARIOUS ROPES ON BLONDIN ANCHORAGES, CONCRETE FOUNDATIONS, TOWERS, ETC

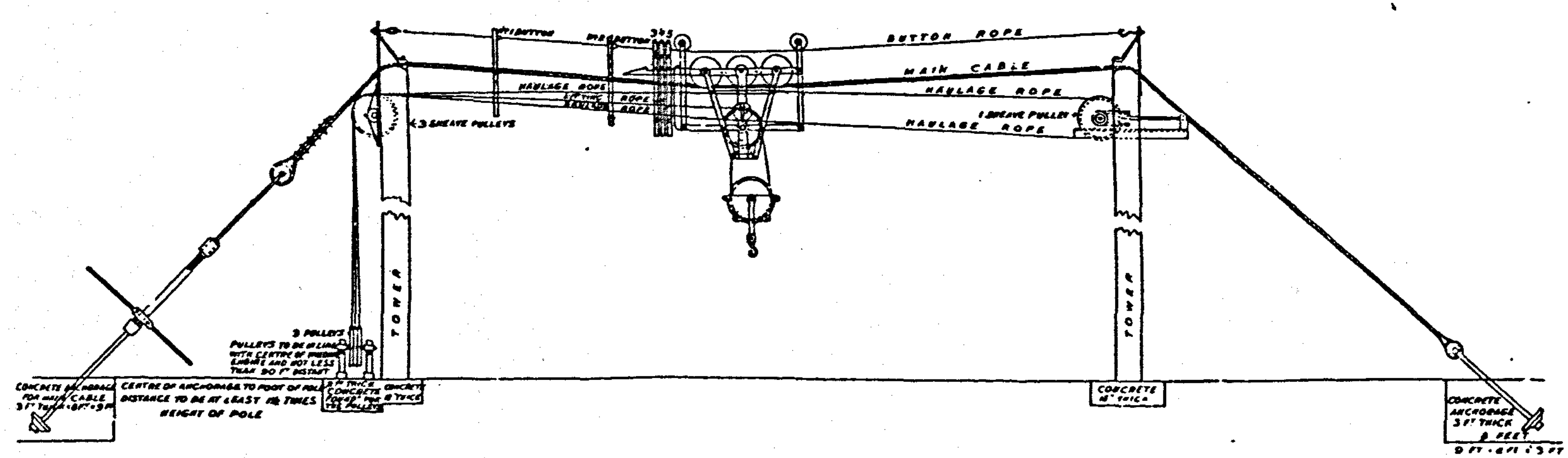


FIGURE 15

picked up from any point along the span of the cableway, thus circumventing the limitation of a single loading point with the chain inclines and also overcoming the technical problems sometimes associated with siting the headgear of the latter in an inconvenient location [225].

Notwithstanding their usefulness in specific circumstances, outlined above, blondins had two disadvantages in comparison with other types of hoisting systems. Firstly, the proprietary plant was expensive to purchase and maintain, the former reason probably arresting the initial take-up of the plant until 'Heath Robinson' solutions were found by poorer concerns that then enabled them to make their own blondins using existing old equipment [226]. Secondly, because there was no complementary returning empty waggon counterbalancing each ascending load, a blondin had only half the winding capacity of the standard 'double-acting' chain incline, and the new haulage system could rapidly became a limiting factor upon production capacity unless additional blondins were added, with consequential implications on costs, or an integrated system of mixed types of plant was adopted [227].

The majority of blondin cableways at the Nantlle quarries were either of the standard design manufactured by Henderson's Cableways Ltd., (of Aberdeen) or the Caledonian Wire Rope Company (of Airdre), or were home-made copies of these designs (see above) [228]. No examples are recorded of the use of improved designs incorporating semi- or automatic tipping facilities, such as in the blondin supplied to the Llechwedd Quarry (Ffestiniog) in the 1930s, although this option had been considered by the Dorothea Company in the case of their new Galltyfedw Quarry blondin of 1932 [229]. A home-made 'self-tipper' had been constructed at Dorothea for use on one of the 'Pit D' blondins in the mid-1930s, but was either never used or was a technical failure [230]. The

Penyrorsedd Quarry, however, in the early 1960s successfully developed a self-tipping facility for loads of rubble, using modified skips which discharged the debris automatically down shutes into waiting dumper lorries on the quarry bank, although changing circumstances led to the abandonment of this method by 1970 [231].

The blondin cableway became, by default, the last aerial haulage system in use in the Nantlle district after the abandonment of the last chain incline system (at Dorothea Quarry) in 1957 [232]. Pit haulage by blondin subsequently ceased at Dorothea Quarry in 1965, when road transport took over (see Chapter 5), and the last blondin at the Alexandra/Moeltryfan Quarry was stopped a year later in similar circumstances [233]. The Penyrorsedd Quarry was, however, forced to continue to rely upon its blondin cableways into the 1970s because of the excessive cost of creating a road to the workings [234]. Its aerial cableway system was the very last of its type in the Welsh slate industry, and the author was privileged to take part in its final operations in February 1979, during the last day of salvage operations of pit machinery and ladders, following the liquidation of the old Company [235].

(d). Processing machinery

The mechanisation of the various sub-stages within the processes of slab production and slatemaking was a progressive one, often associated with changes in the organisation of the work (see Chapter 3). As in the case of the other aspects of mechanisation described in this chapter, it is important to note that the differing circumstances in individual slate concerns resulted in a technological kaleidoscope which did not necessarily follow the general chronological order; each site had its own idiosyncrasies within the general framework. However, the general rule applied that the production of dressed slabs was mechanised at an earlier date than the slatemaking process, because of the commercial need being greater.

(i) Slab processing

The physical evidence of this aspect of the slate industry in the Nantlle district is unfortunately not supplemented by comprehensive primary documentation, particularly in relation to the early period. A general account of the production of dressed slabs at Nantlle can nevertheless be assembled from an analysis of that which is available.

Early factories

Evidence collated from the study by Dr M. J. T. Lewis of tombstones [236], supplemented by the present author's fieldwork, shows that whereas the use of sawn slate slabs in Gwynedd dated at least to 1722 (at Llanfrothen, in Merioneth), examples of machine-cut slabs were comparatively rare until the 1770s in Merioneth, and the 1780s-90s in the slate areas of Arfon other than the Nantlle district [237]. A survey by the present author of churchyards contiguous to the Nantlle slate area has revealed a higher incidence in this district of early sawn slabs than elsewhere, commencing in 1720 (at Llanllyfni) and being common from the 1750s. This suggests that Nantlle had an initial technological lead over the remainder of the North Wales slate industry in the case of slab products until it was matched, then overtaken by its competitors in the last quarter of the eighteenth century (see Chapter 1).

Notwithstanding the lack of original commercial documents, a rough picture of the advance of slab-making technology in the Nantlle district can be constructed from an analysis of the sawmarks on the early slate gravestones at Llandwrog, Llanllyfni and Llanwnda churchyards. The majority of the earliest extant memorials, dating from the first decades of the eighteenth century, were imported sawn sandstone slabs and unsawn local slate slabs which had been shaped manually by exploiting the natural faults and joints in the material to obtain the required shape. These earliest types were slowly eclipsed by sawn slate memorials, although there was a distinct localised variation in their design. At Llanllyfni the first sawn tombstone (of 1720) was the precursor of a standard design of large, thick, sawn slate slabs laid horizontally, a type which remained popular in a modified form until the 1900s, and the pattern was similar at Llanwnda from the 1770s. The gravestones at Llandwrog churchyard differed in that the thick horizontal slabs were supplemented from the 1730s to the 1790s by smaller and thinner vertical slabs of reddish-purple slate characteristic of the rock at Ochr-y-Cilgwyn (see Chapter 1) [238].

With the exception of unsawn ones and those remodelled during subsequent burials, the vast majority of local early tombstones show the characteristic marks on their edges of a horizontal reciprocating sand-saw, a result which correlates with Dr Lewis' findings in other districts. The process of sawing stone using a paste of sand and water as an abrasive under a tensioned and guided iron toothless blade had ancient origins, but it is unfortunate that the sawmarks give no clues as to the power source used to reciprocate the blades, be it either by hand or by a water-wheel [239].

The earliest documentary reference to slabmaking at Nantlle is an entry in the Llanllyfni parish register for 1696 referring to a "slate cutter," that is, a sawyer of slate slabs [240]. In the 1744-52 register, David Hughes of Tregrwyn was recorded in this capacity [241], this farm being conveniently located alongside the Llyfni river for the use of a water-wheel to power his machinery. The site also abutted the Lower

Nantlle lake, over which the large grey-green slabs used in many early gravestones at Llanllyfni could conceivably have been transported by raft from the water-side Cloddfa'r Lôn Quarry. Unfortunately, Tregrwyn Farm has long disappeared under the waste tips of the South Dorothea Quarry, and any physical evidence supporting this hypothesis has consequently been lost [242].

In addition to Tregrwyn, there were two other possible sites of early slab factories in the Nantlle district, neither of which retain any physical remains, and where the evidence is at best inconclusive, and at worst, circumstantial. Of these, a defunct woollen mill known as the Talysarn Factory, may just possibly have had some use as a slate slab sawing-mill by virtue of its date and location adjacent to a cluster of early quarries, although it was already disused by 1805, when it was converted into a chapel [243]. Similarly, the very old mill building at Felin Gerrig (literally, the 'stone mill') near Llanllyfni, that was a woollen factory by 1861, was also a prime candidate for an early slab mill, by virtue of its name [244].

Later slab factories

Subsequent to the eclipse of the early slab-producing industry at Nantlle (see above), a second commercial phase of slab production commenced during the mid-nineteenth century as the result of an upsurge in the demand for the product on a national and export basis [245]. Of the new sawing mills erected in this district between *c*.1840 and *c*.1870, two distinct types can be recognised. The first consisted of '<u>primary mills</u>' that were located at a number of slate quarries, where raw slabs were prepared for re-sale to specialist '<u>secondary mills</u>' manufacturing finished products.

The first of the recorded on-site primary slab mills at a Nantlle quarry was one erected at the Dorothea Quarry *c.*1842 to exploit a thick vein of greyish-green slate that separated two valuable beds of roofing-slate material (see Chapter 3, Table 16, 'Striped Blue Slate,' sub-veins) [246]. Subsequently, slab mills were erected at the Moeltryfan Quarry *c.*1850 [247], at the Talysarn Quarry c.1867 [248], and at the Penyrorsedd Quarry in 1868 [249], although a contemporary proposal to do likewise at the Fron Quarry was possibly abandoned [250]. Two other quarry mills which were possibly built for slab-cutting in the 1860s or 1870s were located at the Cilgwyn Quarry [251] and the Fronheulog Quarry respectively [252], and other quarries might in later years have had a combined slatemaking and slab mill such as that recorded at the Gwernor Quarry by 1900 [253].

Secondary slab mills having commercial connections with the slate industry at Nantlle, were found in two main concentrations, the most important being located in a geographical belt to the west of the quarries [254]. Of the nine secondary slab mills erected in Nantlle district between *c.*1840 and *c.*1870, several appear to have combined the manufacture of slate-slab products with that of school writing-slates, with the remainder specialising in one field or the other. The majority of the secondary mills were independent of the quarrying concerns, and only two of the local off-site slab mills are known to have had direct connections with quarry companies, namely the Dorothea Quarry's working of the Felin Gerrig writing-slate factory (Llanllyfni) in the 1880s, and the connections with slab quarries in the Corris district of the Tudor Slate Works (Groeslon) since the 1920s [255].

There were also a number of slate works centred on the slate harbour at Caernarfon which processed slabs from the Nantlle quarries in addition to receiving material from the quarries of the Gwyrfai Valley and south Llanberis [256]. Some partly-prepared slabs from Nantlle were also dispatched to product manufacturers located at those major British ports which received slates from North Wales [257]. In this last category, the most significant individual having a local interest was George Eugene Magnus of the Plimlico slab works (London), who had quarries at Cornwall, at Valencia (Ireland), and at Tanrallt in the Nantlle Valley [258]. Similarly, Salmen Bros., (of London) had trade connections with the Tyddyn Agnes Quarry, Llanllyfni, *via* Edward Griffiths of the Glanmorfa Slate Works, Caernarfon [259].

Few details are available of the specific items of plant used in these slab mills, although the known chronology of the development of slab processing machinery provides a basis to supplement the limited available inventories. The primary processes of preparing dressed slate-slabs only, required the use of saws and planers, but the secondary product-manufacturing utilised engraving and grooving machines, polishers, and enamelling ovens [260]. Whereas the design of slate planers remained almost unaltered from their inception in the 1840s [261], the design of slab-saws developed quickly. The standard reciprocating sand-saw was often retained for the initial slicing of thick slabs into thinner ones, but saws using toothed circular blades were introduced in the 1840s to 1860s in an attempt to speed up the process of cross- and longitudinal cutting [262]. Within this context, the use of the heavy-duty 'Hunter saw' in a number of the quarry slab mills at Nantlle must be recorded [263], but a variant of the slatemaking 'Greaves' saw (see below) appears also to have been used [264].

The preferred option on the grounds of cost-efficiency for a source of power for the slabmaking machinery at Nantlle, in common with contiguous slate districts, was water. All of the independent 'secondary' mills in this district were specifically located on the banks of rivers or mountain streams, where a water-wheel or turbine could be utilised [265]. In the case of the 'primary' mills in the quarries, the site itself dictated the power source. Whereas an adequate water supply enabled the use of water-wheels and turbines at the Dorothea, Gwernor and Moeltryfan quarries [266], the inadequacy of the supply at other quarries dictated the use of steam-power in the remainder of the on-site slab mills in the Nantlle district [267].

The demise of the slab mills

Notwithstanding its long history in the Nantlle district, slab manufacturing was always a poor relation to the main product of the quarries, that is roofing slates. Despite the rapid growth in the number of mills producing raw sawn slabs, slab products and the spin-off manufacturing of school writing-slates during the 1860s, this golden age was of a very short duration. Slab production was at best a side-line in the Nantlle quarries because the supply of rock of sufficient dimensions was restricted and its value per ton was greater in the form of roofing slates.

By the mid-1880s there had already been a number of closures of independent 'secondary' slate works in this district, with others following suit by the close of the century, and only the Tudor Works (Groeslon) has survived to the present day. Their demise appears to have been caused by the development of larger scale slab factories in the Deiniolen/Llanrug district and at the shipping centres of Caernarfon, Bangor and Porthmadog, which progressively squeezed out the small-scale manufacturers [268].

The majority of 'primary' slab mills in the quarries had also become disused before the First World War, with only very limited slab processing being conducted in a few locations [269]. Slab production was not recommenced on an important scale at Nantlle until the mid-1960s to early 1970s as part of the attempt to rejuvenate the remaining quarries through a diversification of their products. However, the uncertain demand in comparison with the roofing slate market proved a disincentive for a second time, and as the slab trade proved ultimately unremunerative to the local quarries, it was consequently short-lived [270].

(ii) Slatemaking

The mechanisation of the processes involved in the manufacture of roofing slates followed three distinct lines of parallel developments, one being in the sawing of slabs into slatemaking blocks, the second being in the cutting (or 'dressing') of the split slates into their final regular shapes, and the third involving the mechanisation of the splitting process. In this last case, an attempt was allegedly made to develop a slate-splitting machine during the mid-nineteenth century [271], but the first modern version which showed any potential was only developed during the 1970s, and this technology has not been tested at Nantlle to date [272]. Developments in sawing and dressing machinery were, in contrast, of great relevance to the Nantlle quarries, and are outlined below.

Sawing machinery

After a false start in the 1810s at Ffestiniog [273], the application of mechanical sawing of slabs during the slatemaking process became a necessity in that district by the early 1850s because of the significant rate of wastage resulting from the relative softness of the Ordovician slates [274]. The use of the contemporary standard slab saws (see above) in the slatemaking process was not feasible for technological reasons related to the organisation of the contemporary production system (see Chapter 3), which precluded the communal sawing of blocks on one or two large machines. This problem was solved *c.*1852 by J.W.Greaves (of Llechwedd Quarry) with his development of an inexpensive, smaller semi-automatic sawing machine, which could be installed in purpose-built sheds, one each for every gang of slatemakers, and worked off a common power transmission system (see Figures 16 & 17, below) [275].

Within a decade of its development, the Greaves saw had been adopted by the majority of quarries at Ffestiniog, and its use was spreading throughout those contiguous slate-quarrying areas which worked the Ordovician rock [276]. Its progress was greatly assisted by the introduction of cheap Bessemer steel blades in the 1860s, coinciding with the first improvement on the original design by a local commercial manufacturer [277]. It was also realised that in addition to cross-cutting, the longitudinal cutting of slabs was also accomplished more conveniently and accurately by mechanical means, especially in quarries where the 'pillaring' characteristic of the slate was not well developed [278]. Thus, the introduction of the Greaves saw had a secondary effect of making the first stages of slatemaking accessible to less skilled men, removing one impediment to the expansion of the production workforce during the boom years of the slate markets after the mid-1850s.

The above technological advances did not immediately permeate into the Cambrian slate quarries of Caernarfonshire. The reasons for this appear to have been partly a doubting of the merits of mechanised sawing in the case of the more brittle slate worked in the Bethesda, Llanberis and Nantlle districts, and was also partly a question of the cost of purchasing the plant, erecting a mill, and shouldering the subsequent running costs [279].

The eventual adoption of mechanised sawing to the slatemaking operations in the Cambrian slate belt was, however, only a matter of time and circumstances. That it was first introduced *via* medium sized concerns, particularly those at Nantlle, was not surprising because these had the greatest need to improve their cost-efficiency due to their intrinsic above-average operating costs (see Chapter 2). Despite the highly-developed craft skill of the quarrymen by the 1850s, the manual sub-division of slate-slabs prior to their final splitting into roofing slates was, in retrospect, time consuming and wasteful of raw material in comparison with the results achieved after the introduction of mechanised sawing. This was especially the case with the softer purple vein and also with blue slates containing a high concentration of hard green cross-bands (or 'stripes') [280].

The first slatemaking sawing plant in the Nantlle district was erected in 1874-75 by the Penyrorsedd Company, with the aim of capitalising on the output of its new pits [281]. Others amongst the higher echelons of Nantlle concerns consequently followed suit in two distinct batches (see Appendix 3), of which the earliest period was characterised by caution tempered by the uncertain finances of the quarries during the depressed market conditions of the 1880s. For example, the Coedmadog Quarry commenced building a slatemaking mill in 1881, but was not able to fit it out with plant until the end of the decade [282], and the Dorothea Company undertook a trial with a pair of second-hand saws in 1882 before commencing the progressive construction of a large mill, erected in stages over two decades as funds allowed [283]. Many quarries held back until the better economic conditions of the late-1890s before taking the plunge, but by 1910 the majority of the local productive quarries had some sawing plant [284].

Despite the benefits of mechanical sawing in reducing the wastage of slatemaking blocks, some new problems were created by the standard Greaves saw (see Appendix 4 for details of design variations). The main difficulties fell into two categories, which were (a) maintaining a smooth cutting action, so as not to damage the cut face of the slate blocks, thus causing wastage during the splitting process, and (b) maintaining an optimum cutting rate in the case of slates of varying hardness, so as to keep the skilled men splitting the resultant blocks fully occupied.

Both of the above problems were intimately associated with the design of the feed mechanism for propelling the load table of the Greaves saw. In the earliest commercial design, the chain-drive feed was found to be plagued by a jerky motion when cutting the harder types of Cambrian slate, thus causing problem (a) above [285]. Substitution of the chain system by a geared rack drive overcame this difficulty, but the fixed feed rate of the early single-speed models could not suit every type of slate and could leave the slate-splitters standing idle (problem b, above). Both problems were successfully addressed in the De Winton saws installed at Penyrorsedd Quarry in 1875 by the provision of a variable-speed, water-hydraulic ram feed, but the unreliability of this technology in the face of summer droughts and winter freezing prevented its adoption on a wider scale. Thus, the most popular sawing machines in the Nantlle district was a compromise of all of the above, incorporating a dual-, and occasionally triple-speed worm-geared rack-drive motion [286].

The heavy wear on the ordinary steel, toothed saws by the hard Cambrian slates was also a problem encountered in the Nantlle mills. Not only was production time lost in changing saw-blades twice per day, but men had to be employed to recut and reset the teeth on the blunted blades. Furthermore, this constant re-cutting caused a progressive reduction in the diameter of the saw, consequently affecting its performance. However, the development in 1958 by Major Ivor Wynne Williams (of the Dorothea Quarry) of inserted tungsten carbide teeth mounted into slots cut in the periphery of a steel disc, increased the durability of blades to eighteen-months without changing their original dimensions [287].

This development of tungsten-tipped blades extended the economic life of the Greaves saws remaining in use, but the ultimate solution to the inherent problems, both technological and organisational, of the subdivision of slate slabs was the adoption of high-speed sawing, using blades coated with industrial diamonds or carborundum. This technology had its origins in the 1860s, but did not find its first general commercial application until its adoption by the Scottish granite industry by the first decade of the present century. Its adoption by slate quarries in North Wales was, however, delayed until the 1920s by the problems of cost, the requirement for a supply of electric power, and the need to completely reorganise the production system (see Chapter 3) [288].

The first application of high-speed 'diamond sawing' in the Welsh slate industry was in a number of slab quarries working Ordovician and Silurian slates, where the rock was relatively free of hard gritty cross-bands [289]. This technology was contemporaneously investigated by the Dorothea and Penyrorsedd concerns at Nantlle, as part of a wider exercise involving the appraisal of the production systems that had been adopted by the American and German slate quarries [290].

Although the introduction of a centralised high-speed saw feeding a line of splitters and dressers potentially offered considerable savings on the traditional independent production system, neither company felt able to commit themselves to such a major change at this juncture. At Dorothea, the adjournment on the grounds of cost of its comprehensive electrification scheme was the crucial factor in halting the modernisation of the sawing plant [291], but at Penyrorsedd, a board-room revolt resisted the modernising zeal of the chairman, Professor Otto Vernon Darbishire, on the grounds of cost and a fear of resistance to change from the workforce [292].

Neither of the aforementioned Nantlle concerns had realised, however, that unexpected technological problems would have diminished the expected cost-saving of using high-speed saws. These difficulties only came to light in 1938-39, when the Dorothea Quarry was finally able to install an electric saw on a trial basis. Despite operating satisfactorily, this carborundum bladed high-speed saw failed to outperform the old Greaves saws in terms of yield per block, much to the consternation of the quarry's consultant engineer. The source of the problem was identified as the friction-generated heat of the fast sawing action on the hard Cambrian rock, which created excessive wastage by on the one hand baking the sawn face of the blocks and on the other hand it warped the saw-blade causing a rounding of the extreme edges of the cut at the entry and exit points [293].

Further experimentation to overcome the problem was curtailed by the outbreak of the Second World War, and subsequently by the post-war financial difficulties of the Welsh slate industry (see Chapter 1). However, the adaptation of high-speed sawing to cope with the Cambrian slate resurfaced as a high priority during the attempted revitalisation of the

Dorothea Quarry during the early 1960s, because of the mounting cost of running and maintaining the old Greaves saws [294].

On the strength of the apparently satisfactory results obtained from a locally-fabricated test-saw using a modern diamond-coated blade, the Dorothea Company in 1963 installed three 'Wessex' machines to replace the twenty Greaves saws currently in use. Unfortunately, under full production conditions the optimum life of the diamond-blades was greatly reduced due to the white spar commonly found in the slate, leading to a yield reduction as previously experienced in the pre-war trials (see above). This was partly alleviated by adding cutting fluid (a water based oil) to the coolant water, but the economic performance of the new plant continued to be below expectation. Fortunately, the old Greaves saws had been retained pending a gradual transition to the exclusive use of the new plant, and were capable of being returned to production. Subsequently, the electric saws were relegated to producing cladding, flooring tiles and slabs, although they were briefly reinstated to roofing slate production during the last month of operations at the quarry (September 1969) because of the scrapping of the old Greaves saws to provide desperately-required revenue [295].

The Moeltryfan (Crown) Quarry experienced similar problems with its brace of new electric saws in the mid-1960s and both had fallen out of use within a comparatively short time, whereas the old Greaves machines continued in use until the quarry closed in 1972 [296]. Similarly, the Greaves saw at the small Twll Coed Quarry outlived the expensive electric saw installed during an ill-judged investment programme in 1973, because its operating costs better matched the diminutive output of the concern [297].

Notwithstanding the failures discussed above, the replacement in 1969 and 1989 respectively, of the sixteen Greaves saws at the Penyrorsedd Quarry and the single unit at the Twll Llwyd Quarry by electric high-speed saws, was permanent. This reversal of the trend can be traced to improvements in the technology of rock-cutting blades and advances in the design of saw mechanisms [298]. Yet, despite further developments in sawing technology, represented at Nantlle by a set of new high-capacity, laser-guided electric saws installed at Penyrorsedd Quarry in 1994-95, there remains, one unresolved problem with the centralised system of sawing. This involves the potential disastrous effect on the total yield of a mill resulting from any misjudgement by a few individuals of the most advantageous way of sawing the slate, whereas in the traditional system the risk was diminished by virtue of the individual responsibility of each slatemaker for his own slabs [299].

Dressing machines

As in the case of mechanised sawing (above), the mechanisation of the cutting of the split slates to a regular shape within the range of sizes sold (that is, the 'dressing' process) also had its origins outside Nantlle. Despite several attempts dating from the 1840s to produce a cutter to replace the manual dressing knife [300], the first successful machine that replaced the manual method of dressing (see Chapter 3) in a number of quarries at Ffestiniog was the 'Matthews' guillotine cutter (of 1850), followed by the superior 'Greaves' rotary dresser (of the 1860s), which rapidly became the most favoured type throughout the industry [301]. The only serious competitor to appear post-*c.*1870 was the 'Amos & Francis' reciprocating knife-cutter (of 1875), but this was not widely adopted outside the Penrhyn Quarry (Bethesda) because of its disadvantageous idiosyncrasies [302], and only two of this type, of uncertain origin or vintage, are known to have been used at Nantlle [303].

The introduction of mechanical dressing to the Nantlle quarries was closely tied to the mechanisation of sawing (see above), although not exclusively so. The provision of power in the slate mills built in this district from the 1870s (see below) enabled belt-driven dressers to be readily installed when deemed necessary, although machines operated by foot-treadle were also available [304]. That the option to mechanise dressing was not taken in many cases was probably in part due to considerations of cost, but the physical characteristics of the slates at individual quarries was also of prime importance.

TABLE 21

Dressing machines at Nantlle mills

ORIGINAL DRESSERS	VEIN(S)	NO DRESSERS (* Added units)	VEIN(S)
Penyrorsedd	Purple	Dorothea	Blue, purple*
Penybryn (upper mill)	Purple	Cilgwyn	Purple *
Galltyfedw	Purple	Moeltryfan (Floor 3)	Purple *
Talysarn (Small Mill)	Purple/Blue	Tynyweirglodd	Purple *
Blaen Cae	Purple	Moeltryfan (Floor 4)	Purple
Alexandra (New Mills)	Purple	Coedmadog	Purple
Talysarn (New mill)	Purple/Blue	Braich	Purple
Twll Coed	Purple/Green	Alexandra (Old Mills)	Purple
Twll Llwyd	Green	Talysarn (Large Mill)	Purple, Blue
		Penybryn (Lower Mill)	Blue
		Fronheulog	Blue
		Ty Mawr West	Blue
		Gwernor	Blue & Green
		Fron & Old Braich	Blue
		Llwydcoed	Blue & Green
		Tanrallt	Blue

With regards to the role of physical characteristics of the slates, there is a clear correlation between the installation of mechanical dressers and the working of the relatively soft purple slates in over half of the quarries working this vein. However, in the case of the more brittle blue slates and thick green slate, these were generally not dressed mechanically because of a high rate of breakages, although some special single-blade counterweighted Greaves dressers were used for the best grade of greens in a few concerns [305].

In terms of cost considerations, individual largesse or prejudices prevailed. The Penyrorsedd Quarry, for instance, spared no expense in its equipment budget, and installed Greaves dressers in all of their mills (from 1876 onwards), but whereas the more frugal Dorothea Company purchased a dresser as a trial in 1890, it chose not to adopt the machines until manpower reductions forced the change in 1941 [306].

(iii) Mill design

The splitting and dressing of roofing slates was, in pre-mechanised days and in the era of the latter-day tip contractors, carried out either in the open air, or in rough shelters known as *gwaliau* [307]. These shelters came in a variety of sizes and forms, having one or two open sides for light and ventilation, and had either a lean-to roof of lapped small slabs covered by fine waste, or a pitched one of large cantilevered slabs [308]. The *gwaliau* of idiosyncratic design found in some quarries must have been erected by the quarrymen themselves, but at other sites an uniformity of architectural features and 'terraced' construction testified to the provision by the employer of sheltered work-spaces [309].

From the evidence of 1:2,500 O.S. maps, surveyed in 1888, 1899 and 1913, it can be seen that at Nantlle, each working floor typically had its own *gwaliau*, rather than there being a centralised layout. The *gwaliau* were usually arranged in single long rows, probably so as to allow sufficient space for the convenient location of an adjacent stock-yard. In the larger quarries, there appears to have been up to around twenty individual *gwaliau* per row, but in the smaller quarries, the number was typically from four to eight, reflecting the differing scales of operations.

With the introduction of mechanised sawing into the slatemaking process in the Merioneth quarries by the 1850s (see above), the provision of a building to house the machines became desirable. The first type was a simple 'sawing shed,' often a plain rectangular structure housing a single manually-operated saw [310]. Subsequently, the provision of multiple numbers of powered saws in the bigger quarries at Ffestiniog required larger buildings ('mills'), located close to a row of slatemaking *gwaliau*, or having the processing carried out in a separate room within the mill [311]. The placing of all of the sawing and slatemaking process in one room so as to gain the maximum efficiency, dates to *c.*1860, when the first '**integrated mill**' was erected at the Diffwys Quarry (Ffestiniog) [312].

The standard layout that had evolved for slatemaking mills during the 1860s was that of a single-storey building housing saw-tables arranged in a row, side by side, each having an associated dressing machine and slatemaking area, with all the plant being powered from a central power source *via* a system of lineshafts and belt drives. The access railways which brought in the slate slabs and which took out the debris either consisted of one or two tracks running along length of the mill at right angles to the saws (termed a '**longitudinal layout**'), or were multiple lines entering through a series of side-doors to cross the building in parallel to the saws (termed a '**transverse layout**') [313]. Some mills were complete masonry structures whereas others were barn-type in their construction, where the roof-trusses were propped up on timber or masonry piers [314].

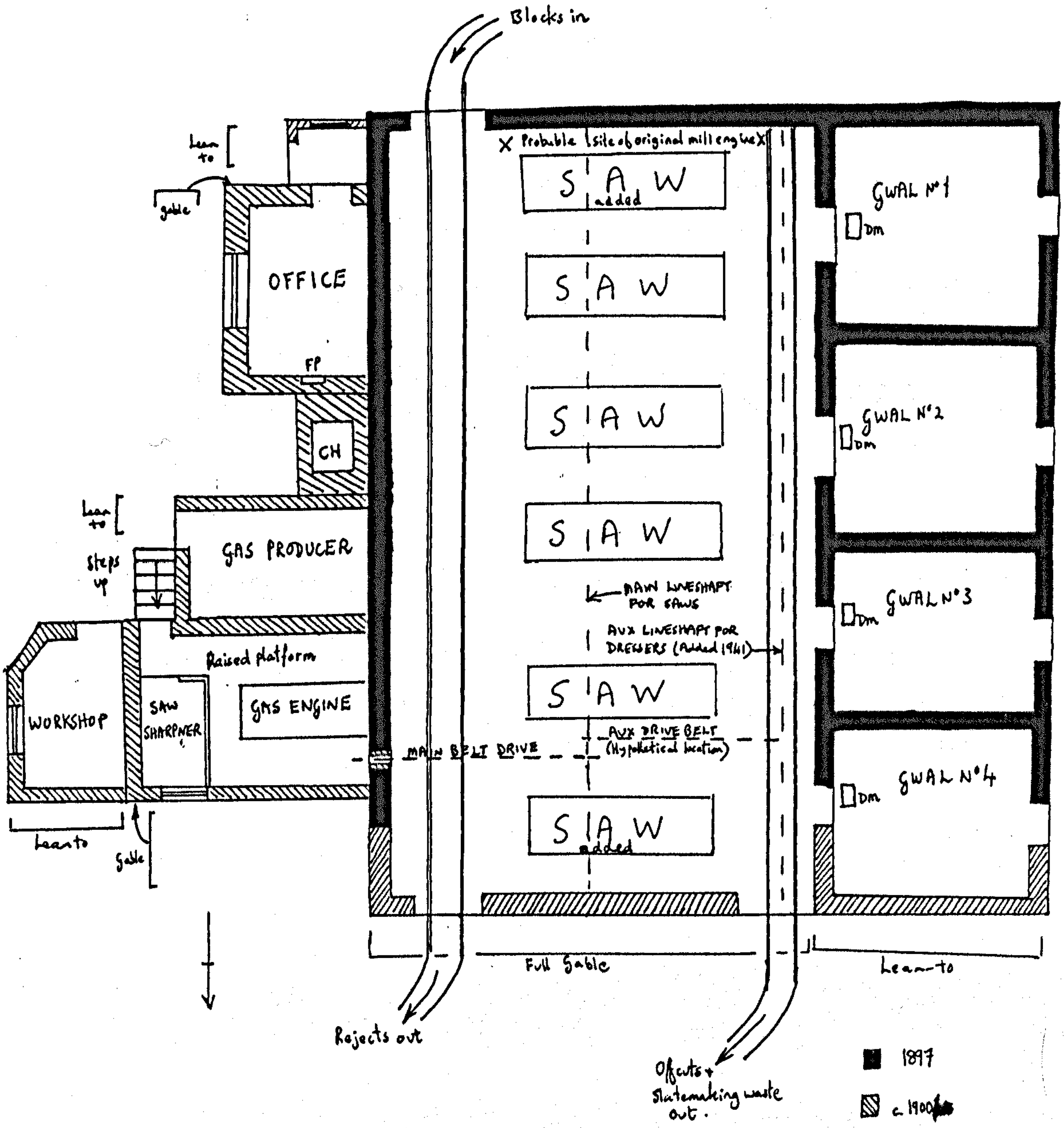
The so-called 'integrated mill' (see above) swiftly spread through the Ffestiniog area and beyond, in parallel to the spread of mechanised slatemaking, and the basic designs described in the preceding paragraph had been the norm in the industry for over a decade prior to the erection of the first one in the Nantlle district. It was therefore not surprising that the majority of the latter embodied many of these external architectural influences.

The first slatemaking mill in the Nantlle district, namely the Penyrorsedd Quarry 'W6' mill of 1874-76, was heavily influenced by contemporary Ffestiniog practice on a grand scale. The new building consisted of two open-plan parallel mills 120 feet long by 45 feet broad, with ten saws apiece on a longitudinal transport layout, separated only by an arcaded timber-framed aisle carrying the overhead power shaft over a central shared longitudinal tramway for removing the slatemaking waste. The plant was powered by a thirty foot diameter by four feet wide water-wheel, supplemented by a steam engine after an extension of eight bays was erected in 1878, this new portion receiving four additional bays in 1900, bringing the total complement of saws to forty two with an equal number of mechanical dressers [315].

The above design of twin open-plan integrated mill became the blueprint for the remaining two mills (of 1878 and 1898 respectively) built at Penyrorsedd, but with the exception of the triple-apex version at the Talysarn Quarry (of 1885), the remainder of this type at Nantlle (see Appendix 3) were 'single' mills, where there was only one line of saws under a single gable. Nearly all were of a longitudinal transport layout, but at least three dating from *c.*1880 were of a transverse design (see above) [316].

FIGURE 16

GROUND PLAN
TYNYWEIRGLODD QUARRY MILL



TYN-Y-WEIRGLODD MILL in 1930s.
Scale 3mm : 1ft.

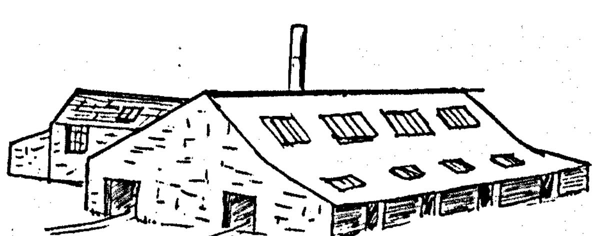
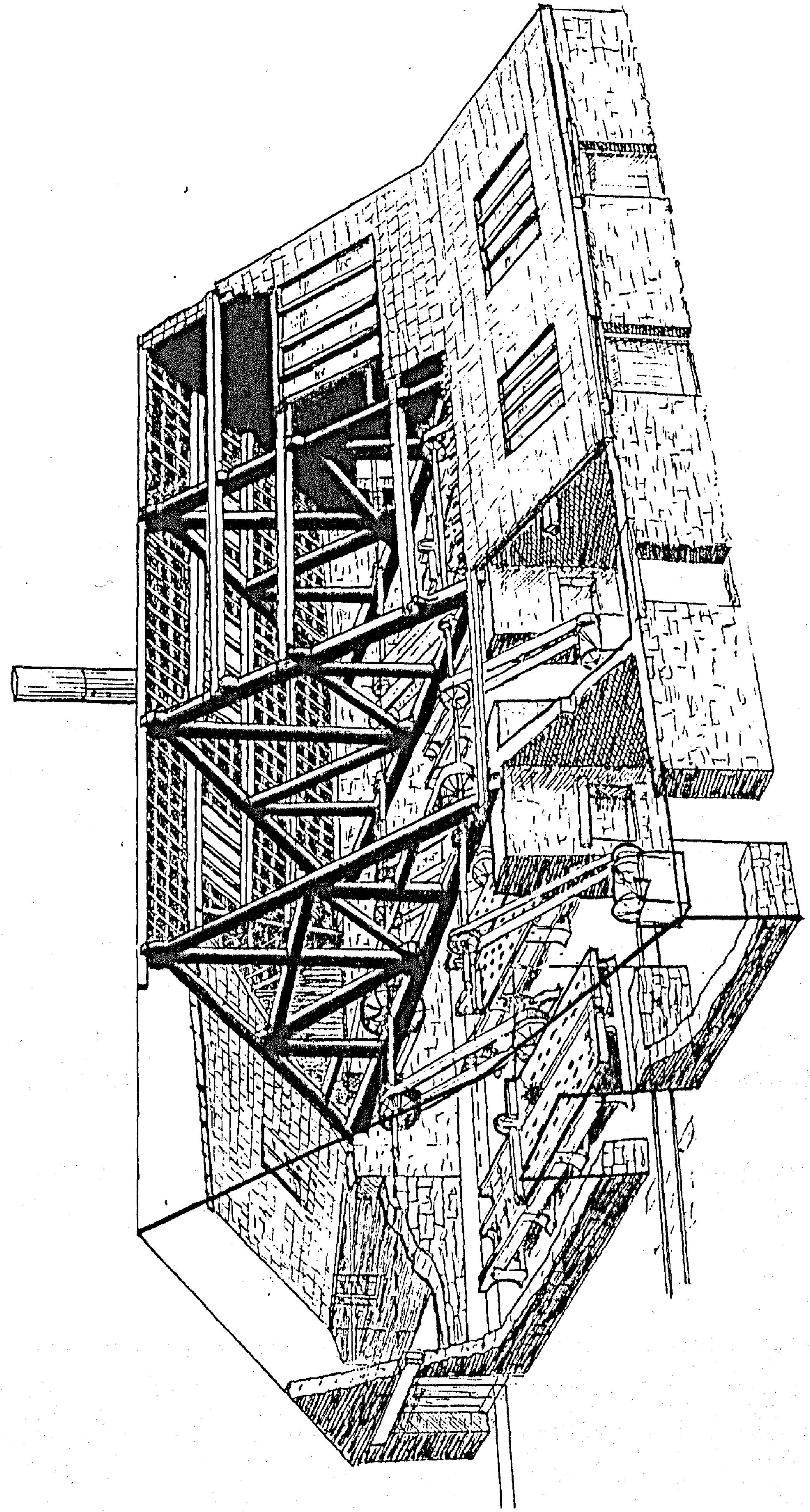


FIGURE 17



RECONSTRUCTION CUT-AWAY
TYNYWEIRGLODDD QUARRY MILL

Notwithstanding the mainstream open-plan design described above, the Nantlle district contributed to the architectural diversity of slatemaking mills by the development of a localised variation, for which the term **'segregated mill'** has been coined [317]. This design harked back to the early Ffestiniog practice of combining sawing sheds with *gwaliau* (see Figures 16 & 17, above), but did so by providing separate slatemaking cabins under a lean-to roof along one or both sides of the main sawing room. The advantages of this design was that of insulating the workmen from noise and sawing dust, and the roofing costs may have been reduced by having a shorter main span.

The first of the segregated mills was the Dorothea Large Mill, commenced in 1883, and completed in discrete sections by the 1920s. In its completed form, the central sawing room measured 300 feet by 60 feet under a queen-post roof which was supported by masonry pillars. The mill eventually contained 42 saw-tables, arranged in two rows astride the central longitudinal tramway which brought in the slabs, with the offcuts being removed by parallel tramways along each side of the sawing room. The slatemaking cabins flanked the sawing room on both sides, their lean-to roofs being a continuation on a shallower pitch of the main roof. The cabins communicated with the sawing room through the gaps between the roof pillars, these having been closed off by a partition and door to reduce the noise and dust levels in the working place. Waste disposal from the cabins and the carrying out of the produce to the stock yard was facilitated by individual external sliding doors [318].

The remainder of the segregated mills at Nantlle (see Appendix 3) had only a single row of saws and lean-to cabins, with the exception of the Tanrallt mill (of *c.*1910) which had cabins on both sides of the building. Mills of the segregated type were, however, significantly in the minority even within the Nantlle district, and only one (at Rhos Quarry, Capel Curig) has been recorded outside this area [319].

Although brevity precludes the listing of individual architectural oddities of slatemaking mills of all types at Nantlle, some general features are worthy of note. Perhaps the most important amongst this heading were the additions erected onto completed mills, these either being extra slatemaking facilities or buildings containing air-compressing plant or a fitting shop that made use of the same power source as the sawing machines. Within the ranks of the former, lean-to rooms on gable walls to accommodate an extra saw-table were common, as were covered loading aisles for finished slates and dressing waste along an external longitudinal wall, this extra roofed area also providing a place for apprentices (or 'rubblers') to work [320].

The progressive extension of mills by the addition of a new parallel or tandem buildings was also common, although in some cases the practice of leaving one end closed with a temporary gable entirely or partially of timber cladding rendered any further lengthening of the structure virtually indistinguishable from earlier construction phases. In a number of cases, extra powered saws were installed in the open air prior to the construction of the building to encase them, and this temporary arrangement became permanent in at least two sites [321].

Mill power sources and power-transmission systems

There are only three known examples of water powered slatemaking mills at Nantlle quarries [322]. This was the opposite case to Ffestiniog, where the vast majority of mills were worked by water-wheels, pelton-wheels or turbines. Water was the cheapest power source, especially for continuous running as exemplified by slate mills, but could not be obtained in sufficient volume on a constant basis at the majority of Nantlle mill sites. In addition, the late date of the Nantlle mill-building programme coincided with a period of relatively inexpensive coal and a reduction in the price of steam engines, whereby the many advantages of this source of power could be utilised (see Sub-section a,iv above). These advantages included being independent of the weather, and a flexibility in locating the plant, which must have both outweighed the addition of the expense of coal to the production costs.

The additional advantage of steam engines over water-wheels came in the matching of power plant to the capacity of a mill which was being erected in stages, thus achieving the most economical running conditions. This construction method was often adopted at Nantlle, with additional machinery being added to an initial nucleus as production and financial circumstances allowed. A low-powered engine (up to about ten horse power) was sufficient for the typical initial installation of about six saws, and this could be readily replaced by a larger machine when (and if) the mill was extended (see sub-section 1.e, above) [323]. At around 1 horse power per saw and half that amount per dresser, plus a factor for friction and transmission losses, an average sawmill at Nantlle might typically require an engine of no more than 25 horse power, although a higher rating was required of any replacement internal combustion engines and electric motors (see sub-sections 1.f and 1.g, above) so as to offset their relative lack of torque [324].

Individual sawing and dressing machines within mills at Nantlle were usually powered from a roof-truss mounted three- or four-inch diameter line-shaft, turning at around 50 r.p.m., (see Figures 16 & 17, above). The motion was transmitted *via* flat belts from flat or crown pulleys on the shafting to the saws on about a 1:1 ratio with pulleys of three or four foot diameter, but with a 2 : 1 reduction in the case of the dressers, which sometimes had a subsidiary line-shaft of their own. Only one example of chain drive to the saw tables (at Moeltryfan Quarry), and of a hemp main drive system (at Penyrorsedd Quarry) is recorded, but there were at least three examples of external power-transmission from one mill building to another *via* heavy endless wire-rope drives [325].

Very few of the mills at Nantlle were still in use when directly-powered electrical plant began to replace belt-driven machinery in the 1960s and 1970s. Only at the Dorothea Small Mill (1963) and Penyrorsedd 'E8' Mill (early-1970s), when individual electric motors drove the saws and dressers, was the overhead line-shaft system made redundant, with a marked reduction in power costs [326].

Modern sawing sheds and non-integrated mills

With the exception of the final completion of timber-gabled 'unfinished' buildings (see above) with a one-bay extension onto a masonry end-wall, the only new mill of traditional design built at Nantlle after the First World War was at the Crown New Quarry (in 1937), reflecting the over-capacity of sawing plant at the surviving quarries in an era of declining demand [327].

Despite the demise of the traditional integrated mill, new buildings involving slate processing continued to be erected at Nantlle post-1918, albeit a return to the "sawing shed" and non-integrated pattern of the earliest Ffestiniog design (see above). The sawing shed was typically utilised in small scale workings, where a single Greaves saw and occasionally a dressing machine was protected from the weather by a rough building constructed usually of slate blocks with a corrugated iron roof, or sometimes the whole structure was of galvanised sheets on a timber frame [328].

The non-integrated mills were associated with the installation of electric high-speed saws, and dated from the 1960s and 1970s. Their design incorporated separate buildings for the sawing and the subsequent slatemaking process as a result of the excessive noise of the new saws. Of the five examples at Nantlle, in three quarries [329], most were simple constructions in brick, timber or corrugated iron, appended onto an existing mill or saw-shed, although a short-lived experiment at the Moeltryfan Quarry involved the erection of a complete sawing and slatemaking unit within the pit so as to reduce the costs of internal transport of quarried material and waste [330].

Decay and demolition

The era following the ending of the First World War witnessed a progressive destruction of the slate mills at Nantlle. Although quarrying continued on a squatter basis on many sites into the 1960s, the valuable timber roofing trusses, roofing slates and scrap machinery of the mills were amongst the first materials that were salvaged at the cessation of full-scale working. In many cases, even the slate block walls were taken away for building material, or were quarried by tip-contractors making small slates for damp-proof courses (see Chapter 3) [331].

Some defunct mill buildings at Nantlle survived for longer than expected due to their conversion in 1939-45 to warehouses for strategic stores of materials such as agricultural fertilisers, a facility which was retained by the Ministry of Works up to c.1960. Subsequently, these survivors were also stripped of all their salvageable materials [332].

In 1973-74, the salvage gangs plundered the slatemaking mills of the recently-closed Crown and Dorothea quarries, thus reducing the number of roofed examples in the district to only four [333]. This total has been subsequently reduced due to the recent destruction of the pioneering 'W6' mill at the Penyrorsedd Quarry (see above), and the descent of its 'W4' mill to a state of dereliction together with the cessation of timber sawing at the former Fron Quarry Mill, threatens further demolition in the near future [334]. Only the upper mill at Penyrorsedd will then remain, and only for the lifetime of the present operations on the site, whence it too will join the other quarry mills at Nantlle in a melancholy state of ruin.

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NOTES: CHAPTER 4

Abbreviations

C.R.O. Caernarfon Record Office, Gwynedd Archives Service
Q.M.J. Quarry Managers' Journal
S.T.G. Slate Trade Gazette
T.C.H.S. Transactions of the Caernarfonshire Historical Society
U.C.N.W. University College of North Wales, now the University of North Wales, Bangor.

1. The main references to the local foundries are for Caernarfon:- Abbot, R., (1956), 'Chronicles of a Caernarfon Ironworks,' T.C.H.S., Vol.17, pp.86-94; Lloyd, Lewis, (1994), De Winton's of Caernarfon 1854-1892, (Author, Caernarfon); Obituary of John Owen, Vulcan Foundry, Carnarvon & Denbigh Herald, 25 September 1903; and for Porthmadog:- Buckingham, F., (1912), 'Traethawd ar hanes Portmadog ar gyfer gwyl lenyddol Capel Tabernacl, Portmadog 1912,' unpublished essay containing details of Owen, Issac & Owen, Union Iron Works, kindly provided to the author by Mr Dewi Williams, Penmorfa; Down, C.G., (1973), 'The Britannia Foundry, Porthmadog,' Industrial Railway Record, Vol.49, (August 1973), pp.68-81; and C.R.O./G.P.Jones Britannia Foundry Mss., (uncatalogued); C.R.O., XD/41 (uncatalogued), Glaslyn Foundry Mss.

(a). Power Sources

(i). Manual Power

2. By the 1890s, up to 30 per cent of workforce in the biggest Nantlle quarries were classified as 'non-productive', i.e., were not quarrymen or slatemakers. See wage ledgers in C.R.O., X/Dorothea Mss; ibid., X/Penyrorsedd Mss; and ibid., G.P.Jones/Nantlle Mss (uncatalogued).

3. A single blondin needed a crew of three men, and although lorries and excavators needed drivers, the same three men using modern plant could move a much greater amount of material in a working day than using the old plant.

(ii). Animal Power

4. Ambrose, Rev W.R., (1872), Hynafiaethau, Cofiannau a Hanes Presennol Nant Nantlle, (Penygroes), p.75; Griffiths, J., *Sylwebydd* (1889), Chwarelau Dyffryn Nantlle a Chymdogaeth Moeltryfan, (ed., W.J.Griffiths, Conway *c.*1930), p.15; Hall, E.Hyde, (1809-11),

A Description of Caernarvonshire, (Caernarfonshire Historical Society, Record Series No.2, 1952), p.105.

5. Ex.info., W.H.Humphreys of Penygroes, and the late Idwal Hughes, recalling period as horse attendants; and Lefi Jones & the late Gwilym Roberts, former members of the Dorothea Quarry engineering staff.

6. Richards, A.J., (1995), Slate Quarrying in Wales, (Llanrwst), p.187; see also Chapter 5, infra.

(iii). Wind Power

7. Lindsay, J., (1974), The History of the North Wales Slate Industry, (Newton Abbot), pp.154-155; U.C.N.W., Porth yr Aur 27514, 27766, 28020, bill, letter and agreement (June 1806) with John Hughes of Gelli Bach, Llanllyfni (a subsequent operator of Llwydcoed Quarry and manager of Coedmadog Quarry) to build a wind engine to pump at Cilgwyn at a cost of £120; ibid., 27037, 27059, refs. to new wind engine at Braichrhydd, 1827-31; J.Griffiths *Sylwebydd* (1889), op.cit., pp.69, 80, although the last page ref. is for Braich Quarry, the actual site of the engine may have been at the Old Braich Quarry, both sites being within the same leasehold sett known collectively as Braichrhydd. See also Note 16, infra. There is also a reference to the possibility of erecting a wind pump at the Cloddfa'r Coed (Hafodlas) Quarry in 1812, although it is likely that this was not done [U.C.N.W., Porth yr Aur, op.cit., 29479].

8. This was the standard design of a pump drive from windmills. A timber structure might account for the total absence of physical remains at either site, although the later expansion of the quarries may easily have destroyed both sites. Two of the five Cilgwyn Company partners were residents of Anglesea, and another was the solicitor to the owner of the Mona Mine, adjacent to the Parys Mountain workings. Le Neve Foster, C., (1894), A Treatise on Ore and Stone Mining, (C.Griffiths & Co., London; 7th ed., 1910, editor S.H.Cox), p.470, stated that the capacity of the Mona Mine wind-pump, raising from 80 fathoms, was 90 gallons per minute.

9. Variation in wind speed remains a problem with optimising the operation of modern wind-powered electric generators.

(iv). Water power

10. For technical details of various water-powered machines, see Greaves, W.F., & Carpenter, J.H., (1969), A Short History of Mechanical Engineering, (Longman), pp.50-54, 77-78.

11. Present author's documentary and field-studies; see A. J. Richards (1995), op.cit., pp.81-86, 199, for an account of water power in Welsh slate quarries. For descriptions of the general industrial uses of water-wheels, see Buchanan, R.A., (1972), Industrial Archaeology in Britain, (Penguin), pp.240-245; C. Le NeveFoster (1910 ed.), A Treatise on Ore and Stone Mining, op.cit., pp.413-414, 471; Roberts, D., (1986) 'Technoleg Draddodiadol yng Ngilfach Ddu - hanes yr olwyn ddŵr,' T.C.H.S., Vol.47, pp.97-107; and Syson, L., (1980), The Watermills of Britain, (Newton Abbot), passim.

12. Present author's field-studies, augmented by information per Dr M. J. T. Lewis. Only one suspected example of an undershot wheel has been discovered, being powered by the river Llyfni near the outlet of the Nantlle lower lake [C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), plan appended to that annual report of the Carnarvon & Bangor Slate Co. Ltd, in 1868].

13. Jones, G.P., (1987), 'The Gwernor Slate Quarry, Nantlle,' T.C.H.S., Vol.48, pp.53-59; A.J. Richards (1995), op.cit., pp.82-83, 199. Originally, one turbine worked the pumps, winding gear and several saw tables at the Gwernor Quarry, but was replaced in the 1890s by three separate pelton wheels, one for each of the functions listed. For a technical description of the applications and design of pelton-wheels, see Gilbert Gilkes & Co. Ltd., Pelton Wheels & Impulse Turbines, (Trade Catalogue, December 1920).

14. C.R.O, XD 35/447. The hydraulic pressure-engine consisted of one or more working cylinders, actuating a directly-coupled force pump, and the machine at Tynyweirglodd needed a supply of 360,000 gallons of water per day.

15. The southern area, immediately below the high Nantlle Ridge, impounded rainfall in deep mountain lakes at Cwm Dulyn and Cwm Silyn. The main northern supply was a single small lake, Llyn y Ffynhonnau, located at the northern foot of Mynydd Mawr, some distance away from the quarries, and fed by springs on the mountainside and by run-off from the surrounding slopes.

16. Present author's fieldwork; ex.info., the late D.R.Jones and G.Roberts, re. water-wheel technology; U.C.N.W., Porth yr Aur 27629, letter dated 20 November 1815, said that the Cilgwyn Quarry had stopped working because it had been overpowered by water, so an additional

water-wheel and pump was to be installed; this would most probably have been the second of the two water-wheels listed in an inventory of 1827 [ibid., Ms 28032]. During the 1820s, a local engineer (John Edwards, of Pen-y-groes, see also Note 22, infra) was able to vastly improve the quarry's water supply by means of a cleverly-graded leat from Llyn y Ffynhonnau to 'Llyn Cob,' a new reservoir [J.Griffiths *Sylwebydd* (1889), op.cit., p.69]. Parts of the system remains in use in connection with the water supply of the Penyrorsedd Quarry and the Cilgwyn landfill site.

17. C.R.O./G.P.Jones Nantlle Mss (uncatalogued), maps of Penybryn Quarry, dated *c.*mid-1880s.

18. C.R.O., X/Dorothea 5, ff.33-35. This equitable distribution of the water from the Kinmel land was a rare feature at Nantlle, and can only have come about because of J.Lloyd Jones' control over the Penyrorsedd and Dorothea quarries during the late 1850s. A Dorothea Company Minute, dated 14 March 1851 [C.R.O., X/Dorothea 1], resolved to construct an aqueduct jointly with the Penybryn Company to obtain the use of the Gelli Stream for the use of both quarries. Jones' own annual profit from the arrangement, being a total charge of £100 per annum each to the three quarries so supplied, minus a nett charge of only £21 per annum for the water rights from the Kinmel Estate, doubtlessly played an important part in the equation, although his own greed brought about the lawsuit chronicled in the above Ms.

19. Loc.cit.

20. G.P.Jones (1987), <u>The Gwernor Quarry</u>, op.cit., pp.67-73. The Gwernor Quarry proprietors realised they held a valuable asset in their water rights and tried to gain an inflated price of £24,000 for their interests, which collapsed the negotiations. A metal mining Company then arrived on the scene to claim a share of the water, and complicated matters for all parties. Much of the difficulty stemmed from the often vague wording of quarry leases when dealing with water rights, and the insecure tenure on supplies derived from sources external to the lessor's property.

21. Loc.cit; C.R.O., X/Dorothea 1488, cuttings from the <u>Carnarvon & Denbigh Herald</u>, July 1907; C.R.O., XD 35/450.

22. U.C.N.W., Porth yr Aur 29523, letter dated 15 May 1802; John Griffiths *Sylwebydd* (1889), op.cit., p.15, described the unique water engine at Cloddfa'r Coed (which was made by John Edwards of Penygroes, see Note 16, supra), as having three inter-geared 15 foot

diameter water-wheels in a vertical tandem arrangement, with the pump drive being taken off the middle wheel.

23. Water rights remain important and, for example, those over the land south of the river Llyfni have been retained by the successive owners of the Dorothea Quarry despite the sale of these properties in the 1980s.

(v). Steam Power

24. J.Lindsay (1974), op.cit., p.154; U.C.N.W., Porth yr Aur 29479, 29480 (partnership deed of July 1812, when the engine was already in existence). The alleged date of erection of the engine (1807) given by John Griffiths *Sylwebydd* (1889), op.cit., p.12, can probably be primarily attributed to an essay dated 1877 by John Hughes *Alaw Llyfnwy* [U.C.N.W., Nantlle 1, f.102], although the origin of the information almost certainly was an oral source. This 'No.1' engine, assumed to have been had a vertical cylinder and a reciprocating beam by virtue of the date and of its purpose, was probably purchased because of problems with the water supply to the quarry water-wheels (discussed in Sub-section a.iv).

25. U.C.N.W., Porth yr Aur 29486; Williams, R., (1899), 'Hunangofiant Chwarelwr, I,' Cymru, XVII, p.55. The 1807 engine plus two whimseys was undermined by a landslide on 16 August 1817 in the aftermath of a storm, and was destroyed by its 60 yards fall to the pit bottom. The engine ['No.2'] listed in subsequent sale particulars of the quarry was a replacement. See Note 34, infra., for a further discussion on this engine.

26. John Griffiths *Sylwebydd* (1889), op.cit., p.52; R.Williams, 'Hunangofiant Chwarelwr, III,' Cymru, XVIII (103), Chwefror 1900, p.131

27. See also Notes 29, 33, 34, 161 infra.

28. Estimated by the author

29. For a technical account of the use of steam power in the quarries, see C.Le Neve Foster, (1910 ed.), A Treatise on Ore and Stone Mining, op.cit., pp.479-481; Jones, G.P., (1985), 'The Nantlle Slate Quarries,' Stationary Power, No.2, (Journal of the Stationary Engine Research Group, latterly the International Stationary Steam Engine Society), pp.14-41. For summary details on steam power see Hills, R.L., (1989), Power From Steam, (Cambridge University Press). passim; and W.F.Greaves & J.H.Carpenter (1969), op.cit., pp.57-71.

30. Although sale notices and summaries of the plant & machinery offered for sale can be found in contemporary local newspapers and sometimes in The Mining Journal, the only complete catalogue for a dispersal auction in a Nantlle quarry during the nineteenth century is that for the Penybryn Quarry in 1891 [Clwyd Records Office, Hawarden, D/DM/244/82].

31. See Shearman, L.R., (1986), Portable Steam Engines (Shire Album No.163), for details of this type of plant. An analysis of the cost of engines purchased by the Dorothea Company, from plant acquisition lists [C.R.O. X/Dorothea 612, 614], shows a considerable variety of types, sources and prices. A new 25 h.p. fixed engine plus boiler cost from £260 (in 1862) to £360 (in 1869), whereas in 1880, a typical semi-portable 25 h.p. engine cost £360. A second-hand 25 h.p. winder bought in 1884 for £125 and not retired until 1957 illustrated the bargains available in used plant. The cost of boilers varied with their design and size, but a new 27 ft X 6 ft diameter Cornish boiler at £137 in 1860 was typical for this period. The price of multitubular boilers at £165 for a horizontal unit in 1899 and £140 for a vertical one in 1883 shows a consistency in costs in a low-inflation economy, but they were over twice the price of second-hand boilers (selling at £60 to £80 in 1889 and 1895, respectively), although the risk of potentially disastrous unseen faults in this used plant was high.

32. G.P.Jones (1985), Stationary Power, loc.cit. The remains of the Penybryn engine are now at the Welsh Slate Museum, Llanberis.

33. See Notes 24-25, supra; John Griffiths *Sylwebydd* (1889), op.cit., pp.14, 41, refers to the relocation of the Cloddfa'r Coed (No.2) engine at the Talysarn Quarry, this apparently being *in situ* in 1889. On the basis of the circumstantial identification of its house in a photograph [see Note 34, infra], this appears to have been a relatively large beam engine.

34. For technical details of Cornish beam engines see Crowley, T.E., (1986), Beam Engines, (Shire Album 15), passim; and Hills (1989), op.cit., q.v. The ruined house of the Cornish engine at the Coedmadog Quarry survived until 1972, and was partly surveyed by the present author [refs., C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), essay 'Hunangofiant Chwarelwr,' by *Ab Owain* (1927), "Newid Sefyllfa"; ex.info., eye-witnesses to scrapping]. Details of the Dorothea Cornish Engine can be found in Bayles, R., (1992), 'The Dorothea Cornish Engine,' Bulletin of the International Stationary Engine Society, Vol.14, No.3; and Rees, D.Morgan, (1970), 'Some Aspects of Industrial Archaeology in Wales', Transactions of the Hon. Society of Cymmrydorion, 1970, Part II, pp.174-176. At

Dorothea, two force pumps in tandem raised a total of one ton of water a distance of 155 yards on every stroke of the 68 inch engine, which worked on an average of 10 strokes per minute. A large, tall building visible on a panoramic photograph of the Talysarn Quarry *c.*1896 [C.R.O., XS 528/195/15], is likely to have been the then-disused 1817 ex-Cloddfa'r Coed engine [see Note 33, supra], because the new plant which had been installed *c.*1870 [C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Annual Reports of the Carnarvon & Bangor Slate Co. Ltd] must almost certainly have been the horizontal pumping engine that was recorded here in 1886 [C.R.O., XM 623/351].

35. C.R.O., XD 35/ Mss 425, 436 passim (Cilgwyn inventories); ibid., X/Dorothea Mss 612, 614; ibid., G.P.Jones/Nantlle, Penyrorsedd Quarry Mss (uncatalogued).

36. A.J.Richards (1995), op.cit., pp.84-85. The opening of the Nantlle Railway in 1828 had an important secondary effect of reducing the cost of transporting coal to the valley from the port of Caernarfon, from an estimated cost by carting of probably near 10*s.* (50p.) per ton to about 2*s.*3*d.* (11½p.) per ton. See Chapter 5, infra., for a fuller discussion of this topic.

37. C.R.O., X/Dorothea Ms 5, ff.53, 99, 103, 107; ibid., Ms 76. In 1896, the price of South Wales coal, delivered to Nantlle station, was 9*s.*3*d.* (48p.) per ton, and North Wales coal was at 7*s.*(35p.), but both had advanced to 22*s.* (£1.10) and 11*s.*3*d.* (58p.) respectively, by February 1900. In 1912, the costs had advanced respectively to 23*s.* (£1.15) and 17*s.*3*d.* (78p.) per ton, and by 1914, North Wales coal was 18*s.*9*d.* (94p.) per ton, delivered.

38. The closure on a large-scale working of steam-powered quarries, chronologically from 1908 to 1938, were of :- Coedmadog (1908), Tyddyn Agnes (1909), Braich (1911), Fronheulog (1911), Cloddfa'r Coed (1913), Tanrallt (1913), Ty Mawr West (1928), Talysarn (1930), Galltyfedw (1931), Ty Mawr East (1931), Penybryn (1932), and South Dorothea (1937).

39. C.R.O., X/Dorothea 5, f.53; ibid., Mss 76, 613, 1424. The quoted coal consumption costs for the whole quarry in 1938 was £196 per month, and if it is assumed that this referred to standard quarry months, then multiplying by 13 gives an annual average cost of £2,600. Steam winders used 6 tons of coal per month on average.

(vi). Internal combustion engines

40. These were the first internal combustion engines, developed initially by Lenoir (in France) in 1860, but not manufactured on a large scale until improved by Otto (of Germany) in the 1870s. The first U.K. version was built under licence by Crossley Bros (of Manchester) by the late 1870s. For further details see Kennedy, R., (n.d.), 'Gas Producers,' The Book of Modern Engines, Vol.V, (London); W.F.Greaves & J.H.Carpenter (1969), A Short History of Mechanical Engineering, op.cit., pp.80-81.

41. C.R.O., X/CV 383, XD/21/111-112, XM/1771, XM/2474/4, XM/6088/458, XM/6277, re. the Nantlle Vale Gas Company.

42. See Kennedy op.cit., pp.151-161 for technical details of gas engines; also Wrangham, D.A., (1960), Heat Engines, (Cambridge University Press), pp.560-583.

43. Ex.info., Mr Idris Phillip Jones of Penygroes, describing the gas engine which he had driven at the Llwydcoed Quarry in the 1920s.

44. C.R.O., X/Dorothea 1046. The cost in fuel of running saw tables at the steam powered Penybryn & Dorothea mills varied from £23.7*s*.6*d*. (£23.37½) to £25.7*s*.5*d*. per annum, respectively, but the figure was only £14.18*s*.11*d*. (£14.95) at the gas-powered South Dorothea mill.

45. Ex.info., Mr Idris P.Jones, op.cit. See also Note 71, infra.

46. Ibid. Mr Jones had also driven the Tynyweirglodd engine in the 1930s; ex.info., his former stoker, the late Hugh Davies; the late D.R.Jones (electrician at the Alexandra Quarry in 1920s, recalling the reminiscences of older employees, pre-1912); and the late Gwilym Roberts (recalling his period as an apprentice blacksmith at the Blaen Cae/Talysarn Quarries in 1920s and subsequently as the assistant blacksmith at the Galltyfedw Quarry in 1926-31).

47. Ex.info., G.Roberts, op.cit.

48. Ex.info., Idris P. Jones, op.cit. The Alexandra engine had the shortest life-span of all the gas engines at Nantlle, being disposed to an undisclosed fate following the electrification of the quarry plant in 1912. The South Dorothea engine was replaced by a diesel in 1933, and that at Tynyweirglodd in 1941. In both of the latter cases, it is believed that the gas plant was scrapped, as was definitely the fate of the plant at the disused Blaen Cae and Llwydcoed quarries in the mid-1930s.

49. For technical details, see W.F.Greaves & J.H.Carpenter (1969), A Short History of Mechanical Engineering, op.cit. pp.82-83. The

petroleum (or 'Petrol') engine was a development of the gas engine, specifically designed to be mobile.

50. Ex.info., Mr Lefi Jones (Dorothea Quarry plant fitter), who privately maintained the plant in several small concerns. See Note 114, infra.

51. Ibid.

52. Ibid; and ex. info., the late Gwilym Roberts, op.cit. Both of these informants had experience of constructing lightweight powered cableways of varying designs. Information from other ex.info., sources described a number of these types of cableway. For instance, at the Tanrallt Quarry (*c.*1949), a stationary ex-army lorry having a hauling winch, was used to raise material from the pit, but at Cloddfa'r Coed Quarry (*c.*1939-*c.*46) and at Singrig Quarry (in 1957-58) there was a simpler system consisting of an Austin Seven Saloon car mounted on a plinth, with the winding cable being wound around a tyreless rear wheel. A more complex system used by David Oliver Owen, subcontractor at the Faengoch Pit, Cilgwyn Quarry *c.*1930, was recalled by Gwilym E.Owen, his son, as utilising the remains of the local butcher's crashed Chevrolet delivery van. The van engine and gearbox was bolted onto a plinth and a pinion gear, welded onto the shortened vehicle prop-shaft, engaged a light cable-winch in a double-reduction gearing to cope with the load of about one hundredweight. The present author used these principles to construct a temporary cableway during attempts to salvage the diesel excavator from the Dorothea Pit in 1973.

53. Ex.info., the late Idwal Hughes, manager of the Tynyweirglodd Quarry, 1941-53.

54. See W.F.Greaves & J.H.Carpenter (1969), <u>A Short History of Mechanical Engineering</u>, op.cit., pp.84-85. Crude Oil Engines, were the ancestors of the modern Diesel Engine. They dated from the 1890s and were based on a number of individual prototypes, of which the British 'Ackroyd Stewart' and the German 'diesel' were the main precursors; C.R.O., X/Dorothea 1046, gives data for the cost of the South Dorothea diesel-powered saws at £8.4*s.*8*d.* (£8.24) each per annum, compared with an average £21.0*s.*4*d.* (£21.02) at the Dorothea steam mills.

55. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry papers, plant inventory dated 1907.

56. C.R.O., X/Dorothea 1278, Gwernor Quarry inventory.

57. Ex.info., Mr Lefi Jones, op.cit., recalling his period as a quarryman at the Fronheulog Green Quarry during the late-1920s.

58. Anon., (1937), 'Increased Efficiency in Slate Quarrying,' The Oil Engine, Vol.5, mid-August issue, pp.126-127; C.R.O. X/Dorothea Mss 1046, 1484.

59. C.R.O., G.P.Jones Nantlle MSS/Crown Quarries (uncatalogued), machinery lists; ex.info. Idwal Hughes, op.cit.

60. Ex.info., H.Davies, W.H.Humphreys, Lefi Jones, and G.Roberts, op.cit., re. plant at Brynfferam, Fronheulog Green, Tanrallt, Twll Coed, Twll Llwyd and Ty Mawr East.

(vii). Electricity

61. For technical details see W.F.Greaves & J.H.Carpenter (1969), A Short History of Mechanical Engineering, op.cit., pp.85-87.

62. J.Lindsay (1974), op.cit., pp.158-162; A.J.Richards (1995), op.cit., pp.155-157. The original generator at Llechwedd Quarry was powered by a water-turbine as an experiment to assess the uses of electricity. Because of its limited output, the plant could only supply a 110 volt lighting circuit, and an experimental electric rock-drill. At a later date, a pair of large pelton-powered D.C. generators was installed at Pant-yr-afon (being still in use), and the whole of the quarry plant electrified [see Jones, Ivor Wynne, (1986), Eagles Do Not Catch Flies; The Story of J.W.Greaves & Sons, (J.W.Greaves & Sons Ltd), pp.9, 19].

63. C.R.O., X/Dorothea Mss 5, 1345, 1391, and 1424.

64. C.R.O., X/Dorothea 1345.

65. C.R.O., X/Penyrorsedd Addit.1875, Minutes 17 December 1902 and 13 May 1903.

66. 'Electrification and the Manufacture of Slate,' North Wales Express, 16 July 1902. See also Note 70, infra. By 1916, the generator was a 3-phase A.C. unit made by General Electric.

67. Ex.info., the late John Morris Hughes, a quarryman at the Talysarn Quarry in the 1890s-1900s, during the period of the electric trial.

68. C.R.O., XD35/424, entry for 2 October 1913, re. Braich Quarry, which was closed, but where an electric pump (possibly powered by an internal-combustion generator set) was at work.

69. Ex.info., J.M.Hughes, op.cit. The Talysarn Quarry experimented with electric winding by driving a D.C. dynamo from a semi-portable steam engine, sending the current three hundred yards to a motor connected to an existing twin double-acting inclined cableway

(requiring some 25 to 30 h.p.). The motor worked satisfactorily under no-load (with the winding drums disconnected), but once loaded to a normal four-ton payload, it refused to function, heated up and stalled the generator. The fault was both in the electrical and mechanical set-up of the trial, suggesting that it was carried out by the quarry engineers, inexperienced in the new technology, and possibly using borrowed or second-hand electric plant, possibly surplus from the Cilgwyn Quarry's conversion to A.C. The Talysarn dynamo was subsequently installed successfully elsewhere in the quarry to power the lights in the owner's mansion.

70. Ex.info., the late D.R.Jones (quarry electrician from the 1920s-60s); C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Crown Quarries papers; C.R.O., XM 923/73, letters dated 24 April 1907, 10 November 1908, and 2 March 1910 in which the quarry agent passed his judgement thus:- "...Electric power, since its introduction here, has proved very uncertain and costly." See also Note 66, supra.

71. C.R.O., X/Dorothea 1636; C.R.O., J.S.Wilkinson, Abstracts of Files of Defunct Companies (in the Public Records Office), The North Wales Green Slate quarry Co. Ltd., of 1896-99 (PRO BT/31/6878/48382) is the most likely concern to have installed the electric plant at Llwydcoed Quarry.

72. Ex.info., Mr Idris P.Jones, op.cit. This neat and efficient power system worked without failure until c.1928, when the quarry closed. It was moth-balled for about a decade, but was obsolete by the time it was unsuccessfully offered for sale to other local concerns, and was consequently scrapped.

73. C.R.O., X/Dorothea 1345.

74. Ex.info., Mr Lefi Jones op.cit.; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Dorothea Quarry papers, technical literature re. the Ferranti Phase Synchrometer and the earlier stroboscopic synchronising system.

75. Raising the voltage after generating allowed the current to be transmitted along a line with reduced power loss; at the other end, it was reduced back to the original or different voltage value. An additional advantage of A.C. was that the motors could have three separate windings, equivalent to having three motors in one, each working a little out of step with the others (under a system known as 'three-phase'), giving more power than the equivalent-sized D.C. rival, but being more complicated, they were more expensive to purchase and more difficult to repair.

76. This concern was set up under the terms of the North Wales Power Act, 1904 and included powers vested in the Portmadoc Beddgelert and South Snowdon Railway Act, 1901 [C.R.O., X/Penyrorsedd addit.99]. For a history of the North Wales Power Co., see Thomas, D.W. (1989), 'Historical Notes on Hydro Electricity in North Wales,' T.C.H.S., Vol.50, pp.87-110.

77. C.R.O., X/Penyrorsedd addit.99, agreement between the Penyrorsedd Company and the Power Company, 6 May 1905; ibid., addit.2321; ibid., addit.100; report of consultant engineers on work of electric contractor, 8 February 1907. The 16 motors cost from £196.10s (40 h.p. rating) to £306 (80 h.p. rating) each, inclusive of gearing, coupling and labour costs, totalling £3,334. The switchgear cost a total of £209 and internal transmission lines cost £1533, giving a grand total of £5,076. The original mains supply was 2,000 volts but this was subsequently raised to 11,000 volts. The quarry sub-station reduced this to 500 volts for internal transmission, with transformers at each cluster of buildings to provide 110 volt lights. Apart from the substitution of an overloaded 20 h.p. motor at one mill for a 40 h.p. unit, the most serious faults with the new plant was that of heavy wear on the original rawhide (silent-running) pinions, rectified by substituting with steel pinions, and of vibrations in the motor armature shafts due to the original bearing being too soft for this application.

78. Dewi Thomas (1989), loc.cit.; C.R.O., X/Penyrorsedd addit.2321.

79. C.R.O., X/Penyrorsedd addit.99, addit.100. The Penrhyn Quarry (Bethesda) was connected to the mains in 1912-13, although this large concern did not create a greatly increased demand on the supply system until after the re-equipping programme of the 1920s. The only new additional quarry customer for the Power Company after the war was the Glynrhonwy Quarry (Llanberis). The inclusion of this quarry must have brought the supply demand on the original Cwm Dyli generating plant close to its maximum capacity, to the probable detriment of all the industrial customers. Fortunately, two of the four generating sets were substituted by more powerful units, so that the supply could be maintained and the customer base expanded.

80. C.R.O., XD 35/422, entry 23 October 1912, re. Alexandra Quarry; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Moeltryfan Quarry papers.

81. C.R.O., X/Dorothea 2 (Minutes, February 1910); ibid., Ms 3 (Minutes, 3 July 1919, 6 December 1919, 3 June 1920, and 17 July 1920); ibid., Mss 1203, 1272, 1275, 1279. Initially, the Power Company

offered electricity at 1.¼d. per unit, but increased this to 1½d. per unit when the quarry load requirement was reduced, but it also demanded a loan of £4,000 from the quarry to pay the construction costs for the transmission mains extension from Penyrorsedd to a new sub-station to be built at the Dorothea Company's cost. In compensation, the quarry would have been allowed a twenty-five per cent discount on the tariff rate during the repayment period, subject to a ceiling of 6 per cent on the principal amount. The proposed Dorothea supply was to have been 3-phase A.C., rated at 500 h.p. capacity, at 500 volts. The cost to the quarry Company for motors and switchgear was estimated at £10,321.

82. The generating system was upgraded in 1952 when electric pumps were installed at Dorothea. The original generator had an insufficient power output to work the new pumps, so a second generator was attached to the air compressor engine outside working hours. Despite the provision of enough current, the pumps experienced starting problems, which was eventually solved by installing starter capacitors, the omission of these from the original specifications being due to the ineptitude of the contractors and inexperience on the part of the quarry.

83. Ex.info., Mr Dafydd Aled Owen, manager of Twll Coed Quarry in the 1970s; witnessed by author.

84. Ex.info., Mr Alan Humphreys, joint-proprietor of Twll Llwyd.

(b). The extraction process

(i). Rock-boring and drilling plant

85. D.C.Davies (1887), op.cit., p.119; E.Jones (1963), op.cit., p.143; A.J.Richards (1995), op.cit., p.48; Williams, M., (1991), The Slate Industry, (Shire Album 268), pp.9-10; Robert Williams, op.cit., Cymru, XIX (109), p.89.

86. The rate of manual drilling was of an order of about 1 inch per five minutes, or 1 foot per hour [experiment by the author, following instructions by the late J.M.Hughes, who had experienced using the jumper in the era before pneumatic drilling]. Thus, an average shot-hole of some six feet depth would take practically a whole working day to prepare.

87. Information from Mr C. Rodney Weaver of Kenilworth, to whom the author is indebted, based on private research into the development of rock drilling technology.

88. This was included in the wide-ranging U.K. Patent No.14165 of 1852 to E.J.J.Dixon and H.J.Dodson. Dixon, who was involved in slate quarrying at Brynhafodywern (near Bethesda) and at Gorseddau (Cwm Ystradllyn) and a slab works at Bangor, was a prolific inventor of quarry machinery, although much of his work appears to have involved securing rights on technological concepts rather than producing useful machines.

89. Information from Mr Rodney Weaver, op.cit.

90. Ibid. The examples of the distinctive circular tunnels cut by the Hunter borer are at Abercwmeiddiaw Quarry (Corris) and Maenofferen Quarry (Ffestiniog).

91. Ex.info., the late J.M.Hughes, recalling the limited use of mechanical drilling in the Nantlle quarries in the 1890s.

92. Information from Mr Rodney Weaver, op.cit.

93. C.R.O, X/Dorothea 612; Lewis, M.J.T. (editor), <u>The Slate Quarries of North Wales in 1873</u>, (Plas Tanybwlch 1987), p.70; J.Lindsay (1974), op.cit., p.162.

94. Lindsay, loc.cit.; information from Mr Rodney Weaver, op.cit., re. Burleigh's (U.S.A.) patent of 1868 and the first use of the drill in driving the Hoosac Tunnel, Massachussets.

95. Information from Mr Rodney Weaver, op.cit., re. Simon Ingersoll's (U.S.A.) patent of 1871, and the amalgamation in 1886 of the Ingersoll Rock Drill Co., with the Sergent Drill Co.

96. Ex.info., R.Weaver, op.cit; M.J.T.Lewis (1987), op.cit., pp.88-89, describing the Burleigh drill at the Cambrian Quarry, Llanberis.

97. Lewis, loc.cit.

98. C.R.O., X/Penyrorsedd addit.1873, Minute 20 December 1877, that a tender was expected from the Ingersoll Drill Co.; and another dated 13 March 1878, that tunnelling using the Ingersoll drill had not been a practical proposition because of the excessive price of the plant.

99. C.R.O., X/Dorothea 612, 614.

100. Information from Mr Rodney Weaver, op.cit.

101. The only recorded examples that are known at present are at the Cambrian Quarry, Llanberis [see Note 93, supra] and at the Rhos Quarry, Capel Curig [information from Dr M.J.T.Lewis, to whom the author is indebted].

102. C.R.O., XM 4874/6, quoting <u>Q.M.J.</u>, Vol.5, No.1, August 1922. In 1894, a representative of the Ingersoll Sergent Rock Drill Company visited

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In general, (recorded) pump diameters ranged from 8-12 inches, and lifts of up to 120 yards were commonplace. On an average 4 ft stroke, a 10 inch pump could move 2.18 cubic feet of water per stroke, or about 262 cubic feet per hour on an average rate of two strokes per minute. If working for 24 hours, this gave a rough average of 24,000 cubic feet per full day.

153. E.g., at the South Dorothea Quarry [ex.info. the late Gwilym Roberts, op.cit., and the late Ifor Hughes, former quarryman at South Dorothea].

154. At the 130 yards deep Talysarn main pit in 1886, for example, the pumping system consisted of a horizontal engine working a four-lift pump system, made up of three lifts of 10 inch and one of 11 inch pumps [C.R.O., XM 623/351]. By the 1920s, the pumping depth had increased by the opening of at least one new 'sinc', water being raised from this to the main sump by a remote pump actuated from the main system by a wire rope. The main pumps were described as having several lifts interconnected in tandem, working in two parallel counter-balanced systems via heavy timber 'sweep rods.' The rotary motion of the actuating engine was translated into a reciprocating motion of these rods via cranks on a low-speed second-motion shaft. This set-up was typical of steam-powered pumping systems at Nantlle [ex.info., the late Gwilym Roberts, op.cit., apprentice blacksmith at Talysarn Quarry in the 1920s, and the late Richard Humphreys, handyman at that quarry].

155. Technical details of pump actuating mechanisms in the Nantlle district were supplied by Mr Lefi Jones and the late Gwilym Roberts, op.cit.

156. Ibid.

157. Ex.info., Mr Lefi Jones and the late Gwilym Roberts, op.cit; extant quarry inventories, mainly in the C.R.O. Recorded pumping water-wheels were in the size range of approximately 20 ft. to 30 ft. diameter, and from 3 ft to 4 ft. wide, giving a nominal 13 to 26 h.p. output (or 8 to 18 effective h.p.). The last pumping wheel in this area was that at Ellen Pit, Penyrorsedd Quarry, this machine ceasing work c.1940 due to the closure of that section of the workings.

158. A.J.Richards (1995), op.cit., pp.84-85; see also Notes 24-27, supra.

159. Auxiliary steam pumping was possibly first employed at the Cloddfa'r Lôn and Dorothea quarries in *c.*1838 and 1842 respectively, these being the dates of the installation of their first winding engines [see Note 26, supra]. The auxiliary rod-drive to the pumps would

have been connected to a low-speed countershaft geared from the engine *via* a detachable link, similar to that seen by the author on the South Dorothea Quarry steam winder (now scrapped).

160. Few statistics are available, but a rate valuation appeal, dated October 1886 [C.R.O., XM 623/351], gives some insight into the technology in use at some of these concerns. At Coedmadog Quarry, for example, the proximity of the pit to the river gave rise to a particularly heavy inflow of both ground and surface water. The pumping machinery had been a dual-purpose Cornish whim engine, but by 1886 a new large tandem-compound horizontal engine had been installed, working 9-inch pumps in two lifts on a total of 100 yards depth. In addition, a separate 12-inch pump worked by a standard horizontal engine pumped surface water which seeped down into the upper galleries adjacent to the river bank.

161. See Note 34, supra.

162 C.Le Neve Foster, (1910 ed.), A Treatise on Ore and Stone Mining, op.cit., pp.496-505. For example, the relatively shallow Galltyfedw New Pit was pumped in the 1920s by a reciprocating steam 'donkey pump' [ex.info., the late Gwilym Roberts, apprentice blacksmith and occasional pump attendant at that quarry, 1926-30].

163. C.R.O., X/Dorothea 1488, newspaper cutting, 'Electrification and the Manufacture of Slate,' North Wales Express, 16 July 1902; C.R.O., XM 923/73, letter dated 10 November 1908, re. limitations of electric pumps. A steam-powered auxiliary centrifugal pump was in use at the Coedmadog Quarry in 1886 in an attempt to stem the seepage of water from the river into the pit [C.R.O., XM 4874/47, f.8].

164. Ex.info., Mr Idris P. Jones, op.cit., driver of the electric generating plant at the Llwydcoed Quarry in the 1920s.

165. C.R.O., XM 923/73, letter dated 31 March, 3 April, and 28 October 1909.

166. C.R.O. G.P.Jones Nantlle/Penyrorsedd MSS (uncatalogued), technical data. This pump is now at the Gloddfa Ganol slate museum, Blaenau Ffestiniog.

167. C.R.O., XD 35/447.

168. C.R.O., XD 35/425, 436 (Alexandra Quarry inventories). Information on the 'Roturbo' pumps was kindly supplied by C.R.Weaver, op.cit.

169. Russell Bayles (1992), op.cit.; ex.info., Mr M.J.B.Wynne-Williams (former managing director, Dorothea Quarry), Mr Lefi Jones, (former

plant fitter, Dorothea Quarry), and the late Gwilym Roberts, (former blacksmith, Dorothea Quarry).

170. Ex.info., Mr Lefi Jones, op.cit., who had much experience of maintaining and repairing these diesel pumps in the smaller concerns.

171. C.R.O., G.P.Jones Nantlle/Crown Quarries Mss (uncatalogued), inventories & correspondence, re. plant at Cilgwyn Quarry 1932-58.

172. C.R.O., G.P.Jones Nantlle/Penyrorsedd Mss (uncatalogued), technical data. These pumps are extant at the quarry, although now vandalised.

(c). Winding machinery

(i). Paths and steps

173. For a comparison of Welsh and Cornish slate quarrying methods, see Pritchard, D., 'Aspects of the Slate Industry: The History of the English and Scottish Slate Industry,' Q.M.J., March 1945, pp.393-395; Williams, M., (1991), The Slate Industry, (Shire Album 268), passim. See also Note 147, supra.

174. Robert Williams, op.cit., Cymru, XIX (109), p.88; J.Griffiths *Sylwebydd* (1889), op.cit., p.14; C.R.O., XM392/1, ff.16-17; U.C.N.W., Nantlle Ms 1, f.101.

175. These concerns were short-lived scratchings on a very small scale, where even the most primitive technology was not applied due to constrained costs or short-term occupation, e.g., D.A.Owen & partner, scavenging at Tanrallt (Plas Du) Quarry for six months c.1935 (when nominally unemployed), worked a rock pillar at the south-eastern corner of pit, and carried their finished slate up ladders to the surface for carting away [ex.info., Mr D.A.Owen].

(ii). Unguided vertical hoisting

176. See C.Le Neve Foster, (1910, 10th ed.), A Treatise on Ore and Stone Mining, op.cit., p.412. The term implies a tree that turned, i.e., using part of a tree trunk as the body (or drum) of the windlass. Contemporary illustrations of the mining windlass [e.g., Bick (1982), op.cit., p.54] show a simple barrel supported in a frame, having a cranked handle (arranged in opposition) at each end of the barrel axle. In a mine, the hemp rope wound onto the barrel passed over a pulley set high on a simple headframe over the shaft, but a means of hoisting over the edge of a precipice was needed in a quarry.

Illustrations of the open cast copper workings at Parys Mountain (Anglesea) show that the windlasses were mounted on timber platforms cantilevered over the lip of the pit, with the vertically hoisted load apparently passing up onto the platform through a trap-door.

177. Robert Williams, op.cit., Cymru, XIX (109), p.88. He described the quarry turntree as having a windlass mechanism similar to that above [Note 176, supra], but fixed onto horizontal timbers and set well back from the lip of the quarry. There were two counterwound hemp ropes leading from the barrel over individual grooved pulleys, each mounted at the head of a timber beam projected out over the quarry lip, and supported by a common simple vertical timber frame.

178. Loc.cit. The quarry kibble was described as an iron bucket with a hinged drop bottom (for rapid unloading into barrows or carts), being identical to that used in metal mining.

179. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Dorothea Quarry plant & machinery records.

180. See C.Le Neve Foster, (1910 ed.), A Treatise on Ore and Stone Mining, op.cit., pp.412-413; Major, J.K., (1985), Animal Powered Machines, (Shire Album 128), pp.11-17; D.Bick (1982), op.cit,. illustration, top of p.60. One particularly fine example of a whim circle at a copper mine can be seen at Brynfelin (Beddgelert).

181. C.R.O., XM 392/1, f.17, suggested that the first whimsey in Nantlle dated from the beginning of the nineteenth century, but the first extant primary reference is to the erection of one at the Cilgwyn Quarry in 1814 at a cost of £70 [U.C.N.W., Porth yr Aur 27447]. Robert Williams, loc.cit., described the headgear used in conjunction with the quarry horse whim in the 1820s as incorporating a pair of crane-type swinging derricks, one for each of the counterwound hemp winding ropes. Thus, the load was suspended well clear of the quarry side wall when being hoisted and could be conveniently swung in onto the quarry bank at the top of the lift. With regards to the numbers of whims used in individual quarries, little information is available except in the case of the principal concerns. The Cilgwyn Quarry had five whims by 1821 [Porth yr Aur Ms 27465], and at Cloddfa'r Coed Quarry there were nine whims in the 1820s [ibid., Ms 29694]. Unfortunately, as a result of later developments, almost no physical remains of horse whims survived into the present century, but one possible whim headgear base (now demolished) could be tantalisingly seen at Cloddfa'r Coed up to 1978, but could not be examined in great detail due to its dangerous

location. The only surviving whim circle found to date at any North Wales slate quarry is that at Hendre Quarry, (Blaenau Dolwyddelan).

182. This derrick crane served the new 'sinc' in the Cilgwyn New Pit during the 1930s, and is shown in contemporary photographs in the possession of the author.

183. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), annual reports of the British Slate Co, Ltd., 1860s. The 'Scotch derrick [sic]' was used in several slate-slab quarries in North Wales, and derelict examples remain at the Hafodlas (Betws y Coed) and Aberllefenni quarries.

(iii). Guided vertical haulage

184. North Wales Chronicle, 12 June 1828 & 8 January 1829, sale adverts of 'Hafodlas' Quarry [sic] included "guide ropes" in list of plant; J.Griffiths *Sylwebydd* (1889), op.cit., p.21; Robert Williams, op.cit., (Hunangofiant Chwarelwr, I,' Cymru, XVII (of 1899), p.57. The Talysarn water-balance hoist of 1829 worked in a shaft sunk relatively close to the main quarry pit, to which it was connected by a tunnel. There was one load cage and a counter-balanced water tank operating in the shaft, which must have been separated into two vertical hoisting runs by timber guides. The cage and tank were connected by a chain running over a braked overhead drum (set in a headgear), and worked in opposition. When filled with water, the tank was heavier than the cage plus slate load, and thus descended under the control of the brakesman, lifting the load to the surface, with the return journey of 'empties' being made with the tank empty. This technology was already well established in the coal industry prior to its installation at the Talysarn Quarry by an English joint-stock company, having several coal mine owners as its shareholders, and Benjamin Smith, its general manager, was probably the first qualified engineer associated with a Nantlle quarry.

185. C.R.O., X/Penyrorsedd addit.1873, Minutes dated 21 March 1864, 10 March 1865, 1 September 1865 (tenders), 20 October 1865, 3 February 1866, November 1867 (order from De Winton), and February 1868 (completion); see point 'No.1' in the opening statement of J.Menzies, in the Report of the Home Office Quarry Committee of Enquiry, 1893, (H.M.S.O., 1894) [U.C.N.W., Welsh Library KF 165], p.21, plus evidence of the 1:2,500 O.S. 1st and 2nd ed. (1889, 1899) maps, re. the Alexandra Quarry lift, which had been totally quarried away by 1899. The two examples at Ffestiniog were in the Rhiw (Welsh Slate) Quarry and the Rhiwbach Quarry (above Penmachno). A photograph of the Penrhyn Quarry lifts in M.Williams (1991) op.cit., p.22, is typical of the surface arrangements, and a diagram

in Isherwood, J.G., (1980), Candles to Caplamps: The Story of Gloddfa Ganol, (Author), p.32, shows the technical arrangements.

186. The interpretation of the plant at the Ty Mawr East shaft winder is based on an investigation by the author prior to the infilling of the shaft and quarry.

187. Interpreting the remains at Ty Mawr West has proved difficult, but there appears to have been a steam-powered vertical lift of some description, which was partly in a shaft, with the upper section in the open.

188. A description of the Faengoch Pit (Cilgwyn Quarry) lift can be found in M.J.T.Lewis (ed.), The Slate Quarries of North Wales in 1873, op.cit., p.67.

(iv). Inclined planes

189. Hughes M., (1984), The Archaeology of the Transport Revolution, (London), pp.43-45, 65, re. early canal technology; John Griffiths *Sylwebydd* (1889), op.cit., p.71, describing a steam powered hoist at Cilgwyn in the late 1830s, which was of very low power. By the theory of resolution of forces, a given power source could cope with an increased load if the angle of lift moved towards the horizontal from the vertical. A sloped ramp cut into the quarry side giving direct tramway communication from the surface to the pit bottom was a more advantageous means of haulage for a given horse-power than vertical lifts.

190. J.Lindsay (1974), op.cit., p.61, re. Dinorwic incline proposal, 1788; Dylan Pritchard, 'The Expansionist Period (1790-1877), V,' Q.M.J, July 1944, p.19, is the first reference (of 1822) seen by the present author of an incline inside the Penrhyn Quarry, although their use here must have at least been contemporaneous with the inclines on the exit railway of 1801.

191. The first references to powered inclines at Nantlle was to the erection of a water engine and incline at the Cilgwyn Quarry in 1823 [U.C.N.W., Porth yr Aur Ms 27321], and the listing at that quarry of two "new engines" (post-1812) valued at £540 in 1821 [ibid., Ms 27465]; ex.info., Mr W. H. Humphreys, describing a short incline powered by a hand-winch, which he had constructed and used in tip-contracting operations at the Tynyweirglodd Quarry in the 1950s; the reference to the horse-whim incline was at the Dorothea Quarry in the 1830s [John Griffiths *Sylwebydd* (1889), op.cit., p.39].

192. Waterwheels were being used for haulage in the larger Welsh metal mines at an early date. It is not known when this technology was introduced into the slate industry. See C.Le Neve Foster, (1910 ed.), A Treatise on Ore and Stone Mining, op.cit., pp.413-414.

193. For a complete winding cycle on a single-acting incline, the load (possibly two waggons, of say 5 tons total weight) was raised by filling the large mobile water tank which, when released down its own rail track, pulled up the counterwound loaded transporter car. The tank then had to be emptied to allow the return journey of the transporter plus empty waggons. Local modifications to the standard plant included reducing the run of water tank by using a differential drum system, so as to take account of the siting of individual water feeds and outlet drains, or the tank incline track could be placed on a separate site or orientation for convenience, if required. In the case of the double-acting balance, this had two transporters, each incorporating a water tank. Thus, on each run of the incline, a load ascended and empty waggons descended [this system is illustrated in J.G.Isherwood (1980), op.cit., p.32].

194. An unattributed oil painting of the Dorothea Quarry *c.*1853-*c.*1859 [in the possession of Mr M.J.B.Wynne-Williams] shows a conventional incline which must have been powered by the adjacent waterwheel; C.R.O., X/Dorothea 1559, cross section of Twll Balast ('Balance Pit'), Cloddfa'r Lôn Quarry. At Dorothea, the new incline winch was powered by a water-wheel, which on standard contemporary metal mining practice would have been in almost continuous rotation, with the winch being actuated when required via a friction clutch mechanism.

195. See sub-sections 1 (d) and 1 (f), infra. The first recorded steam incline at Nantlle was that at the Dorothea Quarry, erected in 1853 [C.R.O., X/Dorothea 1, Minute 26 August 1853], and this may have been the one on which the Rev John Jones (the then manager) sustained his fateful accident [see Owen Thomas, Cofiant y Parch J.Jones, Pennod XIII]. This incline was converted to a water-balance in 1857 [ibid., Minute 6 February 1857].

196. In addition to the Dorothea incline (see Note 195, supra), the only other references to early steam-powered inclines at Nantlle were for one at the Faengoch Pit, Cilgwyn Quarry in 1861 [Public Records Office, Chancery Lane, CRES/2/1578], one at the Fron Quarry in 1866 [C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), annual report of the British Slate Co. Ltd., 1866], another at the Cornwall Pit, Talysarn Quarry (later the South Dorothea Quarry) by 1868 [ibid., plan appended to the annual report of the Carnarvon & Bangor Slate Co. Ltd., 1868], and an illustrated description of a twin, double acting

steam-powered incline at the Talysarn Quarry in Engineering, 8 May 1868, [per Mr D. Clayton, to whom the author is indebted]. The most impressive multi-track inclines were those installed in the slate mines at Ffestiniog, two of which (at Maenofferen Quarry) being still in use.

197. O.S. maps, '6-inch' second edition (1899/1900) Caernarfonshire XXI., N.W., and S.W. and complementary 1:2,500 maps; C.R.O., XD 35/526, 543, plans & section of South Dorothea Quarry. See also evidence of W. W. Jones, Questions 1768-1772 re. the conversion of the South Dorothea winder to an incline, in the Report of the Home Office Quarry Committee of Enquiry, 1893, (H.M.S.O., 1894) [U.C.N.W., Welsh Library KF 165], p.45, and that of R. O. Owen, Questions 2702-2706, re. the relative merits of haulage inclines, in ibid., p.63.

198. See M.Williams (1991), op.cit., p.22, illustration of a surface transporter incline. Tip 'second-level' inclines were thus concentrated at quarries such as Cloddfa'r Coed, Dorothea and Talysarn, which had a variety of inclines of single or double acting, having conventional gear or transporters, according to the requirements of individual circumstances. Such inclines were also found in other slate areas, e.g., at Moel Faban and Brynhafodywern quarries (Bethesda). One specific example is worthy of further comment, this being the 'Domen Fawr Incline' at the Cloddfa'r Coed/Talysarn quarry complex, now destroyed by "landscaping." Originally a steam-powered double-acting haulage incline, it was allegedly converted to an 'endless-rope' system. If it utilised wire rope haulage rather than chain, it may have copied the *megryn* system of the '9 Adit,' Rhosydd Quarry, Ffestiniog [see Lewis, M.J.T., & Denton, J., (1974), Rhosydd Slate Quarry].

199. O.S. maps, '6-inch' second edition (1887/1900/1913-15) Caernarfonshire XXI., N.W., and S.W. and complimentary 1:2,500 maps.

200. See Stanier, P., (1995), Quarries of England and Wales: an historic photographic record, (Truro), p.115; M.Williams (1991), op.cit., pp. 16, 21.

201. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry documents.

202. Ex.info., the late Idwal Hughes (Tynyweirglodd Quarry manager, 1941-53).

203. In a 'gravity incline,' the force imparted by gravity on a descending waggon pulled up an empty one. At Nantlle, gravity inclines carrying slate rock from upper floors down to a mill were

only found at Alexandra, Galltyfedw, Moeltryfan, Penybryn, Penyrorsedd and Talysarn quarries.

204. Author's fieldwork. No examples of gravity inclines using sheaves instead of conventional drums have been found at Nantlle.

205. The 'run through' drumhouse consisted of a pair of parallel walls, one on either side of the rail to the lip of the incline. The winding drum was placed at right angles to the walls, high above the track, with one axle bearing set on a horizontal timber baulk on top of each of the parallel walls. The 'remote drumhouse' (found locally at Moeltryfan Quarry only) was a building enclosing a drum, placed at any convenient location other than where a 'run-through' drumhouse would have been sited. The 'underground drum' (locally at Penybryn, Floor 1/2 incline only) had the drum located in a pit immediately behind the lip of the incline. The Nantlle inclines were either 2 ft gauge for internal transport or exiting to the 'Welsh Highland' Bryngwyn branch line or down to a road vehicle loading dock, or were 3ft 6inch gauge for access links to the Nantlle Tramway (see Chapter 5, infra). Some inclines were dual-gauge for Nantlle access and for internal transport links.

206. E.g., at the Talysarn Quarry, where the author saw three inclines still virtually complete in the mid-1960s, these having been retained after the scrapping of the plant in the late-1930s for the use of contractors up to the late-1940s.

(v). Aerial cableways

207. J.Griffiths *Sylwebydd* (1889), op.cit., p.52; information per Dr M. J. T. Lewis, op.cit.

208. C. R. Weaver (July 1979) 'Blondins,' (Privately circulated, unpublished), notes on chain inclines, ff.1-2; C.R.O., X/Dorothea 1563, section showing the Cloddfa'r Lôn chain incline; information per Dr M.J.T.Lewis regarding the Delabole Quarry, correcting M. Williams (1991), op.cit., p.21. Whereas the majority of recorded chain inclines were steam powered, those at the Killaloe Quarry in Ireland [Note 216, supra] were worked by horse-whims and that at the Bryneglwys Quarry, Abergynolwyn, by waterwheel [see Holmes, A., (1986), Slates from Abergynolwyn, (Gwynedd Archives Service), pp.47-48]. The latter was installed by Robert Williams, former manager of the Penyrorsedd Quarry (Nantlle), which appears to have had a similar unit under Williams' management.

209 Hypothesised by the present author from verbal evidence supplied by former quarry engineering staff and haulagemen.

210 Ibid.

211. Technical data from C.R.O., X/Dorothea 612, 614; 1272; ex.info., the late Gwilym Rowlands, and the late Gwilym Roberts, referring to the continued use of chains at the Talysarn Quarry only, until its closure in 1924, in contrast with the use of wire rope elsewhere. Wire ropes were first used in connection with mine haulage in the Hartz Mountains in 1834 [C.Le Neve Foster, (1910 ed.), A Treatise on Ore and Stone Mining, op.cit., pp.425-427]. The triple chain incline was at Pit 'B' of the Dorothea Quarry; the quadruple chain incline was at the Coedmadog Quarry [ex.info., the late Gwilym Roberts; photographs C.R.O., XS 1412/105, 106, 108].

212. See sub-section a (v), supra.

213. E.g., the rate of adoption at Dorothea, shown in C.R.O., X/Dorothea Mss 1, 612, 614.

214. See O.S. maps, '6-inch' second edition (1887/1900/1913-15) Caernarfonshire XXI., N.W., and S.W. and complimentary 1:2,500 maps. The deepening of the pits and lack of tipping space made the use of aerial haulage up to the upper banks increasingly desirable.

215. C.R.O., X/Dorothea 1563; illustrated booklet of the Angers Slate Quarries, Commission des Ardoisieres D'Angers, (G.Larivière & Cie.), 9 Juin 1895, ff.1-4, per Mr Elfed Williams, Oakeley Quarry manager; author's fieldwork supplemented by ex.info. sources.

216. Siobhan DehOir, "A Welsh Quarryman's Grave at Castletown Arra, Co. Tipperary," North Munster Antiquarian Journal/Irisleabhar Seandáluíochta Tuadh-Mhuman, Vol.XXX (1988), p. 36, plate from George Wilkinson, Practical Geology and Ancient Architecture of Ireland [London, 1845]. Also John Smith's painting "Glynrhonwy Quarry", n.d., National Museum of Wales, Cardiff. The author is indebted to Dr Dafydd Gwyn and Dr M.J.T.Lewis for these sources.

217. Author's interpretation of the above illustrations, supplemented by modelled experimentation of the design.

218. C. R. Weaver, op.cit., passim; ex.info., the late Gwilym Roberts, op.cit., referring to his experience with this plant in service.

219. Second Report of the Royal Commission on Metalliferous Mines and Quarries, 1910-11, (H.M.S.O., 1914) [U.C.N.W., Welsh Library XF 47], p.114; ex.info., the late Gwilym Roberts, describing carriage designs.

220. C.R.O., X/Dorothea 1563 shows a profile of the 1860s Cloddfa'r Lôn headgear design, and its evolution can be charted in photographs (too numerous to list) and in examples, now destroyed, that were recorded by the author in the 1960s and 1970s.

221. Ex.info., the late Gwilym Roberts, op.cit., and others; examples seen by the present author.

222. For a contemporary view of the advantages of inclined cableways over vertical shaft haulage, see the evidence of T. H. Griffiths, Questions 1256-1264 in the Report of the Home Office Quarry Committee of Enquiry, 1893, (H.M.S.O., 1894) [U.C.N.W., Welsh Library KF 165], p.36. With regards to blondins, see C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry engineering records, and the photographs C.R.O., XS 1412/114-115, which record the first blondins erected in the district and in the industry. The secondary role of the Alexandra Quarry is assumed from circumstantial evidence.

223. Second Report of the Royal Commission on Metalliferous Mines and Quarries, 1910-11, (H.M.S.O., 1914) [U.C.N.W., Welsh Library XF 47], p.114; C. R. Weaver 'Blondins' op.cit., ff.3-5.

224. Recorded typology attributable to the present author; the rarer inclined blondin [ex.info., the late G. Roberts, op.cit., re. the pair at the Galltyfedw Quarry] was similar to the cableways used in the Scottish granite quarries [see C. Le Neve Foster (1910 ed.), <u>A Treatise on Ore and Stone Mining</u>, op.cit., pp.432-433], and was almost identical to one at the Easdale Quarry [ibid., p.434], but incorporated novel features designed by the local engineer who erected the first of the pair about 1900.

225. Ibid. For example, the isolation of Dorothea Pit 'D' from the surface transport system in the 1870s by a landslide, forced the tramming of its quarried material via tunnels into adjacent pits for uphaulage, an awkward system alleviated when by a blondin erected in 1901.

226. First Report of the Royal Commission on Metalliferous Mines and Quarries, 1910-11, Vol.I, (H.M.S.O., 1912) [U.C.N.W., Welsh Library XF 47], evidence of A. W. Kay Menzies, Question 7445, p.219; ibid., Vol.II, evidence of W. J. Griffiths, Question 11,272, p.40. With regards to costs of purchase, the Henderson blondin purchased by the Dorothea Quarry in 1901, for example, cost £1,388, and a tender for another in 1921 was £2,390 [C.R.O., X/Dorothea 626, 1484, 1276]. For the price of the timber, wire ropes and some simple technical modifications, a clever engineer could convert an existing winding engine to work a blondin, which could itself be manufactured out of recycled parts of redundant inclined cableways, e.g. at the Galltyfedw and Talysarn

quarries, described in detail to the author by the late G.Roberts, op.cit. One idiosyncratic set-up worthy of mention was the 'blondin dragline' erected at the Moeltryfan Quarry in the late-1930s, where a disused blondin was re-erected over an inaccessible unstable rock face, with the plant being provided with a large ship's anchor for dragging down the dangerous boulders [ex.info., the late Walter Riley, former director of the concern].

227. C.R.O., X/Dorothea 880, letters dated 10 November 1902 and 17 February 1903.

228. Details from machinery records, C.R.O., X/Dorothea 612, 614. There are sufficient differences in the near-identical design (originally the Henderson Patent of 1875) of the products of these manufacturers to allow an identification of the source to be made, where sufficient archaeological features remain.

229. C.R.O., X/Dorothea 1285; the self-tipper would have added an extra £135 to the price, but in the event, a home-made inclined blondin was erected (see Note 224, supra).

230. Ex.info., the late Gwilym Roberts, op.cit., who had made it in the late-1930s.

231. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry, engineering and managerial records, 1960s; the equipment was *in situ*, but out of use when inspected by the author *c.*1970.

232. The Dorothea 'Ratcliffe' steam winder, quarry No. 'C 10', colloquially named "Injian Ol" (after the late Oliver Hughes, its long-serving driver) was the last of the deep-pit type inclined cableways working in the industry.

233. Ex.info; author's recollections; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Dorothea Quarry engineering records; ibid., Crown Quarries papers, Moeltryfan Quarry records. This equipment was recorded by the author just prior to its scrapping in 1972 and 1970, respectively. See also Chapter 5, infra.

234. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry files. See also Chapter 5, infra.

235. Due to the theft of the copper wire in the bell-telegraph system, the control of the operation of the 'E' blondin that was raising the salvage loads had to be conducted verbally, using a chain of three men, of which the author was the last, standing at the winder-house door.

(d). Processing machinery

(i). Slab processing

236. M.J.T.Lewis, 'Early Sawing at Ffestiniog and Beyond, V.1, 1986,' (unpublished privately-circulated discussion paper).

237. Ibid., and fieldwork of the present author. The dates of the earliest recorded slate-slab gravestones discovered are, chronologically, Llanllyfni 1720; Llanfrothen 1729; Ffestiniog 1775, Maentwrog 1777, Llandecwyn 1778, Llandegai 1782, and Llanddeiniolen 1784.

238. Author's survey of tombstones in the Nantlle district. Despite being in a similar hand, the secondary inscription of 1758 on the Llanllyfni 1720 memorial is not of an identical style to the primary script, thus confirming that the stone was laid soon after the first interment.

239. M.J.T.Lewis, loc.cit.; A.J.Richards (1995), op.cit., pp.72-73; M.Williams (1991), The Slate Industry, op.cit., p.17, photograph of sand-saws at the Delabole Quarry, Cornwall. In these machines, the slab remained stationary below reciprocating blades which could be spaced at varying distances within the tension frame, to alter the thickness of finished slab. The reciprocating motion of the blades across the stone was achieved by simply swinging the frame to and fro manually, or via a crank from a power source, the latter being a development dating from the mid-eighteenth century.

240. Richards, Rt.Rev.Gwynfryn (1970), 'Crefftau a Diwydiannau Dyffryn Nantlle a Phlwyf Llanllyfni yn Fwyaf Arbennig,' T.C.H.S., Vol.31, pp.116, 120.

241. Ibid; M.J.T.Lewis, in 'Chwarel y Diffwys to 1800, V.3, November 1986,' (unpublished privately-circulated discussion paper), refers briefly to David Hughes, of Tregrwyn Llanllyfni, as the father of Owen David, who was probably the first slate-slab cutter at Ffestiniog, after 1776.

242. Tregrwyn farm (at approximately SH 494527) abutted the outflow of the river Llyfni from the lower Nantlle lake, and was thus a convenient site for a water-powered mill and also to receive the produce of the early quarries at Cloddfa'r Coed (two fields distant) and Cloddfa'r Lôn (then accessible boat on the lake), the latter's distinctive grey-green slabs being popular for early burial memorials at Llanllyfni.

243. Eames, W.J., 'Seion, Tal-y-sarn', Llawlyfr Undeb Dyffryn Nantlle a'r Cylch, Undeb yr Annibynwyr Cymraeg ym Mhenygroes Mehefin 10-13, 1968, gol. W.J.Eames, p.15, re. 'Capel y Ffactri, (at approximately SH 496533), of which nothing now remains.

244. This building (at SH 472525, but now demolished) could only be inspected externally by the author due to its then dangerous condition. This and Note 243 supra., would have been contemporary with the earliest slab sawing described by M.J.T.Lewis, op.cit., at Diffwys Quarry, Ffestiniog (1776); with powered mills at Rhydysarn, Ffestiniog (*c.*1802); Felin Fawr, Penrhyn Quarry (1803); and Turner's mill, Dinorwic Quarry (1816).

245. A.J.Richards (1995), op.cit., pp.65-66.

246. J.Griffiths *Sylwebydd* (1889), op.cit., p.40; and Robert Williams (Dorothea slab mill attendant 1849-50), 'Hunangofiant Chwarelwr IV,' Cymru, XVIII, (1900), p.171. Photographic and cartographical evidence suggests that the Dorothea slab mill was a rectangular building having tall gables in the longer north and south side-walls. The plant by 1864 consisted of two saws (probably reciprocating) and one planer powered by a water-wheel [C.R.O., X/Dorothea 935]. The production of slab at Dorothea was contemporary with a batch of similar mills [listed by M.J.T.Lewis, op.cit.] erected at the Talyllyn Slate Co., Corris (by 1836); Portreuddyn, Tremadog (1839); Welsh Slate Co. (1842) and Matthews (1842) quarries, Ffestiniog; Maes y Gamlan, Dinas Mawddwy (by 1845), Pant yr Ynn, Ffestiniog (1846); and Dinorwic (1849).

247. The Glandwr mill (at SH 504558, now demolished) had a thirty-foot waterwheel powering several planers and saws [quoting the Carnarvon & Denbigh Herald of July 1855, per Mr D. Clayton, who has published this information in 'An Unrecorded North Wales Quarry Tramway,' Journal of the Narrow Gauge Railway Society, No.128, p.25], with at least one saw being a 'Hunter' [see Note 262, infra., evidence of sawmarks in waste tips]. The mill's location some half-mile downhill from the quarry was the closest convenient site for a water-wheel.

248. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), annual reports of the Carnarvon & Bangor Slate Co. Ltd.; field survey of the site by the author. The parent company of this concern had already erected large slab mills with Hunter and reciprocating saws and planers, at their Cedryn and Cwm Eigiau quarries in the Conway Valley. The Talysarn mill differed in its use of steam power *in lieu* of a water-wheel, for technical reasons, and may not have had sand-saws because the line-shaft drive appears to have been at roof level.

249. C.R.O., X/Penyrorsedd addit.1873, Report 4 February 1868, re. purchase of two slab-saws and steam engine in November 1867; report August 1868 of the ordering of Hunter saw (at £200) and planer (at £100); the latter, by De Winton & Co., survives, and the

former was very possibly from the same manufacturer, made under licence. As originally built, it was a five-bay rectangular, conventionally gabled structure with the western longitudinal side being open, having masonry or timber pillars to support the roof trusses. The gaps between the pillars served as entrances for a number of transverse tramways, this design being similar to some early-nineteenth century quarry mills in the Ffestiniog district.

250. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), annual reports of the British Slate Co. Ltd. The foundations of this building can still be seen on the lower third bank, and its alleged use as an unmechanised slatemaking shed [John Griffiths (1889), op.cit., p.82], probably indicating the abandonment of the original plan, is supported by the lack of any sawn offcuts in the waste tips. However, the 1868 quarry plan appended to the annual reports above, shows another structure, long-buried by the waste tips, which may have been another slab mill.

251. C.R.O., XM 392/1, f.31, records a mill at Cilgwyn Quarry in 1877, this date being 17 years before the first slatemaking mill here [ex.info., former employees of the 1890s]. The older building, which must have been a slab mill by default, was probably the structure appended to a steam winder (both now demolished), the former being a large carpenter's shop by the late 1890s.

252. Concluded by the author from fieldwork prior to the demolition of the remains of this building in 1995. It was a mechanised building with a longitudinal internal tramway and possibly transverse tramways through openings in one side wall, but the power source (water or steam) could not be satisfactorily identified.

253. G.P.Jones (1987), 'The Gwernor Slate Quarry,' T.C.H.S., Vol.48, p.59.

254. Gwynfryn Richards (1970), T.C.H.S., Vol.31, op.cit., p.126.

255. The recorded secondary mills at Nantlle were at Pont Lloc, Nebo (SH 481508); Ty Gwyn, Llanllyfni (SH 473517); Felin Gerrig No.2, Llanllyfni (SH 472525); Water Street, Penygroes (present site of William's Pharmacy); Glanrafon Mill, Penygroes (SH 457 523); Tudor Mill, Grafog, Groeslon (SH 471552); Hafod Boeth, Groeslon (SH 485563); and Bryngwyn, Rhosgadfan (SH 497561).

256. Recorded slab mills at Caernarfon included the Castle Ditch Works (by 1839), the Patent Slip Works (by 1845), and the Glanmorfa Mill.

257. 'Slate Merchants,' Kelly's London Postal Directory, (1876, 1881, 1886)

258. For biographical information about G.E.Magnus, see Chapter 2, Note 18.

259. Kelly's London Postal Directory, loc.cit.; C.R.O., J.S.Wilkinson, abstracts of files of defunct companies, P.R.O., BT31/1920/7894, The Upper Tyddyn Agnes Slate Co. Ltd., of 1873.

260. This topic has not yet been adequately investigated, but the surviving early machinery in the Tudor Mill Groeslon, must be typical.

261. J.G.Isherwood (1980), Candles to Caplamps, op.cit., pp.48-50 (illustrated description); A.J.Richards (1995), op.cit., p.78. Planer patents (not all of which resulted in useable plant) included those to:- J. Hunter (No.6794 of 1835); E. J. J. Dixon & H. J. Dodson (No.14165 of 1852); T. B. Jordan (No.472 of 1853); G. W. Garwood (No.118 of 1855); F. C. Warlick (No.2157 of 1862); G. Hunter & W. F. Cooke (No.2192 of 1866); J. D. Brunton (No.1618 of 1869); E. J. J. Dixon (No.990 of 1881); and one to M. Kellow (*c.*1900, no reference available).

262. Tombstone evidence [surveys by Lewis op.cit., and the author], gives approximate dates for the introduction of circular saws as Ffestiniog (1805); Llanllyfni and Llandegai (1831); Llandwrog (1835/40); and Llanddeiniolen (1838). Saw patents which resulted in useable machines were to J. Hunter (No.913 of 1855) and improvement (No.942 of 1862) incorporating replaceable tools; A. Munro (No.1426 of 1868) was similar; whereas those to A. Searell (No.13790 of 1851); E. J. J. Dixon (No.13087 of 1850) and Dixon & Dodson (No.14165 of 1852) did not. M.J.T.Lewis identified the first practical development of the circular saw to the shipbuilding industry in the late C18th and early C19th, with its introduction to the slate industry being *via* William Turner, the widely-travelled quarry proprietor. The early circular saws had one or more toothed cast-steel saw-blade(s) clamped to a powered axle almost certainly fixed above a travelling load-table, which was fed forwards by means of weights dropping by gravity.

263. Ibid., patent details, Hunter and Munro, op.cit.; D.C.Davies (1887), op.cit., p.126; A.J.Richards (1995) op.cit., p.73; Anon., 'Stone Cutting Machinery, Tyne Harbour Improvement Works,' The Engineer, 14 December 1866, p.473 (illustrated description of the Hunter saw). The Hunter patent was for replaceable steel teeth attached to a powered iron disc, thus providing a versatile and powerful cutting machine. The sawing machine came in two different designs - an early one with an under-table saw - and a more versatile later above-table version in which the number of blades and their spread was adjustable. The Hunter saw was widely used for slab sawing in the North Wales slate industry after 1862, but it has only been recorded in the Nantlle district at Glandwr Mill [see Note 247,

supra], Penyrorsedd slab mill [Note 249, supra], and possibly at the Talysarn slab mill [Note 248, supra].

264. The "Semi-Hunter" was a term used for a heavy duty Greaves saw, e.g., at the Talysarn Quarry in 1891 [C.R.O., X/Dinorwic 1922].

265. See Note 255, supra.

266. See Notes 246 and 253, supra.

267. See Notes 248-250, supra.

268. Evidence of O.S. maps (1889-1915); information of the development of slab mills in Deiniolen, by Jones, D.M., (1868),'Hanes Gwaen Gynfi,' in Traethodau ar Waen Gynfi, (Reprint, 1985), pp.18-20.

269. Of the Nantlle quarries, only Penyrorsedd is known to have continued to process slabs on site, into the early twentieth century.

270. Slab processing restarted at Dorothea and Penyrorsedd in the 1960s and 1970s respectively [ex.info., Mr M. J. B. Wynne-Williams and Mr Stephen Darbishire, op.cit.].

(ii). Slatemaking

271. D.C.Davies (1887), op.cit., p.126; M.J.T.Lewis (1987), The Slate Quarries of North Wales in 1873, op.cit., p.60; A.J.Richards (1995), op.cit., p.76. The only recorded feature of the mechanical slate-splitter designed by Robert Hughes of the Aberllefenni Quarry (a Nantlle man), was its operation by treadle; it is not known to have been used elsewhere, and although its operation was described as "...exceedingly smoothly," it might only have worked on the softer slates found in that district.

272. Ibid., p.86, fn 1; Jones, Ivor Wynne, (1986), Greaves 1836-1986: Eagles Do Not Catch Flies, (J.W.Greaves & Sons Ltd.), p.16. The present author was shown the first French 'Virginie' pneumatic slate splitter trialled in North Wales, at Llechwedd Quarry in the mid-1970s. It appeared to work well, but its operation was slower than that of a skilled man. An improved version seen at the Penrhyn Quarry in the late-1970s remained less efficient than the manual method.

273. M.J.T.Lewis (1986), 'Early sawing....,' op.cit.

274. The slate at the Llechwedd Quarry seems to have been especially resistant to cross-cutting cleanly by manual methods, resulting in an abnormally high rate of wastage. The only solution lay in sawing the slatemaking blocks.

275. D.C.Davies (1887), op.cit., p.125; J.G.Isherwood (1980), Candles to Caplamps, op.cit., pp.38, 40; Ivor Wynne Jones (1986), op.cit., p.9, suggesting a date of 1850; M.J.T.Lewis (1987), The Slate Quarries of North Wales in 1873, op.cit., p.18; A.J.Richards (1995), op.cit., p.74. The consensus of informed opinion is that the Greaves saw was not patented because it integrated existing technology in a simple an relatively inexpensive manner, an important factor when one machine was required for each of the separate slatemaking groups. The machines's main features were **(1)** a revolving, toothed circular saw-blade bolted onto the input shaft, powered by a flat-belt from the mill line-shaft *via* fast/loose pulleys or a live, clutched drive pulley; **(2)** a sectional frame, originally of timber, but soon changed to cast-iron; and **(3)** a powered asymmetrically-split load-table running along the top face of the frame (on v-guides, rollers, or both). The saw at the Glynllifon Park workshops, featuring a slab frame which surely has replaced a timber one, and a simple feed mechanism of a slow-geared hauling chain, might represent a very early design.

276. The spread of the Greaves saw has not yet been chronicled, but current information suggests that it first spread through the Ffestiniog district before spreading out to contiguous quarries working Ordovician rock, only later being adopted in the Cambrian slate beds. The situation is made more complex by the interplay of technological improvements, adaptability and advantages of use, and investment policies.

277. This was the patent (No.2271 of 1860) to Griffith Owen, ironfounder of Porthmadog, which incorporated a two-speed chain-drive feed mechanism and rapid reverse facility. It is possible that the original version of the Greaves saw in the 1850s was manufactured by De Winton of Caernarfon [ex.info., C.R.Weaver, op.cit.], who suggested that these were provided as a kit of castings packed in timber boxes which were then used as the frames, a hypothesis for which there is some physical evidence].

278. Ex.info., former Dorothea Quarry slatemakers, where the pillaring characteristic of the purple rock was not very well developed. The introduction of mechanical sawing did not, however, represent a de-skilling of the slatemakers, as the numbers and sizes of slates that could be made from a block (and hence the amount of wages) depended to a crucial degree upon the men's experience in deciding how to saw the slab for a maximum slatemaking advantage [C.R.O, G.P.Jones/Nantlle Mss (uncatalogued), essay on sawing techniques by the late Owen Humphreys (1944), 'Chwarelyddiaeth,' ff.21-24, 'Sut Mae Llifio'].

279. C.R.O., XM 4874/47, ff.16-17, 28, re. usefulness of saws at Dorothea and Penyrorsedd in 1886; Morgan Richards *Morguryn Machno* (1877), op.cit., p.82-84, discussing the questions of the advantages of mechanical saws and of the alleged resistance by the workforce to new technology. The erection of a mill and its fitting out could cost several thousand pounds [D.C.Davies (1887), op.cit., p.115 costed a small mill at £2,000 in 1877], in addition to its annual running costs [e.g., steam mills costing some £23 to £25 per saw per annum in 1935, C.R.O., X/Dorothea 1046].

280. Richards (1877), loc.cit.

281. C.R.O., X/Penyrorsedd adit.1873, Minutes 1874-76, passim., re. commissioning of the 'W.6 mill', which is credited as having been the first in the district [John Griffiths *Sylwebydd* (1889), op.cit., p.61].

282. C.R.O., XM 4874/47, f.7, recorded that the Coedmadog mill was bereft of plant in 1886, but it was fully fitted out by *c.*1900 [ex.info., the late Morgan Hughes, former rubbler at Coedmadog Quarry by the early 1900s].

283. C.R.O., X/Dorothea 612, two saw tables and a sharpener were purchased second-hand on 7 October 1882 at £58, eight months prior to the purchase of the first of a batch of eight new and used tables destined for the new mill.

284. The increase in the number of mills, and their locations, can be seen from 1:2,500 Ordnance Survey maps of the district. Accurately dating these structures is very difficult in default of documentary evidence, which is in general rare.

285. C.R.O., X/Dinorwic 1922, re. the disadvantages of using the Owen Patent saw with Cambrian slates [see Note 277, supra].

286. J. P. de Winton (No.3455 of 1875, hydraulic control valve for feed motion), and ex.info., former Penyrorsedd slatemakers who had used this plant; the most popular saws at Nantlle were the worm-geared rack-feed tables made by H.Owen of Caernarfon and De Winton & Co. (the latter being incorporating a Patent improved feed mechanism with quick reverse, No.7448 of 1887). Others by Owen, Issac & Owen and J. H. Williams of Porthmadog, and William Lewis of Tanygrisiau have been recorded at the Dorothea Quarry [C.R.O., X/Dorothea 612], and ones by Green & Co., of Aberystwyth; John Owen of Bangor; and Turner Bros., Newtown may also have been used in this district. Other patented improvements to feed motion which may have found an use in proprietary saws (above) were granted to H. P. Hughes (No.2362 of 1862); and to T. E. Morris (No.12900 of 1887). The feed

motion was a very important parameter, as the rate of movement of the slab through the saw had a crucial bearing on the effectiveness of the cutting action and on the life-expectancy of the blade. It had to be strong and steady, but not excessively so, and it was advantageous to have some form of change-speed mechanism for different hardness of rock.

287. Ex.info., Mr M. J. B. Wynne-Williams, nephew of the late Major Ivor Wynne-Williams, the inventor of the improved blade, and the late Gwilym Roberts, recalling his role as quarry blacksmith in finding a satisfactory method of brazing the carbide teeth to the steel disc. Previous attempts to improve the standard blades were made by J. Parry & R. Morris (Patent No.1107 of 1869); A. Dunlope & W. Roe (No.1890 of 1875); and F. W. Turner (provisional, No.3949 of 1883).

288. The first patents for diamond-sawing were granted to E. T. Hughes (No.1802 of 1869); and W. R. Lake (No.3677 of 1875).

289. E.g., at Moelfferna Quarry, Glyndyfrdwy *c.*1925, Q.M.J., No.6, Vol.19, January 1927.

290. C.R.O., X/Dorothea 637; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), files of the Penyrorsedd Slate Quarry Co. Ltd., re. electric sawing, 1920s.

291. Without the electricity supply, high-speed sawing could not be adopted.

292. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), files of the Penyrorsedd Slate Quarry Co. Ltd.

293. Ex.info., Mr M. J. B. Wynne-Williams, op.cit., and the late Owen Humphreys, saw attendant during the 1938-39 trial; C.R.O., X/Dorothea 1383, copy of the confidential Section 2 of the 'Hibberd Report (1948)' with regards to the recommendations for the Dorothea Quarry, para.35.

294. Ex.info., Mr M. J. B. Wynne-Williams, who instigated the modernisation programme when managing director of the Dorothea Quarry from 1959 to 1970; C.R.O., X/Dorothea 1462.

295. loc.cit.; C.R.O., X/Dorothea 1422, para. 4, report dated 27 May 1966, viz:- "We banked on diamond saws being technically successful, so that we could install six in the new mill and stop production in the old mill ...Unfortunately, diamond saws of many different makers ...[were] a failure ....[with] our rock. It is uncertain whether they are as yet a success economically. We must be certain of this before installing more tables in the new mill."

296. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Caernarvonshire Crown Slate Quarry Co. Ltd., papers, Moeltryfan Quarry; recorded by the author, post-1968.

297. Recorded by the author; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), documents salvaged from the now-derelict Twll Coed Quarry office. Previously, the plant had consisted of a single Greaves saw (ex-Dorothea Quarry, 1970) driven from a single-cylinder vertical diesel engine via flat belts. The old saw was sufficient to cope with the output of the concern, but the management aimed at a rapid expansion. This did not occur, and the new electric saw was hardly used during the eight years of operation.

298. Ibid.; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd directors' File 8.2, Herbert, S., (1972), 'An Heir For The Declining Duchess,' Industrial Diamond Review, July 1972, pp.294-298, describing the use of diamond sawing at the Penyrorsedd Quarry, in which the then general manager, O. G. Williams, was quoted [ibid., p.295] thus: "... Being smaller in size and resources than some of our competitors, we couldn't afford to take too much of a chance, so we sat on the fence for a while and learned from other people's mistakes;" Stone Industries: Special Slate Edition, November/December 1971, pp.32-35, in describing the diamond saws at the Penrhyn Quarry, referred to the improved results due to better cutting-fluid lubricants, which went hand-in-hand with the development of improved blades.

299. Ibid. The conclusions are the personal opinion of the present author.

300. E.g., Patent No.10333 of 1844 to J. Carter, involving a potentially lethal cutting knife attached to a revolving flywheel; Morgan Richards *Morgugyn Machno* (1877), op.cit., p.82, re. mechanical dressing and its limitations.

301. Patents granted to N. Matthews (No.13019 of 1850) and J. W. Greaves (No.2397 of 1860 and 1272 of 1861). The former had a cutter moving in a vertical plane within a guide-frame which had to be incorporated into the structure of the mill for stability against vibrations, but the latter, in its final form was a free-standing unit incorporating rotating blades (two, normally) bolted onto a powered revolving spider-drum, both having a fixed blade and gauge attached to the frame [see J.G.Isherwood (1980), op.cit., pp.42-47].

302. Patent to C. E. Amos and J. Francis (No.1844 of 1861); A.J.Richards (1995), op.cit., pp.76, 198; Morgan Richards *Morgugyn Machno* (1877), op.cit., p.83, re. disadvantages of this machine. There were also dressing-machine patents to E. J. J. Dixon & H. J. Dodson (No.14165

of 1852); R. Harrison (provisional, No.1911 of 1861); H. Gilson (No.2678 of 1861); H. Williams (provisional, No.772 of 1863); H. Wren & J. Hopkinson (No.3268 of 1866); R. Harrison (No.1788 of 1869); T. H. Jones & G. Ellis (No.1421 of 1876); R. M. Greaves (No.8931 of 1886); F. Shenton, per agent (No.16988 of 1886); and A. Spemer (No.12247 of 1887), although none appear to have resulted in useful machines.

303. One was at allegedly at the Penyrorsedd Quarry [ex.info.], and the other (now at the Gilfach Ddu museum, Llanberis] was seen at the Moeltryfan Quarry by the author in 1969-70.

304. This was certainly the case at the Dinorwic Quarry, which only employed mechanical dressing for certain slate veins and hand dressing for others, up to the late 1960s. A treadle-powered Greaves dresser was in use by a tip contractor at the Penyrorsedd Quarry in the early 1970s.

305. Table assembled from diverse sources by the present author.

306. C.R.O., X/Penyrorsedd addit.1873, minutes during 1875-77, relating to the erecting and fitting out of the first mills at this quarry; C.R.O., X/Dorothea 612, lists of purchase of plant & machinery; ibid., Ms 880, p.96, letter dated 12 October 1907, where the Dorothea manager had again put to one side the proposals to purchase dressing machines because of the awkward design of the mills and the hardness of the [blue] slates worked therein; ex.info., the late Owen Humphreys, a laid-off slatemaker who was re-employed by the Dorothea Company in 1941 because of his prior experience in using dressers at the Galltyfedw Quarry.

(iii). Mill design

307. Robert Williams (1899), 'Hunangofiant Chwarelwr, I,' Cymru, VII, p.55, re. working in open air. See photograph in M.Williams (1991), op.cit., p.14, of *gwaliau* in a Pembrokeshire quarry, which, from an examination of remains locally, were very similar to those at several quarries at Nantlle.

308 The type with cantilevered roofs, similar to those extant at Foel Quarry, Capel Curig [see A.J.Richards (1995), op.cit., photo., p.105], are to be found in the old workings at Floor 8, Penyrorsedd Quarry.

309. Hypothesised by the author from an examination of extant remains, post-1963.

310. E.g. the Floor 2 mill, Rhosydd Quarry, Ffestiniog [see Lewis & Denton, The Rhosydd Quarry, op.cit., q.v.]

311. E.g. the Old Mill at Holland's Quarry and the 'Alabama Mill' at Diffwys Quarry [result of the practical industrial archaeology courses under the tutelage of Dr M.J.T.Lewis, reports privately circulated].

312. See J.G.Isherwood (1980), op.cit., pp.34-39; A.J.Richards (1995), op.cit., pp.75-77; M.Williams (1991), op.cit., 14-16. It appears the first example of a fully integrated mills was the 'No.6' at Diffwys Quarry, Ffestiniog [provisional report of M.J.T.Lewis' Plas Tanybwlch course at this quarry].

313. Author's typology, based on an analysis of the known architectural characteristics of extant integrated mills.

314. Ibid. Within the Ffestiniog district, for example, the greater portion of the four larger mills at the Votty & Bowydd Quarry, Ffestiniog, were merely a roof propped up on thin masonry pillars, and when dismantled in 1973-74, left very scant archaeological remains. This can be contrasted with the more substantial mills at Holland's Quarry and Diffwys Quarry Floor 6. See also evidence of Dr Evan Roberts regarding the mills at Nantlle, Questions 19-53 in the Report of the Home Office Quarry Committee of Enquiry, 1893, (H.M.S.O., 1894) [U.C.N.W., Welsh Library KF 165], pp.8-9.

315. C.R.O., X/Penyrorsedd addit.1873, Minutes 1874-78 passim; survey by the author of the structure prior to its recent partial demolition.

316. Old photographs, ex.info., former quarrymen recalling these buildings post-1894.

317. Typology attributable to the present author.

318. An analysis by the author of the chronological pattern of the purchase of saw-tables from C.R.O., X/Dorothea 612, plus a survey of the building from 1968 to its dismantlement in 1974.

319. Ex. info., former quarrymen, recalling these buildings; author's fieldwork.

320. Ibid.

321. Ibid.; these permanent sites were at the Galltyfedw Quarry and at the Talysarn Quarry Small Mill.

322. The certain ones were the waterwheel-powered Penyrorsedd Floor 'W6' mill and the 'W4' mill *via* wire-rope drive, and the water-turbine powered Gwernor Quarry Mill.

323. The power requirement for a slatemaking mill can be calculated using "Weaver's Assertion" [attributable to C.R.Weaver, op.cit.], which states that as only a proportion of the plant was running at any given moment in time, then the formula of Power = (N-1)/2, where 'N' is the number of saws, was a satisfactory answer.

324 Application of Weaver's Assertion to recorded examples.

325. Analysis of extant plant inventories, including C.R.O., XD 35/425, 436, Moeltryfan plant list of 1916; the Penyrorsedd 'E8' hemp-rope mill drive seen by the author prior to its scrapping in 1974; reference from Mr D.Clayton re. the wire-rope drive between the Penyrorsedd 'W6' and 'W4' mills from 1878 to 1906; ex.info., former employees re. wire-rope drives from the Blaen Cae mill to the Talysarn Small Mill, and from the Galltyfedw mill to the upper bank external saws in the 1890s.

326. Recorded by the author; ex.info., respective quarry managements.

327. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Caernarvonshire Crown Slate Quarries Co. Ltd. This used roof trusses salvaged from the old Floor 4 mill.

328. These were found at Alexandra 'Lefal Fawr' bank, Brynfferam Quarry, Talysarn 'Bonc Bach,' Tanrallt Quarry, Twll Coed, Twll Llwyd, Tyddyn Agnes Quarry, and Tynyweirglodd Lower Pit [ex.info., former quarrymen; author's fieldwork].

329. Alexandra/Moeltryfan (Crown Co.), Dorothea, and Twll Coed.

330. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Caernarvonshire Crown Slate Quarries Co. Ltd.; author's fieldwork.

331. The Coedmadog Quarry mill appears to have been the first to have been demolished in the Nantlle district, being dismantled by W.J.Davies, tip contractor, soon after 1919.

332. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Caernarvonshire Crown Slate Quarries Co. Ltd., re. storage at the Alexandra mill. The Penyrorsedd 'W4' mill, the South Dorothea Mill and the Ty Mawr West mill were also used for storage purposes by the Government.

333. The author became involved in the dismantling of the Dorothea mills in 1974, albeit with a heavy heart, so as to gain experience of this unrecorded aspect of the slate industry.

334. Witnessed by the author.

CHAPTER 5

TRANSPORT SYSTEMS

This chapter describes the development of the transport systems used in connection with the slate quarries at Nantlle, excluding winding gear and inclined planes, which have been already discussed in Chapter 4. This subject sub-divides conveniently into two main aspects. The first sub-section (a) covers the movement of material within the quarries, whereas sub-section (b) deals with the transport of the product from the quarries to the markets.

(a). Internal transport

The materials that were transported within slate quarry sites varied in their composition and their size depending on their origin. The moving of large slate-slabs and boulders of gritstone posed different problems from dealing with waste offcuts, fine debris or finished slates. Consequently, the methods of handling this variety of material varied according to its composition, size and the era under consideration.

The early era

In the earliest era of commercial slate quarrying, the majority of the workings at Nantlle were small in scale and the volume of the quarried material to be handled was consequently relatively small. Allied to the close proximity on a compact site of the working face, quarry bank and waste tip, the transport of material by box- and wheel-barrows must have been efficient within contemporary criteria. The greatest disadvantage of this early arrangement must have been the limit on the maximum size and weight of each load, this having a direct effect upon the methods of quarrying and processing (see Chapter 3).

Chapter 5: Transport systems

Tramways

The improvements in winding gear for hauling material out of the quarry pits (see Chapter 4), must have produced an impetus for improving surface haulage, by virtue of the increased size and volume of material subsequently coming out of the quarry pits. It is possible that ordinary horse-drawn road-carts were initially used in some quarries for internal transport as replacements for wheel-barrows [1], but rail transport systems were destined to become the most popular means of moving materials within the sites, being much more suitable for the physical environment and system of working in this industry.

The first use of railways (termed 'tramways' in this context) within the Nantlle quarries was probably contemporaneous with the introduction of the horse whim, and their adoption subsequently accelerated in the era of the haulage incline and aerial cableways. The first recorded example of tramways in this district was at the Cilgwyn Quarry by 1805, probably no more than a decade after their first use in the industry at the Penrhyn Quarry (Bethesda) [2]. Cilgwyn was at that time the most important quarry in the Nantlle district, and it is likely that other leading concerns in this district followed suit as circumstances allowed, these quarries being Cloddfa'r Coed, Penybryn and Talysarn [3]. Subsequently, the use of tramways probably spread through the Nantlle quarries in a similar pattern to that assumed for the remainder of the slate industry, that is, in a downwards progression within the scale of concerns, with the smallest quarries awaiting the availability of cheap second-hand materials before being able to follow suit [4].

The development of the design of trackwork used in the quarry railways is a subject which has recently gained prominence as a result of the pioneering work carried out by Dr M. J. T. Lewis in this field. Dr Lewis is of the opinion that the earliest tramways at the Cilgwyn Quarry (above) were almost certainly constructed of strap-rail, that is, longitudinal timbers having a running surface made of iron straps attached by nails [5]. Whilst this theory, based on documentary evidence only, cannot be proved conclusively, Dr Lewis' second hypothesis that there may have been a plate-rail system in at least one of the larger Nantlle concerns by the 1820s, has been supported by the discovery of a fragment of this type of rail at the Cloddfa'r Lôn Quarry [6].

Nevertheless, it seems likely that bar-rail had become the standard form of trackwork at Nantlle by the 1820s, this being constructed of wrought-iron bars, set edgeways into slots cut into timber cross-sleepers [7]. This type of track was relatively inexpensive and was easily laid, but was only suitable for light traffic. Thus, despite the introduction of newer forms of heavier trackwork in the larger quarries by the mid-nineteenth century (see below), bar-rail was still being used up to the 1890s in some of the minor quarries at Nantlle, and survived until the 1960s elsewhere [8].

The gauge of the internal tramways in the Welsh slate quarries probably varied from site to site in the earliest period, with the likely range being from around two to four feet between the rail centres. Dr Lewis has hypothesised that the Cloddfa'r Lôn plate-rail system might have had a 3ft.6inch gauge, thus explaining the adoption of this gauge for the 1820s railway from the Nantlle quarries to the shipping quay at Caernarfon (see sub-section b., below) [9]. However, with the exception of the Nantlle line and its branch lines serving the quarry stock yards and winding engine coal-bunkers, the nominal two-foot gauge came to predominate within the Nantlle quarries, as was the case elsewhere.

This narrow gauge had several advantages over broader track, of which the most important were (a) the size of the rolling stock, capable in its final form of carrying a two ton payload, was within the limit of propulsion by a single man; (b) sharper curves were possible, this being especially useful on narrow galleries, within sawing mills and in confined quarry yards; and (c) major civil engineering structures such as inclined planes could be constructed more cheaply because their formations were narrower. Dual gauge, three-rail track was also very common in those concerns served by the Nantlle Railway (see sub-section b.i, below) [10].

The greatest impetus for improving the trackwork in quarry internal tramways was the increase in loads transported from winding gear to the slatemaking banks and waste tips, which resulted from the expansion of the industry during the 1850s-70s. Furthermore, the introduction of steam locomotives in most of the larger Nantlle quarries during the 1870s (see below) also demanded the provision of stronger, well-laid lines in the works. Stephenson-pattern fish-belly chaired rail had been introduced into the Nantlle district in 1827 on the Nantlle Railway, and much second-hand material from this source probably found its way into the quarries by the middle of the nineteenth century [11]. At various unrecorded dates, other new types of rails were introduced into the quarries, of which the wrought-iron T-section chaired track, rolled-steel bridge-rail and flat-bottom rail (in chrpnological order of development) were the most common [12]. A form of round-section rail was also recalled in the Nantlle district, this being probably the portable track known as "Thomas Hughes rail" [13].

Rolling stock

Little is known of the history of the development of rolling stock on the internal tramway systems of the Nantlle slate quarries, for which no early examples survive. An autobiographical source described the first waggons used in the quarries, during the 1820s, as being constructed of timber, with a hinged forwards-tipping body [14]. An example of this design of waggon having an iron body on a timber chassis (now missing) has been discovered at a local copper mine, but evidence of the continued use of this design in the slate quarries is restricted to a badly crushed body (now destroyed) and an unclear photograph dated *c.*1939 [15]. Another type of early waggon recalled at the Cilgwyn Quarry during the 1830s had a detachable body, to reduce the *tare* weight during hoisting by aerial cableway from the quarry bottom, but none have survived [16].

The origin of the ubiquitous iron-bodied open-end rubbish waggon is unrecorded, but this design was to be found throughout the quarries of North Wales by the late nineteenth century. The majority of those used in the Nantlle district differed from the standard design only in their provision of four projecting straps pierced with holes to receive the hoisting block hooks used in conjunction with aerial cableways [17]. Large slabs of rock were carried on timber-framed trolleys having a protective frame of flat iron bars bolted to the upper timberwork, these also being introduced at some unrecorded date into the larger Nantlle quarries [18]. Only a limited use was made of side-tipping 'Hudson' skip-waggons, these proving rather unstable on the very rough quarry lines, due to their high centre of gravity [19].

Animal motive power

The propulsion of single tramway wagons exclusively by men was the most basic system of motive power found in the smaller concerns at Nantlle and elsewhere until the 1960s [20]. Such manual tramming was also carried out to a lesser extent in larger concerns, particularly within slatemaking mills, on stockyards and at locations within the quarry pits that were unsuitable for alternative means of propulsion [21].

Where the volume of traffic necessitated the running of trains (or 'runs') of waggons, the substitution of manual propulsion by the use of horses was a logical first development. With the assistance of a slight downwards gradient from the quarry pit or haulage unloading point towards the tips, a sturdy horse was capable of hauling a run of around ten waggons carrying about two tons each [22]. With the exception of the Dorothea Quarry, which at one time owned horses and possibly the Talysarn Quarry likewise, the majority of these animals and their handlers were hired from local farmers, but at least one local businessman was also involved in horse-hire during the mid-nineteenth century [23].

Horse power was a very convenient form of transport in slate quarries having relatively light transport requirements or where the layout was compact. Horses were especially useful in situations where single track tramways were the norm (particularly inside mills) because they were capable of by-passing obstructions such as stationary wagons, which might block the path of a locomotive. Also, because they were supplied on hire, all the preparation work on the animals was carried out before the start of the working day at the contractors' expense [24].

Horse haulage at Nantlle was not totally displaced by the introduction of steam locomotives (see below), and in several cases animal power outlasted the latter on economic grounds. For instance, at the Dorothea and Talysarn quarries during the difficult years of the 1880s/early-1890s recession, steam locomotives were retired in favour of horse-haulage because the volume of loads had decreased [25]. The last horse to haul tramway waggons in the Nantlle district, at the Dorothea Quarry, was not retired until 1963, having become lame. It was decided not to replace it with another because the Company was trying to project a new image of modernity, and surface haulage by rail was thereafter dealt with by an agricultural tractor and a fork-lift truck [26].

Steam locomotives

The use of steam locomotives in the slate industry was pioneered by the Dinorwic Quarry on its four-foot gauge Padarn Railway in 1848, but the capability of this technology to operate on a two-foot gauge railway as used within the quarries, was not demonstrated in North Wales until its application on the Festiniog Railway [sic] in 1863 [27]. The first use of steam locomotives on an internal quarry transport system appears to have came about six years later at the Lower Glynrhonwy Quarry (Llanberis), closely followed by the Dorothea Quarry (Nantlle) [28].

Both of the above quarries are reputed to have taken delivery in 1869 of locomotive engines manufactured at Caernarfon by De Winton & Co., ironfounders and engineers, whose application of a vertical yacht engine and boiler to self-propelled haulage provided the slate quarries of North Wales with relatively cheap, simple and efficient engines [29]. The early single-cylinder, geared drive, possibly timber-framed design, had by the mid-1870s evolved to one having a vertical boiler and duplex cylinders directly connected to a cranked driving axle, with connecting rods onto the second set of wheels, although there were infinite minor differences between each individual locomotive [30]. There remain, however, several unanswered questions surrounding this major innovation, particularly the history of their development and details of the earliest batch delivered to the quarries before the mid-1870s [31].

TABLE 22

KNOWN LOCOMOTIVES AT NANTLE

QUARRY	STEAM LOCOMOTIVES							INTERNAL COMBUSTION			
	De Winton	Hunslet	Kerr Stuart	Vulcan	Bagnall	Manning Wardle	Unknown	D	L	Home	RH
								see Key			
Alexandra....	2+1?	-	-	1	-	-	-	-	-	-	-
Moeltryfan...	1	2	-	-	-	-	-	-	-	-	[1]
Braich.......	2?	-	-	-	-	-	-	-	-	-	-
Fron.........	1?	-	-	-	-	-	-	-	-	[1]	-
Cilgwyn......	3	1	-	-	1	1	-	-	-	1	1
Penyrorsedd..	10	3	[1]	1	-	-	-	-	-	1+1	4
Penybryn.....	1	-	-	-	-	-	-	-	1	-	-
Cloddfa'r Lôn	1	-	-	-	-	-	1	-	-	-	-
Dorothea.....	1+2?	1	-	-	[1]	-	-	1?	2	-	-
Galltyfedw...	-	-	-	-	-	-	-	-	-	-	-
S'th Dorothea	-	-	-	-	-	-	-	-	-	-	-
Talysarn.....	2?+[1?]	-	-	-	-	-	[1]	-	-	-	-
Cloddfa Coed.	-	-	-	-	-	-	-	-	-	-	-
Coedmadog....	3?	-	-	-	-	-	-	-	-	-	-
Gwernor......	-	-	-	-	-	-	-	-	-	-	-
Ty Mawr East.	-	-	-	-	-	-	-	-	-	-	-
Ty Mawr West.	-	-	-	-	-	-	-	-	-	-	-
Tynyweirglodd	-	-	-	-	-	-	-	-	-	-	-
Tanrallt.....	-	-	-	-	-	-	-	-	-	-	-
Fronheulog...	-	-	-	-	-	-	-	-	-	-	-
Taldrwst.....	-	-	-	-	-	-	-	-	-	-	-
Tyddyn Agnes.	-	-	-	-	-	-	-	-	-	-	-
Ty'n Llwyn...	-	-	-	-	-	-	-	-	-	-	-
Llwydcoed....	-	-	-	-	-	-	-	-	-	-	-
Foel Clynnog.	-	-	-	-	-	-	-	-	-	-	-
Gelli Bach...	-	-	-	-	-	-	-	-	-	-	-

REFS:- Table based on information abstracted from Bradley (1992) and diverse local primary sources

KEY:-
- `-` No such plant present in any form
- `?` Uncertainty in information
- `+` Uncertain information in same class as recorded data
- `[ ]` Re-use (transfer) of plant on another site
- `D` Deutz petrol/paraffin locomotives
- `L` Lister petrol rail-tractor
- `Home` Fabricated in quarry workshop, using road vehicle parts
- `RH` Ruston & Hornsby diesel locomotive

The 'De Winton' locomotive design was very successful at quarries due to their short wheel-base for negotiating tight curves, and the low overall height for access to the workings through tunnels [32]. In the period 1869-1902 this manufacturer supplied about thirty of these locomotives to at least ten quarries at Nantlle, with the number in each varying from one to about ten engines (see Table 22, above), the highest geographical concentration of this design in the North Wales slate industry [33].

By the 1870s, several English locomotive manufacturers were also supplying locomotives to the North Wales slate industry [34]. A limited number of these non-Caernarfon engines were purchased by quarry concerns at Nantlle to augment or replace the original batch of 'De Wintons' (see Table 22, above), especially during the years of decline of the local manufacturer during the 1890s which led to its closure in 1902 [35]. Of the many makes of non-Caernarfon locomotives, those which performed most satisfactorily in the quarries were the produce of the Hunslet Locomotive Company (of Leeds), which manufactured several classes of engine specifically designed for this task [36]. Locomotives from other manufacturers were less stable on the tight curves, stub points and uneven track that was prevalent in the quarries, or had inappropriate designs of boiler for the requirements of quarry work, although a number of such engines performed satisfactorily when used in more suitable working environments such as long-haul exit railways or steeply-graded tip-lines [37].

The number of steam locomotives at work in the Nantlle slate quarries peaked on two occasions, firstly in the late-1870s and secondly in the late-1890s, corresponding to the maxima of economic activity of the slate industry [38]. No new steam locomotives were purchased by the quarries at Nantlle after 1904 because of the downturn in trade and the consequential reduction in the scale of working, and only two second-hand engines came into the district after this date [39]. Quarry closures and the introduction of internal combustion 'rail-tractors' (see below) further depleted the numbers of active steam locomotives in the quarries during the 1920s-30s, but their final demise at Nantlle was delayed until *c.*1960, when the Penyrorsedd Quarry retired the last remnants of its steam fleet [40].

Internal combustion locomotives

Light locomotives (or 'rail-tractors') powered by internal combustion engines were first introduced in any appreciable numbers into the North Wales slate industry after the First World War [41]. They were utilised at first for light haulage and shunting duties, where the use of steam locomotives was often neither convenient nor cost-effective [42].

The use of internal-combustion rail-tractors became even more attractive after the 1920s, due to the reduction in volume of internal traffic that resulted from a general diminishing in the scale of working in the quarries. Consequently, the numbers of diesel- and petrol-engined light locomotives in the slate industry increased rapidly during the 1930s-40s, eclipsing the diminishing numbers of steam locomotives in the 1950s [43]. Nantlle (see Table 22, above) was a micro-cosm of the general trend, where the dominance of the internal combustion locomotives within internal transport systems only lasted briefly because of an accelerating trend from tramways to road haulage during the 1960s-70s (see below).

Many of the earliest internal combustion locomotives available in Britain were German 'Deutz' petrol/paraffin rail-tractors, one of which was apparently purchased by the Dorothea Quarry *c.*1936 [44]. This machine may not have been used here, but the quarry did purchase three light

'Lister' rail-tractors in 1946 for use in the main pit, on the main bank, and in the Penybryn Quarry tunnel respectively [45]. A number of other quarries at Nantlle also had petrol-engined locomotives by the 1930s-40s, all of which had been fabricated on-site using power units salvaged from scrapped agricultural tractors and motor cars, a practice that had originated in the Penrhyn Quarry (Bethesda) [46].

The development of efficient, portable diesel-oil engines by the 1930s provided rail-tractors with a greater pulling power than had been available from the earlier petrol-engined versions of comparable size. Consequently the former became the most popular form of internal combustion power unit for heavy duties in the quarries. The first diesel loco at Nantlle, delivered to the Cilgwyn Quarry in 1937, was a 'Ruston Hornsby' Type-20DL, a machine which rapidly became the most popular type used in the Welsh slate quarries. The advantages of this design over its competitors were those of ruggedness and the design of the gear-shift mechanism that allowed the driver to operate the engine whilst walking beside it; this was very convenient when shunting and negotiating pointwork [47].

Despite the monopoly of the 'Ruston' design within the diesel rail-tractors at Nantlle due to its superiority described above, only five machines from this manufacturer were used in this district, a symptom of the decline of rail-based internal transport systems by the late-1950s. All of the four remaining diesel-locos were purchased in the 1940s-50s by the Penyrorsedd Quarry to augment, and eventually replace, its fleet of steam engines, the former remaining in service until replaced on economic grounds by a single agricultural tractor in 1973 [48].

Road haulage

The use at the rock-face of a Welsh slate quarry of internal combustion vehicles with road-wheels appears to have commenced at the Dorothea Quarry, in 1942. An inclined roadway was cut into the sandy overburden using a steam excavator, serving road-going front-tipping dumpers to build up a surface inclined tip nearby. The economy of the new system was based upon its eschewing of a haulage incline and the more rapid movement of material than could be achieved with rail transport, and this system was consequently extended to the upper galleries of the quarry as soon as an access by road was available (by the mid-1950s). Subsequently, smaller dumpers were taken down to the pit bottom by cableway, to replace the manual haulage of waste by rail. In 1963 the roadway was finally extended to the floor of the pit, allowing full access to the production faces by heavy plant, superseding the regime of cableways and tramway waggons [49].

The Dorothea Quarry also appears to have been the first to introduce large dump-trucks to the slate industry. The first of this plant was hired in 1962-63 to clear a substantial amount of debris in an accessible old working, and in response to a favourable result the quarry operators purchased two 'Ford' dump-trucks and an excavator to continue the work. Subsequent to the completion of the access road to the quarry bottom, slate blocks were brought up from the rock face to the mills using an ex-army 'Commer' four-wheel-drive flat-body lorry which had been converted to run on propane gas fuel [50].

The Moeltryfan Quarry also had introduced front-tipping dumpers as part of its post-1945 development programme of the Alexandra pits. Working in conjunction with a face-shovel excavator, the dumpers provided a greatly increased rate of removing debris than could be achieved with the traditional tramway system, particularly when the material was to be taken up a gradient to the dumping ground. One of these dumpers was also used at the Crown Company's Cilgwyn Quarry during the 1950s, when a workable face in an old pit was accessed by road and was worked by an excavator. Improved road access was provided to the Moeltryfan pit in 1966, allowing the use of dumper lorries with a payload of up to thirty tons in place of the blondin cableway with its awkward railway tunnel access, which had hitherto been the only means of access from the workings [51].

The layout of the Penyrorsedd Quarry did not conveniently lend itself to the construction of internal access roads, and a lack of finance restricted the ability of the management to institute a more cost-effective transport system than that provided by cableways, inclines and railways. The quarry was exclusively served by railway haulage until small front-tipping dumpers and an excavator were first lowered into the pit by cableway in the mid-1960s. Debris from a landslide was subsequently raised by the aerial ropeways in skips to surface discharge chutes, whereby the loads were tipped into a pair of 5-ton 'Austin' motor lorries having strengthened hopper-bodies [52].

During the complete re-development of the Penyrorsedd Quarry under new ownership after 1979, road access was finally achieved into the lower workings. This allowed 'Aveling Barford' and 'Foden' six-wheel dumpers with hopper bodies, having a payload of some thirty-eight tons, to be used to carry large blocks of slate and debris from the working face. In 1990, several ex-army six-wheel-drive lorries, with girder flat-bodies, were purchased to carry slatemaking slabs to the mill, wherein the capability of unloading by fork-lift trucks was an improvement to the former necessity of tipping the loads onto a hard floor [53].

Idiosyncratic systems

This concluding part of the sub-section on internal transport discusses two examples concerning boats.

Following the chronological order, the first case is the transport of overburden from the Dorothea Quarry in 1840-41 by barge. The scheme that was implemented here involved the cutting of a canal from the tipping ground of the Lower Nantlle Lake through the meadow to the west of the original Dorothea pit, so as to expedite the removal of the clay and gravel surface deposits covering the slate beds [54].

The second case involved the boating by contracting independent quarrymen of finished slates from their workings in the distant corners of flooded quarries to a water-side location accessible for the offloading of the produce. This is known to have been carried out at the old Cloddfa'r Lôn pits by Dafydd Jones & Co. during the 1920s and 1930s, and it is likely that this may also have occurred in a number of other defunct pits occupied by contractors [55].

(b) External transport

The organisation and cost-effectiveness of the system for conveying the finished product from the quarries to its markets had important economic implications for the slate industry of North Wales. The cost of transport from this relatively remote area increased the wholesale price of the slates at their final destination, and any economies gained in transit charges were therefore advantageous in increasing the competitiveness both of the product in general and of the individual quarry concerns.

Whereas the general role of transport economics in the development of the North Wales slate industry has already been outlined (see Chapter 1), this account concentrates upon the effects of specific technological developments in the system. Up to the advent of direct deliveries using long-distance motor-lorries in the 1950s, and with one technical exception [56], two distinct stages can be identified in the transport of slates from the Nantlle quarries to their markets.

The first (or **'primary stage'**) was the movement of the slates from the quarry stock-yards to either a coastal loading point or to a standard-gauge rail-head, wherein the forward shipping (the **'secondary stage'**) by sea or along the British railway network to the final market was undertaken. A comprehensive history of the various means of transporting the slates from Nantlle involves a high degree of complexity. This short discussion is structured in an integrated form within three distinct, albeit overlapping chronological periods, delineated by changes in the relative importance of the secondary transport systems (see above).

(i) The maritime era *c.*1650-1939

The earliest phase of rapid growth in the economic prosperity of the North Wales slate industry, commencing in the late seventeenth century, was to a great extent the result of the ease of access to the sea from the major quarries in the Ogwen Valley, at Llanberis and in the Nantlle district. Once loaded aboard ships, the slates could conveniently and cheaply gain access to the early major markets of the main U.K. ports and to the fledgling export trade (see Chapter 1).

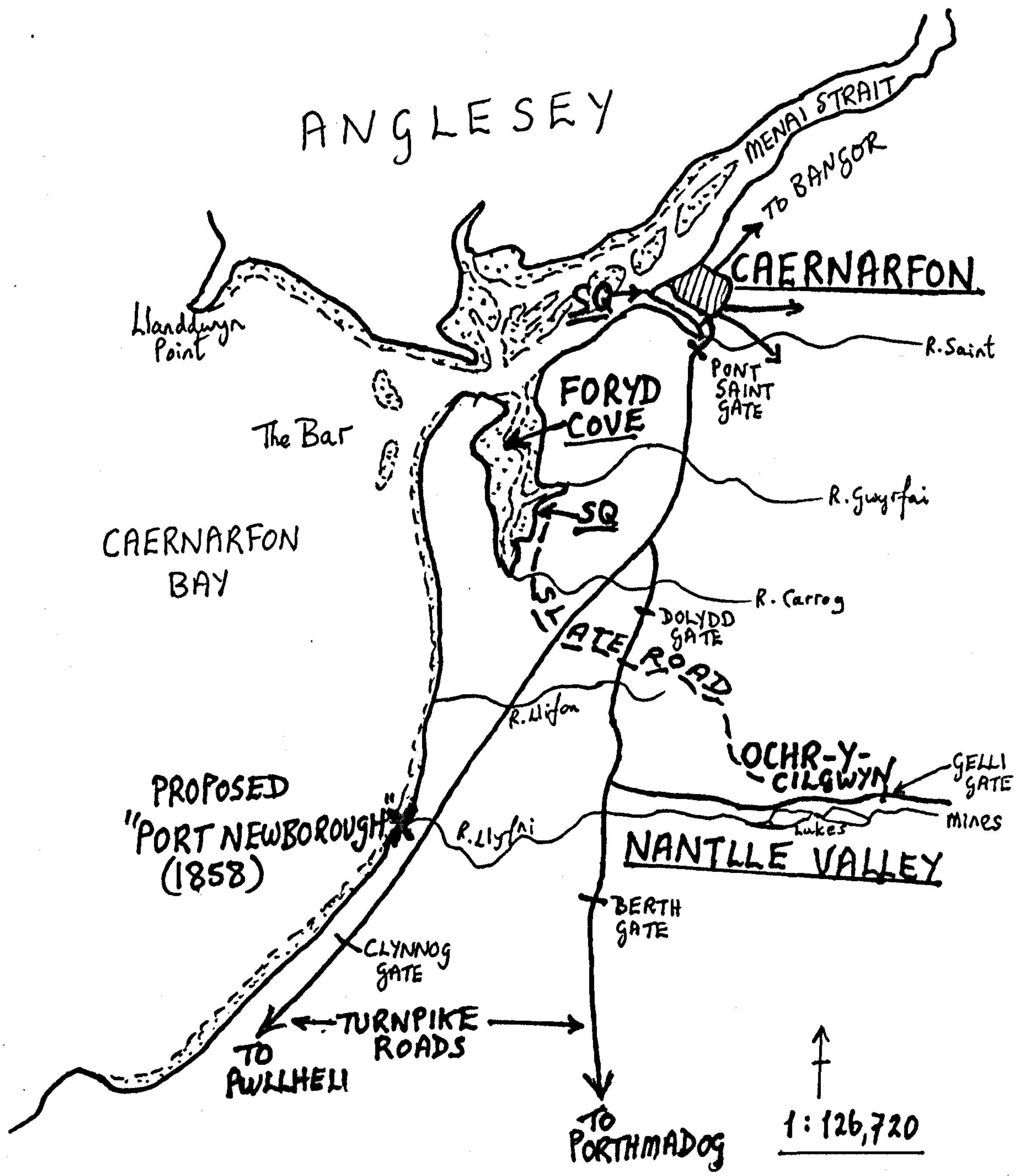
Furthermore, the development of the British canal network after the 1790s assisted the growth in demand for Welsh slates by greatly reducing the cost of carriage to inland markets [57]. Regardless of their premier attributes as a roofing product in term of strength and resistance to chemical deterioration, it was the low cost at the point of use which attracted the attention of speculative builders to Welsh slates. Thus, the cost-effectiveness of the seaborne transport system was the key factor in establishing the predominance of this product in the U.K. roofing market during a period of rapid industrialisation and urbanisation.

The early quarrying concerns of the Nantlle Valley were fortunate in that the nearby Foryd Cove provided an ideal location for loading ships (see Figure 18, below). This sheltered inlet lay to the south of the town of Caernarfon and was only four miles from Ochr-y-Cilgwyn, the site of the first commercial slate quarries in this district (see Chapter 1). Despite the long-standing silting of the tidal bay, the river channel which meandered through the sand banks provided a sufficient depth of water at Foryd for shallow-draught vessels to navigate upstream on high tides, and the mud-flats exposed on the ebb provided convenient beaching points for ships loading and discharging cargoes [58].

Larger ships of deeper draught could not be accommodated in the cove, but such vessels were loaded at anchor in the deeper waters of Caernarfon Roads by means of a shuttle of small boats, in a similar manner to that later employed on the Dwyryd estuary in the case of the produce of the Ffestiniog slate quarries [59]. A further advantage of the Foryd was the common land which made up the banks adjacent to the deepest channel. This provided ample space at no cost for the accumulation of stock-piles of slates, thus balancing the relatively low daily capacity of the primary transport system (see below) with the demands of vessels requiring immediate loading [60].

The suitability of the Foryd to the requirements of the early slate trade lasted for over a century. However, the cove was later eclipsed by the

FIGURE 18



RELATIVE LOCATION OF NANTLLE QUARRIES AND THEIR PORTS superior facilities offered at the new Slate Quay on the inlet of the Seiont estuary at Caernarfon, which were established as the result of an investment by the town corporation over the two decades after 1793 [61]. The deeper channel approaching the new wharves allowed the larger merchant ships to load directly at the quayside, and the patronising of the new harbour by 'tramp' coasters, together with the toll-free storage (up to 1852) and the convenience for merchants based in the town, must have been important factors in the complete relocation of the slate trade from the Foryd by *c.*1810 [62].

It is not known whether the relationship between the early local proprietors of the Ochr-y-Cilgwyn quarries and the maritime trade from the Foryd Cove was other than purely contractual and based upon trading only. In 1729-30 a quarter of all ships entering the Caernarfon Customs zone were local, and these had a near monopoly on the slate trade, particularly with Ireland [63]. The direct influence of the slate industry upon the seaborne secondary transport system became more apparent by the early nineteenth century, when the farmers and seamen who constituted the original ship-owning class were increasingly replaced by slate merchants, quarry proprietors and the developing Welsh middle classes. A number of important Nantlle quarry owners have been identified amongst the ship-owners of the early nineteenth century, of whom John Evans (Cilgwyn Quarry), Griffith Jones (Talysarn Quarry) and William Turner (Penybryn and Penyrorsedd Quarries) were the leading figures [64].

By the 1870s, a number of locally-based limited liability shipping companies had been set up to purchase larger iron vessels. These concerns were promoted by businessmen from Bangor and Caernarfon such as Hugh Pugh (a banker and quarry proprietor), and much of the funds were raised from the quarrying communities, which were reaping the rewards of the spectacular post-1860 boom in the slate industry. However, the backbone of the fleet of local ships specialising in the slate coasting trade from Caernarfon was the two- or three-masted brigs and schooners which were owned by private partnerships typically involving slate merchants, master mariners and well-to-do farmers [65].

The slate-storage facilities at Caernarfon harbour were adequate for many years, but by the late 1850s the quay had become heavily congested as a result of a huge expansion in the slate trade. Together with increasing discontent in some quarters regarding the operation of the public railway from the Nantlle quarries to the port (see below), this resulted in the promotion of the 'Port Newborough' scheme. This proposed new harbour for the specific use of the Nantlle district, was to be located at the mouth of the Llyfni river, two miles to the south of the Foryd Cove (see Figure 18, above). It comprised a length of exposed coastline, where an enclosed harbour was to have been constructed from slate waste transported from the quarries by means of a new narrow-gauge railway, which would subsequently have carried the slate traffic. This scheme had many commendable features, but suffered from the fact that its promoter Thomas Harvey, a prominent quarry speculator, had few local supporters and many influential opponents with vested interests to protect. This ensured that neither Harvey's first Llyfni Vale Harbour Bill of 1858 nor a revised version of 1859 was able to proceed through Parliament [66].

The mid-nineteenth century phase of development in maritime transport system coincided with the arrival of the standard-gauge railway at Caernarfon (in 1852; see below). The threat posed to the shipping fraternity by this rival freight carrier was held at bay initially by the geographical isolation of the new secondary transport system. Yet, despite the logistic problems, increasing amounts of the slate traffic were diverted from the port. Once a through-line to the Nantlle Valley had been completed in 1869, the full force of competition from the railway was felt through the cut-throat tactics of the railway operator (discussed below) which diminished the volume of slates carried by sea, yet the maritime trade of Caernarfon was not brought to a complete halt.

The sea-borne carriage of Nantlle slates from the Seiont estuary continued at a significant scale after *c.*1870 for two main reasons, viz: **(a)** the continuing export trade, which was still more cost-effective from Caernarfon than from larger distant ports such as Liverpool; **(b)** the continuing competitiveness of the coasting trade. Dylan Pritchard's (1944) data for comparative roofing costs and transport charges show an increasing margin in terms of price-on-delivery in favour of Welsh slates against clay tiles during the first three-quarters of the nineteenth century. This was the direct result of a constant reduction in coastal sea-borne transport costs from north-west Wales from *c.*1805 to *c.*1880, in which the repeal in 1831 of the coasting transport tax (of 1794) was only one of several important features. The significance of these economies is illustrated by the large rise of 64 points on Pritchard's index of average slate prices between 1805 and 1880 (see Figure 3, Chapter 1, above), compared with a drop in the London price on delivery by sea of twenty-one per cent in the same period [67].

The explanation advanced by Dylan Pritchard (1944), and corroborated by Dr Lewis Lloyd (1989), for this reduction in sea-borne carriage rates centres on the internal competition amongst ship owners, amplified by competition against the railway network. Thus, in comparing the average cost of sending one ton of 20 x 10-inches slates from Caernarfon Harbour to London by sea in 1805 (at 55*s.* [£2.75] per ton) and 1845 (at 15*s.* [75p.] per ton), we see that the removal of 20*s.* (£1) in transport tax (see above) was matched by an equal reduction in gross rates, attributable to internal competition. Even though a 22*s.*6*d.* (£1.12½) per ton increase occurred in the quarry-gate price of these slates during the same period, the diminishing cost of transport resulted in a net reduction of twenty-seven per cent in the price-on-delivery at the London wharves. After connecting Caernarfon to the British railway network (see sub-section b (ii), below), the sea-borne transport charges were further reduced, with the carriage rate to London of one chartered vessel in 1876 being only 8*s.*6*d.* (42½p.) per ton [68].

Although the setting of the average Caernarfon/London water-borne freight rate in 1880 at 10*s.* (50p.) per ton represented the commencement of a cycle of increases in the maritime transport costs for slates, which was the first reversal of the downwards trend since *c.*1815, railway freight charges also rose during the last quarter of the nineteenth century. The continued inter-transport competition in the slate trade thus maintained a cost advantage in favour of the local ships. For example, the carriage of slates to London from Caernarfon in 1880 was cheaper in ships by a margin of 7*s.* (35p.) per ton, the transport costs representing an addition of twelve per cent to the price of the slates at the port of lading. In comparison, the transport costs by rail added twenty-one per cent to the wholesale price for the same journey [69].

After 1880, transport costs increased generally because of factors appertaining to the British economy, but the relative rates for slates from Caernarfon by sea and rail continued to be tempered by stiff competition. The ship owners maintained their undercutting of the railway rates as the only option to countering the logistic advantages of the latter (e.g., convenience). While the mini-boom of 1896-1902 must have provided the local fleet with a welcome breathing space from the post-1877 depression in the slate trade, the savage recession of 1903-1913 is likely to have finally placed its economic viability under considerable strain in view of its low profit margins. The inevitable slow decline of the local shipping fleet was, however, overtaken by the international political events of 1914, and the consequent brief collapse of the Welsh slate industry proved a death-blow to the slate-ships [70].

After 1918, only occasional shipments of slates were dispatched by sea from Caernarfon harbour, due to the reduction in the number of active local coasters and the promotion of the export trade routes via the larger ports of Liverpool, London and the east coast by the main-line railway company, merchants and shipping companies alike. Consequently, the sea-borne slate traffic from Caernarfon was reduced to just a trickle by the 1930s, ceasing altogether at the outbreak of the Second World War [71].

The early primary transport system; Sledges, paniers and carts

Despite the absence of any record of their use, it is very likely that the earliest mode of transport for slates from the upland quarries of Nantlle to the Foryd Cove was by means of horse-drawn sledges. This is based on circumstantial evidence, viz: (a) that sledges were the most common form of transport in the uplands of Wales at this time, and were likely to have been in the possession of the early Nantlle cottager/quarrymen; (b) the route to the coast from the early quarries of Ochr-y-Cilgwyn was suitable for this form of transport, with over half of the journey being downhill through open ground prior to the wholesale enclosure of the mountain 'wastes'; and (c) the annual estimated tonnage of slate shipped from the Foryd was in the order of hundreds of tons per annum before the mid-eighteenth century, a volume of traffic well within the capability of a primary transport system based on a fleet of sledges [72].

Chapter 5: Transport systems

The introduction of pack animals for transporting slates from the quarries to the coast, the earliest method recalled in folk lore, must have been a response to the continued growth in slate output from Caernarfonshire during the second quarter of the eighteenth century (see Chapter 1) [73]. Pack animals excelled over sledges in such circumstances by virtue of their ability to operate as a 'train'. This had the dual advantages of carrying a significant amount of slate per 'run' whilst simultaneously reducing the manpower required to superintend the work. This change implies that a limited number of contractors or perhaps quarry owners themselves, were owning a greater number of animals than normally required for agricultural work, and represented a significant advance in the capitalistic structure of the local economy.

Surviving details regarding the operation of the animal slate-trains at Nantlle are comparable with other slate-quarrying districts in the county, showing the adaptation by the industry of the existing practices for the general transport of goods. Extant descriptions show that when the load comprised standard small 'single' or 'double' sizes, up to sixty-four slates were carried in wicker panniers slung over the back of each animal, giving an estimated payload of from one to two hundredweight [74]. Less common larger sizes of slates required a different method of loading, and were supported on iron hooks attached to a special leather saddle [75]. Whereas the most common beasts of burden were apparently mountain ponies, the colloquial name for one part of the old Cloddfa'r Coed Quarry, *Parcia Mulod* ("the mule enclosure"), suggests that the use of ponies was not universal [76].

By the third quarter of the eighteenth century, the significant expansion of the slate industry at Nantlle and elsewhere in North Wales (see Chapter 1), must have placed a considerable strain on a primary transport system based on pack-animals. Not withstanding the greater number of slates to be transported to the coast, the average increase in the size of the slates would have resulted in a decreasing number carried per animal.

Consequently, a general transfer of the slate traffic from animal trains to horse-drawn carts occurred in the closing decades of the eighteenth century, when improvements to roads in the region were leading to the more widespread use of wheeled vehicles [77]. Although none of the roads serving the Nantlle area was turnpiked until 1810 [78], the main routes from the quarries to the coast had already been privately improved for the benefit of the slate carts during the previous decade [79]. Further improvements to the Caernarfon/Porthmadog road by the Turnpike Trust must have benefited the slate traffic, which became the greatest source of revenue for the tollgates on the route north of Pen-y-groes [80].

The surviving details of slate-carting shows a similarity throughout the region in the earliest period, although local variations appeared later [81]. The organisation of carting shows all the hallmarks of a pragmatic response to the rapid increase in the demand for slates, whereby extensive local sub-contracting became the most cost-effective option for all quarry operators. Most, if not all the earliest carters serving the Caernarfonshire slate quarries were independent, small-scale contractors drawn from the ranks of local cottagers and farmers, who had found transporting of slates a lucrative addition to the meagre rewards of practising agriculture on marginal land [82].

Whereas the previous stages in the development of the primary transport system had developed uniformly throughout the North Wales slate industry, the carting coincided with the economic divergence which altered the relative importance of individual districts within the slate industry, and saw the Penrhyn Quarry became the dominant concern. Dylan Pritchard has calculated that whereas at the close of the eighteenth century, around 180 single-axled carts, having an average maximum payload of nearly one ton each, were needed to service the numerous slate concerns at Nantlle in the 1790s, only 120 larger carts with almost twice that payload were needed at the Penrhyn Quarry to move around a third more tonnage per annum, with a consequential reduction in transport costs [83]. Extrapolation of Pritchard's calculations suggests that in 1788 the cartage costs at Nantlle were probably equal in magnitude to production costs, effectively doubling the quarry-gate price at the coast. Yet, at the Penrhyn Quarry, cartage was only two-thirds of production costs, illustrating the greater efficiency attained by that concern [84].

This difference was indicative of the large investment in road building by the Penrhyn owner during the 1790s, which matched that sunk into the development of his quarry [85]. Furthermore, the contracting out of carting at Penrhyn to estate tenants in a district dominated by one large concern, also controlled the costs, whereas at Nantlle the existence of independent farmers and quarrymen did not provide such a regulatory mechanism. Thus the 11*s.* (55p.) per ton cost of carting from the Cilgwyn Quarry (Nantlle) to the coast in 1802 had increased to 12*s.*3*d.* (61½p.) by 1812, when it was further increased to 14*s.* (70p.), showing the stranglehold of the carters over the totally dependent quarry operators [86]. Furthermore, there were additional hidden costs involved in this free market. The Nantlle carters had to pay compensation for the damage done to the turnpike road by the heavy flow of slate traffic, and there is evidence that the Cilgwyn Quarry Company, for instance, paid this cost plus the tolls on behalf of its contractors in an effort to keep them in its service [87].

Whereas the early phase of carting illustrated a low-investment, opportunistic activity, it appears that the larger two-axle, three-horse carts having a probable payload of around two tons, which were becoming popular by the first decades of the nineteenth century [88]. These may have been custom-built for the slate traffic and were probably owned by specialised contractors or the quarry concerns themselves. Such people probably did not totally take over the role of the cottagers at Nantlle, where the persistence of high-density small workings lent itself to a mixed economy within the contemporary primary transport system.

Dylan Pritchard concluded that although this was an improvement on previous practice, carting was slow, the rate of breakages high and the system economically 'inelastic'. In Springtime, when demand for slate-transport was at its highest, horses were in shortest supply due to agricultural requirements [89]. Furthermore, the number of carts could not be readily increased at peak periods, resulting in the raising of carriage rates as each quarry strove to attract the services of the carters [90]. These considerations were highlighted by Rev P. B. Williams in 1821 as being a major impediment to the slate trade at Caernarfon, whereby the urgent demands of the 'tramp' ship-captains trading speculatively were not satisfied:

> "...from the uncertainty of such supply [of slates at the quayside],and the consequent delay, proprietors and masters of vessels are unwilling to expose themselves to the risque [*sic*] of incurring a heavy expence [*sic*] in waiting their turn to land ...and it is certain that many Americans and other Foreigners are deterred ...from coming to this port" [91].

Chapter 5: Transport systems

The primary transport system serving Caernarfon had therefore become the critical limiting factor in the Nantlle district in the early decades of the nineteenth century. The time was ripe for a development, which ultimately came about in the form of the Nantlle Railway (see following sub-section). A limited number of carters was still able to continue to serve the industry for nearly a century after the construction of this railway. Some farmers gained contracts to provide horse haulage on the new line, whilst others carted slates from distant quarries to the railhead or intermediate loading points, and a number specialised as suppliers of horses for internal transport systems within the quarries.

The Nantlle Railway, 1825-1867

Richard Pennant, the owner of the Penrhyn Quarry (in the Ogwen Valley) opened up a new field of primary external transport for slates in 1801, when a horse-drawn edge-railway connecting the workings to the port of shipment, was opened [92]. Whereas three horses were previously required to convey 1½-tons of slate by road, now one horse could deal with a payload of up to about ten tons on rails, and the cost of the journey was consequently reduced from about 5*s*.3*d*. (26½p.) per ton to about 1*s*. (5p.) per ton [93].

This was the culmination of a programme of capital investment made by an immensely wealthy owner in the development of his estate and it endowed the Penrhyn Quarry with an added economic advantage over its competitors. However, despite the enhanced competitiveness and the consequential enhancement of profits that resulted from the transfer of the slate traffic from the roads to the railway, the example of the Penrhyn Quarry was not readily emulated elsewhere because of financial and organisational reasons [94].

The slate-producing district of Nantlle contrasted profoundly with the Penrhyn Estate on the above criteria, with the result that despite the desire among its leading quarrying concerns to copy the market leader, this ambition was not achievable in the short term. In addition to the lack of finance that characterised the slate industry at Nantlle, which was devoid both of wealthy landowning interests and capital-rich quarrying concerns, every potential railway transport route out of the district required the granting of wayleaves through the patchwork of landed estates which encompassed the area. Despite these difficulties, the increasing expense of using road transport from Nantlle by the 1810s [95] prompted the larger local slate concerns to examine the feasibility of the construction of railways to carry their produce more economically to the coast.

It is possible that the first of these mineral railway proposals was that initiated unilaterally by the very productive Cloddfa'r Coed (or Hafodlas) Quarry probably *c.*1812-13. The £4,000 scheme involved a four mile private railway from the quarry to the coast at or near the Foryd cove (see Figure 18, above), where a new loading quay was to have been built. The line was expected to carry up to thirty tons of slate per day at an estimated cost of 3*s.* (15p.) per ton, or 8*d.* (4p.) per ton-mile, compared with the contemporary 14*s.* (70p.) per ton, approximately 17*d.* (8½p.) per ton-mile) by cart, an annual saving of about £2,700 per annum. However, no progress was made beyond the planning stage, probably as the result of the internal difficulties faced by the concern after 1813 [96].

The proposal may have acted as the catalyst which in February 1813 brought together the proprietors of the three remaining main concerns at Nantlle, the Cilgwyn, Penybryn and Talysarn quarries, to consider applying for a private Act of Parliament authorising the construction of a nine-mile railway from the quarries to Caernarfon harbour. This proposal must have been associated with a contemporaneous documented scheme to construct a railway from four un-named quarries to Caernarfon, which suggests that the Cloddfa'r Coed Quarry had subsequently joined forces with its neighbours in the cause of financial prudence [97].

It was estimated that this proposed line, which would probably have been a commercial public railway, would have reduced the slate carriage rate by 10*s.* (50p.) per ton (probably to 4*s.* (20p.), or approximately 5*d.* (2p.) per ton-mile), producing an annual saving of £12,000 over road cartage on a 24,000-ton total output. This optimistic projection promised a one-year payback of the estimated cost of construction. This was notwithstanding the financial benefits promised to the promoters from an expected reduction in the average five per cent breakage rate experienced on the uneven roads, and also from potential revenue to be gained from back-carriage [98]. However, neither of these joint proposals proceeded further at this juncture, probably because raising the initial capital was too onerous a task for the relatively small circle of individuals involved in the quarry companies.

Despite the failure of this first flurry of railway schemes, the aim of overthrowing the stranglehold of the local carters on the primary transport of Nantlle slates, and thus regaining some of the quarries' lost competitiveness lingered amongst the interested parties. For instance, the Rev P. B. Williams's *Tourist Guide* of 1821 articulated what must have been the aspirations of the Harbour Trust and the Corporation of Caernarfon, whose commercial lifeblood had become inextricably linked to the slate quarries at Nantlle. He decried the financial loss to the port arising from the inefficiency of the carriage of slates by road-carts, and reminded the Nantlle quarry owners that if they united to-:

> "...form a good iron road or tramway to Caernarvon, which though may be attended with great expence [*sic*] in the execution, [it] would eventually be productive of considerable advantage to the adventurers" [99].

Notwithstanding this acute economic argument, it required a greater incentive to dissipate the economic inertia that had overcome the slate industry at Nantlle by the early 1820s (see Chapter 1). The required impetus was probably supplied in 1823-24 by the twin events of the construction of a railway to connect the rapidly-expanding Dinorwic Quarry at Llanberis with its shipping quay at Felinheli, and the lodging of two competing Bills for railways to connect the quarries of the Ffestiniog district with the new harbour at Porthmadog [100].

As a consequence of both the completed and proposed improvements to the primary transport systems of their main competitors, the writing seemed on the wall for the Nantlle quarries by 1824 in terms of remaining in the upper league of slate producers. Events moved quickly. The route for a railway from Nantlle to the Caernarfon quayside was surveyed by W. A. Provis, Telford's able assistant, before the end of 1824, and a meeting of thirty-one promoters of a railway Bill resulted in the formation of the Nantlle Railway Company on 18 January 1825 [101]. The Parliamentary petition was presented in February 1825, and after an untimely objection had been overcome by the enlistment of influential support, the Act was granted its Royal assent in May 1825 [102].

The full subscription of the Company's nominal capital of £20,000 (made up of 200 shares at £100 each) initially offered an assurance of adequate financing in the face of an estimated cost of construction of £19,000 [103]. However, this funding was obtained at the cost of diluting the power of the local interests, made up of the partners in the biggest quarries and several local landowners, by the sale of shares to external investors, who appear to have been involved in the wholesale slate trade, possibly based around Liverpool [104].

Despite the high initial capital, additional finance had to be obtained to finish the construction work in 1827-28, by which time the original optimistic completion date of September 1826 had long passed [105]. A second Act granting an extension of five years for construction proved superfluous because only about two-thirds of the projected route was built (see Figure 19. below), and the first official train on the truncated line ran in July 1828 [106]. Neither the authorised eastern section beyond the Cloddfa'r Lôn Quarry, leading to the Drws-y-coed copper mines, nor the branch line to the old loading point at Foryd Cove were ever commenced. Though this may have been a facet of the financial crisis enveloping the Company by 1827, it may equally have represented a change of aspirations on the part of the promoters [107].

A further departure from the original plan involved the final form of track to be laid. The original specification for the 3ft.6-inch gauge line was L-section, cast iron plates, which was a characteristic of the progressive railway movement of the late eighteenth and early nineteenth centuries, but which ultimately proved a technological dead-end [108]. It has already been noted in the context of internal transport (sub-section a., above) that Dr M. J. T. Lewis has suggested that this choice of rail was dictated by the prior existence of 3ft.6-inch gauge plate-railway(s) in one or more of the important quarries at Nantlle. This hypothesis is supported by the discovery in 1994 of a single, albeit incomplete, plate-rail at the Cloddfa'r Lôn Quarry, which is of a similar specification to that at the sister Diffwys Quarry (Ffestiniog) provisionally dated as *c.*1817 [109].

At the eleventh hour, a radical change in design was instituted to the Nantlle Railway trackwork. Wrought iron, chaired fish-belly edge-rails were substituted on the recommendation of George and Robert Stephenson, who had been brought in as consulting engineers at a late stage by one or more influential shareholders [110]. Thus, this direct influence of the newly-opened Stockton and Darlington Railway placed the Nantlle line temporarily at the leading edge of railway technology, although thereafter it became an anachronism. The retention of the original gauge of the plateway at 3ft.6-inches despite the Stephensons' recommendation to increase it, was probably dictated by pragmatic considerations such as the costs of both widening the already completed trackbed and rectifying the apparent omission from the clauses of the original authorising Act of powers to increase the gauge [111].

In view of the practices of later railways, the commercial organisation of the Nantlle Railway might seem somewhat unusual, but it was typical of the 'hybrid' type of railway, according to Stephen Hughes' (1990) criteria [112]. It was authorised as a public railway to specifically carry goods and minerals, utilising an unregulated system of independent horse-powered traffic, in the manner of a toll road. Thus, any person was permitted to make use of the line, upon the payment of dues at toll gates erected at various locations between Caernarfon and Nantlle, or by crediting a ledger account in the case of regular customers [113].

Provision was made in the authorisation Act for fixed steam haulage, however, although this was never instituted [114]. Locomotive haulage was not envisaged - the Act pre-dated the Rainhill trials by four years - but it was eventually provided on the upgraded central section of the route in 1865 (see Section b.ii, below). The retention of horse-haulage on the Nantlle Railway prior to standard gauge lines in the 1860s suggests that

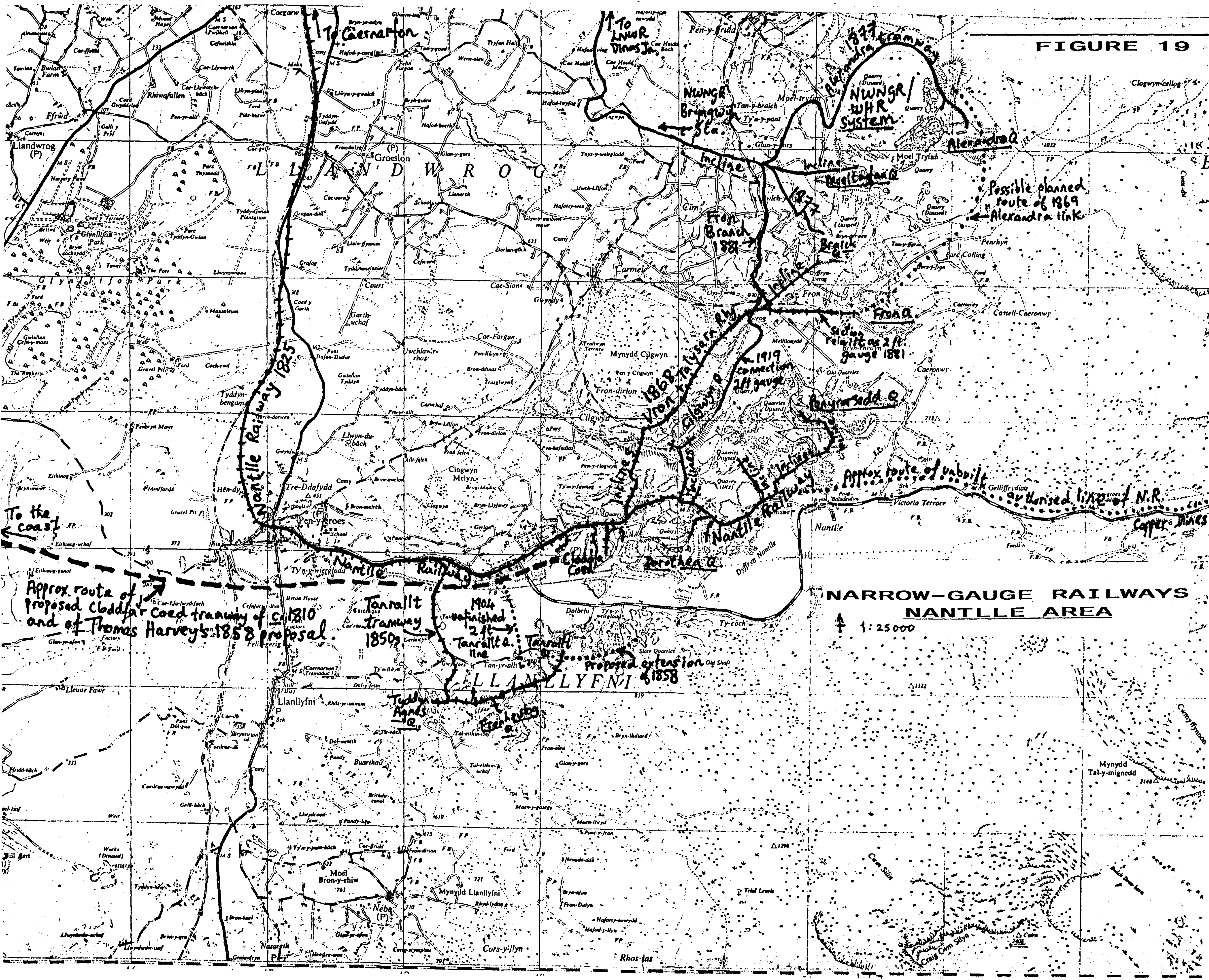


FIGURE 19
NARROW-GAUGE RAILWAYS
NANTLLE AREA
1:25000
To Caernarfon
To LNWR Dinas Jn.
NWNGR Bryngwyn Sta.
1877 Alexandra tramway
NWNGR/WHR System
Alexandra Q
Incline
Moel Tryfan Q
Possible planned route of 1869 Alexandra link
1877
Fron Branch 1881
Braich Q
Incline
Fron Q
section rebuilt as 2 ft. gauge 1881
1868 Vron & Talysarn Rly
1919 connection 2 ft gauge
Cilgwyn Q
Penyrorsedd Q
Nantlle Railway 1825
Inclines
Approx route of unbuilt authorised line of N.R.
Copper Mines
To the coast
Nantlle Railway
Cloddfa Coed
Dorothea Q
Approx route of proposed Cloddfa'r Coed tramway of c.1810 and of Thomas Harvey's 1858 proposal.
Tanrallt tramway 1850s
1904 unfinished 2 ft Tanrallt Q. line
Tanrallt
Proposed extension 1858
Tyddyn Agnes Q
Fronheulog Q
LLANDWROG
LLANLLYFNI
Nantlle
Llanllyfni
Pen-y-groes
Groeslon
Llandwrog
Mynydd Cilgwyn
Moel Tryfan

the loading capacity of the two- or three-horse trains at about thirty tons was a more important consideration than the speed of travel, which averaged a leisurely two- to three-miles per hour [115].

The operation of the slate traffic hauled by horses on the Nantlle Railway appears to have followed the contemporary trend of retaining the system of contracting out, as had been the case with road-carting (see above). No comprehensive list of rail-haulage contractors exists for the Nantlle district, but the pattern revealed from the Dorothea Slate Quarry records (extant post-1849) may well be typical. In this case, the haulage contract from 1849 to 1857 was held by a farmer, who was well placed to supply the necessary animals and attendants required for the work, although it subsequently passed to a local entrepreneur.

By the late 1860s, the majority of the Nantlle quarries were connected directly to the Nantlle Railway, and the system attained its maximum extent just before its demise as an independent concern (see Figure 19, above). Despite the advantages of a direct physical connection to the railway, the rate of achieving this was often under the influence of factors outside the control of the concerns involved. The degree of benefit also diminished by additional costs in such cases. For instance, a wayleave was often required to cross the 'hostile' territory of a rival mineral leasehold to reach the railway, involving a toll per ton. A few details only are known of the excess costs involved in such cases. The Penyrorsedd Quarry, for example, required a wayleave through the Cloddfa'r Lôn Quarry to reach the terminus of the railway, and was charged 1*d.* (½p.) per ton by a new agreement signed in 1882, although this was reduced by half in 1890 [116].

Some of these private branch lines (see Figure 19, above) were several miles long and their cost of construction must have been high. The best example of this was the two mile long 'Vron & Talysarn Railway' (of 1868), connecting the Fron Quarry, located on the northern Nantlle plateau, with the Nantlle Railway *via* a line following the contours above the Cilgwyn Quarry, and subsequently dropping down steeply to the valley floor *via* a series of inclines [117]. Similarly, the Tanyrallt Quarry on the southern side of the valley was connected to the Nantlle Railway *via* a 1½ mile long private branch railway constructed *c.*1853 over a route leased from an adjacent landed estate [118]. Some revenue was earned in these two cases by tonnage tolls paid by adjacent quarries *in lieu* of using the private tracks, for example the 3*d.* (1¼p.) per ton paid by the Fronheulog Quarry on the Tanrallt Tramway [119], but in neither case above was the cost of construction probably ever recovered because the quarries they served were barely profitable.

A small number of Nantlle quarries only never obtained direct links to the railway, being either too distant from the line for a cost-effective connection, or deterred by financial or legal difficulties [120]. These quarries had therefore to use road-carts to gain access to several distant trans-shipment sidings on the horse-railway up to the year 1872, when the destination of the primary transport system for most of the district became the centralised freight depot established at the terminus of the new standard-gauge branch line serving the valley (see sub-section ii, below).

The economic benefits of the Nantlle Railway to the slate quarries of this district were on a par with those conferred by other quarry exit-lines serving the North Wales slate industry. Consequently this allowed for more competitive pricing to match the Dinorwic and Penrhyn quarries;

helped increase profitability for the quarries; and was an asset in the inducement of new capital investment into the district in the important years of the mid-nineteenth century.

The Nantlle Railway allowed the slate industry in this district to develop between the 1830s and the early 1860s without being restricted by the capacity of its primary transport system. This would not have been true thereafter had not the technology of the line been updated in 1865-69 (see sub-section ii, below). The maximum recorded slate traffic carried on this hybrid transport system, at 43,000 tons in 1868, represented only a forty-one per cent saturation level of the claimed 104,000 tons maximum annual railway capacity, although the timetabling of the previously unregulated slate trains after 1856 must have restricted carrying capacity [121]. Secondly, the organisation of loading and unloading the finished slates at the quarry stock-yard and harbour respectively, must also have been more convenient after the replacement of hired carts by quarry-owned railway waggons. Thirdly, stock breakages were probably much reduced when the slates were carried by rail rather than over rutty roads.

Fourthly, the cost of primary transport was also drastically reduced. Comparative costings for the primary exit-railways serving the slate industry are not available on a comprehensive scale, but in 1858 the average cost of slate freight movements on the Nantlle was quoted as 2*s*.3*d*. (11 p.) per ton over eight miles (3.4*d*. [1.6p.] per ton-mile) not including haulage costs, which was more expensive than the 3*s*.3*d*. (16 p.) per ton *total* cost over thirteen miles (2.8*d*. [1.4p.] per ton-mile) quoted for the Festiniog Railway [*sic*] [122]. By virtue of their status as profit-making public railways, the transport costs on both of the above were naturally much greater than in the case of the private lines owned by the Dinorwic and Penrhyn quarries. However, this premium had to be balanced against the saving by the users of the public railways of the large construction costs borne by the owners of private lines [123].

With only one exception, the slate carriage rate on the Nantlle Railway saw a steady reduction during its period as an independent concern (see below). Although the reason for these negative tariff changes is not known, it is possible that a recession in the slate industry locally during the 1830s and 1840s may have been partly responsible for this (see Chapter 1). Alternatively, this may have been a ploy to capture the road-traffic from distant concerns that might have resisted using the railway at first.

The outward rate for slates on the Nantlle Railway was initially 6*d.* (2½p.) per ton mile [124], this being an average of 4*s.* (20p.) per ton, excluding haulage costs, which was a huge saving on the peak rate of 14*s.* per ton for road-carting (see above) prior to the opening of the line [125]. In 1838 the standard rate for slates was reduced by one-third to 4*d.* (2p.) per ton mile, an average total of 2*s.*8*d.* (14p) per ton, net of cartage costs of possibly 3*d.* (1½p.) per ton, this being about 7½ per cent of the market value of the slates [126]. In 1846, the rate was reduced again, to 3*d.* per ton mile (an average 2*s.* [10p.] per ton), but was advanced a penny in 1856, when the line was taken on lease by an external entrepreneur [127]. However, the rate of 3*d.* per ton mile was reinstated in 1862 by a new owner of the railway (see below) [128]. An equally important factor was the reduction in the rate of back-carriage, especially that for the coal that was required by the increasing number of steam engines employed in pumping and winding duties at the quarries. This was initially charged at a rate of 3*d.* (1½p.) per ton mile, but had increased by a penny *c.*1856, prior to its reduction to 2*d.* (1p.) per ton *c.*1862 [129].

The final years of the Nantlle Railway as an independent company were marked by threats to its continued existence from the encroachment of competitors onto its territory. The failed proposal of 1859-60 to channel the output of the Nantlle quarries *via* a new harbour and railway route (the 'Llyfni Vale' scheme) has already been discussed, but its significance as the first challenge to the *status quo* must be re-emphasised. Proposals to establish a standard-gauge link southwards from Caernarfon also threatened the continued existence of the horse-railway, which attempted to defend its tenuous independence with proposals to modernise itself (see following sub-section).

However, upon the defeat of the Nantlle Railway Company's modernisation Bill in 1862 in the face of the Carnarvonshire Railway Bill [*sic*], the game was up. Consequently, half of the shares of the Nantlle concern were bought by Thomas Savin, a haberdasher turned railway contractor, who was the mainspring of the victorious party [130]. Savin, for reasons outlined below, proceeded in 1864-65 to rebuild the Pen-y-groes to Bryn Seiont (just short of Caernarfon) section of the horse railway to standard-gauge specifications, leaving both the three mile section of the horse railway leading east of Pen-y-groes to the quarries, and the final mile at the Caernarfon end unchanged at a gauge of 3ft.6inches. Loco-hauled transporter (or 'piggy-back') waggons were provided by the railway Company to expedite the carriage of freight across the two breaks of gauge. However, slates destined for forwarding on the London & North Western Railway had still to be unloaded at Caernarfon harbour into road-carts prior to re-loading at the station [131].

The explanation for the apparently eccentric development of the Nantlle Railway during its final years as an independent concern, lay in Savin's ever-open eye for a profitable opportunity. As contractor of the uncompleted Carnarvonshire Railway and a major shareholder in both concerns, Savin was ideally placed to broker the substitution of the unbuilt northern portion of the authorised route towards Caernarfon of the former, by the already-operational standard-gauge portion of the Nantlle line. However, as a result of the Vesting Act of 1867 which authorised this latter transaction, the whole of the subscribed capital of the Nantlle Railway Company was converted into Carnarvonshire Railway Preference shares, and the former concern consequently ceased to exist. Thereafter, the remaining horse-drawn portions of the former Nantlle Railway were regarded as narrow-gauge feeder lines for the standard-gauge, and their subsequent history is discussed in sub-section ii, below [132].

(ii) The standard-gauge railway era, 1852-1963

This section deals with the era when the extension of the national standard-gauge railway network into Caernarfonshire challenged the maritime industry for the premier role in the secondary transport of slates to the internal U.K. market. This period also saw the demise of the horse railway from Nantlle to Caernarfon (see previous sub-section), other than for a short feeder system from the quarries to a standard gauge trans-shipment yard.

The historical background

The first standard-gauge railway proposal which impinged upon the Nantlle district was floated against the background of the struggle between Holyhead and Porthdinllaen for the status of Packet Station to Ireland. In competition with a direct route westwards from the Midlands, an extension was planned in the early 1840s from the proposed north Wales coast railway at Bangor, running south *via* Caernarfon to the Llŷn Peninsula. The scheme, labelled the North Wales Railway, was authorised

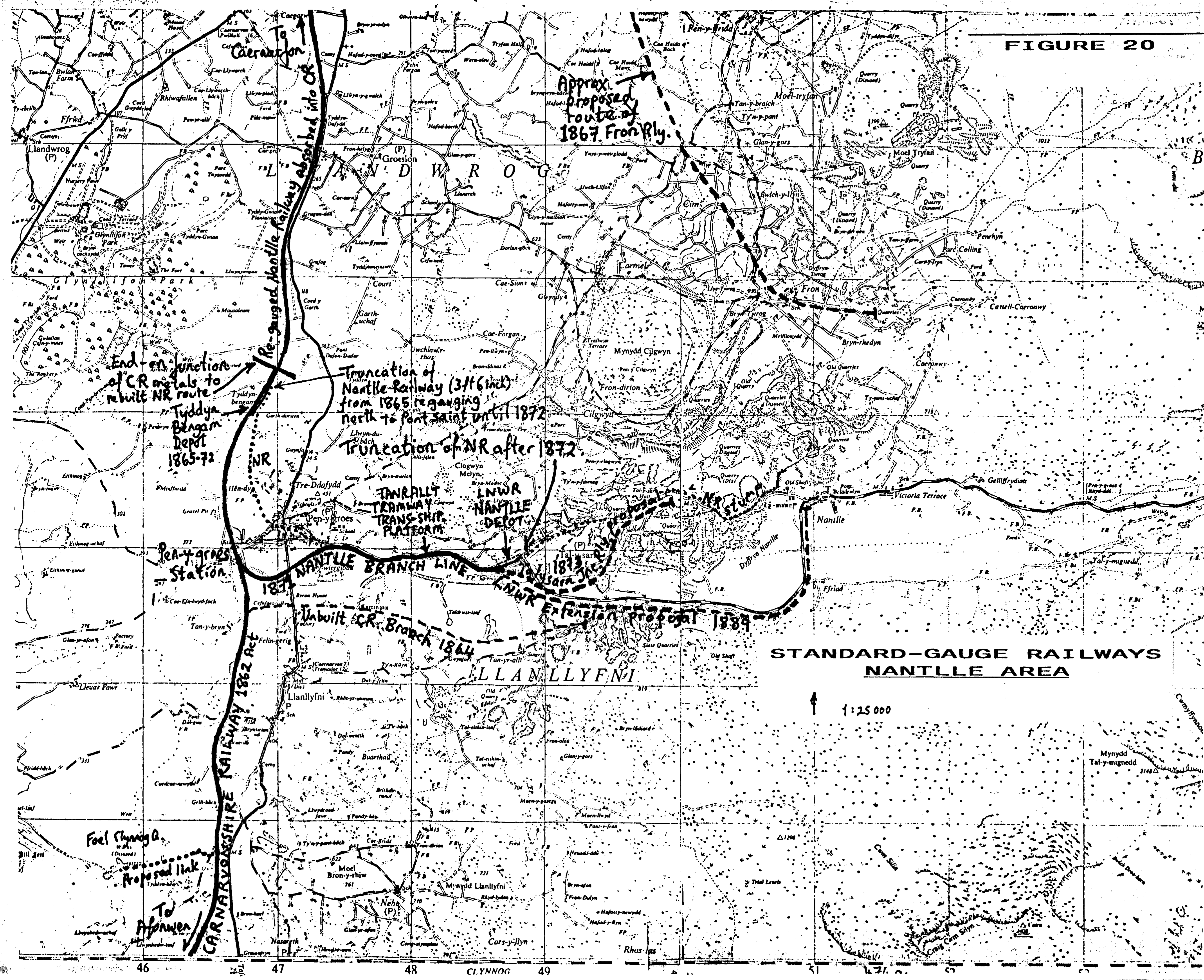


FIGURE 20
STANDARD-GAUGE RAILWAYS
NANTLLE AREA
1:25 000
To Caernarfon
Re-gauged Nantlle Railway absorbed into CR
Approx. proposed route of 1867 Fron Rly.
End-on junction of CR metals to rebuilt NR route
Truncation of Nantlle Railway (3ft 6inch) from 1865 regauging north to Pont Saint until 1872
Tyddyn Bengam Depot 1865-72
Truncation of NR after 1872
NR
TANRALLT TRAMWAY TRANS-SHIP. PLATFORM
LNWR NANTLLE DEPOT
Pen-y-groes Station
1872 NANTLLE BRANCH LINE
LNWR Extension Proposal 1889
Unbuilt CR Branch 1864
CARNARVONSHIRE RAILWAY 1862 Act
Foel Clynnog Q.
Proposed link
To Afonwen
LLANDWROG
LLANLLYFNI
Moel Tryfan
Mynydd Cilgwyn
Nantlle
Pen-y-groes
Groeslon
Llandwrog
Llanllyfni
Tal-y-sarn
Carmel
Fron
Cilgwyn
Victoria Terrace
Glynllifon Park
Moel Bron-y-rhiw
Mynydd Tal-y-mignedd
Nebo
Nasareth
CLYNNOG
46
47
48
49
51

in 1844, but was subsequently abandoned amidst charges of financial impropriety [133]. Had the line been constructed, a branch of the fledgling standard-gauge British railway network would have passed within four miles of the centre of slate quarrying at Nantlle, on a route which would have allowed a convenient interchange with the existing horse-railway from the quarries to Caernarfon harbour (see Figure 20, above).

The opening of the Chester & Holyhead Railway (authorised in 1844) along the north Wales coast by 1848, provided a main artery for the development of branch lines to tap the home-market slate traffic of north-west Caernarfonshire, although only the Dinorwic and Penrhyn quarries at first benefited by the direct trans-shipment facilities that were provided by 1852 [134]. Despite the opening of the Bangor & Carnarvon Railway, which formed a junction with the Chester & Holyhead line, a standard-gauge connection from its terminus to the Slate Quay at Caernarfon, to provide trans-shipment facilities for the Nantlle Railway, appears to have been opposed by the Harbour Trustees, who had a vested interest in protecting the coastwise maritime transport of slates from the threat posed by the standard-gauge line [135].

Despite an initial burst of interest in immediately extending the standard-gauge railway southwards from Caernarfon, this proposal was arrested for a decade by a complex clash of vested interests and competing promoters [136]. In default of any progress during the 1850s, the succeeding decade witnessed a flurry of competing schemes, all involving routes that were capable of tapping the valuable freight slate traffic from the Nantlle valley. This rivalry culminated in a period of intense action during the early 1860s which resulted in legal and organisational confusion [137].

The final scenario witnessed the Carnarvonshire Railway Company (of 1858) being authorised in 1862 to construct a link from the existing Caernarfon railhead to meet the allied Aberystwith and Welch Coast Railway [*sic*] at Porthmadog [138]. This objective was not, however, achieved in the short term due to the acquisition of the old Nantlle Railway by Thomas Savin, who subsequently held controlling interest in both lines [139].

At the opening of the Carnarvonshire Railway in 1867 [140], only the route to the south of Pen-y-groes (see Figure 20, above) provided the Nantlle quarries with their first direct connection with the British standard-gauge network, *via* Porthmadog, because the northern link line had yet to be built [141]. However, there is no record of this tortuous route having been used for the transport of slates from this district, although it is possible that a limited number of loads were sent out in that direction. On the shorter route northwards from Pen-y-groes, the standard-gauge railway still ended in a field on the southern outskirts of Caernarfon. Thus, the transporter service and the road-shuttle described in the preceding section, had to continue until a direct standard gauge connection to the Caernarfon Quay was provided as part of the link line constructed by the London & North Western Railway (hereafter referred to as the **L.N.W.R.**), after it had taken over the Carnarvonshire Railway Company in 1870 [142].

The three mile section of the horse railway leading east of Pen-y-groes to the quarries remained unchanged at this juncture, and none of the authorised standard-gauge branches leading up the valley from Pen-y-groes to tap directly into the quarry stockyards was constructed. This inertia was attributable to the financial predicament both of the

Carnarvonshire Company and of the Cambrian Railways Company, which was poised in 1868 to take it over but failed [143].

This purchase of the Carnarvonshire Railway by the L.N.W.R. realised the fears that had been voiced in the 1850s about the potential threat to the prosperity of the Nantlle slate concerns emanating from London in the form of monopolistic powers in the external transport system [144]. The completion of the standard-gauge railway network in north-west Caernarfonshire during the 1860s should have been the dawn of a new era for the slate quarries of the Nantlle district.

For quarries serving the home market, the new railway service offered direct shipment by steam-powered freight trains to their trade customers' yards. The advantages of prompt delivery, faster dispatch, the capability of handling small orders, reduced breakages and the elimination of several manual trans-shipments should have far outweighed any excess cost of sending slates by rail compared with coastal maritime transport [145]. These advantages of rapid transport should have been particularly beneficial even in the case of quarries specialising in the export market, where the slates made only a relatively short journey over the standard-gauge metals from the Nantlle freight terminal to the Slate Quay at Caernarfon.

However, the eventual resolution of the external transport system from Nantlle during the late-1860s, was not wholly advantageous to the slate industry. The early enthusiasm of the quarry Nantlle owners for an upgraded rail system was quickly dampened. They were almost immediately pitched into a long-running struggle with the L.N.W.R. over several issues, of which the two most important were the operation of the local freight service and the high premiums imposed on the freight charges [146]. Had the earlier proposals for the full conversion of the Nantlle Railway to a locomotive-powered line (of either two foot or standard-gauge) been fully implemented, the Caernarfon harbour exit route would have been protected from the influence of the major railway companies, in a relationship similar to that enjoyed by the Ffestiniog quarries with Porthmadog harbour via the Festiniog Railway [*sic*].

The operational problems stemmed both from the shambolic system bequeathed by Thomas Savin (see above) and from the policy of the L.N.W.R. in discouraging the use of Caernarfon harbour for the shipment of slates and the importing of coal, in favour of channeling this traffic onto its own network [147]. The railway Company sought to achieve this *coup* both by the imposition of penal tariffs on the harbour-bound traffic and by inconveniencing the quarry owners, who were devoid of private standard-gauge stock, by the inadequate provision of freight waggons for the Nantlle/Caernarfon Quay trains [148].

The construction of the L.N.W.R. link line at Caernarfon, but without a corresponding rebuilding of the surviving horse-drawn railway serving the quarries, further disrupted the transport of slates from Nantlle in the short term [149]. The new arrangement necessitated the trans-shipment of slates into standard-gauge waggons at the former Tyddyn Bengam transporter depot (north of the new Pen-y-groes station), where the facilities had not been designed for this purpose and were consequently unsatisfactory for the volume of freight traffic involved [150]. Delays and increased breakage rates therefore occurred, and the mounting discontent of the quarry operators had to be appeased.

A number of investigations by railway engineers raised several possible solutions to the problem, but the eventual compromise created many lasting animosities between neighbouring slate concerns, and between factions among the quarry proprietors against the railway management at Euston. Despite the apparent reluctance on the part of the L.N.W.R. to increase its already considerable expenditure in this district, improvements were instituted to the standard-gauge provision in the Nantlle valley in 1871-72 to silence the critics. This remedial work involved the construction of a new standard-gauge branch from a junction at Pen-y-groes to terminate at a large trans-shipment depot at Tal-y-sarn (see Figure 20, above) [151], plus introducing independent trans-shipment facilities on the truncated private horse-railway leading to several of the southern Nantlle quarries and constructing a similar loading platform at Pen-y-groes station to serve the road-hauled slate traffic from a number of the remoter quarries [152].

Despite these improved facilities, the compromise failed to dampen the expectation amongst a number of the Nantlle quarry owners of direct standard-gauge loading facilities. They desired to be relieved of the haulage and trans-shipment costs associated with using the horse-powered feeder lines. Consequently, agitation both for a standard-gauge extension east of Tal-y-sarn and for the construction of other standard-gauge feeder branches, authorised back in the 1860s, continued until the present century, but nothing was achieved [153]. On only one occasion, in 1888, was the L.N.W.R. temporarily converted to the cause of extending its standard-gauge lines eastwards to Nantlle village as a foil to a proposed expansion of the North Wales Narrow Gauge Railway (see below) [154].

This cessation of further gauge-conversion at Nantlle after 1872 was partly the result of the refusal to meet the cost of overcoming the physical problems of reaching the individual quarry stock-yards with standard-gauge metals. The sole exception was the Coedmadog Quarry, which was adjacent to the L.N.W.R. Tal-y-sarn depot ('Nantlle Station'), and was thus able to construct a private direct connection in 1881-82 [155]. Furthermore, the campaign to extend the standard-gauge branch network was irrevocably weakened by a lack of solidarity amongst the slate proprietors stemming from the pre-eminence of individual vested interests. For instance, the influential Dorothea Slate Company was the main opponent to every proposal to replace the horse-drawn rump of the Nantlle Railway by a standard-gauge track because an inconvenient and expensive transport system was the price it had to pay as a guarantee of its vital water supply [156].

Perhaps to overcome the limitations imposed by the concentration of trans-shipment at the Tal-y-sarn depot, several of the bigger concerns at Nantlle had initially dispatched some of their orders from a secondary stock-pile at the Caernarfon Slate Quay, but after *c.*1910 this was largely discontinued in favour of a cheaper system of direct shipments from the Tal-y-sarn rail depot [157]. Any residual secondary stock-piling that remained on the Seiont quayside post-1918, was quickly killed off due to the development by the L.N.W.R. of a major sorting and stock-piling depot for slates, located at the freight centre of Mold Junction. Its patronage by those Nantlle quarry companies which had formerly stock-piled at Caernarfon was encouraged by the offer of 'special terms' to customers who switched their allegiance [158]. However, this new arrangement was not without its problems, the greatest of which in the 1920s-30s was the damage caused to some consignments through rough shunting, which tended to cause the fracture of slates containing cross-cleavage (or *pefals*) [159].

The operation of the horse-tramway, post-1867

With the opening of the L.N.W.R. Nantlle Branch in August 1872, the former 3ft.6-inch gauge Nantlle Railway was cut back to a network of branches leading off a 1½-mile trunk 'tramway' feeding the standard-gauge trans-shipment depot at Tal-y-sarn village. The operation of this rump, however, continued in much the same manner as in earlier years, whereby the quarry operators ran their own horse-drawn trains on the line, paying a toll standardised at 3*d.* (1½p.) per ton on the notional mile of L.N.W.R.-owned track. A suggestion by the railway Company that the addition of a third rail, at a two-foot gauge, to the tramway would allow the quarries to substitute locomotive haulage for horses was not implemented because of the impossibility of obtaining unanimity amongst the users, and possibly because the existing arrangements proved still adequate [160].

No additional branches were opened from the 3ft.6-inch system to the minority of smaller quarries unconnected to the primary railway transport system after *c.*1870 [161], though the slate industry continued to grow until a peak was reached in 1877. In that year, it is estimated that up to 70,000 tons of slates were carried on the horse-tramway feeder lines from thirteen quarries [162]. This must have approached the maximum handling capacity of even the new trans-shipment facilities at Tal-y-sarn. Thereafter, the number of individual users of the line declined due to closures during the trade depressions of the 1880s and the post-1902 years, and the quarry amalgamations which characterised the intervening mini-boom of the 1890s (see Chapter 1).

The number of quarries using the horse-tramway was reduced through closures to eight by 1899 and six in 1919, with only two of these concerns (namely Dorothea and Penyrorsedd) remaining in business by 1939 [163]. This created a concentration of the horse-haulage contracts into the hands of only two families, that of William Jones (of Nantlle) which held the Penyrorsedd one, and that of Richard Jones (of Talysarn) which by the 1930s held most others than the Dorothea Quarry, which supplied its own horses [164]. Despite its apparent archaic character, the horse-haulage primary transport system was a more efficient and cost-effective than the contemporary short-haul motorised road-transport from the stockyards to the railway station, thus explaining its continued survival up to the 1960s [165].

The North Wales Narrow Gauge Railway/Welsh Highland Railway

Despite the construction of a number of feeder lines by private wayleaves, the tracks of the Nantlle Railway were destined only to reach half the northern Crown estate slate quarries in the district. The southernmost member of this group, the Cilgwyn Quarry, had been a promoter of the precursors the Nantlle Railway (see above) and had been connected to the completed line soon after its opening in 1828, but the six remaining Crown quarries continued to rely on road-carting until well into the second half of the nineteenth century because of their remoteness (see Figure 3, Chapter 1, above) [166].

The lack of a direct railway outlet from the Nantlle Crown slate concerns, other than the Cilgwyn Quarry, must have been an important factor in their initial slow rate of development in comparison with the quarries enjoying better transport facilities on the valley floor. This unsatisfactory situation was overturned with the arrival in the 1860s of several high-capital companies as lessees of a number of these upland setts.

The first railway exit route to reach the Crown land beyond the boundaries of the Cilgwyn Quarry, was opened as the result of the abandonment on financial grounds in 1867, of a private proposal by the British Slate Company Ltd., to construct a standard-gauge line from its Fron Quarry to join the Carnarvon & Llanberis Railway [*sic*] just outside Caernarfon town [167]. Subsequently, the promoters had to be satisfied with a less direct route *via* a private 3ft.6inch gauge exit line (of 1868) from its quarry to the Nantlle Railway and hence to the London & North Western Railway at Pen-y-groes until 1872, and afterwards at Tal-y-sarn (see previous sub-section and Figure 19, above) [168].

Whereas the abandoned Caernarfon/Fron Quarry standard-gauge line (above) had been designed to fulfil the role of a revenue-earning feeder for the whole of the northern Nantlle uplands, it is uncertain whether the British Slate Company had any such ambitions for the less-adventurous exit route that eventually materialised. However, its completed Vron & Talysarn Railway [*sic*] did earn some external revenue by transporting slates from the neighbouring Braich Quarry for nearly a decade, though the extension of its track to the distant Alexandra Quarry *via* a second private line which was being arranged in 1869, did not materialise [169].

Despite its potential, the Vron & Talysarn Railway failed to address the transport problems of the majority of the Nantlle Crown quarries for a number of reasons, the most important of which were probably its control by an avaricious quarry concern and the fact that its terminus was at the most costly branch of the London & North Western Railway in terms of freight tariffs (see below). Thus, the spoils still remained available to any promoter of an exit railway which could serve all these Crown quarries, but which followed a shorter route north-westwards to reach either the Caernarfon quays directly or interchange with the L.N.W.R. on the Afonwen 'main' line. However, the cost of railway building by the 1870s, at upwards of £10,000 per mile even on a two-foot gauge [170], required a corporate promoter to raise such a large investment needed for the scheme to materialise. Furthermore, the general lack of co-operation amongst the competing quarry concerns made the intervention of an external promoter an essential pre-requisite to the success of such a project.

The involvement of Hugh Beaver Roberts (a solicitor and businessman of Bangor, who was the lessee of the Braich Quarry during the 1860s and 1870s) [171], in the promotion of an ambitious narrow gauge railway network titled the North Wales Narrow Gauge Railway, promised a solution to the twin questions of finance and organisation. Within the proposals included in a comprehensive Bill (of 1872) was one for the 'Moeltryfan Undertaking', a public railway extending from an interchange with the London & North Western Railway, four miles south of Caernarfon, to the Nantlle Crown quarries, with a branch along the Gwyrfai Valley to Rhyd-ddu [172]. This railway was to be a modern steam-powered concern, based upon the successful principles of narrow-gauge working that had been established by the Festiniog Railway [*sic*] after 1863.

The pivotal role of H.B.Roberts in the North Wales Narrow Gauge Railway scheme and the consequent priority to the 'Moeltryfan Undertaking' can be gleaned from the initial proposals and the subsequent history of this ill-fated enterprise. The retention of the Moeltryfan line in the slimming down of the full scheme during its Parliamentary passage made it the only portion of the authorised works actually constructed [173].

Despite the rapid commencement of construction work after authorisation in 1872, the first phase of the 'Moeltryfan Undertaking' of the North Wales Narrow Gauge Railway Company was not completed until 1877 because of the serious financial troubles which had beset the project from the outset. The line serving the Nantlle Crown quarries (later known as the 'Bryngwyn Branch') provided a passenger and general goods service for a number of villages *en route*, and catered for slate traffic from private feeder lines connecting with the public railway. Initially, only the Alexandra, Braich and Moeltryfan quarries of the Nantlle Crown group were directly served by the Bryngwyn Branch (see Figure 19, above), but the private mineral feeder network was extended in 1881-82 to reach the Fron & Old Braich Quarry. For unknown reasons, the small Brynfferam Quarry operated by the chairman of the North Wales Narrow Gauge Railway Company during the 1880s, never acquired a direct connection [174].

Of the large quarries on the periphery of this upland mineral feeder network, neither the Cilgwyn nor the Penyrorsedd concerns were tempted to use it instead of their existing Nantlle Railway exit routes at first. Though Cilgwyn was eventually connected to the Bryngwyn outlet (see below), Penyrorsedd was never captured despite approaches by the railway Company from the outset [175].

This was surprising given the enthusiasm for shipping *via* the Bryngwyn Branch displayed by the Penyrorsedd Company, perpetually unhappy with its transport arrangements *via* the Nantlle system after 1865. However, the requirement to up-haul the produce of this quarry to the lip of the northern Nantlle plateau and the cost of building a link to the Bryngwyn Branch prior to the construction of the Fron feeder line, made this outlet an unattractive proposition in the 1870s, while the prospect of a direct standard-gauge connection to the quarry remained a possibility (see above).

The continuing dissatisfaction of the Penyrorsedd Company with its valley-floor transport outlet resulted in it supporting in 1885 of an Act to authorise the extension of the North Wales Narrow Gauge Railway from its terminus at the Dinas Junction interchange to the Slate Quay at Caernarfon [176]. Unfortunately, the financial troubles of the railway precluded the commencement of work, and the powers lapsed. Deprived of its alternative outlet to the harbour, the interest of the Penyrorsedd Company in the patronage of the narrow gauge line also waned. Despite a temporary resurrection of interest in the Bryngwyn outlet in the 1890s, the continued inability of Penyrorsedd to reach amicable terms with the North Wales Narrow Gauge Company forced an impasse that was never overcome [177].

Derived of the large traffic volume that would have come from Cilgwyn and Penyrorsedd, the slate-freight carried by the North Wales Narrow Gauge Railway during the slump of the 1880s was insufficient to generate the profits required to enable the line to recoup its construction costs. Consequently, this railway, saddled with debts and in perpetual receivership, assumed a 'hand to mouth' existence. Nevertheless, the line boosted the development of the Nantlle Crown quarries sufficiently to keep the operation in business with a slate traffic volume of around 10,000 to 15,000 tons per annum during the better trading period of the 1890s. At a tariff of ½*d.* (¼p.) per ton mile over six miles from Bryngwyn to Dinas, the slate traffic earned the railway an average of 2*s.* (10p.) per ton revenue during this period, but the decline of the quarries after 1903 brought about such a dramatic deterioration in the line's finances that it had assumed an air of dereliction by the First World War [178].

The resurrection of the North Wales Narrow Gauge Railway within the new Welsh Highland Railway Company (of 1922) [179], corresponded with the revitalisation of the main Nantlle Crown quarries under the the Amalgamated Slate Associations Ltd., (of Caernarfon). This concern was responsible for the connection of its Cilgwyn Quarry to the Bryngwyn Branch line by *c.*1920, replacing its former outlet *via* Nantlle. However, the closure of the Cilgwyn and Moeltryfan quarries by 1929, followed by the Alexandra Quarry in 1930, left the Welsh Highland Railway (which was already in receivership), bereft of its largest source of freight revenue [180].

The reopening of the ex-Amalgamated quarries in 1932 by the Caernarvonshire Crown Slate Company brought a ray of hope to the Welsh Highland line, but this soon faded. The Alexandra Quarry was closed after only a year, and rail-freight traffic from the Cilgwyn Quarry also ceased due to the greater cost-effectiveness of sending the slates by motor lorry to the London & North Western Railway depot at Pen-y-groes, substituting a two-day journey to the Dinas depot by a twenty minute trip by road [181]. Only the lack of a suitable road access prevented the Moeltryfan Quarry from also abandoning the Bryngwyn outlet route in favour of using motor-lorries to Pen-y-groes station. However, the anticipated demise of the Welsh Highland Railway Company led to the construction of a road to this quarry, and its commissioning corresponded with the long-awaited closure of the line in 1937 [182].

Economic considerations of secondary railway transport

The arrival of the standard-gauge railway at Nantlle had been expected to lead to a significant reduction in the cost of transport. A sale prospectus of the Dorothea Quarry had confidently predicted the forthcoming slashing of total rail transport costs to Caernarfon harbour from 2*s*.11*d.* (14½p.) per ton to only 11*d.* (4½p.) per ton in anticipation of the Carnarvonshire Railway proposal of 1857-58 [183]. This was probably over-optimistic, but nevertheless expressed the expectation to be found in the Nantlle district at that time. However, disappointment was at hand. The Act of 1867, which vested the old Nantlle Railway in the Carnarvonshire Railway Company, stipulated the retention of the 3*d.* (1½p.) per ton mile rate of the horse-railway, equivalent of 2*s*.3*d.* (11½p.) per ton total, exclusive of haulage costs. The only concession was a reduction of coal back-carriage to 2*d.* (1p.) per ton mile from a previous high-point of 8*d.* (4p.) per ton [184].

Following the L.N.W.R. take-over of the Carnarvonshire line in 1870, freight charges in fact were significantly increased, resulting in the unprecedented combination of the Nantlle quarry owners in January 1874 in protest [185]. The quarry operators also had to face an additional cost of 1*s.* (5p.) per ton for the carriage of slates to the Nantlle depot by means of the horse-railway [186]. This was even more contentious in view of the large surcharge voluntarily paid by the quarries since *c.*1870 on inward coal deliveries to cover the cost of maintenance of the horse-railway [187].

The quarry owners demanded a reduction to the previous rate of 2*s.* (10p.) per ton from Nantlle to Caernarfon, free of the added 3*d.* per ton standard toll on the horse-drawn link. They also requested a reduction of the through-rate for slates carried on L.N.W.R. metals beyond Caernarfon [188]. However, the pleading of the Nantlle slate proprietors cut no ice at Euston during the boom years of the 1870s, although some concessions were made when the deepening depression of the early 1880s bit into the profitability of the slate industry.

In July 1882, representatives of the quarry owners put forward a case for a reduction in the railway freight charges from Nantlle on the basis of the proportionately higher cost of transport from this district compared with the other slate areas of North Wales. This request was partially satisfied by a reduction of 1*s.* (5p.) per ton in the 'through' rate, albeit conceded at a price of a 6*d.* (2½p.) per ton increase on the Nantlle/Caernarfon Quay rate [189]. This was a shrewd move on the part of the L.N.W.R., in that it benefited the railway company by promoting its own interests [190].

This rates differential earned the displeasure of all the quarries that made use of the harbour both for shipping slates and for importing coal [191]. Revenge was eventually at hand in the form of an amendment tabled by the Welsh Liberal Members to the L.N.W.R. Rates and Charges Provisional Order Bill (1890), giving the Parliamentary Railway Rates Committee the charge of fixing the maximum carriage rate for coal and slate to and from Nantlle [192]. However, this victory was marred by a loophole, which allowed the railway company to increase the 'terminal' (or handling) charges to counteract the loss in rate revenue [193].

The L.N.W.R. also sought to rupture the fragile unity of the quarry owners by further biassing the carriage rate differential against the harbour users by 7*d.* per ton [194]. Furthermore, the average Nantlle Branch forwarding surcharge of 17*d.* (7p.) per ton compared unfavourably with the 9*d.* (4p.) per ton average paid by those Nantlle quarries which shipped from Dinas Junction (see above). Consequently, in view of the equal cost of the primary transport to the L.N.W.R. in both cases, a number of Nantlle quarries enjoyed a significant economic concession over their local competitors on the sole basis of their geographical location, much to the chagrin of the disadvantaged parties.

Opposition to the tariff system thus collapsed in April 1893 as the result of a cabal of Nantlle concerns that were interested only in the harbour route breaking ranks and accepting the *status quo* [195]. The remaining quarry concerns settled for a fixed surcharge on through-freight, which probably amounted to about 1*s.* (5p.) over Bangor forwarding charges [196]. This state of affairs was reasserted in 1896, in a L.N.W.R. Bill, which included an exemption for coal and minerals in an amendment requiring the equalisation of its rates throughout its network. This was sanctioned despite efforts on behalf of the Nantlle quarry proprietors by David Lloyd George, the Member for the Caernarfon Boroughs [197].

Consequently, the net figure for the Nantlle slate carriage rates remained at a relatively high level [198]. The only specific figures available for comparing the rail dispatch rates from the Nantlle area concerns the freight rate from Caernarfon to London, which increased from 17*s.* (85p.) per ton in 1880 to 18*s.*11*d.* (94½p.) per ton by 1914 [199]. This represented only a ten per cent increase over thirty four years, and this degree of restraint shown in the pricing policy of the railway company must be a measure of the competition posed by the contemporary coastal shipping trade, and was in direct contrast to the position post-1918 (see below).

The comparative cost was not the sole consideration in the sea versus rail transport battle for the produce of the Nantlle slate quarries, fought between 1870 and 1914. Despite its higher freight rates, the standard-gauge railway secondary transport system boasted several advantages over its coastal maritime competitor, of which speed and convenience were the most important. Sea-borne transport was slow in comparison with the steam-drawn trains, and the delay in delivery (and the cost) was increased if the slate was destined for inland locations, thus requiring trans-shipment onto the canal system.

Before the establishment of the British railway network in the mid- to late-nineteenth century, the geographical distribution of these waterways delineated the market penetration of Welsh slates. Inland areas not in close proximity to the canals generally continued to use traditional local roofing materials until the cheaper Welsh slates gained access following the expansion of the rail network, a process which was enhanced when the full journey was possible without recourse to several trans-shipments [200].

Slate consignments for coastwise transport had also to form a full or significant load for a ship, and thus the fulfilment of small orders was not convenient until the advent of the railway, on which individual waggon loads of about five to ten tons could be dispatched. Consequently, the achievement of a direct transport route from the Nantlle quarries to the British standard-gauge railway network had an effect on the structure of the marketing system in that it provided an opportunity for large builders to buy slates in bulk from the quarries, by-passing the major merchants.

Paradoxically, whereas the transport system was the key to the early success of North Wales slate, changes in the organisation of that system by the turn of the century was one important factor in the decline of the industry. The key development was the capture by certain major companies of the main railway exit routes from North Wales, whereby the monopolistic power was often exploited for short-term gains until it was ultimately challenged by the development of long-distance motorised road transport (see sub-section iii, below).

Insofar as the establishment of the terrestrial transport monopolies laid the foundation of future events, the victory of the railway over the ships in the slate transport trade was achieved by the destruction (both financially and physically) of the independent local maritime transport system during the First World War [201]. The economic repercussions of the war irredeemably altered the balance of freight charges in favour of the railways. By 1919, the freight rate by sea from Caernarfon was about thrice that of rail, and had increased from its pre-1914 norm of 6*s.* (30p.) to 7*s.* (35p.) per ton on coastal voyages to a range of 40*s.* (£2) to 45*s.* (£2.05) per ton by 1921 [202].

This was a massive tariff rise even allowing for price inflation, and this wide margin allowed the major U.K. railway companies to exploit the situation by charging a premium on slates whilst still remaining competitive compared with the coasters. Thus, the mean U.K. railway rates for slates were, at 25*s.*6*d.* (£1.27½) per ton in 1921, double the 1914 average charge of 12*s.*6*d.* (62½p.) per ton. Expressed as an average rate per mile, the figures above represented charges of 45*s.*11*d.* (£2.29½) and 22*s.*6*d.* (£1.12½) respectively [203].

It is important to note that the slate producers had since the early-1890s clawed back a portion of the costs by imposing a loading surcharge on their customers [204]. In 1914 the typical rate was 1*s.* (5p.) per ton, rising to 4*s.* (20p.). per ton by around 1920. There were also price increases to compensate for increased freight charges [205]. This had an important and damaging effect on the industry during the 1920s in the British home market. The relatively cheap sea journey to the East Coast from the Continental ports exaggerated the existing price advantage enjoyed by French slates in particular, when compared with the high-cost cross-country rail journey from North Wales. This competitive disadvantage of Welsh slate became even more severe after 1926 when roll-off ferries brought loaded rail waggons of Continental slates directly onto the English rail network, giving a deeper penetration into the country [206].

The London and North Western Railway Company ceased to exist in 1922, when it was amalgamated with a number of other railways to form the new London Midland Scottish group under the Government-sponsored reorganisation of the railways [207]. At Nantlle, there was hardly any perceivable change, other than the withdrawal of the loss-making passenger service on the Nantlle Branch in August 1932 [208]. In terms of freight traffic, however, the railway remained the only cost-effective means of long-distance transport until after the Second World War. It was not until the 1950s that an effective competitor for the transport of slates appeared in the guise of the resurgence of the pre-railway primary system of road transport, using motor-lorries.

(iii) The change to motorised road transport, from *c.*1910 to date

This last sub-section deals with the introduction of motorised road transport initially to replace short-haul horse-carting to the local railhead, and the subsequent development of long-distance road transport in competition with the standard-gauge rail network.

Motorised road haulage was not well received during the first three-quarters of the nineteenth century. Reliable steam 'traction' engines for road use were developed from about the 1840s [209], but do not seem to have made an appearance in north-west Caernarfonshire until the 1860s. Of a small number of traction engines used in the slate industry of North Wales, one belonged to the Talysarn Quarry (Nantlle) [210]. It was possibly briefly used during the mid-1860s to pull trailer-loads of slates to Caernarfon by road when the free flow of traffic on the Nantlle Railway was adversely affected by re-construction work (see above). However, in view of the poor state of contemporary road surfaces and the general objections of the authorities and other road users to such machines, this experiment was short-lived and traffic returned to the railway as soon as it was practicable to do so [211].

Despite a greater use of road haulage by traction engines and steam lorries in the county by the 1900s, there is no evidence linking this technological development with the slate industry at Nantlle [212]. It appears that the first tentative steps in the adoption of powered traction to the road haulage of slates in this district was made as the result of the progressive replacement by local haulage contractors of horse-carts and waggons by petrol-engined motor lorries after *c.*1910 [213]. These lorries replaced animal-drawn road vehicles on the contracted transport of the produce of a number of the smaller quarries to the local railway freight depots [214].

As with horse-powered road and rail transport, the hire of vehicles was more common than ownership by the slate concerns. The first known quarry-owned motor lorries at Nantlle were at the Fronheulog Quarry, which purchased a pair of ex-army 'Thorneycroft' machines c.1920. They ran a shuttle service from the quarry to the slate freight depot at Pen-y-groes station, replacing a horse-worked tramway connecting an older trans-shipment facility on the western edge of Tal-y-sarn village. In addition to providing a more rapid carriage of the slates, the lorries were probably more cost-effective than the tramway, which was subject to leasehold rents and tolls [215].

Whereas the motor-lorries of pre-1914 vintage provided only a marginal improvement on the larger horse-waggons for the short-haul carriage of slates by road, technological improvements after the First World War widened the advantage in favour of the motorised vehicles. Allied to the upgrading of metalled road surfaces in the 1920s, the improved inter-war 'Austin', 'Ford' and 'Morris' flat-bodied lorries of two to three tons gross, owned by local haulage contractors, became increasingly used over longer distances, thus capturing some of the local traffic from the railway for small shipments of slates [216].

W. G. Rear (1986) suggests that the catalyst which alerted the quarries to the feasibility of long-distance motorised road transport was the rail strike of 1926 [217]. However, the use of motor lorries for the transport of slates to more distant destinations outside the district of origin, probably dates from the 1930s, when a number of Nantlle haulage contractors began to offer a long-distance service, in which a large, ten-ton lorry owned by Harry Parry (of Dinas Garage) featured particularly [218]. Although the greater capacity of the railway remained essential for moving bulk orders to merchants' yards, small consignments sent direct by lorry to building sites proved a more convenient and rapid system than delivery to a railway freight depot for collection by the customer, echoing advantages of railway transport over coastwise shipping in the late nineteenth century (see above).

Despite the slow growth inter-war in the road haulage of slates, this remained secondary to the railway until after the Second World War, when in common with industry and commerce in general, there was a rapid movement away from rail to road transport [219]. The driving force behind this change was the big swing in cost-effectiveness towards the latter, particularly in terms of average freight rates, which according to T. R. Gourvish (1986), increased on the British Railways network from 2*d.* (1p.) per ton mile in 1948 to a maximum of nearly 4½*d.* (2.1 p.) in 1957 [220]. Furthermore, the cost-advantages of a door-to-door delivery by larger modern lorries, which attained greater speeds on upgraded roads, were additional factors in tipping the balance further away from the railways by the late-1950s [221]. Thus rail mineral traffic, which held up remarkably well until around 1957, suffered a sharp decline thereafter despite a reduction in average rates to less than 3½*d.* (1 p.) by 1962, in a vain attempt to retain freight business [222].

This trend was mirrored by the slate industry at Nantlle, where the Dorothea Quarry, for instance, abandoned the railway in 1958 except for special loads [223]. Slate merchants from the Wirral and Manchester had collected loads from the smaller Nantlle quarries since the end of the Second World War, and an eight-ton lorry operated by Royles of Manchester was one regular visitor to the Tanrallt quarries during this period [224]. Furthermore, a number of local hauliers had qualified for long-distance zone licences after the Attlee Government imposed strict regulation on the road transport industry c.1948. Of those engaged in slate transport during the 1950s, Grey Motors (of Bethesda) was one of the first firms to specialise in this service, and the long-distance haulage business established in the late 1950s by R. Osborne Parry (of Pen-y-groes) was built upon contracts to carry slates from the Nantlle quarries [225].

The utilisation of long-distance motorised road transport by the smaller quarries at Nantlle was more rapid than in the case of the larger Dorothea and Penyrorsedd quarries because of considerations of traffic volumes and site access. In the first instance, the balance of cost-effectiveness of rail *versus* road was not clearly defined until the output of these main concerns had diminished to below a certain level, a situation which was reached in the mid-1950s. Furthermore, the larger lorries required by the main quarries for dispatching bulk orders could not approach the stock-yards until road improvements had been instituted by the local authority. However, the purchase of articulated lorries such as the 'Atkinson' twenty- and thirty-ton gross units owned by R. O. Parry (above) partially alleviated the problem of accessibility, these vehicles being capable of manoeuvring into sites not accessible to the rigid 'eight-wheelers' of a similar payload [226].

The Penyrorsedd Quarry was particularly disadvantaged by poor road access, whereby its working upper levels were not accessible to motor vehicles until the early 1950s, and the public road leading from the upper bank remained unsuitable for large lorries into the 1960s. Consequently, until the early 1960s, slates from this quarry that were destined for delivery by road had to be trans-shipped onto lorries at the foot of the internal tramway-incline system from the 3ft.6-inch gauge tramway waggons which formed the first link in this hybrid transport chain [227].

The demise of the Nantlle railway outlet

After the Second World War the progressive adoption of road haulage by the Dorothea and the Penyrorsedd quarries, the two remaining users of the horse-tramway feeder to the Tal-y-sarn standard-gauge freight depot, contributed to a general reduction in the volume of traffic carried on the old system [228]. However, the economic viability of this transport system seems not to have been initially threatened because the low maintenance costs of the branch line and tramway and the political shielding afforded by the nationalisation of the railways in 1948, probably balanced the revenue obtained from the slate and incoming coal traffic [229].

The retention into the early 1960s of the tramway route for the carriage of Penyrorsedd slates destined for forwards transport by rail from Tal-y-sarn station, was based upon its cost-effectiveness within the special conditions found there. In default of a suitable road access to the quarry stock-yard (see above), the use of tramway waggons for the initial part of the journey from the Penyrorsedd site made the continuation of the short 'run' to the station a better option than trans-shipment onto a lorry [130]. However, the poor returns earned as a consequence of the reduced traffic by Oswald Jones (of Tal-y-sarn), the Penyrorsedd tramway-haulage contractor since 1951, hardly covered the costs of keeping the pair of horses used for this work. Thus, early in 1963, after threatening to do so for several years, Jones finally ceased to offer horse-haulage when the work had become grossly unprofitable [131]. The motive power for the Penyrorsedd 'runs' on the tramway was subsequently provided by a quarry-owned agricultural tractor, although the original proposal for a successor to the horses was to have been one of the quarry's two-foot gauge Ruston Hornsby diesel locomotive, mounted on a 3ft.6-inch rail-chassis [132].

The last 'runs' of the Penyrorsedd tractor-powered tramway trains took place around November 1963, preceding the closure of the standard-gauge branch by about a month [133]. The branch line had been under threat of closure since 1959 because the Penyrorsedd slate traffic and the domestic coal inwards freight was insufficient to cover the operating costs [134], and its fate under Dr Beeching's 1962 policy of closing small freight depots loading under 200 tons a week was unambiguous [135]. In any case, had the Tal-y-sarn freight depot survived this first round of Beeching closures, the subsequent withdrawal of services from the Caernarfon/Afonwen 'main' line in December 1964 [136] would have sealed the fate of this mode of secondary slate transport, which had almost reached its centenary.

Modern road transport, post-1970

Road transport from the surviving slate quarries at Nantlle hardly changed from the late 1950s to 1980s. Slates were still loaded individually, by hand, from external stock-piles, and the Penyrorsedd Quarry continued until *c.*1974 to use 3ft.6-inch gauge tramway waggons to collect the slates from its stock-yard for delivery to a lorry loading-bay three-hundred yards away [137].

The sale of Penyrorsedd Quarry in 1979 to a company which had few pre-conceived ideas about slate quarrying, brought about the adoption of new stock and transport procedures which were an improvement on the methods formerly used. The stock-piling of slates indoors, in crates, provided greater security from theft and convenience for loading. This storage method allowed a more rapid loading of pre-sorted bulk orders into lorries using fork-lift trucks and simplified the stock-control procedures. Furthermore, the general move by the 1980s towards customers taking responsibility for transport relieved the quarry operators of this major burden [138].

The volume of road traffic in the Nantlle district generated by the concerns producing roofing slates has not been very great, but this is not true of quarry sites where the removal of slate rubble and crushed slate aggregate has been the chief undertaking since the late-1980s. The bulk of the lorries engaged in this business are six- and eight-wheel tippers, which are preferred to articulated vehicles, because they have a better traction on sites 'off-road', whilst being capable of carrying over twenty tons [139].

However, the significant increase in heavy traffic occasioned by the rise in the slate rubble trade has raised environmental considerations for the district, which have been partly addressed by the imposition of notional maximum traffic levels by the local planning authorities. The problems of air pollution and dangers posed by the passage of the large lorries through narrow streets have been especially marked for the inhabitants of Pen-y-groes, Llanllyfni and Groeslon which are on the haulage routes. The proposed by-pass for these villages, along part of the old Carnarvonshire Railway trackbed, will eventually alleviate part of this problem [240].

The threatened saturation of local roads by heavy mineral traffic has created a limiting factor to the granting of additional mineral licences for the extraction and processing of slate waste in the Nantlle valley [241]. In this context, it is apparent that the closure and subsequent dismantlement of the railway outlets from this district were both premature and ill-conceived. On the other hand, the inclusion of a proposed restoration of the railway link to Caernarfon or Porthmadog harbours in the most recent (1992) planning application for the removal of slate rubble from the Dorothea Quarry [242] was more of a naive political gesture to overcome objections to the allied landfill proposal than a feasible proposition. However, the suggested rebuilding for mineral traffic of the Bryngwyn Branch of the Welsh Highland Railway to complement the planned restoration of the main line, was a very viable alternative to the heavy road traffic that would have been generated had the 1994 proposal to remove slate rubble from the Alexandra/Moeltryfan quarries gone ahead [243].

NOTES: CHAPTER 5

TRANSPORT SYSTEMS

Abbreviations

C.R.O.	Caernafon Records Office
Q.M.J .	Quarry Managers' Journal
S.T.G.	Slate Trade Gazette
T.C.H.S.	Transactions of the Caernarfonshire Historical Society
U.C.N.W.	University College of North Wales, now University of North Wales, Bangor

(a). Internal Transport

Tramways

1. Although there is no direct evidence or otherwise of the use of horse-drawn carts for internal transport in the Nantlle quarries, it is not implausible that they may have been used for this purpose in certain circumstances, in a similar fashion to those illustrated in the promotional booklet of the Anger slate quarries (France), Commission des Ardoisieres D'Angers, (G.Larivière & Cie.), 9 June 1895, passim, per Mr Elfed Williams, Oakeley Quarry manager, to whom the author is indebted.

2. This is the first reference to an internal railway in the Nantlle quarries that has been discovered by Dr M. J. T. Lewis ['Railways in Gwynedd to 1830,' Version 3, April 1990, an unpublished discussion paper, privately circulated. The author is indebted to Dr Lewis for permission to quote from this document].

3. Although no specific dates are given, Robert Williams, in 'Hunangofiant Chwarelwr VIII,' Cymru, XIX (109), Awst 1900, stated that tramways were common in the Nantlle quarries by the 1820s. They would have been particularly so at the largest concerns, which had the greatest volume of material requiring on-site transport.

4. This is assumed, on the basis of the precedence of the pattern of dissipation of other types of technology.

5. M. J. T. Lewis, 'Railways in Gwynedd to 1830,' op.cit., citing evidence for the likely use of strap rail at the Manod Quarry (Ffestiniog), which had commercial links with the Cilgwyn Quarry at Nantlle in the very early years of the nineteenth century.

6. This portion of plate-rail, found on the Cloddfa'r Lôn Quarry tips by Mr Brinley S. Jones in 1994 (and remaining in his possession), has provided substantial weight to Dr Lewis' hypothesis, postulated in his 'Railways in Gwynedd to 1830,' op.cit.

7. Robert Williams, loc.cit. It is clear from the details given, that Williams is referring to bar rail slotted into timber sleepers.

8. The author's fieldwork has uncovered much bar rail re-used in agricultural fences, and a number of discarded cast iron chairs have also been found, one of which (at Penyrorsedd Quarry) remained attached to its slate sleeper block. The only track of this type discovered *in situ* was at the Ty Mawr East Quarry, where the excavation of a waste tip for aggregate production in 1995 by Watkin Jones Ltd., resulted in the uncovering of several yards of line laid in bar rail mortised into timber sleepers. Whereas the latter probably dated from the 1880s, bar rail was still being used on the inclines at the Dinorwic Quarry (Llanberis) until their abandonment *c.*1967.

9. M. J. T. Lewis, 'Railways in Gwynedd to 1830,' op.cit.

10. The dual gauge track, incorporating one common rail with two others set at 2 feet and 3ft.6-inches gauge, was economical on both materials and space, and was widely used in those quarries connected to the Nantlle Railway.

11. Lewis, 'Railways in Gwynedd to 1830,' op.cit. Much discarded fish-belly survives in agricultural fencing in the Nantlle area.

12. Loc.cit. The present author's fieldwork has uncovered examples of a variety of patterns of rail within these major design categories, although hardly any remain *in situ.*

13. Loc.cit; ex.info., the late Gwilym Roberts, former quarry blacksmith, recalling re-using lengths of discarded old 'round rail' at the Dorothea Quarry for other uses. Thomas Hughes was a Penrhyn Quarry blacksmith of the mid-nineteenth century, who is said to have invented the lightweight portable track which consisted of ordinary wrought iron 'round bar', fashioned into down-turned spikes at both ends for slotting into holes in slab sleepers.

Rolling stock

14. Robert Williams, Cymru, XIX (109), op.cit., p.88.

15. Discovered by Mr Brinley S. Jones at the Diffwys Tarw copper mine in 1995. A similar waggon (see end-on) can be seen in a photograph

of constructing the new internal tramway from the main Dorothea Quarry bank to 'Foundry Terrace' in 1939 [private collection, author], this apparently having been bought at the dispersal of the plant used to construct the new Nantlle to Talysarn road in 1924-27 [ex.info].

16. John Griffiths *Sylwebydd* (1889), Chwarelau Dyffryn Nantlle a Chymdogaeth Moeltryfan, (W.J.Griffiths ed., Conway *c*.1930), p.71.

17. Not all rubbish waggons had straps, because some quarries did not require aerial cableways. Whereas the larger concerns had sufficient on-site engineering facilities to enable them to construct waggon bodies, with only the wheels and axle-bush boxes being purchased from local foundries, the smaller concerns had to buy complete waggons from these external sources or from liquidation sales.

18. It is uncertain when trolleys were introduced or how many quarries used them, but they have been noted by the author at Dorothea, Moeltryfan and Penyrorsedd (one derelict example).

19. The only recorded use of Hudson 'skips' in the Nantlle district was at the Cilgwyn and Moeltryfan quarries of the Caernarvonshire Crown Slate Quarries Co. Ltd., from the 1930s to the 1950s [C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Crown Quarries photographs].

Animal motive power

20. Ex.info., former employees. Manual tramming continued at the small quarries until the availability of cheap time-expired motor lorries in the early 1960s led to the adoption of internal road transport in those few concerns still operating.

21. Ibid. Limited manual tramming was observed at the Dorothea, Moeltryfan and Penyrorsedd quarries by the present author.

22. Ex.info., Mr W. H. Humphreys and the late Idwal Hughes, former quarry horse-attendants.

23. John Lloyd Jones, a quarry entrepreneur [see Chapter 2, supra], had held the Penyrorsedd internal and Nantlle Railway haulage contract for the new Company of 1862 [C.R.O., X/Penyrorsedd addit.1873, Minute dated 21 March 1864 re. cessation of the contract]. The chief farms supplying horses to the main quarrying area in the valley were Dolbebi and Taldrwst [Hughes, Idwal, (1980), Chwareli Dyffryn Nantlle, (Penygroes), p.13]. The ruins of the Dorothea Quarry stables, having a capacity of up to eight horses, survive. In 1905, the cost of hired horses at Dorothea was £742,

compared to £78 for the Company's own horses [C.R.O., X/Dorothea 880, letter dated 10 January 1906].

24. Ex.info.

25. Whereas the internal transport system of the Penyrorsedd Quarry had virtually become a horse-less zone by the 1890s, due to its purchase of many locomotives (see below), the sole locomotive listed in a report on the Dorothea Quarry in 1894 was out of use and in need of considerable repair [C.R.O., X/Dorothea 1254].

26. Ex.info., Mr M. J. B. Wynne-Williams, former managing director, Dorothea Quarry, who instituted the change; C.R.O., X/Dorothea 2074, pp.529-543, plant purchase records October 1963 (forklift @ £500), November 1963 (tractor @ £245).

Steam locomotives

27. See Boyd, J.I.C., (1975), Festiniog Railway, Vol.1, (Oakwood Press), passim; Carrington & Rushworth, (1974), Slates to Velinheli, (Maid Marian Loco Fund), passim.

28. Bradley, V.J., (1992), Industrial Locomotives of North Wales, (Industrial Railway Society), pp.252, 305, 367; C.R.O., XM 4046/51, letter 25 December 1945, re. the Glynrhonwy single-cylinder locomotives. There is much uncertainty about the circumstances and dates of the introduction of the first locomotives to the quarries, a situation which is compounded by inconsistencies and omissions in conflicting primary sources. An example of this is the lack of any reference to locomotives in the Penyrorsedd Mss prior to November 1877, when it is certain that one, and possibly two existed here prior to that date.

29. Abbot, R. A. S., (ed., J.W.Lowe). Vertical Boiler Locomotives (Oakwood Press, 1989), pp.164-171, re. De Winton locomotives; Bradley, op.cit., pp.433-434, list of De Winton locomotives; Lloyd, Lewis, (1994), De Winton's of Caernarfon, 1854-1892, (Author), passim; ex.info., Mr D. Clayton, who has researched the history of the De Winton works and its products, and to whom the author is indebted.

30. Ex.info., Mr D. Clayton, op.cit.

31. Ibid; Bradley (1992), op.cit., p.305.

32. Ex.info., the late Harry Eddy, Glyn Griffiths and Ellis Williams, former drivers of De Winton locomotives at the Penyrorsedd Quarry.

33. Analysis of information in Bradley (1992), op.cit., pp.433-434.

34. Bradley, op.cit., passim. The most popular English suppliers of locomotives to the North Wales quarries during the last quarter of the nineteenth century were Adamson, Hunslet, Lewin, Manning Wardle and Vulcan [see ibid., Index of Locomotives, pp.424-477]

35. See Lewis Lloyd (1994), De Winton's of Caernarfon, 1854-1892, op.cit., pp.28-29.

36. Bradley (1992), op.cit., passim; Rolt, L.T.C., (1964), Hunslet Hundred, (Newton Abbot), passim; ex.info., former locomotive drivers at the Dinorwic and Penyrorsedd quarries, regarding the comparative merits of different engines.

37. Ex.info., former drivers, op.cit. For example, the marine fireboxes fitted to the Spooner-designed 'Vulcan' locomotives *KATHLEEN* and *KELSO* [Bradley, op.cit., pp.187, 367] is likely to have made them unsuitable for general shunting [ex.info., Mr C. R. Weaver, an authority on this topic].

38. Analysis by the present author of the data in Bradley (1992), op.cit.

39. Ibid., pp.252, 367, re. *WENDY* (Dorothea Quarry) and *DIANA* (Penyrorsedd Quarry), both of which were obtained second-hand from the Ffestiniog district.

40. Ibid., p.367; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), technical papers of the Penyrorsedd Quarry, re. locomotive boiler certification. A number of locomotives were retained in serviceable condition at the Penyrorsedd Quarry up to *c.*1960 for use in changing the heavy wire ropes of the blondin aerial cableways, a duty which had hitherto defeated the Ruston diesel locos.

Internal combustion locomotives

41. Bradley (1992), op.cit., passim.

42. Ex.info., Mr C. R. Weaver, op.cit.

43. Analysis by the present author of the data in Bradley (1992), op.cit.

44. Ibid., p.252. However, although the source recording the sale of the 20 h.p. Deutz loco to the Dorothea Quarry is not doubted, its listing in the earlier 1968 edition [Birmingham Locomotive Club, Handbook 'F'] led the present author to investigate further. Whereas the omission of this item from the official plant acquisition lists was not in itself unusual in the prevailing circumstances, the unequivocal rejection of its presence by former employees suggests that the Deutz may have languished amongst the piles of unused

second-hand plant amassed by the works manager, all of which was eventually consigned to the war-time scrap drive.

45. Bradley (1992), loc.cit.; C.R.O., X/Dorothea 2074, pp.529-543, plant purchases 8 April 1946 (two at £150) and 13 June 1949 (one at £240). The type of Lister rail-tractor used at the Dorothea Quarry had a 600 c.c. JAP petrol engine, which was somewhat under-powered.

46. Bradley (1992), op.cit., pp.359-360; ex.info., the late Francon Thomas, Penyrorsedd engineer, who had been apprenticed at the Penrhyn Quarry Coed y Parc workshops; unfinished home-made petrol loco recorded by the author at the Penyrorsedd Quarry, prior to scrapping in 1971.

47. Bradley (1992), op.cit., p.218; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Crown Quarries papers; experience of the author as unofficial relief driver of a Ruston loco at Penyrorsedd Quarry, 1970-73. The ex-Crown Quarry loco is now at the Gilfach Ddu Museum, carrying the new name *CILGWYN*.

Road haulage

48. Ex.info.; recorded by the present author.

49. Ex.info., former employees; contemporary photographs in the author's private collection;s; C.R.O., X/Dorothea 2074, pp.529-543, plant acquisitions October 1942 (front dumper @ £570), August 1945 (ditto., @ £240), March 1949 (ditto., @ £325) and October 1950 (ditto., @ £145).

50. Ibid., June 1963, (one dump truck @ £2,575 each) and August 1963 (ditto.); Houston, W.J., 'New Developments at Dorothea Quarry,' Q.M.J, February 1964, pp.68-70.

51. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Crown Quarries papers. The author recalls two large dump trucks at Moeltryfan, one having an A.E.C. engine and the other being powered by a Rolls Royce unit.

52. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry papers; author's fieldwork; ex.info. the late Francon Thomas, op.cit., who designed and fabricated much of this unloading equipment.

53. Witnessed by the present author.

Idiosyncratic systems

54. John Griffiths *Sylwebydd* (1889), op.cit., pp.37-38. This source suggests that it was the presence of this abandoned canal that

enabled the floodwater of the Lower Nantlle Lake to flow into the Dorothea Quarry in the wake of the massive landslide of December 1884 (see Chapter 3, supra).

55. Ex.info., the late Hugh Davies and Robert Hughes (Nantlle).

(b). External Transport

56. This exception was the direct standard-gauge railway link to the Tal-y-sarn goods depot, achieved by the Coedmadog Quarry in 1881. See Note 155, infra.

(i). The maritime era, *c.*1650-1939

57. Pritchard, D. Dylan, 'Aspects of the Slate Industry: The Expansionist Period, II,' Q.M.J., April 1944, p.471.

58. Williams, W. G.; 'Ponc y Foryd,' Moel Tryfan i'r Traeth, (ed. G.Haulfryn Williams, 1983). The activities at the Foryd Cove also included ship-building and lime-burning; Thomas, D., (1952), Hen Longau Sir Gaernarfon, pp.21, 38-39, re. export of slates during the seventeenth and early eighteenth centuries.

59. Lewis, M. J. T., (1989), Sails on the Dwyryd, (Plas Tanybwlch), Chapter 5, passim.

60. U.C.N.W., Porth yr Aur Ms 27283, re. threat of enclosure of this land, in 1812. A field survey by the author of the coast south of Caernarfon showed that the Foryd was the only natural sheltered location suitable for loading and unloading ships in all weathers. Despite ongoing silting of the main channel, it is still navigable on high tides up to the former slate-loading banks by boats up to at least 25-ft. in length. There is much evidence of broken slates in the shoreline silt along the southern and eastern edge of the cove, near the river inlet.

61. Evans, Rev John, (1800); A Tour Through Part of North Wales In The Year 1798 and at other times, (London), p.167; Lloyd, Lewis, (1989), The Port of Caernarfon, 1793-1900, (Author), p.6; Williams, Rev P. B., (1821), A Tourist Guide To The County of Caernarvon, (Caernarfon), pp.84-85.

62. W. Gilbert Williams (1983 ed.), op.cit., p.101; U.C.N.W., Porth yr Aur Ms 28479 lists the Cilgwyn, Cloddfa'r Coed and Penybryn quarries as the principal users of the Foryd; ibid., Ms 27283, re. threatened enclosure of common land at Foryd, where quarry proprietors at Nantlle were objecting on the grounds that they occasionally used

the place. It is likely, however, that Foryd had been virtually abandoned by the slate trade by this date (1812).

63. D. Thomas (1952), op.cit., pp.113, 116.

64. Ibid., pp.122-131; L.Lloyd (1989), op.cit., pp.113-119.

65. Lloyd (1989), op.cit., p.119; D. Thomas (1952), op.cit., pp.122-123, 146-147. The main local joint-stock shipping concerns were **(a)** the Arvon Shipping Co. Ltd., of 1876 (£10,000 nominal capital in £20 shares), with Hugh Pugh the chairman, and John Thomas the secretary, both being involved in slate concerns at Nantlle; **(b)** the Eryri Shipping Co. Ltd., of 1876; and **(c)** the Gwynedd Shipping Co. Ltd. (£100,000 nominal capital, of which £18,500 was subscribed to 143 members, of whom 121 were quarrymen from Llanberis and Nantlle).

66. C.R.O., X/Plans/R/64; C.R.O., X/JW/Maps/9.

67. Dylan Pritchard, 'Aspects of the Slate Industry: The Expansionist Period, III,' Q.M.J., May 1944, pp.516-518, giving data for water transport rates that reached a maximum average of 38*s.* (£1.90) per ton in the war year of 1814, but had reduced to its 1790 price of 10*s.* (50p.) per ton by 1880. Because of the increase in the average price of slate from 47*s.*6*d.* (£2.37½p.) per ton to 82*s.*6*d.* (£4.12½p.) from 1814-80, the percentage average cost of sea-borne transport was greatly reduced from around eighty per cent of market value in 1814 to only twelve per cent in 1880. Pritchard's data (ibid., Table 2, p.518) is reproduced in modified form below:

COST OF SLATING AND TILING ON BEST COMPARATIVE CRITERIA

Year	Price index of slates	Total cost of slating 100ft^2	Ditto Tiling cost 100 ft^2	% slate price advantage
1805	36	43s.	43s.5d.	1
1825	55	42s.	46s.1d.	10
1845	55	25s.	45s.0d.	30
1855	65	29s.	45s.0d.	55
1865	77	32s.	46s.3d.	45
1870	78	33s.	49s.9d.	49
1877	135	49s.	49s.9d.	1
1880	100	35s.6d.	49s.9d.	39

68. Lloyd (1989), op.cit., pp.41-2; 47; Pritchard, Q.M.J., May 1944, loc.cit.

69. Pritchard, Q.M.J., May 1944, op.cit., p.516.

70. Lloyd (1989), op.cit., pp.265-266, 268.

71. Ex.info., the late Gordon H. Richards, former slatemerchant, recalling the decline of the maritime trade in slates.

The early primary transport system; sledges, paniers and carts

72. Bingley, Rev W., (1804), North Wales, including its scenery antiquities customs and some sketches of its natural history (excursions of 1798 and 1801), (London), p.226, refers to the use of sledges in the Westmorland slate quarries; Evans, Rev J, (1800), op.cit., p.62, describing the use of sledges near Machynlleth. A 'small horse' was probably a Welsh Cob of about 11.2 to 12.2 hands [ex.info]; Warner, Rev R., A Second Walk Through Wales in August and September 1798, Vol.2., pp.185-186, describing sledges carrying peat at Bwlch-y-groes near Waunfawr, five miles from Cilgwyn. Based on details from Evans and Warner (op.cit), it is estimated that one sledge-load might be taken as 3-4 *cwt.* If only one round trip was made per day, the theoretical maximum amount that one sledge might carry from the quarries to the coast in a year of 300 days was around 60 tons, a sufficient order of magnitude for this mode of transport to have been feasible, although no supporting documentary evidence has been uncovered.

73. C.R.O., XM 392/1, f.15; Dylan Pritchard, Q.M.J., April 1944, op.cit., p.470; W. G. Williams (1983 ed.), Moel Tryfan i'r Traeth, op.cit., p.99; Hughes, Hugh Derfel (1866), Hynafiaethau Llandegai a Llanllechid, (Reprint, Cyhoeddiadau Mei, 1979), pp.121-124, describing animal trains in the Ogwen Valley.

74. C.R.O., XM 392/1, loc. cit; Evans (1800), op.cit., p.208, referred to panniers in use during haymaking; Dylan Pritchard, Q.M.J., April 1944, loc.cit. The average weight of 'doubles' (12-inch X 6-inch) was 15 *cwt.* per *mille* of 1,260 slates, so that one animal carrying 64 slates (0.05 *mille*) would be required to carry only 3/4 *cwt.*

75. Hugh Derfel Hughes (1866), loc.cit.

76. Evans (1800), op.cit., p.62; ex.info., Mr Ellis Evans of Tal-y-sarn, recalling his experience of using mules in civil engineering work in South America, maintained that mules excelled on horses for carrying heavy weights due to differences in the structure of their respective backbones.

77. Dodd, A.H., (1968), A History of Caernarvonshire, (Reprint, Wrexham 1990), p.213; Pritchard, R. T., (1956), 'The Caernarvonshire Turnpike Trust,' T.C.H.S., Vol.17, pp.63, 66.

78. Ibid.; Basset, T.M., and Davies, B.L., (1977), Atlas Sir Gaernarfon, (Caernarfon), pp.164-5. The Turnpike Trust obtained an empowering Act in 1810 to turnpike additional routes, including the road to Porthmadog, with a branch from Pen-y-groes to Rhyd-ddu (on the Caernarfon to Beddgelert road), *via* Nantlle.

79. John Griffiths *Sylwebydd* (1889), op.cit., p.70, suggests that the Cilgwyn Company had a road from the quarry to Llwyn-y-gwalch Farm [the property of the Company], where it joined the main turnpike; Bingley, op.cit., pp.390-392; Fenton, R., (ed. J.Fisher), Tours in Wales 1804-13, (Cambrian Archaeological Association, Supplemental Volume, London 1917), p.233. Fenton described the route through the valley in 1813 in a much more favourable tone than Bingley, and referred to a major diversion involving some civil engineering near the Drws y Coed mines, work which is still in evidence.

80. Hall, E. Hyde, (ed. E.Gwynne Jones, 1952), A Description of Caernarvonshire 1809-1811, (Caernarfonshire Historical Society, Record Series No.2), p.187; Lindsay, J., (1974), A History of the North Wales Slate Industry, (Newton Abbot), p.108, quoting U.C.N.W., Porth yr Aur Ms 28297; Dylan Pritchard, Q.M.J., April 1944, op.cit., p.470; R. T. Pritchard (1956), T.C.H.S., Vol.17, op.cit., Appendix 1, pp. 68-69, 71; W. G. Williams (1983 ed.), op.cit., p.101. The Pont Saint gate was erected *c.*1770 and had the highest revenue of all the gates in the Carnarvonshire Turnpike Trust, being leased in 1808 at a very high rental of £208 per annum.

81. Dylan Pritchard, Q.M.J., April 1944, op.cit.; Hugh Derfel Hughes (1868), op.cit.

82. E. Hyde Hall (1810), op.cit., pp.172, referring to the high earnings of 6*s.* (30p.) per day of the carters in the Ogwen Valley; J.Lindsay, (1974), op.cit., p.108, quoting U.C.N.W., Porth yr Aur Mss 2840, 29081; and W. G. Williams (1983 ed.), op.cit., pp.99-101, re. the carters. Hall (1810), passim, commented on the apparent neglect of agriculture because of the lure of the slate carting trade in the quarrying parishes, which resulted in the loss of tithe revenue.

83. Hyde Hall (1810), op.cit., p.211; C.R.O., XM 4874 uncatalogued addition, research notes by D.Dylan Pritchard from U.C.N.W., Porth yr Aur Mss, quoting contemporary data; Dylan Pritchard, Q.M.J., April 1944, op.cit., p.470.

84. Dylan Pritchard, Q.M.J., April 1944, op.cit., pp.470-471. The costs of carting at Ffestiniog was even more expensive.

85. See J.Lindsay (1974), op.cit., Chapter 3, passim., re. the investments made in the Penrhyn Quarry in the 1790s and early 1800s.

86. J.Lindsay (1974), op.cit., p.108; see also carters accounts, U.C.N.W., Porth yr Aur 28222; 28225; 28302; 28475; 28479; C.R.O., XM 4874/28, research notes by D.Dylan Pritchard quoting Porth yr Aur Ms 27600, letter dated May 1812 re. cartage rate increase, when Thomas Jones of the Cilgwyn Company stated that he had no option but to concede to the carters demands, lest they move on to other quarries in the district.

87. Dylan Pritchard, Q.M.J., April 1944, op.cit., p.470.

88. Hyde Hall (1810), op.cit., p.211; also described by Bingley (1804), op.cit, p.226, at Llanberis in 1801, although he thought sledges would be an improvement!

89. Dylan Pritchard, Q.M.J., April 1944, op.cit., p.470.

90. Loc.cit.

91. Hyde Hall (1810), op.cit., p.211, referring to the quarries in Llanllyfni Parish, wondered "... how any profit can be derived from a work, which, exclusive of rent and expense of preparing the materials, can only be conveyed in single tons, requiring the labour and food of three horses and a man for a whole day;" P. B. Williams (1821), op.cit., pp.84-85. Slates were carted to Caernarfon from the Gwyrfai Valley and Cefn Du (Llanberis) in addition to those from the Nantlle quarries.

The Nantlle Railway, 1825-1867

92. Boyd, J.I.C., (1985), Narrow Gauge Railways in North Caernarfonshire, Vol.2 - The Penrhyn Railway, (Oakwood Press), passim. In this context, the term 'railway' is defined as trackwork utilising edge-rails for rolling-stock having flanged wheels, in contrast to 'plateways,' which had L-section track incorporating the guide-flange for rolling stock with flangeless wheels. The term 'tramway' has been used for many years without a specific definition. In the slate industry, 'tramway' was the general term for the railways inside the quarry workings, but it was also applied as a title to the truncated eastern portion of the Nantlle Railway (see below), post-1870, when this was under the control of the London & North Western Railway and its successors.

93. Ibid.; Bingley (1804), op.cit., p.177; and Hyde Hall (1810), op.cit., p.105, described the contemporary practice on the Penrhyn Railway of using long multi-horse trains; Dylan Pritchard, Q.M.J., April 1944,

op.cit., p.471, re. cost-estimates. In 1788 the costs of carting at 5*s*.3*d*. (26½p.) per ton (or 8*d*. [say 4p.] per ton/mile) was equal to two-thirds of the production costs; in 1801 it was about 1*s*. (5p.) [1½d per ton/mile), which allowed for more competitive market pricing.

94. See Note 85, supra., re. investments in the Penrhyn Quarry. The large sums poured into the development of this concern were out of the reach of the majority of the industry.

95. See sub-section (a), above.

96. Boyd, J.I.C., (1981), Narrow Gauge Railways in North Caernarfonshire Vol.1- The West, (Oakwood Press), p.10. The line was surveyed by R.Thornton of Liverpool, who became co-partner in the new Hafodlas Company in 1812. Despite the water-mark of 1809 on the paper, the letter referred to by Boyd is likely to have been written after the incorporation of the above Company, because the previous sole-trader is unlikely to have been in the position of financing this venture alone. In 1814 the Company joined a consortium of three other quarries to build a railway on a different route.

97. Boyd (1981), op.cit., pp.9-10.

98. Loc.cit.; Hughes, S., (1990), The Brecon Forest Tramroads, (R.C.A.H.M., Wales), pp.165-166, 173, showed that this was not an unusual practice, with tramways being authorised under the statutory powers of canal Acts in the late eighteenth century, and being given their own Acts by the early nineteenth century. Between 1801 and 1812, at least thirteen public railways had been authorised in this way, most of them being located in South Wales or the Border country

99. P. B. Williams (1821), op.cit., pp.104-105.

100. Boyd, J.I.C., (1986), Narrow Gauge Railways in North Caernarfonshire, Vol.3 - Dinorwic Railway etc. (Oakwood Press), passim; Lewis, M.J.T., (1968), How Ffestiniog Got Its Railway, (Railway and Canal Society), pp.9-24, re. early attempts to build a line between the Ffestiniog quarries and the coast.

101. Boyd (1981), op.cit., pp.11-12.

102. Loc.cit. The objector was George Bettis, one of the original promoters - an early example of the 'Nantlle disease' of internecine hostilities.

103. Boyd (1981), op.cit., p.11, quoting an estimate made by W. A. Provis, engineer of the Menai suspension bridge, dated February 1825.

104. C.R.O., XM 9309/4, list of subscribers in Nantlle Railway Journal 2, ff.1*r*.-4*v*. Of the twenty-one names, only eight can be recognised as residents in the county or were local landowners.

105. Boyd (1981), op.cit., pp.13-17, 25; Baughan, P.E., (1980), A Regional History of the Railways of Great Britain, Vol.11 - North and Mid Wales, (Newton Abbot), pp.95-100. A further Act, dated 21 March 1827, authorised the raising of £20,000 by means of a mortgage (or possibly debenture stock). This tends to suggests that the subscribed capital of the Company might have been too low.

106. Baughan (1980), loc.cit.

107. It is not known why these portions of the proposed system were abandoned, but it is likely that in the case of the eastern extremity the reason was financial, whereas in the case of the Foryd branch the role of local politics with regards the Caernarfon Harbour Trust cannot be discounted.

108. Boyd (1981), op.cit., p.15; M.J.T.Lewis, 'Railways in Gwynedd to 1830,' op.cit.; Stephen Hughes (1990), Brecon Forest Tramroads, op.cit., pp.112, 157, 171-176, outlines the context of the development of the plateway.

109. M.J.T.Lewis, loc.cit.

110. Boyd (1981), op.cit., pp.15, 19, 91. Improved edge-rail was being promoted by the Stephensons on the Stockton & Darlington Railway as a rival to the plate-rail.

111. Boyd (1981), op.cit., p.16. The original gauge was retained despite R.Stephenson's suggestion that it be increased, possibly because of the specifications of the completed earthworks and of the apparent lack of powers to do so in the incorporating Act.

112. Stephen Hughes (1990), op.cit., pp.103-112.

113. Boyd (1981), op.cit., p.14.

114. Boyd (1981), op.cit., p.13, re. Section IV of the Nantlle Railway Act, 1825.

115. Ibid., pp.31, 56, 112-113; see discussion on the haulage capacity of horses in Hughes (1990), op.cit., p.43.

116. C.R.O., X/Dorothea 116; the haulage contract was subsequently held by John Lloyd Jones, a major shareholder in the company.

117. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Annual Reports of the British Slate Co. Ltd., 1860s.

118. Boyd (1981), op.cit., pp.89-90.

119. C.R.O., XM 2344/8, 10, tramway wayleaves.

120. The northern 'Crown' quarries of Alexandra, Brynfferam and Moeltryfan were too distant, as were the south-western quarries of Llwydcoed, Gelli Bach, and Foel Uchaf. The south-eastern block of Gwernor, Ty Mawr East, Ty Mawr West and Tynyweirglodd were nearly connected, but the projected branch was never built.

121. Boyd (1981), op.cit., pp.112-115.

122. Ibid., footnote p.31.

123. Only four Nantlle quarry concerns had been involved in the promotion of the Nantlle Railway in the 1820s, and none of these local promoters remained in business a decade later. Thus, for most of the operational life of the railway, it was used by parties who had not contributed to the cost of its construction, in direct contrast to the private Dinorwic/Padarn and Penrhyn railways.

124. Boyd (1981), op.cit., p.5.

125. See sub-section (a), above.

126. C.R.O., X/Dorothea Mss 911, 915-6, 935; Boyd (1981), op.cit., p.5.

127. Boyd (1981), loc.cit.

128. Ibid., p.56.

129. Ibid., pp.13, 56.

130. Ibid., pp.46-47; Christiansen, R., & Miller, R. W., (1971), <u>The Cambrian Railways</u>, Vol.1, (Newton Abbot, 2nd ed.), pp.21-73, re. involvement of T. Savin (1826-89) in railway contracting during the years 1853-66.

131. Boyd (1981), op.cit., pp.47-49.

132. Ibid., pp.44-47, 53.

(ii). The standard-gauge railway era, 1852-1963

133. Baughan (1980), op.cit., pp.91-92; Boyd (1981), op.cit., p.27. For example, the North Wales Coast Railway authorised in 1845 from Bangor to Porthdinllaen via Caernarfon and the coastal plain through Pontllyfni and Clynnog. This was aborted in a financial scandal before construction began. There were also several unbuilt precursors of the Chester & Holyhead Railway.

134. Baughan (1980), op.cit., p.92, and Chapter II, passim.

135. Baughan (1980), op.cit., pp.92-95; Boyd (1981), op.cit., p.28; Lloyd (1989), The Port of Caernarfon, op.cit., pp.249-250, 258.

136. Baughan (1980), op.cit., p.95; Boyd (1981), op.cit., pp.31-33, 37. The shareholders included Joseph Huddart, owner of the Brynkir Estate and shareholder in the Festiniog Railway [sic]. The final blow was the refusal of the Gwynfryn estate to donate the necessary land free of charge.

137. Baughan (1980), op.cit., pp.97-98; Boyd (1981), op.cit., pp.34-40. The lure of potential revenue from minerals, agriculture and tourists drove these schemes.

138. Baughan (1980), loc.cit., p.97; Boyd (1981), op.cit., pp.39-40.

139. Boyd (1981), op.cit., pp.44-47, 60; see also Note 130, supra. This may have been an enactment of a purchase option originally granted to Edward Preston, the railway's lessee from 1856-*c*.62, who disappeared off the scene at this juncture, despite having four years remaining of his lease term.

140. Baughan (1980), op.cit., pp.97-99;

141. Loc.cit.; V. J. Bradley (1992), Industrial Locomotives of North Wales, op.cit., p.121. The through-running connection from the Carnarvonshire line to the L.N.W.R. metals at Caernarfon was not achieved until 1869-70, but details unclear. Lewis Lloyd (1989), op.cit., Chapter 14, passim., contains repeated references to the worries of the Caernarfon Harbour Trustees of the potential loss of the slate trade were a railway built from Nantlle to Porthmadog harbour, and also if the Nantlle Railway became directly connected to the L.N.W.R. system.

142. Baughan (1980), op.cit., pp.99-100; Boyd (1981), op.cit., pp.44-45.

143. Baughan (1980), op.cit., pp.157, 161; Bradley (1992), op.cit., p.114; Christiansen & Miller, (1971), op.cit., pp.65-73. Savin's ambitions were partially realised upon the incorporation of the Cambrian Railways Company from a number of independent mid-Wales lines in 1865, which also absorbed the Aberystwith & Welch Coast Railway [sic]. Yet, Savin's attempts to amalgamate the Cambrian with other independent lines to form the Welsh Railways Company, was thwarted, as was the bid to take over the Carnarvonshire Railway.

144. Boyd (1981), op.cit., pp.31-32. A telling phrase, in a report of 1867, is:- "Since the change of gauge, the quarry owners are altogether dependent on the Railway Company" [present author's underlining].

145. Dylan Pritchard, Q.M.J., May 1944, op.cit., pp.516-7.

146. Boyd (1981), op.cit., pp.46-66

147. Difficulties faced by the Nantlle quarries in connection with the trading policies of the L.N.W.R. are detailed in ibid., pp.65-6; M.J.T.Lewis (1987), The Slate Quarries of North Wales in 1873, op.cit., p.74.

148. Lewis (1987), loc.cit.; C.R.O., X/Dorothea Ms 1242, refers to a request to the L.N.W.R. for discounted freight rates if the quarry provided private waggons, and also that an additional ten L.N.W.R. 7-ton waggons be provided specifically for trains from Nantlle to the Caernarfon Slate Quay; C.R.O., X/Penyrorsedd.addit 1875, reports dated 7 November 1896 and 4 November 1899, reporting dissatisfaction with the railway service, particularly with regards the allocation of sufficient waggons.

149. The exact chronology of certain details of the upgrading of the railway serving the Nantlle quarries is uncertain. It seems likely that the transporter service from Tyddyn Bengam to the Quay continued for some time, to be replaced by a direct standard-gauge connection to the wharves at around the same time (1872) as the opening of the new branch line to the Tal-y-sarn (or 'Nantlle') depot [Boyd (1981), op.cit, p.51, footnote; ibid., pp.64-65; Bradley (1992), op.cit., pp.66, 114, 121, 126-125].

150. Boyd (1981), op.cit., pp.57-64.

151. Baughan (1980), op.cit., p.100; Boyd (1981), op.cit., p.64; Bradley (1992), op.cit., pp.126-127; Rear, W. G., (1986), L.M.S. Branch Lines in North Wales, Vol.1, (Wild Swan), pp.153-156.

152. Rear (1986), op.cit., pp.82, 154, 158. The remains of the 1872 loading platform at '*Giatiau Gwynion*' ("White Gates") Tal-y-sarn, for the Tanrallt tramway, and the more recent one (date uncertain) at Penygroes Station were recorded by the present author before their demolition in the 1970s.

153. Boyd (1981), op.cit., pp.40, 47 (additional lines empowered by 1862 Act); ibid., p.66 (re. the Talysarn-Nantlle private extension schemes); ibid., pp.49, 68-70 and C.R.O., X/Penyrorsedd.addit 1873, Minutes dated 3 February 1865, 3 August 1878, 11 February 1879, 19 March 1880, 2 February 1881; ibid., addit 1875, Minute dated 28 November 1894 (re. Mr Darbishire's direct connection ambitions).

154. C.R.O., X/Penyrorsedd.addit 1873, Minute dated 14 February 1888.

155. C.R.O., X/LNWR 87, plan of proposal 11 March 1881; Boyd (1981), op.cit., p.68, although the alleged previous 2-ft gauge private connection is unlikely to have existed, the quarry being formerly

connected to the Nantlle Railway [see C.R.O., X/LNWR 75, 77, 79]. The laying of the private branch as a mixed standard-gauge/2-ft. gauge line to allow quarry locomotives to pull coal waggons up to the quarry bank and also the L.N.W.R. empty stock up to the loading platform [ex.info., the late Morgan Hughes, former employee, and the late Gwilym Roberts], is confirmed by a photograph in the private collection of the present author.

156. C.R.O., X/Dorothea 5, f.62, re. withdrawal under duress of an objection to J.Robinson's proposed Talysarn Junction Railway in 1873; ibid., f.40, and Ms 1945, p.297, re. evidence of Dorothea agent in defence of the L.N.W.R. in action brought by Mr Darbishire in 1894 (see Note 153, supra); ibid. Mss 964, 1346; and X/Penyrorsedd 93, re. water rights and tramway wayleave agreement in 1890; X/Dorothea 5, f.72, re. agreement in 1902, under duress, to support Mr Darbishire' request for a railway wayleave through Pant Du estate land, which was subsequently refused by the landowner to protect the Dorothea water rights.

157. C.R.O., X/Dorothea 883, p.662, letter dated 19 November 1909. It was suggested that direct dispatch would save 7*d.* (about 3p.) per ton on carriage charges, with better quality control, although the amount that could be dispatched at any one time was not as great because there was no stacking space at the station.

158. N.L.W., HD 9621, The Slate Trade Gazette, October 1922; ex.info., the late Evan Williams, the Dorothea Quarry slate shipper at Tal-y-sarn Station, and the author's maternal grandfather.

159. Ex.info., the late Evan Williams, op.cit., recalling the great problems encountered with the slates from the subsidiary Penybryn Quarry, where he was employed, resulting in the closure of that quarry in 1932 because of the detrimental effect on the reputation of the Company as a whole of loads of broken, faulty slates being returned.

The operation of the horse-tramway, post-1872

160. Boyd (1981), op.cit., pp.49-50.

161. By *c.*1870, all of the main quarries had been connected to the Nantlle Railway, with the exception of those listed in Note 120, supra.

162. Estimated from assumed output of the connected quarries, extrapolated from available data for other years.

163. Analysis of 'Lists of Quarries' appended to the reports of H.M.Inspectorate of Mines & Quarries, North Wales & Isle of Man district.

164. Ex.info., Mr R. Oswald Jones, former horse contractor, and son of R. Jones, who was also a coal merchant and was involved in general haulage, a car taxi service and hiring a motor hearse.

165. Ibid.

The North Wales Narrow Gauge Railway/Welsh Highland Railway

166. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), report of the annual general meeting of the British Slate Co. Ltd., in 1866, refers to the problems of carting from their Fron Quarry to Caernarfon.

167. Ibid., report of the 1867 annual general meeting; ex.info., Mr D.Clayton, op.cit., citing details of the Vron Railway Bill, of 1867.

168. Bradley (1992), op.cit., p.124.

169. P.R.O., Crown mineral leases, per Mr D.Clayton, op.cit; G.P.Jones (February 1983), 'Hanes Rheilffordd y Fron,' Lleu, 93, p.9.

170. Thomas, J.E., (1874); A Geographical and Geological Description of Carnarvonshire, (Caernarfon), pp.73-74. The estimated costs of building local standard gauge railways was £15,000 per mile for the Carnarvon & Llanberis line, £16,700 per mile for the Carnarvonshire Railway, £20,000 per mile for the Cambrian, and £23,500 per mile for the Chester & Holyhead Railway.

171. H.B.Roberts (1820-1903), of Bangor, Plas Llanddoget (Llanrwst) and Leamington, was variously a solicitor, owner of the Croesor Estate, proprietor of the Braich Quarry (1868-1880) and director of a number of other quarries and narrow gauge railways in Gwynedd.

172. Boyd, J.I.C., (1988, 2nd ed.), Narrow Gauge Railways in South Caernarfonshire, Vol.1, (Oakwood Press), pp.150-185; Degan, P., (1983), 'The North Wales Narrow Gauge Railways Company,' Railway World, June issue, pp.298-301; and Lee, C.E., (1945), The Welsh Highland Railway, (Welsh Highland Railway, Porthmadog, 1970, reprint of part of Lee's Narrow Gauge Railways in North Wales, Railway Publishing Co., 1945), passim.

173. Boyd (1988)m op.cit., pp.154-165; G.P.Jones (May 1983), 'Rheilffordd yr Ucheldir,' Lleu, 96, p.16, discussing the role of H.Beaver Roberts with regards the Bryngwyn branch line.

174. Boyd (1988), op.cit., pp.184 (map), 205-208; G.P.Jones (February 1983) op.cit.

175. C.R.O., X/Penyrorsedd.addit 1873, Minutes 6 December 1872, 23 March 1877, and 3 August 1878.

176. Ibid., Minutes 28 July 1885, and 18 June 1896; Boyd (1988), op.cit., referrs only briefly to the Caernarfon extension Act.

177. Ibid., Minutes 28 November 1894, and 18 June 1896.

178. Boyd (1988), op.cit., p.171.

179. See Note 172, supra.

180. Bradley (1992), p.137; C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Caernarvonshire Crown Slate Quarries Co. Ltd., papers and letters re. transport 1933-37.

181. Ibid.

182. ibid.

Economic considerations of secondary railway transport

183. C.R.O., X/Dorothea 1077.

184. Boyd (1981), op.cit., pp.30-31, 53-56, 107.

185. C.R.O., X/Penyrorsedd.addit 1873, report dated 24 January 1873; C.R.O., X/Dorothea 1242.

186. Ibid., letter 17 March 1893.

187. Ibid., letters from John Robinson (Talysarn Quarry) to the L.N.W.R., 12 April 1893, and from Robinson to the Dorothea Quarry agent, 30 August 1893. There was no further correspondence between Robinson and the Dorothea agent after August 1893.

188. Ibid.

189. Ibid; C.R.O., X/Penyrorsedd.addit 1873, Minute 27 January 1883.

190. See Note 147, supra.

191. C.R.O., X/Dorothea 1242.

192. C.R.O., XM 669/2, cuttings from the North Wales Observer and Express, 31 July 1891; C.R.O., X/Penyrorsedd.addit 1875, Minute 5 August 1890, and reports dated 19 March 1891, and 29 August 1891.

193. Ibid., report 19 March 1891 and Minute 8 December 1892.

194. C.R.O., X/Dorothea 1242. The Nantlle rates ranged from an 8*d.* (4p.) rebate to a 1*s.* 10*d.* (9½p.) surcharge, compared to the Dinas Junction range of a 4*d.* (2p.) to 1*s.*2*d.* (6p.) surcharge.

195. Ibid., letters from J. Robinson to R. N. Davies (Dorothea), 26 and 27 April 1893. The 1*s.*10*d* was made up of a 3*d.* per ton 'tram-toll'; 6*d.* per ton Nantlle 'terminal charge'; 10*d.* per ton conveyance charge; and a 3*d.* per ton Caernarfon Quay 'terminal charge'. These 'terminal charges' added up to nearly the cost of conveyance on the standard gauge track, and were 41 per cent of the total cost.

196. Ibid., letters from J.Robinson to the L.N.W.R., 22 and 24 April 1893.

197. C.R.O., XM 669/2, unidentified newspaper cuttings dated 15 and 25 April 1896, reporting Lloyd George's objections to the L.N.W.R. Bills.

198. N.L.W., HD 9621, S.T.G., June 1913, (notes abstracted by Dr Dafydd Roberts, to whom the present author is indebted for their use), Leader Column, reporting the increase of rail charges by up to 5%, commented that "....the advent of the motor should make for greater dispatch."

199. Dylan Pritchard, Q.M.J., April 1944, op.cit., p.516; Joint Research Dept. of the T.U.C. and the Labour Party (1923), The Slate Quarrying Industry of North Wales, (Caernarfon), p.31.

200. D.C.Davies (1887), Slate and Slate Quarrying op.cit., pp.174-175.

201. Dylan Pritchard, Q.M.J., January 1944, op.cit., pp.319-320.

202. S.T.G., October 1919, quoting maritime charges; The Slate Quarrying Industry of North Wales, op.cit., p.31.

203. Loc.cit.

204. C.R.O., X/Dorothea 1242, letter from J. Robinson to R. N. Davies, 27 April 1893.

205. The Slate Quarrying Industry of North Wales, op.cit., p.31.

206. S.T.G, March 1926; Dylan Pritchard, Q.M.J., December 1943, p.255.

207. This was termed "Grouping."

208. Baughan (1980), op.cit., p.104.

(iii). The change to motorised road transport, from *c.*1910 to date

209. Hughes, W.J., (1972), A Century of Traction Engines, (London, 3rd ed.), pp.10-17, 59-60.

210. Information per Mr D.Clayton, to whom the author is indebted.

211. Ibid.

212. Ex.info. Morris & Jones, grocery wholesalers of Caernarfon, used Foden steam lorries by the 1920s, and Lake's of Caernarfon had a traction engine distributing supplies to upland shops before the First World War.

213. Ex.info.

214. Ex.info., Mr Lefi Jones and the late Idwal Hughes.

215. Ex.info., Mr Lefi Jones and the late Ifor Hughes, former employees of the Fronheulog Green Quarry. A photograph of one of these lorries has been seen by the present author. The lorris superceeded the Tanrallt (or 'Carnarvonshire Company's') tramway, see Note 118, supra.

216. Ex.info., Mr Lefi Jones and the late Idwal Hughes.

217. W. G. Rear (1986), op.cit., p.59.

218. Ex.info., Mr Iorwerth Thomas, former independent tip contractor from the 1950s, whose stock was always carried by lorry.

219. Gourvish, T.R., (1986), British Railways 1948-73: a Business History, (Cambridge), p.178

220. Ibid., pp.184; 186-190; 260; 471.

221. Ibid., p.178.

222. Ibid., pp.184; 186-190; 260; 471.

223. Ex.info., Mr M. J. B. Wynne-Williams, who ended the use by Dorothea of the tramway soon after becoming the managing director of the quarry in 1958.

224. Ex.info., Mr Iorwerth Thomas, op.cit.

225. Ex.info., R. O. Parry (now deceased).

226. Ibid., ex.info., Mr Iorwerth Thomas, op.cit.

227. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry papers.

The demise of the Nantlle railway outlet

228. Ex.info., Mr R. Oswald Jones, former horse contractor.

229. Previous to the Beeching era, the railways appear to have settled into a state of benign atopy [see Gourvish, op.cit.].

230. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry papers.

231. Ex.info., R.O.Jones, op.cit.

232. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry papers.

233. Bradley (1992), op.cit., p.66.

234. C.R.O., G.P.Jones/Nantlle Mss (uncatalogued), Penyrorsedd Quarry papers.

235. Gourvish (1986), op.cit., Chapter 9, part 1; and ibid., p.428.

236. Baughan (1980), op.cit., p.104.

Modern road transport, post-1970.

237. Recorded by the present author. This practice was carried out because it was the only means of gathering an order from a stock-yard which was then organised in individual sub-stocks of the ongoing production of each slatemaker.

238. Ibid.

239. Ibid., ex.info., contemporary lorry drivers.

240. Ex.info., Mr Jeremy Gibbins, Gwynedd County Council Mineral Planning Dept.

241. Ibid.

242. Ibid. This scheme, by Capital Landfill (Bath) Ltd., was supplemental to its primary aim of using the quarry as a landfill site. Neither scheme gained planning consent.

243. This solution to the traffic problems that would have been created by this proposal by Mr Ifor Beaumont of the Alexandra Slate Group/Cilgwyn Slate Company, was proposed by the present author, acting in a consultative capacity for the quarry concern.

EPILOGUE

The Nantlle Valley became an industrialised area because of market demand, initially in Britain and later abroad, for the thin roofing slates that could be produced from its ample reserves of economically-viable rock. This demand increased progressively during the eighteenth and first three-quarters of the nineteenth centuries, a period of great development and profound changes in this district.

The development of the quarries at Nantlle was aided by cycles of inwards investment, which overcame the early restrictions imposed by local shortages of capital, albeit at a price of handing over control of the quarries to outside interests. However, the geological and technical problems encountered at Nantlle, which progressively increased the production costs beyond their norm for the industry, placed the long-term future of the slate quarries in the balance when the economic tide turned in the 1880s. Consequently, within the long-drawn phase of cyclical contraction of the slate markets after 1877, the Nantlle quarries suffered to a greater degree than the other major areas of production in north Wales, though quarrying continues in the district on a small scale.

Despite a growing demand for slates in the U.K. and on the international market since the mid-1970s and an increasing interest in alternative slate products, a renewal of quarrying at several potentially valuable defunct sites in the Nantlle valley is dependent upon attracting new capital investment and the utilisation of modern technology to overcome the inherent difficulties of exploiting the rock reserves.

Although several sites in the Nantlle district have been investigated by outside slate concerns during the last decade, leading to the extraction of aggregate from a number of waste tips, only the Penyrorsedd Quarry has witnessed a revival. The reopening of the Alexandra/Moeltryfan Quarry, leased since 1992 to the new Carmel Slate Company (of Norfolk and latterly of Anglesey), has been mooted on several occasions but the site still remains inactive. Of all the defunct quarries at Nantlle, the most valuable in terms of workable slate reserves is the Dorothea complex. Frustratingly, this has been since 1973 under the ownership of a variety of property developers who have unsuccessfully sought to establish a variety of developments on the site, ranging from a private holiday complex to a waste-disposal facility.

This short-term financial speculation continues a tradition which has dogged the economic development of the Nantlle district from an early date, resulting in a continuing failure to achieve a sustainable level of economic development. Neither has the intervention of public bodies proved beneficial. Recent land reclamation schemes have indiscriminately erased important monuments of the industrial past and rendered valuable reserves of slate rock unworkable without creating an economic benefit. Hopefully, it is now becoming accepted that a renewal of commercial quarrying, balanced against a publicly-funded development of the industrial heritage of the district as tourist-amenity, might provide the best opportunity for a recovery in the district's depressed economy. Thus, while new generations of Nantlle quarrymen might continue to fulfil the prophecy of a mystic poet, *Merfyn Wyllt*, who metaphorically foretold that the rocks of Snowdonia would be 'turned into bread' [W. Williams, 1892, p.106], the surviving physical remains of the endeavours of their forefathers to do likewise might also be utilised to provide additional economic sustenance to their successors.

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(6) Personal Reminiscences

[ex.info. sources]

Interviewees now deceased (February 1996) are marked thus: *

Ifor Beau-Mont, Norwich....... slatemerchant and proprietor of the Carmel Slate Company/Alexandra Slate Group (early-1990s).

*Mrs A.Breen-Turner M/Bridge.. source on John and Thomas Robinson of Talysarn Hall, quarry owners (respondent's grandfather and father respectively).

Stephen Darbishire, Sussex.... managing director of the Penyrorsedd Quarry (1960s-79).

Bleddyn Davies, Talysarn...... quarryman at Fron Quarry & Dorothea Quarry (1940s, 1950s-60s respectively).

*Hugh Davies, Talysarn........ gas engine stoker at Tynyweirglodd Quarry (1930s).

*Miss Mary Davies, Talysarn... recalling Frederick Davies and W.J.Davies, tip contractors (respondent's father & brother respectively).

*Rheinallt Davies, Talysarn... quarryman at Tanrallt (1950s) and Dorothea quarries (1960s).

*Harry Eddy, Nantlle.......... locomotive driver at Penyrorsedd Quarry (1930s-50s).

R. E. Esplin, West Kirby...... managing director of the Cocklebank Conservations Ltd., of the Twll Coed Quarry (1970-84).

*Glyn Griffiths, Nantlle...... locomotive driver at Penyrorsedd Quarry (1920s-50s).

*Tecwyn Griffiths, Talysarn... rockman at Dorothea Quarry 1940s-60s.

*Idwal Hughes, Penygroes...... clerk to W.J.Davies, tip contracting agent (1930s), works manager of Tynyweirglodd Quarry (1941-53), working proprietor of Fronheulog Green Quarry (1950s-73).

*Ifor Hughes, Talysarn........ quarryman at Fronheulog Green Quarry (1920s-38) and at Dorothea Quarry (1940s).

*John M. Hughes, Talysarn..... apprentice slatemaker at Talysarn Quarry (1890s), quarryman at South Dorothea, Cloddfa'r Coed and Dorothea quarries (1900s-50s).

John R. Hughes, Talysarn...... apprentice slatemaker at Tanrallt Quarry (1950s); source on Morgan & Arthur Hughes, q.v., (respondant's uncles).

Leonard Moss Hughes, Nantlle.. driver of the Dorothea Quarry's Cat.955 loader (1960s); loader driver at Penyrorsedd Quarry in 1970s.

*Morgan Hughes, Caernarfon.... apprentice slatemaker at Coedmadog Quarry (1900s) and South Dorothea Quarry (1910s); garage proprietor (1920s), works manager of Tynyweirglodd & Talysarn (1930s), independent tip-contracting agent and speculator at Blaen Cae, Tanrallt, Fronheulog Green, Twll Coed, Twll Llwyd, Tynyweirglodd and Cilgwyn quarries (1940s-60s).

Peredur Hughes, Porthmadog.... works manager of Penyrorsedd Quarry (1984-95).

*Robert Hughes, Nantlle....... quarryman at Penyrorsedd Quarry (1920s-60s) and tip-slatemaker (1970s).

Alan Humphreys, Penygroes..... quarryman at Twll Llwyd (1970s) and joint-owner (1980-).

*Owen Humphreys, Talysarn..... slatemaker at Galltyfedw Quarry (1920s) and the Dorothea Quarry (1930s-40s).

*Richard Humphreys, Talysarn.. mule attendant for the Ordnance Survey surveying team (1913); handyman at the Talysarn Quarry (1918-1924) and at the Galltyfedw Quarry (1925-31).

Robert Humphreys, Talysarn.... apprentice slatemaker, apprentice stonemason at Penyrorsedd Quarry (1950s) and jobbing labourer dismantling various mills (1960s).

Wm. H. Humphreys, Penygroes... horse attendant at Galltyfedw Quarry (1930s), tip-slatemaker at Cloddfa'r Coed, Tanrallt and Tynyweirglodd quarries (1940s-63), proprietor of Twll Llwyd Quarry (1963-).

*William J. Jarvis, Carmel.... slatemaker at Cilgwyn Quarry (1930s). An eminent local historian.

*Alexander Jones, Groeslon.... handyman at the Blaen Cae Quarry (1910s-20s).

*Dafydd R. Jones, Rhosgadfan.. horse attendant at Alexandra Quarry (*c*.1918), pump attendant and electrical fitter (1920s), transferring to Moeltryfan Quarry (1930s-60s).

Eifion Jones, Talysarn........ pit labourer at Dorothea Quarry (1950s) and blondin driver at Penyrorsedd Quarry (1960s).

*Hugh H. Jones, Talysarn...... quarryman at Dorothea Quarry (1930s) and works manager (1945-64).

Idris P. Jones, Penygroes..... gas engine driver at Llwydcoed and Tynyweirglodd quarries (1920s-30s); mill engine driver at Galltyfedw Quarry (1930s) and fitter at Dorothea Quarry (1950s-60s).

Lefi Jones, Talysarn.......... apprentice slatemaker at Blaen Cae Quarry (1924), slatemaker at Fronheulog Green and Cilgwyn quarries (1920s-30s), petrol loco driver at Penybryn Quarry (1946-51); general fitter & wire-rope inspector at Dorothea Quarry (1950s-60s).

*Llewelyn Jones, Talysarn..... inclined cableway, beam-engine and blondin engine driver at Dorothea Quarry (1930s-65).

*John W. Jones, Y Fron........ quarryman at Penyrorsedd Quarry (1930s), pit foreman (1940s-64), and works manager (1964-70s).

R. Oswald Jones, Talysarn..... coal merchant, haulage contractor and horse contractor on the Nantlle Tramway (1940s-63).

*Wm. John Jones, Talysarn..... independent tip contractor (1940s-60s).

*Eddie Moss, Penygroes........ inclined cableway driver at Talysarn Quarry (early 1920s).

*Elfed Moss, Talysarn......... tip-slatemaker and general labourer, Talysarn and Dorothea quarries (1930s-50s). Son of Phillip Moss, driver of former quarry's pumping engine (details recalled).

*Aneurin Owen, Y Fron......... slatemaker at Cilgwyn Quarry (1940s-50s) and at Penyrorsedd Quarry (1960s-70s).

Dafydd Aled Owen, Talysarn.... tip-slatemaker at Tanrallt, Tyddyn Agnes, Singrig and South Snowdon (1930s-50s); works manager of Twll Coed (1970s).

Gwilym E. Owen, Talysarn...... tip-slatemaker at Cilgwyn Quarry (1930s). Source re. Dafydd Oliver Owen, small-scale entrepreneur (respondent's father).

Stanley Owen, Talysarn........ wages clerk at Penyrorsedd Quarry (1960s).

*R. Osborne Parry, Penygroes.. coal merchant and haulage contractor, specialising in long-distance haulage in 1960s.

*Wm. F. Plemming, Penygroes... slatemaker at Graig Ddu (Ffestiniog), under-manager at Dorothea Quarry (1940s-63) and works manager (1963-69).

*W.Gordon Pritchard, Talysarn. blondin driver and standby beam-enine driver at Dorothea Quarry (1940s-60s).

*Gordon H. Richards, C'narfon. secretary of the Amalgamated Slate Association Ltd., (1920s), and slatemerchant (1930s-70s). Source on Alfred Richards (responent's father) and A. W. Kay Menzies, both quarry directors.

*Walter Riley, Penygroes...... slatemaker at Hafodlas (Betws-y-Coed), Rhos (Capel Curig); director/secretary of the Caernarvonshire Crown Slate Quarry Co. Ltd., (1930s-72).

*Gwilym Roberts, Talysarn..... apprentice blacksmith at Talysarn Quarry (1920s) and assistant at Galltyfedw (1930s); blacksmith at Dorothea Quarry (1938-69).

*William Roberts, Talysarn.... tip-slatemaker at Talysarn Quarry (1930s) and quarryman at Dorothea Quarry (1940s-60s).

Idwal Thomas, Carmel.......... quarryman and contractor at Cilgwyn 1950s.

Iorwerth Thomas, Talysarn..... tip-slatemaker at Braich, Cloddfa'r Coed and Fronheulog & Tanrallt quarries (1930s-50s), independent operator (in partnership) at Rhos Clogwyn & Glanrafon (Rhyd Ddu, 1950s), Cilgwyn (1950s-60s), Penybryn, Tynyweirglodd, & Twll Coed (1960s).

Jack P. Thomas, Talysarn...... slatemaker at Penyrorsedd Quarry (1933-80s, at various periods).

*James Thomas, Talysarn....... slatemaker at Cilgwyn Quarry (1930s-40s) and quarryman at Dorothea Quarry (1950s-60s).

*Francon Thomas, Nantlle...... engineer of the Penyrorsedd Quarry (1940s-70s, two periods).

Ronald Thomas, Penygroes...... slatemaker at Dorothea Quarry (1960s) and works manager of Twll Coed (1980s).

Glyn Tomlinson, Talysarn...... clerk at Dorothea Quarry (1950s).

Eifion Williams, Ffestiniog... managing director of the Nantlle Slate Quarry Co. Ltd., (1979-) and the Cocklebank Conservations Ltd., (1984-).

*Ellis Williams, Y Fron....... locomotive & steam excavator driver at Penyrorsedd Quarry (1920s-30s).

*Evan Williams, Talysarn...... slatemaker & bargainman at Dorothea Quarry (1906-1927), slate inspector (1927-58), latterly also slate shipper. Maternal grandfather of the present author.

Michael J. B. Wynne-Williams.. managing director of the Dorothea Quarry (1958-70).

*Owen Glyn Williams, Bethesda. general manager of the Penyrorsedd Quarry (1959-76).

*Oswald Williams, Carmel...... rockman at Dorothea and Penyrorsedd quarries (1940s-70s).

Owen Williams, Talysarn....... apprentice blacksmith at Penyrorsedd Quarry (1950s).

Richard H. Williams, Talysarn. quarryman at Dorothea Quarry (1940s-60s), Moeltryfan (1960s-1972) and Twll Coed (1970s).

*Robert Williams, Talysarn.... clerk of the Galltyfedw, Talysarn and Tynyweirglodd quarries (1910s-53).

Robert J. Williams, Carmel.... blondin driver at Penyrorsedd Quarry (1920s-79).

Walter Williams, Penygroes.... apprentice fitter at Penyrorsedd Quarry (1950s).

APPENDIX 1

RANK ORDER OF MAJOR SLATE CONCERNS BY WORKFORCE TOTALS

1882		1898		1913		1937	
Dinorwic	2,757	Dinorwic	3,010	Dinorwic	2,573	Dinorwic	2,369
Penrhyn	2,089	Penrhyn	2,809	Penrhyn	2,001	Penrhyn	1,916
Welsh Slate	720	Oakeley Co	1,628	Oakeley Co	632	Oakeley Co	765
Dorothea	**533**	**Penyrorsedd**	**613**	**Penyrorsedd**	**461**	Llechwedd	438
Llechwedd	531	Llechwedd	606	**Dorothea Co**	**379**	Maenofferen Co	426
Hollands	524	**Dorothea Co**	**600**	Maenofferen	324	**Dorothea Co**	**359**
Cwmorthin	516	**Talysarn Co**	**485**	Votty &Bowydd	311	**Penyrorsedd**	**351**
Talysarn	**400**	Votty &Bowydd	474	Llechwedd	310	Votty &Bowydd	314
Matthews	362	Maenofferen	435	**Talysarn Co**	**275**	**Crown Co**	**171**
Votty &Bowydd	344	**Cilgwyn**	**331**	**Alexandra**	**216**	Aberllefenni	131
Cilgwyn	**300**	Cwmorthin	279	**Cilgwyn**	**193**	Cwm Machno	123
Bryneglwys	297	Glanrafon	277	**Moeltryfan**	**139**	Glyndyfrdwy	121
Penyrorsedd	**261**	Glynrhonwy	273	Craig Ddu	136	Braichgoch Co	101
Maenofferen	238	**Alexandra**	**239**	Bryneglwys	120	Moelferna	98
Penybryn	**234**	**Moeltryfan**	**236**	Park &Croesor	120	Graig Ddu	91
Diffwys	221	Bryneglwys	220	**S. Dorothea**	**102**	Bwlch	65
Llanberis Co	197	Craig Ddu	218	Aberllefenni	101	Bryneglwys	58
Alexandra	**195**	Llanberis Co	206	Cwm Machno	97	Rhos	52
Rhosydd	192	Upper Glyn	187	Moelferna	97	Cwt y bugail	41
Abercwmeiddaw	188	Moelferna	184	Cambrian	94	**Tynyweirglodd**	**39**
Braichgoch	187	Rhosydd	183	Glynrhonwy	91	**Fronheulog**	**36**
Aberllefenni	175	Cwm Machno	178	Bwlch	84	Wrysgan	27
Braich	**124**	**Coedmadog**	**158**	Rhosydd	80	Gartheinog	26
Craig Ddu	110	Park &Croesor	156	Diffwys	76	Hendreddu	15
Minllyn	108	Diffwys	153	Llanberis Co	73	Gartheniog	15
Coedmadog	**100**	Braichgoch	148	Penarth	72		
Cwm Machno	100	Aberllefenni	145	Upper Glyn	72		
Fronheulog	**98**	Wrysgan	122	**Galltyfedw**	**64**		
Glanrafon	97	**S.Dorothea**	**121**	Glanrafon	56		
Wrysgan	96	Rhiwbach	109	Moel Faen	56		
Cloddfa'r Coed	*	Llwyngwern	103				
Upper Glyn	90	**Fronheulog**	**87**				
Moeltryfan	**81**	Pantdreiniog	80				
Prince(Dolelen)	74	Cambrian	73				
Cwt y bugail	73	Abercwmeiddiaw	70				
South Dorothea	**70**	Cwt y bugail	68				
Fron	**62**	Cook & Ddol	67				
		Wynne	64				
		Fron	**50**				

NOTES: (1) The suffix 'Co' denotes multiple sites; (2) Nantlle quarries are in **bold**; (3) Cloddfa'r Coed in 1882 guessed (data "in confidence").

APPENDIX 2

CHRONOLOGY OF NANTLLE LIMITED LIABILITY COMPANIES

See Key below for expanded column criteria

COMPANY TITLE	DATE OF REGIST'ION	£K NOMINAL xPAR PRICE	ISSUED x No HOLDER	VEN %	TOTAL CALLS	LIQUID'OR APPOINTED
Carnarvonshire SCL.	21/10/1856	£50K x £1	14250 x 34	?	£39136	by 1881
Talysarn S C L.....	10/06/1859	£50K x£10	105 x 7	*100*	£1050	by 1861
Lower Taldrwst & Cloddfa'r Coed SCL.	08/09/1860	£25K x£2½	28 x120	*.35*	£19973	04/02/1864
British S C L......	18/09/1860	£75K x £1	6036 x116	?	£6788	23/05/1874
Ty Mawr West Q C L.	27/12/1861	£10K x £5	185 x 40	*11*	£8375	13/03/1873
Nantlle Vale Talysarn Freehold S C L.....	31/01/1862	£25Kx£100	250 x 7	*77*	£3860	18/04/1868
Penyrorsedd Q C L..	19/09/1862	£55K x£10	5550 x 8	*45*	£51044	1979
East & West Dolbebin Slate Quarry C L...	03/01/1863	£30K x £5	1705 x 30	*7*	£8525	19/09/1866
Alexandra S C L....	17/04/1863	£20Kx£500	38 x 10	*50*	£19000	01/07/1869
Alexandra Galltyfedw Slate & Slab Q C L.	08/10/1863	£25K x£10	24 x 7	*29*	-	Unfloated
Talydrws S C L.....	15/10/1863	£20K x£10	2000 x 78	*8*	£20000	30/03/1874
Vronheulog S C L...	04/01/1864	£50K x £5	5340 x 30	*41*	£26700	18/05/1877
Coedmadog S C L....	19/01/1864	£15K x £1	11800 x 16	*30*	£11800	16/01/1877
Brynfferam S Q C L.	05/01/1865	£50K x£10	2142 x 42	*24*	£21420	14/04/1877
Dorothea West Green Blue & Red S C L...	10/11/1865	£50K x £5	3671 x 14	*6*	£8375	30/08/1869
Gwernor Slate Q C L	23/02/1866	£50K x £5	1695 x 7	?	£8475	by 05/1883
Carnarvon & Bangor SCL.........	01/02/1867	100K x£10	4258 x141	*.35*		
renamed TalysarnSCL	07/06/1870	ditto	ditto	do	£42580	05/09/1873
Freehold Estates CL	22/08/1872	£10K x£50	76 x 19	?	?	11/03/1875
The Slate C L......	28/01/1873	£15Kx£100	99 x 25	*26*	?	15/11/1879
Vron S C L.........	22/07/1873	£50K x£10	580 x 81	*44*	£2900	05/11/1880
Upper Tyddyn Agnes S C L........	11/12/1873	£20K x£50	227 x 26	?	?	22/07/1880
West Dorothea S C L	16/03/1874	£30K x £5	4105 x 21	*49*	£15195	14/07/1880
Alexandra S C L....	29/06/1874	£50K x£20	2500 x 30	?	£30000	15/03/1918
Nantlle Vale SQCL..	16/01/1874	£30K x£10	690 x 9	?	?	18/01/1879
Gwernor S Qs C L...	22/12/1875	£20K x£10	? x ?	*33*	?	01/08/1883
Eryri S C L........	04/09/1877	£35K x £5	178 x 26	?	£598	01/03/1882
South Dorothea SQCL	18/11/1878	£25K x£50	105 x 7	100	£16750	16/04/1880
Foel (Clynnog)SQsCL	26/02/1879	£30K x £5	4207 x 10	?	£21035	06/09/1893
Moeltryfan Slate & Slab Q C L.......	01/11/1879	£40K x£10	4000 x 13	*9*	£22000	15/03/1918

Appendix 2

COMPANY TITLE	DATE OF REGIST'ION	£K NOMINAL xPAR PRICE	ISSUED x No HOLDER	VEN %	TOTAL CALLS	LIQUID'OR APPOINTED
New Vronheulog SCL.	10/04/1880	£20*K* x£20	1000 x 7	*100*	£6000	15/07/1915
Penybryn S C L.....	25/02/1882	£1035x£35	240 x 11	?	£10325	01/07/1887
Vron & Old Braich Welsh Slate Qs C L.	29/01/1882	£15*K* x£25	380 x 9	*53*	£8510	05/11/1891
New Brynfferam SCL.	10/08/1882	£10*K* x£25	? ?	?	?	by 1900
Victoria S Q C L...	11/12/1883	£10*K* x £5	960 ?	*36*	?	by 12/1887
G. Williams SCL....	24/01/1884	£10*K* x£10	150 x 7	?	£1179	by 1900
Carnarvon Green SCL	20/08/1884	100*K* x £1	? ?	?	?	by 12/1891
Nantlle United Qs L	30/12/1887	£20*K* x £1	1945 x13	*3*	?	28/09/1891
Llwyd-Coed Slate Quarry Syndicate L........	23/02/1888	£16*K* x£50	134 x22	?	£1670	by 05/1897
United Quarries C L	20/10/1891	£5*K* x £1	2250 x17	*30*	?	10/1909
Dorothea S Q C L...	08/09/1892	£10*K* x£50	100 x16	*100*	£2500	03/1970
Galltyfedw S Q L...	04/05/1895	£10*K* x £5	686 x42	*26*	£953	11/03/1903
New Llwydcoed SQCL.	25/07/1895	£120 x £1	120 x 7	*100*	Paidup	05/02/1897
North Wales Green S Q C L......	17/06/1896	£25*K* x £1	7 x 7	*40*	Paidup	by 11/1899
Coedmadoc S C L....	09/10/1896	£9*K* x£10	750 x11	?	?	30/12/1908
Cilgwyn S C L......	18/11/1896	£40*K* x£10	3600 x16	?	£30000	15/03/1918
Vron & Old Braich S Qs L......	11/12/1896	£3*K* x £1	2200 x12	*13*	£2200	1901
Vron Welsh S Qs L..	24/07/1902	£5*K* x£25	96 ?	6	?	11/02/1914
Talysarn S Qs L....	15/08/1904	£20*K* x £1	20000 x 7	*100*	Paidup	20/01/1925
Gwernor S Qs C L...	10/11/1905	£8*K* x £1	6074 x ?	*48*	?	by 1920
Menai Straits C L..	08/11/1905	£5*K* x £1	5000 x 3	*50*	?	1911
South Dorothea SQL.	17/10/1907	£16*K* x £1	16000 x ?	*99*	?	1922
Old Penybryn S Q L.	13/11/1907	£6*K* x £5	1030 x10	*68*	Paidup	23/06/1931
Welsh Green S Q C L	1908	? ?	? ?	?		
New Braich S Qs L..	02/11/1908	£10*K* x £1	? 18	?	?	15/10/1915
Ty Mawr S Q C L....	01/05/1909	£1*K* x £5	180 x 9	?	?	by 02/1923
Greenarvon S Q C L.	1910	? ?	? ?	?	?	by 1930
Amalgamated Slate Association L	22/04/1918	£50*K* x £1	43057 x60	*84*	£6675	09/01/1931
Vronlog Green SQsL.	08/05/1920	£20*K* x £1	4800 x ?	?	?	by 1940
Vron S Qs (1927) L.	05/08/1927	£6*K* x ?	? ?	?	?	by 1940
Caernarvonshire Crown S Qs C L.....	01/04/1932	£5*K* x £1	5000 x 5	?	?	in limbo?
Tynyweirglodd SQCL.	26/11/1941	? ?	? ?	?	?	by 1955
Cocklebank Conservations L....	02/1972	£100 x £1	4 x 2	?	?	Active
Nantlle S C L......	1979	? ?	? ?	?	?	Active

__Refs__: J.S.Wilkinson P.R.O., BT/31 Abstracts; D.D.Pritchard C.R.O.,XM4874.

Key to Appendix 2:

COMPANY TITLE......... *xxx* S[late] Q[uarry]/Q[uarrie]s C[ompany] Limited.

£K NOMINAL x PAR PRICE Nominal Capital at registration
x face value of ordinary shares.

ISSUED x No HOLDER... No of shares issued of original nominal capital
x number of shareholders of these shares.

VEN % .... Vendor's shares as percentage of original issue.

TOTAL CALLS.......... Recorded calls on shares.
"Paidup" records that all of issue was paid-up.

APPENDIX 3
NANTLLE MILLS CHRONOLOGY

QUARRY Codes:	MILL (change)	DATE BUILT (approximation)	SAWS	DRESSERS (added)	POWER SOURCES W	S	IC	E	RD
Penyrorsedd ..	W6 Mill, Pt.1.	1875 ...	20	20	*	*	-	*	-
do.	W6 Mill, Pt.2.	1877 ...	12	12	(*)	(*)	-	*	-
do.	W4 Mill, Pt.1.	1877 ...	10	10	-	-	-	*	*
Fronheulog ...	Old Mill	(1877-86)	7?	-	*?	*?	-	-	-
Llwycoed	Lower, Pt.1 ..	(1877-88)	3?	-	*?	*?	-	-	-
Moeltryfan ...	Fl.3, Pt.1 ...	(1877-88)	5	(1)	-	*	-	(*)	-
South Dorothea	(Large, Pt.1).	(1878-88)	7	(7)	-	*	*	-	-
Coedmadog	Mill	1881 ...	8?	-	-	*	*	-	-
Penyrorsedd ..	W4 Mill, Pt.2.	1881 ...	10	10	-	-	-	*	(*)
Penybryn	Upper, Pt.1 ..	(1882-85)	5	5	-	*	-	-	-
do.	Lower Mill ...	(1882-85)	6	-	-	*	-	-	-
Fron	Mill	(1882-89)	-	-	abandoned unfinished				
Dorothea	Large, Pt.1 ..	1883 ...	10	(4)	-	*	-	*	-
do.	Large, Pt.2 ..	1884-86.	19	(9)	-	(*)	-	(*)	-
Talysarn	Large Mill ...	1885 ...	18	-	-	*	-	-	-
Alexandra	Old Mill, Pt.1	1887 ...	15	-	-	*	-	-	-
Dorothea	Large, Pt.3 ..	1888 ...	13	(5)	-	*	-	*	-
Blaen Cae	Mill	(1888-94)	10	10	-	*	*	-	-
Braich	Mill, Pt.1 ...	(1888-99)	13	-	-	*	-	-	-
Llwydcoed	Lower, Pt.2 ..	(1888-99)	3?	-	(*?)	(*?)	-	-	-
Moeltryfan ...	Fl.3, Pt.2 ...	(1888-99)	6	(6)	-	(*)	-	(*)	-
do.	Fl.3, Pt.3 ...	(1888-99)	8	(4)	-	*	-	*	-
South Dorothea	Large, Pt.2 ..	(1888-96)	4	3	-	(*)	(*)	-	-
do.	Small Mill ...	(1888-96)	5	-	-	(*)	(*)	-	-
Gwernor	No.1 Mill	(1888-97)	2?	-	*	-	-	-	-
Ty Mawr West .	Mill	(1888-99)	4?	-	-	*	-	-	-
Cloddfa'r Coed	Mill	1889 ...	-	-	abandoned unfinished				
Foel Clynnog .	Mill	(1880s)..	2?	-	*	-	-	-	-
Alexandra	Old Mill, Pt.2	1890 ...	5?	-	-	(*)	-	-	-
do.	Old Mill, Pt.3	(1890-99)	7?	-	-	(*)	-	-	-
Dorothea	Small, Pt.1 ..	1893-94.	5	(3)	-	*	*	*	-
Talysarn	Small Mill ...	(1894-96)	6	6	-	*	-	-	*
Fronheulog ...	New Mill, Pt.1	(1895-97)	6	-	-	*	-	-	-
Galltyfedw ...	No.1 Mill	(1895-99)	6	6	-	*	-	-	-
Cilgwyn	'A' Mill	1896 ...	10	5	-	*	(*)	-	-
Dorothea	Small, Pt.2 ..	1896 ...	6	-	-	(*)	-	-	-
Moeltryfan ...	Fl.4, 'A' Mill	1896 ...	7	-	-	*	-	-	*?
Penyrorsedd ..	W6 Mill, Pt.3.	1896 ...	10	10	(*)	(*)	-	(*)	-
do.	(W4 Slab refit)	1896 ...	8	6	-	-	-	(*)	(*)
Penybryn	Upper Mill,Pt.2	1897 ...	6	-	-	(*)	-	-	-
Tynyweirglodd	Mill Pt.1	1897 ...	4	(4)	-	*	*	-	-

Appendix 3

QUARRY Codes:	MILL	DATE BUILT (approximation)	SAWS	DRESSERS (added)	POWER SOURCES W	S	IC	E	RD
Cilgwyn	'B' Mill	1898	15	6	-	(*)	*	-	-
Penyrorsedd	E8 Mill	1898	32	32	-	*	*	-	-
Moeltryfan	Fl.4, 'B' Mill.	1899	7	-	-	(*)	-	-	(*)
Galltyfedw	Top tip external	(1890s)	10?	-	-	-	-	-	*
Tyddyn Agnes	Sawing shed	(1890s)	1	-	-	*?	*?	-	-
Old Braich	Mill	(1899-1904)	8	-	-	*	*	-	-
Fronheulog	New Mill Pt.2	(1899-1911)	8	-	-	(*)	-	-	-
Llwydcoed	Upper Mill	(1899-1913)	5?	-	-	-	*	-	-
Gwernor	No.2 Mill	(1899-1913)	3	-	*	-	-	-	-
Tanrallt	Mill	(1899-1913)	9	-	-	*	-	-	-
Galltyfedw	No.2(uncompleted)	1900s	15	-	-	(*)	-	-	-
Penybryn	Upper Mill, Pt.3	1902	6	-	-	(*)	-	-	-
Moeltryfan	Fl.3, Small Mill	1904	7	-	-	(*)	-	*	-
Blaen Cae	'B' Mill	(1904-13)	-	-	abandoned unfinished				
Talysarn	New Mill	(1904-13)	9	4	abandoned unfinished				
Alexandra	New Mill,'A' Nth	1905	7	3	-	-	*	*	-
do.	New Mill,'B' Nth	1905	8	4	-	-	(*)	(*)	-
do.	New Mill,'A' Sth	(1906-08)	16	8	-	-	(*)	*	-
Braich	Mill, Pt.2	1909	6	-	-	(*)	-	-	-
Alexandra	New Mill,'C' Nth	1909?	4	2	-	-	(*)	(*)	-
do.	New Mill,'B' Sth	1910	6	3	-	-	(*)	(*)	-
Talysarn	Small, External	(1910s)	5	-	-	(*)	-	-	-
TyMawr E.Green	Sawing shed	(1920s)	1	-	-	-	*	-	-
Crown New	Mill	1937	5	-	-	-	-	*	-
Alexandra	Lefal Fawr Shed	(1930s)	1	-	-	-	*	-	-
Cilgwyn	Small Mill	(1930s)	-	-	unmechanised shed				
Dorothea	Small, Pt.3	(1930s)	1	-	-	(*)	-	-	-
do.	Large, Pt.4	(1930s)	2	(2)	-	(*)	-	(*)	-
Tynyweirglodd	Mill, Pt.2	(1930s)	1	(1)	-	-	(*)	-	-
Tanrallt	Pit,Sawing shed	1949	1	-	-	-	*	-	-
Tynyweirglodd	Twll Isaf Shed	1953	1	-	-	-	*	-	-
Brynfferam	Sawing shed	(1950s)	1	-	-	-	*	-	-
Dorothea	Small Mill Extn	1963	-	-	unmechanised shed				
Twll Llwyd	Sawing shed	1964	1	1	-	-	*	-	-
Alexandra	Diamond Saw Shed	1966	1	1	-	-	-	*	-
Moeltryfan	Diamond Saw Shed	1966	1	-	-	-	-	*	-
Twll Coed	Sawing shed	1970	1	-	-	-	*	-	-
Twll Coed	Diamond Saw Shed	1973	1	1	-	-	-	*	-
Twll Llwyd	Diamond Saw Shed	1990	1	-	-	-	-	*	-

KEY: **Mill**: Underlined segregated mills; **Dressers**: ( ) shows addition of dressers; **Power**: **W** Water; **S** Steam; **IC** Internal combustion; **E** electric; **RD** Rope-drive; * recorded use of power source(s); (*) power source shared from another mill (or part of mill) listed.

APPENDIX 4

SPECIFICATION OF GREAVES-TYPE SAWING MACHINES USED IN THE NANTLLE AREA

MANUFACTURER	SPECIFICATION OF VARIANTS.
Griffith Owen, Porthmadog	Greaves prototype saw. Possibly wood-frame. Single-acting chain feed motion, actuated from low-level drum-shaft powered from saw axle via right-angle intermediate shaft and reduction gearing .
	Cast Iron frame, eccentric mechanism with chain feed (1860 Pat). Centre mechanism 5ft 10in X5ft wide, with bolt-on end sections of 6ft 4in and 4ft 1 in length. load-table 9ft x 5ft wide, running on rollers, some on axles and others in cast sockets on frame. Central frame had V-guide.
Owen, Isaac & Owen, do.	Owen Patent saws as above.
	Small size model with load-table 8ft x 4ft.
	"Hunter" or heavy-type saws for slabs, incorporating Pat. feed motion. Cast Iron frame 22ft x 5ft, with load-table 9½ft x 5ft.
De Winton, Caernarfon	Timber-framed, late 1850s. no further details.
	Unknown specification, mid-1860s, but one had a frame measuring 30ft x 4ft.
	Cast iron frame 19ft x 5ft, hydraulic feed (1875 Pat.3455) on table 11ft x 5ft. Supplied in pairs with common belt drive Cast iron frame, rack feed (1887 Pat.7448) to table 11ft x 5ft and smaller 9ft x 5ft option. Usually supplied in pairs.
	Small size of above, 4ft wide; load-table 7ft x 4ft.
	"Hunter" saw for slabs, by 1890, of heavier construction, with slower feed (lower gearing on double worm-reduction).

John Owen, Bangor	Small Cast Iron frame, triple-gear (1875 Pat, not identified). Small table 8ft x 4ft running on V-guides only (no rollers).
H.Owen & Son, Caernarfon	Cast Iron frame, double worm-reduction drive. Early type with load-table 8½ft x 4½ft, some two-speed, in production by 1883. Cast Iron Frame 5ft wide on later model, retaining worm reduction, but with load-table 9ft x 5ft. In production by 1888. Cast Iron Frame 12ft x4ft wide, possibly last model, having load-table of 7ft x4ft.
W. Lewis, Tanygrisiau	Cast Iron frame, 5ft wide. load-table 9ft x 5ft running on V-guides only (no rollers). In production by 1884.
J.H.Williams, Porthmadog	Cast Iron frame, 9ft x 4ft load-table (in production by 1883). Morris Pat.12900 of 1887 (under licence); cast iron frame 5ft wide. Load-table 9ft x 5ft.
Green & Co., Aberystwyth	No specification available. In production pre-1890.
Coalbrookdale Iron Co.	Cast Iron frame 5ft wide, with load-table 9ft x 5ft. In production by 1885; possibly special batch only for the Dorothea Quarry. Alternatively, these tables were from an unrecorded source, with the Coalbrookdale Company acting as sales intermediates or used-plant agents.

The patents referred to above are :-

1860 No.2271 G.Owen	Improved feed mechanism for slate saw, consisting of a driving chain wound around an axle which was actuated by a two-speed twin pawl and ratchet wheel, incorporating clutches for arresting motion and for connecting a rapid reverse gear train.
1862 No.2362 H.P.Hughes	Improved feed motion for slate saw.
1875 No.3455 J.P.De Winton	Hydraulic control valve for saw table feed motion.

1887 No.7448 J.P.DeWinton Improved feed mechanism having worm drive and quick return

1887 No.12900 T.E.Morris Improved feed mechanism having gearing enclosed in bath of lubricant.

Some manufacturers do not appear to have been represented in the identified saw tables in the Nantlle district, namely Richard Jones, Porthmadog (an early supplier to the Ffestiniog district); Turner Bros., Newtown; and an unidentified firm from Chester (the last two having supplied plant to other districts). However, as Nantlle records are incomplete, it cannot be stated with certainty that none of their machinery was used here].