THE SCOTTISH GAS INDUSTRY UP TO 1914

by

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1976

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The University of Strathclyde

Thesis Submitted For The Degree of Doctor of Philosophy

In Four Volumes

VOLUME 2

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II Special Gases - Animal Oil, Water, Tar, Mineral Oil, Petroleum, Portable, Acetylene and Suction Gases

Although coal-gas predominated until after 1914, a wide variety of substitutes were tried in Scotland for illumination and heating purposes, either in direct competition with coal gas, or as a cheaper means of supplementing or enriching the candlepower of existing coal gas supplies. Animal-oil gas, from seal or whale oil, was a technical success but an economic failure[1] which drew considerable early support because of purification problems with coal gas, fears for the Greenland whale trade,[2] the 'nursery' of Naval personnel, and the

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1. "Oil Gas Schemes Versus Fact" J.G.L., 24/6/1856 pp. 372-4.

2. Scottish whaling began at Leith in 1750, with Treasury bounties to reduce foreign oil imports. It stimulated shipbuilding in many ports. Oil was used for domestic and industrial lighting, soap, candle and paint manufacture, and machine lubrication. Oil prices rose from £27 a tun in 1808 to £50 in 1813, but the bounty ceased in 1824 and the rival gas-light industry became an important potential market.

Average Annual Ships in Whaling Industry

Date	Scotland	England
1750-69	11.5	39
1814-17	48.5	98

Leith, Bo'ness, Kirkcaldy, Dundee, Montrose, Aberdeen, Kirkwall and Greenock all provided vessels.

Increasing public lighting by oil-lamps, which Glasgow introduced in 1783 and financed at £232 per year in 1786-93, was a market lost to coal gas. The number of Dundee whaling vessels fell from eight in 1814 to four in 1833 before whale-oil again became useful for softening jute fibres during manufacture. On the possibility of oil-gas in the 1820s Faraday believed thousands of fishermen would find employment, providing raw material for gas; Atkins stated that 10,000 fishermen, and 10,000 rope, sail and allied industrial workers would become redundant if coal was used. In the late 1820s, Newcastle colliers became the new source of naval manpower.

S.G.E. Lythe, "The Dundee Whale Fishery" Scottish Journal of Political Economy 1964 vol. III pp. 158-69.
BPP 1820 (138) XII p. 189; BPP 1823 (446) XIII p. 597
T. Adams, Ed. Edinburgh 1329-1929 (1929, Edinburgh) p. 174.
C. Dickens, All The Year Round Vol. XVIII pp. 349-55; IX p. 280
J. Sinclair, Ed. New Statistical Account (1839) Vol. XII p. 75
F. Accum, Practical Treatise on Gas Light (1815) pp. 137-42

failure of scientists to give accurate standards of photometry. Oil gas provided the first centralized gas supply in Leith (1821) and Aberdeen (1824) as well as producing a second gas company in Edinburgh (1823). Portable gas in the 1820s was also an expensive failure, but was later developed by the Pintsch company as an important aid to marine navigation and vehicular lighting. Mineral oil gas, used to increase the candlepower of coal-gas as supplies of high quality coal became depleted, and water gas for enrichment, or for specialized industrial equipment, achieved considerable importance in Scotland towards the close of the nineteenth century. Atmospheric air 'carburetted' with petroleum provided an inexpensive substitute for coal gas in small markets which could not otherwise afford a gas supply. This was also the function of Acetylene gas, which in the late nineteenth century superseded existing coal gas works in several villages. 'Suction-gas', a water-gas generated with mechanical assistance from the gas engine which it powered, competed with conventional mains supplies of 'town gas' as gas-engine fuel in the 1890s.

D. Chandler, Outline History of Lighting by Gas (1936) p. 58;
Views of Earl Lauderdale Hansard 1816 Vol. 34 ref. 1280.
T.S. Peckston, Theory and Practice of Gas Lighting (1819) p. 400
The Times 30/7/1817; J. Cleland Statistics of Glasgow (1828, Glasgow) Appendix lx p. 186
Quarterly Journal of Science, Literature and the Arts (1819) Vol. VII pp. 312-8
Evidence of Capt. Cochrane on naval training BPP 1830 (9) VIII p. 19 (423)
British Association Handbook 1867 Part II p. 148
P. Mathias The First Industrial Nation (1969) op. cit., p. 265.
Extracts from the Records of the Burgh of Glasgow 1781-95 Vol. VIII 16/5/1786.

i Animal Oil Gas

Investment in the Taylor and Martineau oil gas process[1] revealed the extent to which speculators were willing to trust professional chemists without adequate cost-benefit analysis. Publicists of popular science in journals and newspapers,[2] mobilized by Richard Phillips[3] the editor of the Philosophical Magazine, also encouraged the speculators while castigating coal-gas technology. W.T. Brande[4]

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1. Dr W. Henry (Manchester) in 1805 published early experimental results on wax and oil distillation. A commercial apparatus was patented in 1815 by John Taylor (Pat. 3929), who sold the design in 1819 to Messrs. Philip Taylor and John Martineau jnr. In 1816 it superseded a private coal gasworks at the Apothecaries Hall, London, and proved the most successful oil-gas plant throughout the 1820s. The design achieved publicity at several London establishments like Whitbread Brewery (£1,022 in 1820), Covent Garden Theatre (1821), J. and P. Taylor's factory (using cod oil), Hawe's Soap Works, and Lombard St. Post Office (1823).
   In 1824 John Martineau also manufactured steam engines and other machinery, but his main export business was in oil-gas apparatus sent to Paris. W. Henry's work is described elsewhere, vide infra p.26
   Evidence of J. Martineau B.P.P. 1824 V 1 Select Committee on Exportation of Tools and Machinery p. 8. Evidence of J. Taylor, Glasgow Chronicle 7/10/1819 p. 4.
   R.D. Thomson, Records of General Science (1836) Vol. IV, p. 395; W. Mathews, Historical Sketch (1832) op. cit., pp. 95-106, 193, 185; Abridgements of Patents op. cit., p. 15; Gas and Water 1886 p. 297; W.T. Brande, A Manual of Chemistry (1819) p. 156; W. Mathews, Compendium (1832) op. cit., pp. 37-41; Journal of Science and the Arts 1819 Vol. VI pp. 108-11; F. Accum, Gasworks in London (1820) op. cit., p. 289; G. Maltasa, Coal Tars (1920) op. cit., pp. 155-9; Quarterly Journal of Science, Arts and Literature 1819 Vol. VII, pp. 312-8; Annals of Philosophy 1821 Vol. II p. 175; 1823 Vol. VI p. 404; E.C. Stewart, Town Gas (1958) op. cit., p. 11; The Analectic Magazine 1819 Vol. XIII p. 170.

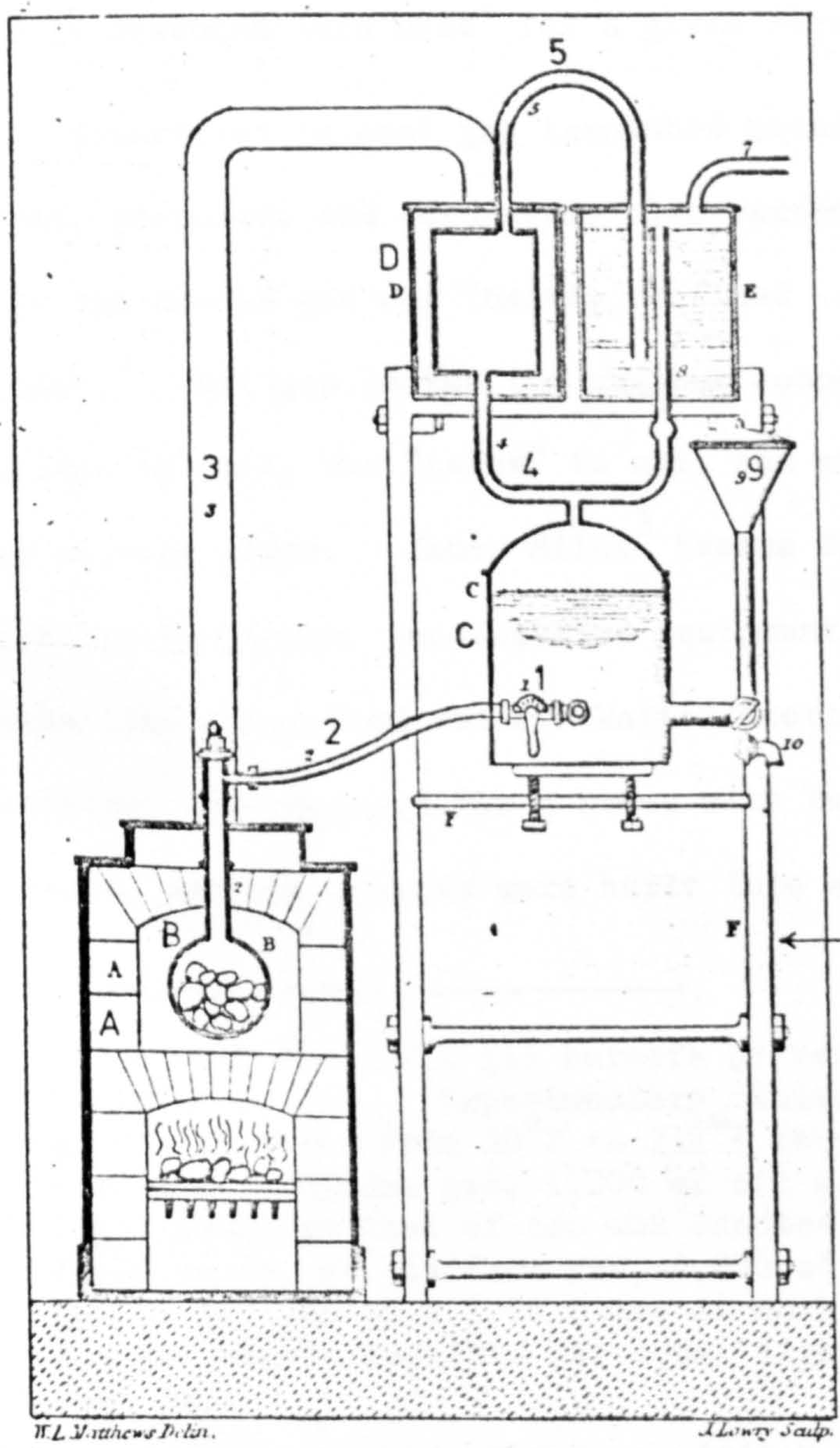
2. E.g. Inverness Courier 17/6/1824 p. 4

3. R. Phillips (1778-1851) - 1817 Chemistry Lecturer at London Hospital; 1822 F.R.S.; 1849-50 President of Chemical Society. W. Richards, Practical Treatise (1877) op. cit., p. 28; Dictionary of National Biography 1909 XV p. 1097

4. Brande's opinion carried considerable weight, as he had built the original coal gasworks at the Apothecaries Hall, London.
   Analectic Magazine 1816 Vol. VIII p. 347; Edinburgh Review 1820 Vol. 34, pp. 431-8; vide infra p.418

Fig. 3.77 OIL GAS APPARATUS

Taylor and Martineau System



Patent Apparatus for making Oil Gas.

A - section of oven

B - cylindrical iron retort filled with coke and broken bricks.

C - copper oil-reservoir with control cock (1) and pipe (2) to retorts.

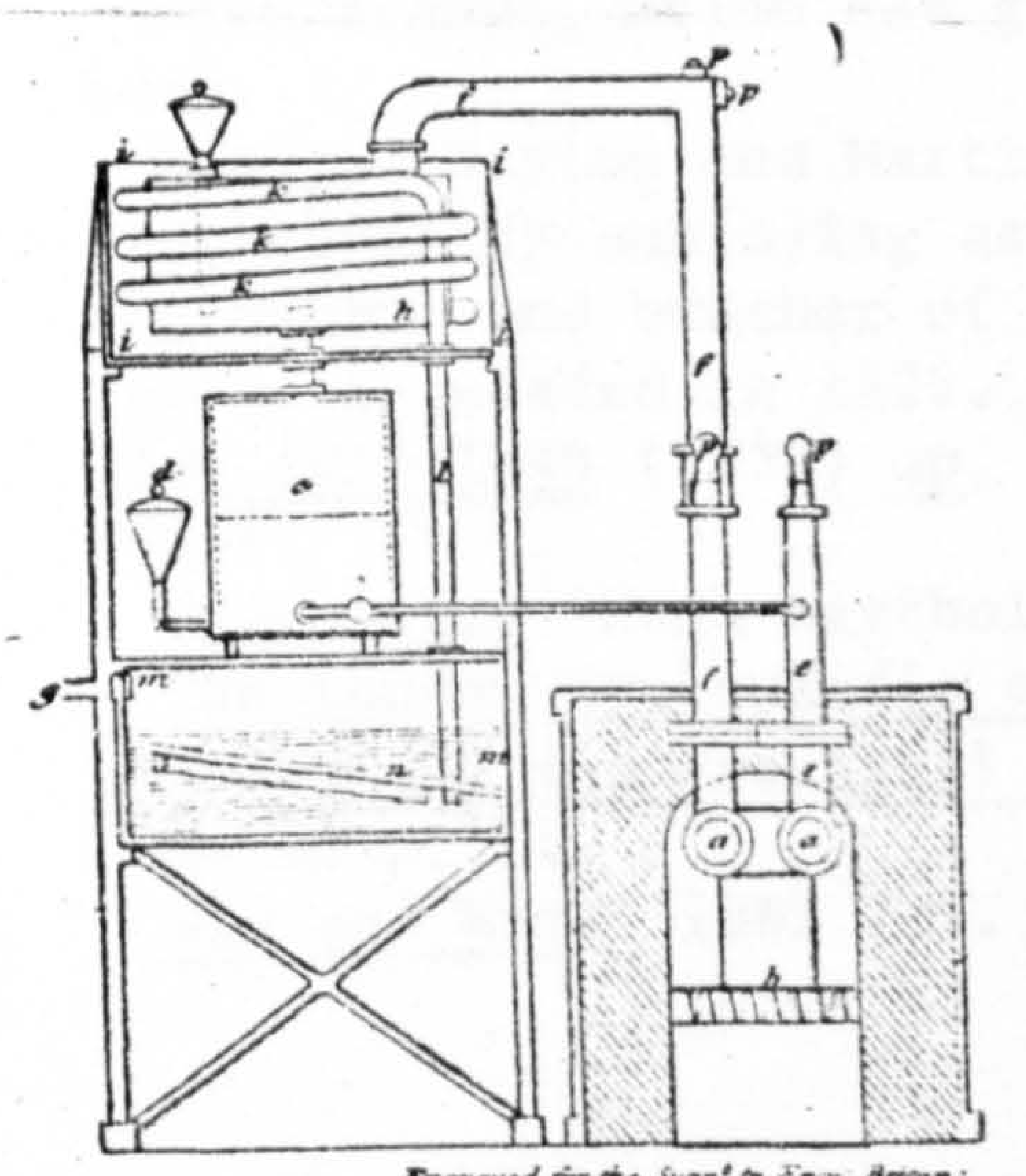
Gas and volatile products ascended pipe (3) to condenser (D) comprizing two iron vessels, one within the other.

Condensed oil returned (4) to reservoir; permanent gas passed to purifier (E) or "washer" full of oil, and then to gasholder.

9-oil supply to reservoir

cast iron stand

Source - W. Matthews A Compendium of Gas Lighting 1832



Modified apparatus described by H. Creighton

Encyclopaedia Britannica Supplement 1824 op cit in the Edinburgh Review of 1820 spoke warmly in favour of oil gas, which gave three times as much light as an equal quantity of coal gas, because of a higher proportion of 'olefiant gas', or ethylene; and it produced less heat[1] for a given degree of illumination.

Impurities in coal gas tarnished metals and injured furniture, books, pictures, and supposedly also personal health, so that in 1819 the use of gas was "nearly confined ... to open shops and street lamps".[2] Oil gas lacked the sulphur compounds derived from iron pyrites in coal, was "safer" to use, and even failed to corrode copper service pipes. James Milne[3] became Taylor and Martineau's agent in Edinburgh, and supplied equipment for several private gasworks like Abbotsford for Sir Walter Scott. A one-hundred cu ft gasholder was adequate for a house with twelve to twenty Argand burners, and the retorts were built into a domestic fireplace at low

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1. The heat from coal gas burners prevented gas being used in some domestic houses. Experimenters claimed that heating a fixed amount of water from 50°F to 212°F required 870 cubic inches of 'olefiant' ethylene gas, 1,300 of oil gas, or 2,190 of coal gas. Light equal to that of ten wax candles per hour was given by 2,600 cu in. of olefiant gas, 4,875 of oil gas, or 13,120 of coal gas. Oil gas gave 1.68 times as much heat from a given volume, but the amount required for equal light was 2.69 times less than coal gas.

2. Quarterly Journal of Science 1819 Vol. VII Art. XII.
   Vide infra 'Markets' p.1218

3. Like Brande, Milne had great prestige in gas technology in Scotland.
   Messrs. Taylor and Martineau also made a considerable impact in Lancashire by employing as their agent Alfred King, formerly an Accountant and brother of the Liverpool gasworks manager, to which job he succeeded in 1826. S.A. Harris, Gas Supply of North Merseyside 1815-1949 (1956) op. cit., p. 40; Liverpool oil gas co. pp. 29-39
   Vide infra Hugh Bartholomew p.633
   The London Cyclopaedia or Universal Dictionary of Science, Art, Literature, and Practical Mechanics (1829, London, Pub. T. Tegg) Vol. 10 p. 11.
   Gas and Water 1885 Vol. II p. 11.

cost, thereby obviating reliance upon "monopolistic" coal gas companies.[1] One gallon of whale oil supplied an Argand burner with 1 cu. ft. gas per hour for ninety hours.

Table. 3.78 Private Lighting Expenditure[2] (1819)

Equal Illumination from -		Cost per Hour
One oil-gas Argand	¾d.	(including manufacture and oil)
Two Oil Argand Lamps	1½d	
Ten Mould Candles	3½d	

SOURCE: Quarterly Journal of Science 1819 Vol. VII

Leith gas company in 1821 was among the first to produce oil gas on a large scale,[3] but changed to coal[4] gas in 1825. Old Ford oil gasworks in London, however, became the publicity centre for the pro-

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1. Charles Macintosh had oil-gas apparatus at his country house, and in 1825 used it for making steel. G. Macintosh, Biographical Memoir of Charles Macintosh, F.R.S. (1848, Glasgow). 1825 Pat. 5173.

2. Quarterly Journal of Science 1819 op. cit.
 2½ lbs mould candles costing 2s 11d lasted ten hours.

3. This was a result of objections made in Leith against the quality and noxious manufacturing process of coal-gas in Edinburgh. Vide infra 'Chartered Companies' p. 999; also p. 244
J. Colston, The Town and Port of Leith (1892, Edinburgh) p. 85.
 Other companies in 1821 included the Old Ford Co. at Whitechapel, London (using cocoanut oil), and the Norwich and Hull companies, followed in 1822 by Dublin, Plymouth and Taunton; in 1823 Liverpool; and later Cambridge, Colchester, Whitby and Leeds. Bristol and Norwich subsequently tried Edward Luscombe's process of 1826.
 W. Mathews, Historical Sketch (1832) op. cit. pp. 231, 37-41, 208; S. Everard, Gas, Light & Coke Co (1949) op. cit., p. 156; G.E. Davis, "The Distillation of Coal", Journal of the Society of Chemical Industry Vol. II p. 518; Annals of Philosophy Vol. V, p. 414; S. Hughes, A Treatise on Gasworks (1853) op. cit., p. 17; Centenary of the British Gas Light Company (1924) pp. 7, 13.

4. In 1825-6 the British Gaslight Co. held some shares in the Leith gas company, possibly with the hope of purchasing the works and converting to coal gas, as they did at Hull and Norwich.
 Centenary of the British Gas Light Company (1924) p. 7.

cess,[1] where Moses Ricardo,[2] claimed that twenty cu ft oil gas gave as much illumination as seventy cu ft coal gas. Ten gallons of oil, and one bushel of coal as fuel, were required to produce 1,000 cu ft gas.

Table 3.79 Size of Oil and Coal Gasworks for producing Equal Light

Oil Gas	-	2 million cu ft gas from 20,000 gallons oil (79 tons)
		74 tons fuel coal
		8 to 10 retorts
		12,000 cu ft gasometer
Coal Gas	-	7 million cu ft gas from 700 chaldrons coal
		174 chaldrons furnace coal
		50 tons lime for purifiers (and cost of disposal after use)
		40 retorts
		40,000 cu ft gasometer.

SOURCE: Annals of Philosophy 1821 Vol. I pp. 209-15

Table 3.80 Working Costs for 1,000 cu ft Oil Gas (1821)

10 gallons oil (£20 per ton) at 2s per gallon	£1	0	0
1 bushel coals	0	1	6
Labour, wear & tear, contingencies	0	5	6
	£ 1	7	0

SOURCE: Annals of Philosophy 1821 op. cit.

On Ricardo's estimate, coal gas had to be cheaper than 7.7s per 1,000 cu ft to compete with oil gas.[3] The fixed capital equipment

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1. Dr. J. Bostock was employed by Taylor and Martineau to give well-publicised demonstrations of oil gas to eminent chemists, Faraday, Children, Aitken and Phillips. Annals of Philosophy 1821 Vol. I pp. 46-50

2. M. Ricardo held £500 stock in the Old Ford company, and was a director.W.Mathews, Historical Sketch (1832) pp. 129,161; Annals of Philosophy Vol. I 1821, pp. 209-15.

3. Despite contrary evidence of coal gas sold at 12s in Sheffield and 7s 6d in Derby, Ricardo broadcast that the minimum long-term manufacturing cost of 1,000 cu ft coal gas was 10s, and the sale

was also far less than for coal gas, and the system was most appealing to Scottish seaboard towns like Perth and Dundee.

Adam Anderson's laboratory[1] in Perth in 1822 produced the first quantitative evidence against oil gas technology. For a given volume, the light produced by oil gas and coal gas was in the ratio 70 : 65, and the heat emitted 100 : 80.5. In a thousand experiments, ten gallons of Scottish whale oil[2] gave only 700 cu ft gas at a cost over ten times as great as an equal quantity of coal gas. Photometry showed that light from oil gas was twenty-three per cent less than that from burning an equal quantity of liquid oil. The loss rose to forty-two per cent when manufacturing costs were also considered. Reasonable manufacturing costs and dividends involved an overhead of 8s to 10s per 1,000 cu ft oil gas, producing a much higher price for gas than Taylor and Martineau claimed.

Table 3. 81 Oil Gas Costs estimated by A. Anderson (allowing 10s 2d overheads)

Price per Ton Oil	Gas Price per 1,000 cu ft.
£30	33s 11d
£40	41s 10d
£50	49s 9d

SOURCE: W. Mathews, Historical Sketch (1832) op. cit.

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price 15s. Old Ford Works (Whitechapel) used a £5,000 Taylor and Martineau plant, but labour and other costs reached 50s instead of 5s 6d per 1,000 cu ft., and ultimately the venture collapsed. Annals of Philosophy 1821 Vol. I pp. 300, 383, 431; 1821 Vol.II p. 47; 1823 Vol. V p. 218; W. Congreve, "Observations on Gas Light Establishments" Annals of Philosophy 1823 Vol. V p. 424.

1. Anderson's results were used in 1825 to oppose the London and Westminster Oil Gas Bill. W. Mathews, Historical Sketch (1832) pp. 427-31, 223-4; King's Treatise (1878) Vol. I op. cit., p. 45.

2. One gallon, specific gravity 0.925 and weight 7lbs 11½oz, gave light equivalent to 700 Kensington candles per hour (six candles in 1 lb.). No standard photometry scale was available.

This information was not supplied to Dundee, where a new gas company in 1823 was encouraged by the press[1] to try oil-gas. J.B. Neilson of Glasgow quoted experiments from Bristol[2] to warn them that oil gas gave only about twice as much light as coal gas, and could not compete in price near the Scottish coalfields. The Dundee directors were extremely cautious, and after prolonged dalliance with the oil process,[3] chose coal-gas.

James Milne surveyed Dundee, and stated that gas would be required by 321 public lamps, using 2,514,000 cu ft if lit sunset to sunrise, and by about 700 shops, dwelling houses and inns, each using about 3,100 cu ft per year. Allowing ten per cent leakage, Milne estimated an annual demand for 3,318,480 cu ft gas, provided one-fifth of all the factories purchased gas. This could be sold at 50s per 1,000 cu ft if oil cost £30 per ton, or 40s if oil was £18.

The great wastage of capital upon animal-oil gas was caused not by idle speculation but by the failure of pure science[4] to make

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1. Dundee Advertizer 20/11/1823

2. Neilson quoted work by Herepath and Rootsey in Bristol which showed oil gas to give 28 per cent less light than liquid oil. J. Neilson "On the Manufacture of Gas obtained from Pit Coal, and its relative value to Oil Gas" Glasgow Mechanics Magazine 1825 Vol. III.

3. They obtained the most extensive data on animal-oil gas extant in Scotland. The Appendix to the Report of the Committee of Subscribers to the Dundee Gas Light Company (Dundee Ref. Lib.) contains verbatim letters on oil-gas from J.B. Neilson of Dundee, James Milne of Edinburgh, Mr Tait of London, Taylor and Martineau of London, a director of Edinburgh coal-gas company, a partner in Hull oil gas company, a partner in Liverpool gas company, and from James Russel of London. Neilson is incorrectly termed 'John' but is stated to be the Superintendent of Glasgow coal gas company. Vide supra 'Technology' p.262

4. Some observers, unable to comprehend the problem, falsely blamed the scientists for "wilful misrepresentation" vide The Penny Magazine of the Society for the Diffusion of Useful Knowledge (1834) pp. 492-3.

Table 3.82 Milne's Estimate for Dundee Oil Gas Works[1]

Two benches, each of 6 retorts	£ 1,200	0	0
"Set of large condensing pipes and troughs"	83	0	0
Two gasometers (30 ft dia., 12 ft high) with cast iron tanks	1,158	0	0
Stone buildings to contain apparatus and gas-holders	1,967	0	0
Water-traps, pressure-proving machines &c.	380	0	0
8036 yards mains pipes (5 to 1" dia.)) 4084 yards service pipe (¾" dia.))	2,104	1	4
	6,892	1	4
10% "contingent expenses"	689	2	0
Purchase of land, foreman's house, engineer's fees	2,000		
	9,581	3	4
Large gas-meter	75		

SOURCE: Dundee Ref. Lib., *op. cit.*

Annual Revenue				Annual Expenditure			
Gas (2,672,553 cu ft at 5/-)	£6681	7	7	Oil (131 tons 72 gallons @ £30)	3938	11	0
Public Lamps (321 at 26/8d)	428	0	0	2 Gas Managers (25/- per week & free house)	130	0	0
	7109	7	7	4 Labourers (15/- a week)	156	0	0
				Fuel (£3 per week)	156	0	0
Profit £2351 16s 7d				Wear and Tear (2/6d per 100 cu ft)	377	0	0
					4757	11	0

If consumers' meters were used, capital expenditure was increased:-

600 small meters (73/6d each)	£2205	
100 large meters for factories (84/6d each)	£ 422	10/-
	2627	10/-

Meter rent, at 8s for small and 10s for large meters, would however increase annual revenue by £290 per year.

SOURCE: Dundee Ref. Lib., *op. cit.*

1. *Ibid.* (Dundee Ref. Lib.) Note use of depreciation "wear and tear" fund.

accurate measurements of light intensity, and the effect of different burners upon the amount of combustion achieved. Without rigorous experimental procedures some gas escaped unburnt and unnoticed.[1] Thus the 1824 Westminster Oil Gas Bill[2] was supported by Sir Humphrey Davy, (1778-1829) Michael Faraday (1791-1867), W.T. Brande, and Sir William Congreve, but opposed by Mr Herenpath of Bristol, J. Dalton (1766-1844), J.T. Cooper, George Lowe of the Chartered Company, and a bevy of Scottish academics, Professor Leslie, Dr. A. Fyfe and A. Anderson of Perth.

Andrew Fyfe (1792-1861)[3] operated a miniature oil gasworks[4] at the Edinburgh School of Arts in 1824, and made a detailed study of the Leith gasworks.[5] There, retort temperature had to be closely controlled.[6] Low red heat gave volatile oil vapour but little gas,

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1. This was one of the most striking cases in which gas technology by rule-of-thumb methods was in advance of pure science in defining the commodity being sold. Accurate definition was vital for both investors and consumers, and was first achieved in Scotland. vide infra p.1256

2. W. Richards, Practical Treatise (1877) op. cit., p. 28

3. A. Fyfe graduated M.D. at the University of Edinburgh (1814); Fellow of the College of Surgeons, Edinburgh (1818) and President 1842-3; Professor of Chemistry at the University of Aberdeen 1844-61; Published Elements of Chemistry (1827, 1833); took considerable interest in all aspects of the Scottish gas industry. One of the Scottish 'medicos' who played a leading role in early nineteenth century chemistry. F. Boase, Modern English Biography 1965 Vol. I p. 1114; S.G. Checkland, The Rise of Industrial Society in England 1815-1885 (1969) p. 75.
Vide infra p. 27, 460, 1275

4. Glasgow Mechanics Magazine 1824 Vol. I op. cit., p. 93

5. T. Dewy of New York inspected the Leith works in 1822, but no description has been located. New York used animal-oil gas from 1824-8; Annals of Philosophy 1823 Vol. VI p. 404; S.G.E. Lythe, Scottish Journal of Political Economy 1964 op. cit.

6. Dr Fyfe "On the Nature of the Gaseous Fluid Emitted by the decomposition of Oil and Coal" Edinburgh Philosophical Journal 1824 Vol. 11 pp. 173-86.

while intense heat decomposed the oil into lamp black. Nevertheless ten gallons whale oil could produce 980 to 1,080 cu ft gas, or ten gallons of palm oil could make 970 to 1,140 cu ft gas. Six retorts, working ten hours a day, produced on average 8,000 cu ft from eighty gallons of oil costing 1s 6d a gallon.

Table 3.83 Leith Oil Gasworks - 1824
(Capital stock £15,000)

Daily Operating Costs with Oil at 1s 9d per gallon
(average price)

Animal Oil	£7	0	0	
Fuel Coal and Coke	0	8	0	
Manager's Wages[1]	0	6	0	
Men's Wages	0	8	0	
Wear and Tear (£100 per year)	0	6	0	
	8	8	0	for 8,000 cu ft
Leakage (1/6 total output)	1	8	0	
	8	8	0	for 6,600 cu ft

SOURCE: Edinburgh Philosophical Journal (1824) op. cit.

The gas could have been sold at 25s 6d per 1,000 cu ft, but a charge of 40s was made[2] in 1824 because, like other new gas companies, the demand was insufficient to make optimal use of the equipment, thereby raising overheads. Whereas a coal-gas company could reduce the price to stimulate demand for gas and thereby obtain a greater return on capital equipment, this was less effective in an oil-gas company because the increased cost of oil and labour offset the gain

1. Gas Manager undertook all duties of engineer, book-keeper and secretary to the company.

2. Leith company charged 8s a year rent on gas meters hired out, and told consumers to use jet or thistle burners with 2-inch flames, or Argand lamps, for the best lighting results.

to a far greater extent than did extra coal expenditure.

Table 3. 84 Leith Oil Gasworks

Estimated Expenditure and Revenue for Doubling Annual Output (1824)

6 new retorts and equipment	£51,000
Revenue at 36s per 1,000 cu ft (4 million cu ft year; maximum winter output 16,000 cu ft per day)	£7,200
Annual Profit	£2,100

SOURCE: Edinburgh Philosophical Journal (1824) op. cit.

Meanwhile, in the autumn of 1823 a clique of Edinburgh Whigs led by Sir Walter Scott[1] (1771-1832) prepared to commence the Edinburgh Oil Gas Company.[2] In January 1824, Edinburgh City Council[3]

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1. A.S. Cowper, The Other Sir Walter Scott - The Eighteen Twenties in Edinburgh (Law : Banking : Business : Insurance) (1971, Edinburgh College of Commerce). No pagination. In February 1824, Scott's private Abbotsford gasworks supposedly gave 1,000 cu ft gas from 10 gallons of "the basest train [sic] oil" costing 35s. c.f. Post offices in London and Dublin strongly favoured oil gas for better working conditions without noxious combustion products BPP 1824 (289) XVIII 183

2. The blame for promoting oil gas later fell upon W.T. Brande, but comments made in 1823 by Sir William Congreve, advocating government support for oil gas to give employment in the fisheries cannot have escaped notice.
   Sir William Congreve (1772-1828) Comptroller of Royal Laboratory, Woolwich 1814-28; developed military rocket for Napoleonic Wars; 1813 became first Factory Inspector under Home Department; checked gasworks after St. Peter Street explosion in London 1822.
   W.T. Brande (1788-1866) Doctor and Chemist; 1812 Professor of Chemistry at Apothecaries Company; 1816-26 Secretary to the Royal Society; 1816-19 published several papers on coal gas.
   Dictionary of National Biography (1908) Vol. II p. 1124; D.A. Chatterton, "State Control of Public Utilities" Business History 1971 Vol. XIII op. cit.

3. A round table discussion between directors of the Edinburgh coal gas, Edinburgh gas, and Leith oil gas companies and Council representatives approved the measure only on the understanding that oil gas mains pipes could never carry coal gas, and the new company would never manufacture coal gas. Edinburgh City Archives Edinburgh Council Record 1823-4 Vol. 188 28/1/1824, 6/1/1824; vide infra 'Chartered Companies' pp. 988, 973, 1118

decided to allow both the Leith and the Edinburgh oil gas companies to supply the city. These were soon competing furiously, and opening trenches "in different parts of the town unconnected with their main pipes" to block the rival's advance.[1] Scott's company[2] ignored the scientific controversy over oil gas, and built a pretentious gasworks on Tanfield estate[3], adjoining high-value residential property. With a private Act of Parliament the company[4] had a capital stock of £80,000 which was rapidly expended. By December 1826, £61,193 had been used on capital equipment.[5]

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1. E.g. on North Bridge in September 1824. Edinburgh Council Record 1823-4 Vol. 188 1/8/1824 p.163

2. W.Scott was not a leading member of the Edinburgh coal gas company, as some authors have claimed e.g. W.H. Marwick "Municipal Politics in Victorian Edinburgh " Book of the Old Edinburgh Club (1969-72) Vol. XXXIII p.36

3. A 5 acre site, west of Canonmills Bridge. "Moorish-fortress style" works by James Jardine C.E., and W. Burn architect. Jardine was a prominent engineer in the city, who was employed by the Water Company in 1817 to improve supplies. A.Cowper claims, without supporting evidence, that the Company did not employ Taylor and Matineau equipment.
   Scots Magazine 1824 Vol. XIV p.246
   Edinburgh Magazine 1824 Vol XIV p. 761
   Edinburgh Evening News 1/2/1936
   Architectural Review 1945 Vol. 97 pp.131-4, quoting Aus Schinkel's Nachlass (1863, Berlin)

   W.H.Marwick Book of the Old Edinburgh Club (1969-72) Vol. XXXIII op cit
   A.S.Cowper The Other Sir Walter Scott (1971) op cit.

4. The undertaking was very popular, and more than the entire stock was subscribed within a few days of the first public meeting, before an Act was applied for.
   Edinburgh Council Record 1823-4 Vol.188 7/1/1824 p.313

5. J.Ker Nuisance in Coal Gas Works (1828) op cit p.47
   i.e. £20,627 mains pipes; £15,357 service pipes, meters etc. Two gasometer houses were built in Lower Brandon Street.
   Gas World 10/10/1885
   F.H.Groome Ordnance Gazetteer of Scotland (1882, Edinburgh) Vol. I p.526

Doubts soon assailed the sponsors. In October 1824, a month before the public supply began, Scott had an experimental apparatus built at the works in great secrecy.[1] The gas was sold at forty shillings per 1000 cu.ft., plus a meter rent of eight shillings a year, and the Company concentrated upon cultivating the upper class market in lighting the offices of "Bankers, Merchants, and Men of Business".[2]

Table 3.85 Lighting Expenditure Comparison in Edinburgh(1824)

(300 days per year, on average 4 hours per day to 9 p.m.)

	£	s	d
One Argand Oil Gas Burner	3	12	0
Tallow Candles (9d per lb.)	10	2	6
Wax Candles (3s 6d per lb.)	52	10	0

SOURCE : J.G.L. 25/8/1874

In July 1824 the Edinburgh coal gas company published a detailed technical attack upon the claims made for oil-gas[3]. They

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1. A.S. Cowper The Other Sir Walter Scott (1971) op cit

2. Reprint of 1824 advertisements by Leith and Edinburgh oil-gas companies Vide J.G.L. 25/8/1874
   T.Newbigging Ed. King's Treatise (1878) Vol.I op cit p.38
   Vide infra p. 1773

3. Philip Taylor who was trying to improve the process in England, introduced vertical oil-gas retorts and a hot 'filter' of inert stone and oxides in 1824 (Pat. 4975). This increased the gas output.

employed Professor Leslie[1] who analysed oil gas made at James Milne's factory, and concluded[2] that 1000 cu. ft. oil gas costing forty shillings produced only as much light as 1500 cu. ft. coal gas costing eighteen shillings. Scottish cannel coal produced a gas of far greater 'candlepower' than the Newcastle coals used in London, thus dumbfounding the earlier claims made for oil gas.

Table 3. 86 Analysis of Coal and Oil Gases by Professor Leslie (1824)

	Coal Gas	Oil Gas
Specific Gravity	0.6 - 0.7	0.8
Density	0.6	0.9
Ratio of Combustion Speed in Same Burner	5	4
Ratio of Illumination	5	6

SOURCE : Comparative Price of Gas (1824) op cit

The oil-gas company replied with the evidence of eminent scientists who had supported the Westminster Company's Bill and publicised the attack made by W. Ritchie[3] against Leslie's

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1. Sir John Leslie (1766-1832). Divinity student at St. Andrews (1779-83) and Edinburgh (1784-7) universities. Self taught in natural sciences. 1790 science author to Monthly Review. Tutor to Wedgwood family at Etruria, Staffordshire (1790-2) Pub. Experimental Inquiry into Heat (1804). 1805 succeeded his friend L. Playfair as Prof. Mathematics at Edinburgh. 1810 experiments on refridgeration. 1819 Prof. Natural Philosophy at Edinburgh. Pub. Elements of Natural Philosophy (1823)
   Dictionary of National Biography (1909) Vol. XI p. 984
2. Leslie used a No.1 Argand with 10 holes of 1/40th inch diameter, supplied with gas at 1/2 inch water-pressure; 2 3/8 cu.ft. coal gas burned in the same time as 1 8/18 cu.ft. He failed to recognize that different burners were required for optimum combustion of the different qualities of gas.
   Vide infra p. 1631
   Edinburgh Ref. Lib.- Edinburgh Gas Light Company Illuminating Powers and Comparative Prices of Gas From Coal and Oil. (26/7/1824, Edinburgh)
   Leslie's scientific work vide :
   Notes and Records of the Royal Society (1971) Vol.27 pp.53-6
   A.Clow "Scotland's Contribution to Industrial Development" (1944) op cit p.44
   W.Mathews Historical Sketch (1832) op cit pp. 220, 416-9
3. Technical comments by W.Ritchie of Tain Academy were not published until 1825 vide Edinburgh Journal of Science 1825

photometer. A pamphlet[1] war developed, describing the success of Dublin oil gas company, Dr Fyfe's shadow-photometry tests which vindicated Leslie, and condemning the majority of armchair scientists who made no practical experiments. Dr Brewster[2] unsuccessfully challenged Leslie to demonstrate his photometer to a "jury of scientific men in Edinburgh", and the oil gas company employed Sir Robert Christison[3] and Dr E. Turner,[4] opponents of Leslie's photometer, to

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Vol. II pp. 321, 339-41. Photometry vide infra p.1630 et seq.
William Ritchie (1790-1837) educated as a priest; became rector at Tain Academy Ross-shire; pupil of Gay-Lussac and Biot in Paris; friend of J. Herschel; 1829 Professor of Natural Philosophy at Royal Institution; 1832 Professor of Natural Philosophy at University of London. Research work on electricity. Dictionary of National Biography 1909 XVI p. 1212.

1. Many were reprinted for the benefit of posterity. Vide "Documents in the Coal and Oil Gas Controversy" Edinburgh Magazine 1824 Vol. 15 pp. 736-44; 1825 Vol. 16 pp. 481-8.

2. Brewster stated that since Leslie held 32 shares in the coal gas company, his results varied accordingly; that company employed Mr Buchanan to examine Leslie's apparatus, and verify its accuracy (15/11/1824).
Sir David Brewster (1781-1868) educated for priesthood at Edinburgh University where attended lectures by L. Playfair; 1800 honorary M.A., Edinburgh; 1802 Editor of Edinburgh Magazine (renamed Edinburgh Philosophical Journal in 1817); 1805 unsuccessful rival of J. Leslie for Chair of Mathematics, Edinburgh; 1807 L.L.D. St Andrews; M.A. Cambridge; Editor of Edinburgh Encyclopaedia; 1813 paper on "Properties of Light" to Royal Society London; 1814 studied in Paris under Biot and Berthollet; 1815 F.R.S.; 1820 Member Inst. Civil Eng.; 1819-29 publications on defraction and optics; founding member of Scottish Soc. Arts (1821); British Association (1831). Dictionary of National Biography 1908 Vol. II.

3. Sir Robert Christison (1797-1882) M.D. Edinburgh (1819); 1820-21 studied analytical chemistry in Paris under Robinquet; 1822 Prof. Medical Jurisprudence, Edinburgh; 1832-77 Prof. Materia Medica and Therapeutics; 1855 Prof. Clinical Medicine; 1868-73 President Royal Soc. Edinburgh. Dictionary of National Biography 1908 IV p.290.

4. Edward Turner (1798-1837) M.D. Edinburgh (1819); 1820-22 studied chemistry and mineralogy at Gottingen under Stomeyer; 1824 Chemistry lecturer, Edinburgh; 1828 Prof. Chemistry, University College, London; 1831 F.R.S; great interest in atomic weights, and the ideas of T. Thomson (1773-1852). Pub. Laws of Chemical Combination and Atomic Theory (1825), Elements of Chemistry (1827). Dictionary of National Biography 1909 Vol. XIX, p. 1262.

make a detailed analysis of oil and coal gases.[1] Meanwhile, H. Creighton,[2] a coal gas engineer in Glasgow, published in the Encyclopaedia Britannica a detailed comparison of the two systems (Table 3.87)

Creighton showed the prime cost of coal gas as 8s 10d per 1,000 cu ft, and the sale price 11s 2d after allowing interest on capital. The prime cost of oil gas was 20s 7d. Oil gas plant to provide equal light was £6,100 less expensive to build than coal gas equipment, but annual running costs were almost twice as much, even assuming that the illuminating ratio of coal to oil gas was as low as 1 to 2. Although oil gas gave high quality coke and other by-products, compared to coal gas, this only partially offset the vastly greater working costs.

Public confidence in oil gas was weakened by an explosion[3] in March 1825, which killed an Edinburgh servant,[4] and finally dissipated when Christison and Turner[5] reported that Leslie had been largely

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1. King's Treatise (1882) Vol. III op. cit., pp. 85, 87.

2. H. Creighton of Glasgow gasworks.
W. Henry, Elements of Experimental Chemistry (1823) Vol. I. 9th Edn. p420
H. Creighton, "Gas Lights" Encyclopaedia Britannica - Supplement to the 4th, 5th and 6th Editions (1824, Edinburgh) Vol. 4, pp. 448-462.

3. c.f. From 1817-23 coal gas produced only one, very minor explosion in Edinburgh. BPP 1823 (193) V. p. 88 (302) evidence of J. Watson.

4. The "footboy" in 1825 had removed an oil-gas burner, installed by Messrs Milne, to burn gas directly from the service pipe, and to play with paper bags full of gas. Gas accumulated in an outhouse, and produced an explosion heard over much of the city.
"Account of the Explosion of Oil Gas ... with Observations on the Safety of Gas" Edinburgh Journal of Science 1825 Vol. III pp. 83-93.
Edinburgh Advertizer 25/3/1825.

5. Dr Christison "On the Comparative Advantages of Oil and Coal Gas" Annals of Philosophy 1825 Vol. X pp. 190-3.
"A Chapter in the Early History of Oil Gas" J.G.L. 1885 p. 1149.

Table 3. 87

(1824) Comparison of Coal and Oil Gas Supplies to a Medium Sized Town

by H. Creighton

COAL GAS -

Fixed Capital

	£
21 retorts, accessories, tar vaults, condensers, purifiers, buildings	5,500
2 gasholders, tanks, fittings, buildings	5,200
Mains pipes, valves, water traps, distribution equipment	10,300
	21,000

Output

Winter maximum 50,000 cu ft. per day from 17 retorts, 3 in reserve. Average daily output 25,000 cu. ft.

Working Costs

	Per Year (£)
48 cwt. cannel per day at 20/- per ton	880
Lime and water for purifiers	270
Management, wages and salaries	1,090
Annual renewal of 16 or 17 retorts	230
2½% depreciation on mains, &c.	260
10% depreciation/repairs on other equipment	1,070
Total	4,020

OIL GAS

Fixed Capital

	£
Retorts, apparatus, condensers, purifiers, buildings	3,700
Gasholders (half the capacity required for coal gas)	3,500
Mains pipes (same length as for coal-gas, bur half the capacity)	7,700
	14,900

Output

Average daily output 12,500 cu ft.

Working Costs

	Per Year (£)
125 gallons per day at £32 per ton	5,780
Common coal fuel, and water	220
Management, wages and sundries	820
Annual renewal of retorts	100
2½% depreciation on mains	190
10% depreciation on apparatus	720
Total	7,830

SOURCE: Encyclopaedia Britannica Supplement (1824) op. cit.

correct. Oil gas, of specific gravity 0.92, had previously been compared to London gas at 0.41, whereas Edinburgh cannel gas was 0.62. By November[1] 1825 the market value of Edinburgh oil gas shares had fallen from £5 to £1 15s. The company, however, blamed its failure on a new factor, condensation in the main pipes which reduced every 1,000 cu ft produced to 750 cu ft. before sales.

A further year was spent on experiments. Daniel's patent process[2] of mixing the oil residuum with rosin to make gas was tried, together with cheap "brown oil" at £18 per gallon.[3] In November 1826 the company unsuccessfully petitioned Edinburgh Council[4] to manufacture coal gas, and in July 1827 made[5] a fourth ten per cent call upon shares to finance a Bill for coal gas which proposed[6] to increase

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1. A.S. Cowper, The Other Sir Walter Scott, op. cit.

2. Martineau manufactured Daniel's first apparatus. Mechanics Magazine 1829 Vol. XI p. 127.
   One Glasgow ironmonger H. Field and Sons, in the 1850s sold private gasworks which made "rosin gas" of similar type.
   The Practical Mechanic and Engineer's Magazine 2nd Series, 1852-3 (Glasgow) p. 9.
   W. Mathews, Historical Sketch (1832) op. cit., p. 232.
   E.A. Parnell, Applied Chemistry (1844) Vol. I, op. cit., p. 102.

3. Thomas Dick, the gas manager, was in charge of the experiments. 329 gallons of high quality oil gave 28,623 cu ft., whereas 'Brown oil' of the same value gave 38,440 cu ft., but of lower quality.
   S.R.O. Letter from T. Dick to William Mackenzie, W.S., the company's agent. (GD 271/6 ref. 'North West Securities').

4. Edinburgh City Archives - Edinburgh Council Record Vol. 198 22/11/1826 p. 412

5. S.R.O., Circular to W. Mackenzie 27/7/1827 (GD 271/14.)

6. Many shareholders, led by Neill, objected to the Bill and the call on shares. It represented a further £250 to W. Mackenzie on one hundred shares, and in December Sir Walter Scott was summoned for £140 arrears.
   Vide S.R.O.(GD 2771/14.)

the Capital stock to £130,000. Strident objections by the residents[1] and nearby Royal Botanic Gardens led a Commons Committee[2] to reject the Bill, and Tanfield gasworks were purchased by the Edinburgh coal-gas company[3] for £25,000 in their own paid-up stock. Thereafter they were used only for "district gasholders" to equalize pressure in that area.

Elsewhere, an abortive attempt was made in March 1825 to float an oil gas company in Glasgow,[4] but Aberdeen was more unfortunate and opened an oil gasworks in 1824 which charged 40s per 1,000 cu ft. That rose to 50s, and fell to 45s before finally a conversion[5] was

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1. A radical pressure group of environmentalists, the "Committee of Proprietors of Tanfield" in 1828 published Considerations Relative to the Nuisance of Coal Gas Works, with Remarks on the Principles of Monopoly and Competition (Edinburgh Pub. Lib.). They commissioned a report by Andrew Fyfe on smoke pollution, and gathered evidence on the migration of wealthy residents from the New Street coal gasworks in Edinburgh; headaches and bleachfield damage around Perth gasworks; pollution damage to the Apothecaries Garden, Chelsea, and Liverpool Botanic Garden; and vegetation damage by sulphuric acid, hydrogen sulphide, ammonia, carbonic oxide etc.

2. The Oil-Gas company used all the 'influence' it could, and spent £2,000 on lobbying: vide S.R.O., Hugh Bruce letter MSS. 3/4/1827 (GD271/7); J.W. Mackinnon 2/6/1827 (GD271/11), J. Loch 4/6/1827 (GD271/11); J. Inch 24/2/1827 (GD271/4); Sir H. Innes 28/3/1827, 4/4/1827 (GD271/4, GD271/7); Sir J. Mackenzie 12/4/1827 (GD 271/7), H. Bruce 3/4/1827 (GD271/7) etc. Meetings of the Company considered promoting Strutt of Derby's views on gas cooking vide Edinburgh Advertizer 22/6/1827 p. 398, 25/1/1828 p. 62, 15/6/1827 p. 382.

3. New Statistical Account Vol. I p. 758; Edinburgh Evening Courant 26/4/1828; Report of the Edinburgh Gas-Light Company (1828) Edinburgh Pub. Lib. Subsequently a radical splinter group from the oil gas company tried to open a new coal gasworks. Vide infra 'Consumer Relations' p.1118

4. Extracts from the Records of the Burgh of Glasgow Vol. XI 24/1/1825 p. 145 (Glasgow City Archives). Vide infra pp. 1118, 1513 Oil gas was claimed to be suitable for domestic use, and for jewellers, silk merchants and so on, who could not use coal gas. Mr Dowdie, MP., member of the Edinburgh Oil Gas Co. claimed the Glasgow oil venture was "frozen out" by the coal-gas company there. Edinburgh Advertizer 22/6/1827 p. 398.

5. New Statistical Account - Aberdeenshire Vol. XII p. 78.

made to coal gas in 1828. Despite the wastage of capital on new apparatus and larger mains pipes, coal gas was sold at 15s and was a far greater success.

Private oil-gasworks[1] remained popular, however, being cheaper, requiring less labour, and giving less waste-material than their coal-gas rivals. Creighton in 1824 estimated that oil gas costing 4½d from such equipment gave light equal to 1lb of tallow candles or 10.6d oil in an Argand oil-lamp.

1. In 1824 a private oil gasworks cost £50, excluding the gasometer. Glasgow Mechanics Magazine 1824 Vol. I pp. 147-8. Cheaper designs soon followed, by S. Teulon, Benevole, and the "Domestic Oil Gas Apparatus" for construction by amateurs. Mechanics Magazine ; 1830 Vol. 13 p. 41; 1833-4 p. 257
1824 Vol. 2 p. 177.

ii Portable Gas

Portable gas in animal bladders or waxed textile bags was a 'toy' for many researchers[1] from 1733. In 1819 Mr Mair[2] of Kelso used wax-cloth bags filled with coal gas from his apparatus, like candles, and _Blackwood's Magazine_ suggested using pit gases the same way. Paterson,[3] a road surveyor at Montrose, built his own gasworks and proposed providing miniature gasometers for each of the public lamps, and for private families. By filling them daily under pressure from bellows, he hoped to eliminate the high cost and smell of mains pipes used for distribution.

With low pressure gas, those ideas were impractical, but in 1819 David Gordon[4] (1774-1829) of Edinburgh demonstrated high-pressure

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1. _Vide infra_ Chapter I
   In 1733 a bladder of coal gas from Whitehaven pits was sent to the Royal Society in London.
   1739 Dr Clayton filled bladders with coal gas from his retorts.
   1792 Murdoch at Redruth had bags of leather and varnished silk, and tinned iron, to use gas as a hand lantern and on his steam engine.
   1806 S. Clegg placed coal gas under pressure in copper balls at Deans Gate, Manchester.
   1814 coal gas in 'butts' sold in London.
   1820 iron tanks (50 cu ft capacity) on a carriage transported coal gas two miles from Phillip and Lee's factory in Manchester to Lee's dwelling house. W. Mathews, _Historical Sketch_ (1832) T.S.Peckston, _Theory and Practice_ (1819) _op. cit._, p. 95; _Notes and Queries_ 17/3/1923, p. 212; _Annals of Philosophy_ 1820 Vol. XV p. 34; _Mechanics Magazine_ 1834/5 Vol. 22, p. 470.
2. Blackwood's _Edinburgh Magazine_ 1818 Vol. III p. 724
   The Analectic Magazine 1819 Vol. XIII p. 171
3. _Scots Magazine_ 1818 Vol. 82 p. 465
4. Member of Culvennan family. His son Alexander (1802-63) wrote _Elemental Locomotion_ (1832).
   Notes and Queries 31/3/1923 p. 258, quoting J.M. Bulloch _Dumfries Courier_ 25/8/1906 - 6/10/1906

portable gas[1] in that city and in London. Copper spheres or cylinders were filled with animal oil gas[2] from John and Philip Taylor's process, under pressure from Gordon's patent Quick Silver Syphon Pump. A patent valve then controlled the gas outlet to burners and lamps, which themselves had a special design of six radiating grooves to give a broad flame 2½ inches high, resembling a candle.[3] It was warmly reviewed by the Edinburgh scientific press,[4] who saw the potential to light ships, stagecoaches, carriages, and isolated villages or "lonely cottages of the poor" which had no access to coal gas; as well as concealment in gold vessels and statues to light opulent mansions. Scottish financial support, however, was not forthcoming until 1825 which "was the period of the most violent Joint Stock mania".[5]

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1. The experiments and patent were in collaboration with Edward Heard, a former assistant of F.A. Winsor at the Chartered Gas Co., London. 1819 Patent no. 4381; improved in 1824 Pat. 4940. W.Richards, Practical Treatise (1877) op. cit., p. 25; Abridgements of Patents op. cit., p. 30; Mechanics Magazine 1831-2 Vol. 16, p. 195 (diag. of pressure pump used); details of the pressure cylinders vide W. Mathews Compendium (1832) op. cit. pp. 41-4.

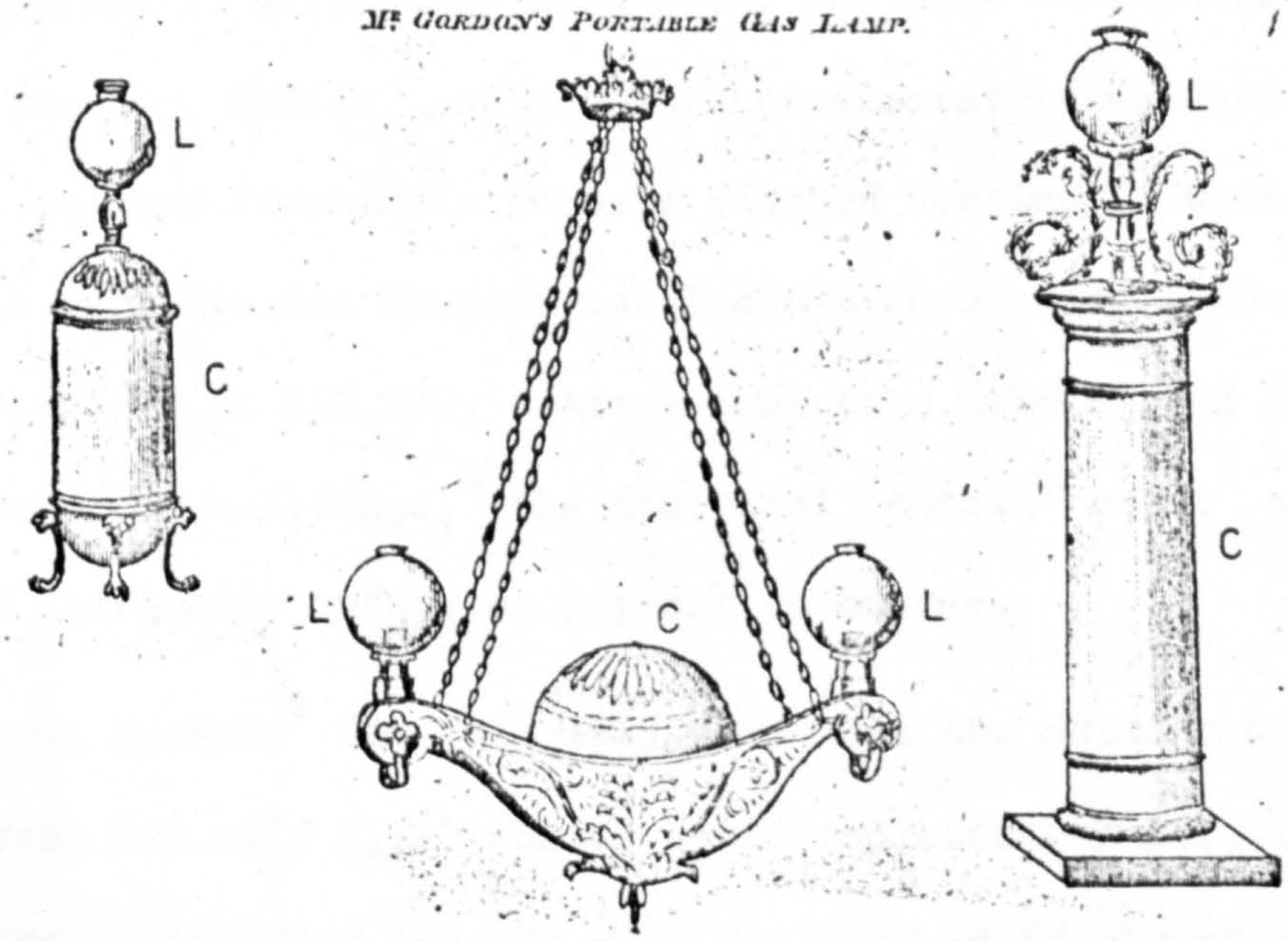
2. In the residue of this compressed oil gas, M. Faraday discovered Benzol for the first time in 1820. Condensation caused a loss of one gallon of liquid per 1,000 cu ft gas, in the preliminary high-pressure gasholder before gas was transferred to portable vessels.
M. Faraday, Experimental Researches in Chemistry and Physics (1859) pp. 154-74; Philosophical Transactions 1825 p. 440; W. Richards Practical Treatise (1877) op. cit., p. 25; E.A. Parnell Applied Chemistry (1844) Vol. I op. cit., p. 100.

3. R. Christison and E. Turner, "On the Construction of Oil and Coal Gas Burners" Edinburgh Philosophical Journal 1826 Vol. 13 pp. 1-39. A safety ratchet prevented excessive pressure being turned on accidentally. Vide Edinburgh Philosophical Journal 1819 Vol. II pp. 373-6.

4. People accustomed to carrying candles were reluctant to adopt fixed gas-burners, and approved the portable lamps. Blackwood's Edinburgh Magazine 1819 Vol. V p. 614; 1820 Vol. VIII pp.445-6; Edinburgh Philosophical Journal 1819 Vol. II p. 373; Scots Magazine 1819 Vol. 84, pp. 361-2.

5. H.A. Cockburn, Ed. Memorials of His Time by Henry Cockburn (1909, Edinburgh) p. 403; W.H. Marwick Economic Developments in Victorian Scotland (1936) p. 52.
This was the only Scottish gas company which resulted from the "mania".

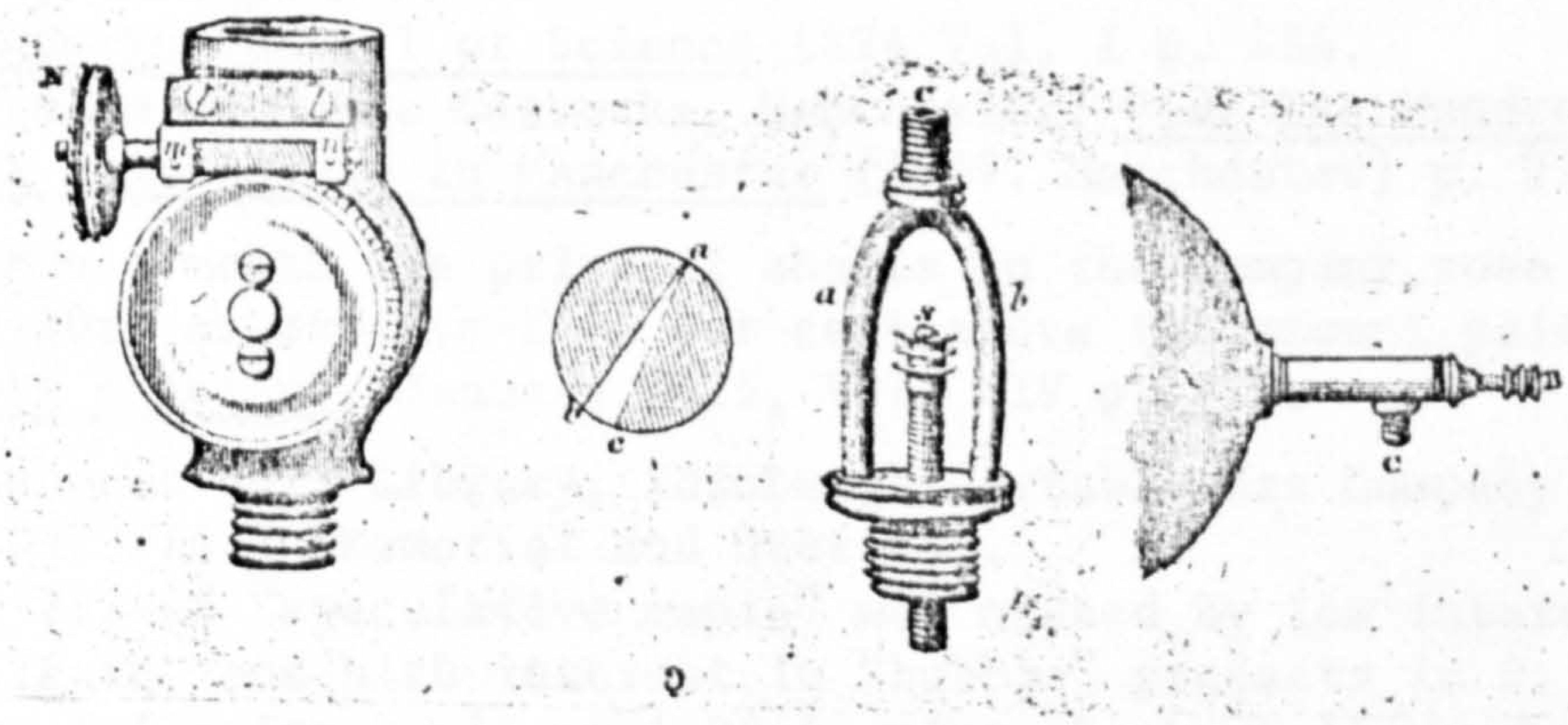
Fig. 3.88 Portable Gas Lamp by David Gordon 1819



Ornamental Gas Lamps (L)

with concealed gas cylinders (C)

Details of fail-safe control valve



Source - Edinburgh Philosophical Journal 1819 Vol. II

The London Provincial Portable Gas Company[1] had the use of Gordon's patents at preferential rates, and promoted a series of provincial companies in which they held fifty per cent of the stock.[2] By 1824 Manchester, Dublin, and several continental towns used Gordon's portable gas and favourable reports reached Scotland,[3] where the Edinburgh Portable Gas Company was founded in January 1825 with a nominal capital of £50,000. After contracts were signed for machinery, ground and buildings,[4] the financial 'bubble' burst[5] and the company had difficulty enforcing payment on shares.

Extant records[6] for July 1829 show that the Edinburgh Portable Gas Company had sold 2,225 shares of £5 representing £11,125. The 124 investors included 106 who were resident in Edinburgh and who contributed £9,325 stock. Investors included J. Cadell (20 shares) and John Jardine (10) advocates, Dr Fyfe[7] surgeon (20), Sir J. Counel (20),

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1. London company 1819-39 Vide:
E.G. Stewart, Town Gas (1959) op. cit p. 11; King's Treatise (1878) Vol. I op. cit., p. 34.

2. Perthshire Courier 29/4/1825

3. Paris, Rouen, Amsterdam, Bordeaux, Lyons and Nantes all had portable gas companies.
Edinburgh Journal of Science 1824 Vol. I p. 384.
Gaythorn Portable Gasworks, Manchester, vide One Hundred Years of Gas Manufacture in Manchester (1949, Manchester) p. 22.

4. Within a month the price of shares in the company rose from par to £7 10s, or seventy-five per cent above the amount paid-up.
Scots Magazine, January 1825, Vol. XIV p. 120.

5. Edinburgh Ref. Library, Edinburgh Portable Gas Company - Minute Book 31/3/1828 "Memorial and Queries".
The 1824-5 "speculative mania" was caused by low interest rates in Britain, and high interest in "bubble" projects in S. America; in the following panic of 1825-6, sixty banks collapsed.
P. Mathias, The First Industrial Nation (1969) op. cit., pp. 322, 354.

6. Edinburgh Ref. Library - Edinburgh Portable Gas Company Minute Book.

7. Possibly Andrew Fyfe, vide infra p.416

the Earl of Moray (20), W.H. Ker (20), F. Cameron of the Water Company (20), John Patterson[1] ironfounder of Leith Walk (20), Stirling and Kenny publishers (10), H.J. Cadell[2] of Cockenzie (20), Robert Dundas advocate of Arniston (10), David Gordon[3] of London (10), G. Pent Sheriff Substitute of Dunse (20) and Mark Sprot[4] advocate of Garnkirk (10). Both within and outside Edinburgh the company was almost entirely financed by the professional classes and gentry.

Table 3.89
Investment in Edinburgh Portable Gas Company (1829)

I. Residents of Edinburgh			II. Outside Investors		
Occupation	No. of Persons	£ stock	No. of Persons	£ stock	(£) % Total
Advocate	16	1,275	2	150	64.3
Writer	34	2,900	2	400	
Banker	2	200	0	0	
Surgeon	8	550	2	300	
Other Professions	9	1,075	3	300	
Gentry	16	1,425	8	550	17.8
Women	5	225	1	100	2.9
Corporate Body	1	50	0	0	0.4
Manufacturers	2	200	0	0	1.8
Merchants	4	750	0	0	6.7
Retail Shops	8	575	0	0	0.5
Artizans	1	100	0	0	0.8
					95.2

SOURCE: Edinburgh Portable Gas Company Share List 9/7/1829

In April 1825, before the financial climate changed, the London Portable company promoted an offshoot at Dundee, and claimed one

1. J. Patterson supplied ironware to Edinburgh coal-gas company.
2. *Vide supra* Chapter I p.88
3. The inventor of the portable-gas process.
4. Mark Sprot (1802-1843) was Chairman of the Garnkirk-Glasgow Railway.
   Butt and Ward "Caledonian Railway" *Transport History* 1970 Vol. 3, *op. cit.*, p. 239.

already in existence in Glasgow.[1] The Dundee works were expected also to supply neighbouring towns like Perth, "within the circle of from 20 to 30 miles around Dundee", where depots of refilled lamps would be maintained. Subscriptions were therefore sought in the outlying towns. Half of the £16,000 stock was to be financed from London, and the works would have produced 12,000 cu ft per day, but were opposed by the Provost and Council of Dundee.[2]

Most of the Edinburgh equipment was purchased in London,[3] including £2,000 to Taylor and Martineau, from whom "two sets of three throw pumps" with mercury, a steam engine and exhauster, cost £1,200. Each set condensed only 500 cu ft per hour. In total, the company invested £5,340 in lands and buildings at Tanfield, £4,400 in machinery and pumps, and £3,400 in lamps and fittings.[4] Martineau appointed a foreman, J. Dunn, to supervise the installation, but the con-

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1. "Proposals for Establishing a Portable Oil-Gas Company in Dundee" <u>Perthshire Courier</u> 29/4/1825.
   The Glasgow venture was short-lived, and no further details have been found.

2. <u>Gas and Water</u> 4/7/1885 Vol. III, p. 10

3. Edinburgh Ref. Library, Edinburgh Portable Gas Co. Minute Book 27/10/1827, 4/1/1828, 3/10/1827, 12/11/1827.
   The order was placed on 23/5/1825. Equipment by Gordon and Gordon, Bramah and Son, and the portable lamps from Richard Routh of the London Portable company, were all imported from London. Only masonry, and the tank and low pressure gasholder at £217 from Shotts Iron Co., were purchased locally.

4. <u>Ibid</u>. 27/2/1828. : Full inventory 15/12/1828, 19/12/1828.
   The company may have purchased gas from the adjoining Edinburgh Oil Gas Company. In the period 27/1/1825 to 15/12/1827 £11,476 of Edinburgh capital was subscribed, and £10,795 expended; the London parent company contributed a minimal amount. Richard Routh, chairman of the latter, controlled the cash transactions between the companies; e.g. in January 1828 £450 of the Edinburgh reserve funds were held by him, in the Bank of England, and £301 in the Royal Bank of Scotland.
   <u>Vide</u> <u>ibid</u>. 15/1/1828, 4/1/1828.

densing pumps were never completed successfully and the Edinburgh company refused to pay a balance of £1,113 on them. Compression cost 3s 6d per 1,000 cu ft, but transport for delivery[1] of the gas cost 10s per 1,000 cu ft., and the Edinburgh company was liquidated[2] in 1828.

Railway expansion a decade later stimulated renewed interest in portable gas[3] but oil-lamps remained almost universal until the 1880s when the Pintsch system was imported from Germany. Clyde Lighthouse Trustees were among the first British consumers of Pintsch mineral-oil gas, with a gas-lit buoy at Roseneath Point[4] in May 1880 supplied

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1. C. Denroche (original essay no longer extant) Minutes of the Proceedings of the Institute of Civil Engineers Vol. I 1837 p. 173; Vol. II 1842 pp. 137-8.

2. £500 was paid to Taylor and Martineau, but the pumps were returned to them. £500 lamps were sold to Nicoll of Liverpool.
Edinburgh Portable Gas Co. Minute Book op. cit., 15/1/1828, 4/1/1828, 19/10/1827.

3. 1845 J. Blofield proposed a 'National Railway Gas Company' with railway tankers to supply cities from gasworks on the coalfields.
1849 Higginbotham's Portable Gasworks, built on a railway waggon.
1856 coal gas "bags" on Galena and Chicago railway carriage roofs. 1857 copied by J.T. Thompson in England.
1866 Newall's rubber gasholders on Metropolitan Railway, London.
1879 F.W. Clark's system, with coal gas and petroleum vapour, at 10 atmospheres pressure, tried by Chartered Company at Kings Cross, London. Used on the Aberdeen service.
1879 Pintsch's mineral oil gas at Dirschau, Germany, superseded rape-seed oil lamps.
The Practical Mechanics Journal 1849-50 p. 172; Mechanics Magazine 1845 Vol. 42 pp. 99, 123.
British Association (1859, Aberdeen) p. 235.
J. Kitson, "Lighting Railway Carriages" Proceedings of the Institute of Mechanical Engineers (1857) p. 242.
"Gas Lights in Railway Trains" The English Mechanic 1866 Vol. III p. 251.
J.G.L. 9/12/1879; 1879 p. 283
See also - "British Portable Gas Co" using A. Longbottom's process for resin oil J.G.L. 2/9/1856 p. 497; Mechanics Magazine 1838-9 Vol. 30 p. 57.

4. J.G.L. 25/5/1880

by tanks from Pintsch gasworks in London.[1] In 1882 a Pintsch gasworks was built at Port Glasgow, and the gas became used very extensively along the Clyde channel.

Two D-shaped cast-iron retorts,[2] set one above the other, were heated to cherry-red by a coal or coke fired furnace. Mineral oil fed by gravity, produced brown vapour in the upper retort, which was converted to permanent gas in the lower retort, before entering an ascension pipe, hydraulic main, water washer, purifiers with three layers of lime and sawdust, and a low-pressure gasholder. Compressors provided by Pintsch and operated by hand or by steam-engine, then forced the gas into four high-pressure tanks from which an iron main pipe carried it to the quayside, and through a flexible hose to the ship used for transport. Pumps forced it to 12 atmospheres pressure in the transport holders.

Table 3.90

Estimated Pintsch Oil Gas Production Costs (about 1903)

13 gallons oil (5d per gallon)	5s	5d
1½ cwt coke (20s per ton)	1	6
5 hours wages (6d per hour)	2	6
Sundries	0	7
Cost of 1,000 cu ft oil gas	10	0

SOURCE: Pamphlet at Clyde Lighthouse Trustees offices, Port Glasgow.

1. Trinity House first used the system in 1879-80 at Sheerness, R. Thames. Gas-lit aids to navigation had long been considered possible, and Edmunson's coal-gas system was tried in place of liquid oil at Granton lighthouse, Edinburgh, in 1868, but rejected.
BPP 1868/9 (2410) LV 329 "Gas for Oil Substitution"
T.S. Peckston, Theory and Practice (1819) op. cit., p. 385.

2. Pintsch Co. publicity brochure (c.1903) held by Clyde Lighthouse Trustees; photocopy in Glasgow City Archives.
Pintsch patents 3101 (in 1873), 4514 (1876), 4976 (1883)

One gallon of oil produced seventy to ninety cu ft gas of about sixty candlepower, which was reduced to about forty-five candlepower when compressed to 150 lbs per square inch.

The s.s. Tourch[1] was built to carry gas from Port Glasgow to navigation buoys and lightships, followed by the s.s. Hesperus from a second gasworks at Oban, and s.t. May from a third at Granton. Meanwhile, in 1882 the Pintsch company used Port Glasgow gas supplies in experiments they financed on gas lighting from cylinders under the seats in steam 'cars' run by the Vale of Clyde Tramway Company at Govan.[2] This was followed by an experiment with Pintsch gas in thirteen carriages on the Glasgow to Greenock line of the Glasgow and South Western Railway.[3] By October 1882 all Govan tramcars had been converted, the Glasgow railway used gas lighting down to Carlisle,

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1. c. 1903 Pintsch Brochure ibid.
   1881 gas-lit lightship at Garvel Point, Clyde; later one at Otter Rocks, Islay.
   1891 gas-lit buoy at Sound of Kerrera, Oban; 1893 Ardlamont Point; 1894 Sound of Mull.
   Later buoys held sufficient gas for six months illumination e.g. Strone Point, Clyde; Loch Ryan, Stranraer. Fixed beacons were also converted to gas e.g. 1896 Garvel Beacon, Clyde; Bunessan, Mull; Breasclete, Lewis. By 1903 a whole series of beacons used gas light on the west coast e.g., Cardross, Gareloch, Grayrock, Crowlin.
   1897 Pintsch gas used in a lighthouse, at Cairn Ryan, Stranraer; in 1897 also at Corran, Oronsay and Kyleakin.
   Pintsch gas was used for fog-horn engines, in preference to gasoline engines, and was quicker to use than steam-engines, e.g. 1882 Toward Point, Clyde; Little Cumbrae etc.

   J.G.L. 4/1/1881, 20/6/1882
   Gas World 26/8/1893.

2. J.G.L. 21/3/1882 p. 531.

   Gas of forty to fifty 'candlepower'.

3. Engineering 1882 Vol. XXXIV p. 509.

and the Caledonian Railway had commissioned a Pintsch gasworks[1] in Glasgow to supply 500 carriages. Built at Bridge Street Station, this plant in 1892 produced eighty cu ft gas per gallon of Scottish mineral oil, of fifty-six candlepower, stored at 150 lbs pressure in nearby tanks.[2] The North British Railway[3] built a Pintsch gasworks at Waverley Station, Edinburgh, in 1884 to supply short-distance trains, and later in the 1880s the Caledonian Company built one at Perth[4] with four high-pressure tanks of 10,000 cu ft.

Shipboard gasworks were also developed, such as Muller's equipment[5] installed in 1880 on the Clyde steamer Iona, and the 'Alpha' machine[6] in 1881 which supplied 100 jets on Macbrayne's Staffa steamer at 4s per 1,000 cu ft.

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1. J.G.L., 8/10/1882

2. Gas World 1892 J. Mackay (Peterhead) "Enriching Coal gas by Paraffin Oil" N.B.A.G.M.
The gas-lights inspired W. Foulis, Glasgow gas manager, to devize water boilers heated by the light,which carried hot water beneath carriage seats on the Glasgow and S.W. line. Gas World 21/4/1888.
Pintsch gas was reviewed in:-
E.C. Riley (G.W.R., Swindon) "The Development of Gas Lighting in Railway Carriages" Gas World 16/4/1892.
"Railway Carriage Lighting" Gas World 1/5/1897
W.I. Macadam "Processes for Manufacturing Gas from Oil" Gas World 26/8/1893
B. Redwood, Treatise on Petroleum (1922) pp. 922-3.

3. In 1884 North British trains from Edinburgh to Musselburgh carried a 48-hour supply of gas at 120 p.s.i (pounds per square inch) built beneath the seats. Waverley gasworks was damaged by fire in 1885. J.G.L. 8/7/1884, 1/9/1885.

4. Explosions were a major hazard in the use of high pressure gas. An explosion at Perth gasworks in 1891 caused £2,500 damage. J.G.L. 17/11/1891

5. 'Alpha' Gas Apparatus by H.L. Muller of London. J.G.L. 18/5/1880; Engineering 1877 Vol. XXIII p. 69; B. Redwood and G.T. Holloway, Petroleum (1896) Vol. II p. 692.

6. J.G.L. 12/4/1881.

iii Tar and Mineral Oil Gases

Mineral oil gas in a less specialised form was developed on a far larger scale by the Scottish coal-gas industry, especially during the 1880s and 1890s. The experiments were a progression from earlier attempts to enrich coal gas with tar-gas, produced by special redistillation of coal-tar residuals[1] as J. Grafton[2] tried at Edinburgh in 1818. Archibald Cook[3] of Paisley in 1825 introduced the most popular method, with equipment resembling an oil-gas works. Iron cylinders fixed above the retort bench kept the tar warm, and it was supplied under gravity down a pipe heated by a special coke-fire, and into the retort where permanent gas was produced.

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1. Tar from early gasworks swamped the market for by-products. By 1814 pyroligneous acid works in Scotland were stockpiling tar, and in 1817 John Loudon Mc Adam despaired of making profits at Muirkirk coal-tar works which closed in 1829.
   In 1816 W.T. Brande described the tar-gas experiments at London gasworks, and in 1820 F. Accum devised an improved process.
   R. Devereaux, John Loudon Mc Adam (1936)
   J. Sinclair, Appendix to the General Report of the Agricultural State and Political Circumstances of Scotland (1814, Edinburgh) Appendix 2, Chapter XVI pp. 302-4.
   Quarterly Journal of Science and the Arts 1816 Vol. I, pp. 71-80.
   F. Accum, Manufacturing Coal Gas (1820) op. cit., pp. 282-8
   Annals of Philosophy 1815 Vol. VI pp. 16-19
   Journal of Science and Arts 1816 Vol. II p. 282
   S. Everard, Gas, Light and Coke Company (1949) op. cit., pp. 64, 89
   Quarterly Journal, of Science, Literature and the Arts 1822 Vol. XII p. 227.
   Vide infra 'By-Products' pp. 548, 546

2. Vide infra 'Technology' p. 281
   Patent 4306 (10/12/1818); Gas World 1886 p. 522; 10/7/1886

3. W. Mathews, Compendium (1832) op. cit., pp. 35-7; Mechanics Magazine 1827-8 Vol. VIII pp. 342-3
   In 1894 William Young of Peebles again developed a process for tar-gas production because coal was so expensive. Vide Gas World 4/8/1894 p. 142.

Several Scottish industries[1] produced illuminating gas as a by-product and used it themselves. The first to make public supplies available was the shale-oil industry as it expanded[2] in the 1860s, though two factors handicapped them. Many were in rural locations, and produced a constant output of incondensible gas, whereas demand for gas-light was vastly greater in winter than in summer. Young's Paraffin Light and Mineral Oil Company near Bathgate built a gas-holder[3] for their own use in 1862, and from 1866 to 1880 provided oil gas to the Bathgate gas company[4] which ceased to manufacture coal gas during that period.

James Young's Addiewell oilworks[5] in the 1860s produced 1.25 million cu ft of residual gas each day, and in 1867-9 offers were made to sell it to Edinburgh gas company at 1s 6d per 1,000 cu ft., but this proved impractical. Some of the gas was used from 1872 to light Addiewell village. In 1870 many oilworks still used coal fuel[6] for the retorts, but thereafter regenerative heating with gaseous fuel reduced the wastage of gas.[7] Nevertheless, in 1876 William Young

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1. E.g. in the 1850s Messrs John Poynter, Sons and Macdonald at Greenock, converting bones into glue, manure, etc., produced illuminating gas, as did E.C. Stanford's seaweed distillation in iron retorts for chemicals in 1863 at Whitecrook Chemical Works, Dalmuir. A. McLean, <u>Local Industries of Glasgow and the West of Scotland</u> (1901 British Association) p. 177; E.J. Mills, (Prof. Tech. Chem. Anderson's College) <u>Destructive Distillation</u> (1878, Glasgow) pp. 45-8; <u>Principal Manufactures of the West of Scotland</u> (1876, British Association)

2. In 1866 new shale-oil works at Coatdyke, with 150 retorts, offered unsuccessfully to supply gas to Airdrie and Coatbridge at 2s per 1,000 cu ft. <u>J.G.L.</u> 17/4/1866 p. 261.

3. J. Butt, "James Young" (1963) <u>op</u>. <u>cit</u>., pp. 138,292.

4. Bathgate Gas Co. Minute Book (GB1/8/1) S.R.O. 12/6/1866, 23/6/1874, 7/6/1867, 15/6/1880.

5. J. Butt 'James Young' (1963) <u>op</u>. <u>cit</u>., p. 301.

6. In 1870 D. Cowan suggested regenerative gaseous firing like the Siemens system; D. Cowan "On Mineral Oils" <u>North of England Institute of Mining Engineers</u> 1870 Vol. XX pp. 177-84.

7. Young and Beilby retorts at Linlithgow Oil Co also made coal gas separately for use as fuel. <u>The Scotsman</u> 14/1/1887 p. 5.

urged[1] the development of 20,000 cu ft railway gas tankers to deliver the gas to towns, and in 1887 large oilworks wasted up to 100,000 cu ft per day. Most could not be used for illumination because it was 'scrubbed' while hot, but Beilby and McArthur at Oakbank[2] works in 1887 devized a method of making fifty candlepower oil gas which they hoped to sell to villages and railways. This was not widely adopted, and in 1898 about 1,000 cu ft was wasted for every 2,000 gallons of crude oil produced.[3] Broxburn[4] oil company, which supplied gas to the villages of Broxburn and Uphall until 1928 was one of the few exceptions.

In the gas industry itself, the first important experiments[5] were made in the mid 1860s when cheap paraffin oil became available. George Mackenzie[6] of Glasgow in 1866 experimented at Johnstone gasworks with one ton of ground coal and thirty gallons of shale oil mixed in a grinding mill before distillation. The results were promising and led the Chartered Company in London to finance more research

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1. W. Young "The Utilization of the Gases Resulting from the Destructive Distillation of Shale in the Manufacture of Paraffin" J.G.L. 22/8/1876, 21/9/1880.
   Vide infra 'Labour' p.638

2. G. Beilby and J.B. McArthur, "On Waste Gas from Oil Stills" Journal of the Society of Chemical Industry 1887, Vol. VI, pp. 31-3.

3. Redwood thought it "incredible that arrangements are not more generally made for its collection and use".
   I.I. Redwood, Mineral Oils and their By-Products (1897) pp. 125, 108.

4. Edinburgh Evening Dispatch 8/1/1928

5. In 1854 researchers like T.I. Dimsdale (Pat. 1389) were still confined to mixing animal oil and vegetable resin with the coal.

6. Patent on 15/3/1866 Patent 769 J.G.L. 20/3/1866 p. 165
   "The New Gas Patents", and "Artificial Gas Coal" Engineering and Mechanics Magazine 1866-7 pp. 365-7, 180-1.
   King's Treatise 1882 Vol. III op. cit., p. 358; The Artizan 1/8/1866.

by Mackenzie. In the same year, Walker and Smith[1] at Kilmarnock gasworks used one ton of shale-oil (240 gallons) mixed with two tons of air-dried peat. At white heat it produced 20,000 cu ft gas, with few sulphur impurities. Purification was cheaper and large quantities of by-products were recoverable. John Hamilton,[2] also in 1866 mixed hot "bottoms" of mineral oil residuals over coal 'duff' in a pugmill, and compressed this into bricks for distillation.

By 1868 prominent gas engineers[3] urged the development of shale-oil gas in view of high cannel prices. The Patent Gas Coal Compound Company Limited[4] of Edinburgh attempted to promote Mackenzie's

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1. Patent on 12/7/1866 Patent 1827.

2. Patent on 6/8/1866 Patent 2025 J.G.L. 21/8/1866 p.653

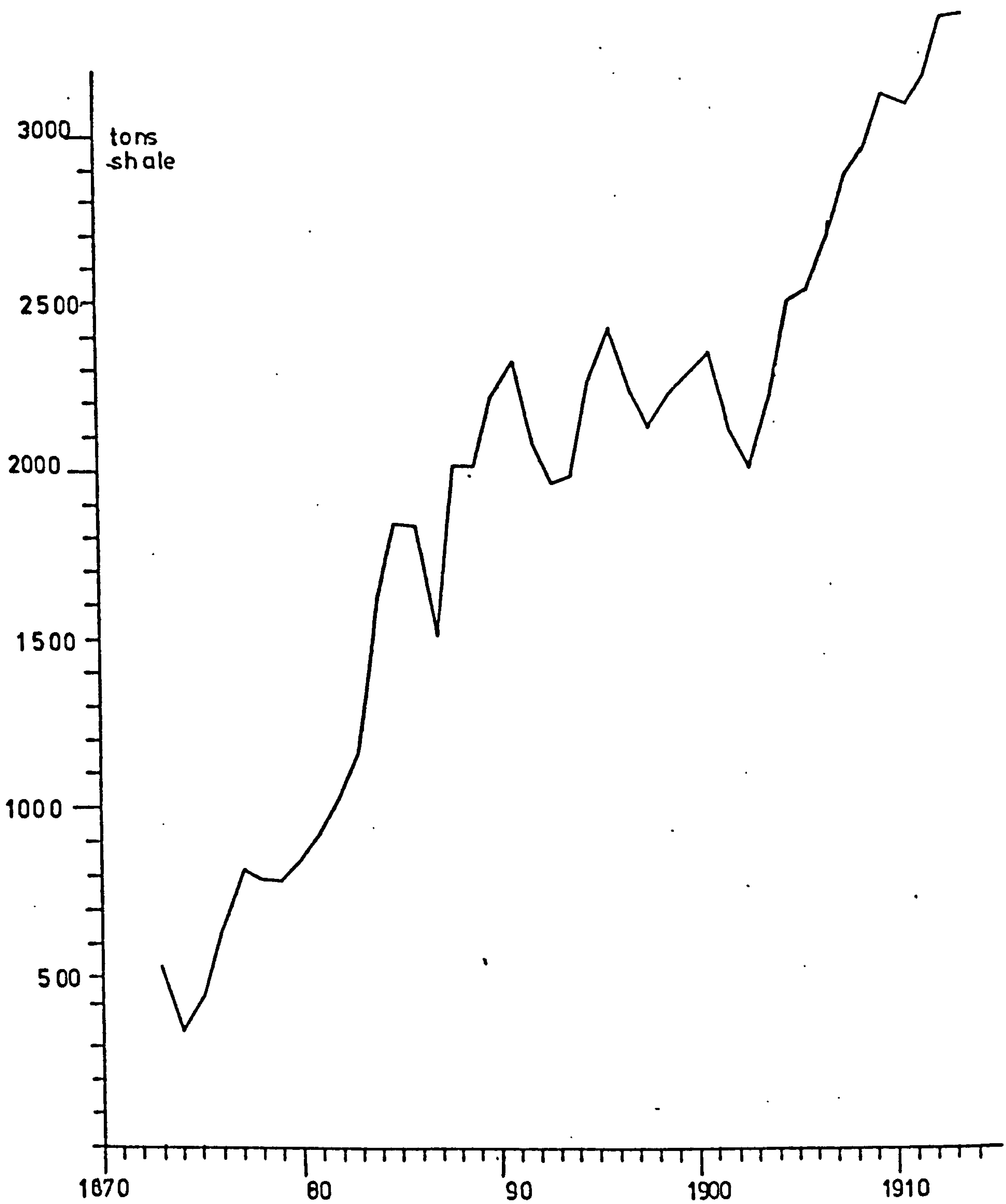
3. E.g. T.J. Barlow to the British Association of Gas Managers in 1868.
W. Foulis examined Mackenzie's process at Dublin gasworks in 1873, but decided it was insufficiently reliable for use at Glasgow gasworks. W. Foulis "Notes on the Use of Oil as a Substitute for Cannel " Gas World 30/5/1891.

4. S.R.O. Registered 14/6/1873 (Board of Trade BT2/500): Nominal £16,000; based at James McKelvie's premises, Edinburgh. Liquidated 13/12/1876.

Shareholders (1873)

	£8 Shares given Gratis for Use of the Patent		New Stock issued for Cash
	Ordinary	15% Pref.	Ordinary Shares
Henry Aitken, Falkirk, coalmaster	100	200	2
James Aitken, Falkirk, coalmaster			1
Wm. Drummond, solicitor, Edinburgh			1
Wm. Reid, W.S., Edinburgh			1
James McKelvie, coal-master, Edinburgh	100	200	2
George Simpson, coal-master, Benhar	100	200	2
Trustees of George Gray, Ventnor, I.o.W.	100	200	2

Fig. 3.91 Scottish Shale Oil Output - A Stimulus to Oil Gas Technology



Source - H.S. Bell <u>Oil Shales and Shale Oils</u> (1948, New York)

<u>Vide infra</u> p. 1687

process in Scotland, but with very little success. Gasworks purchased oil-shale[1] for enrichment, until the 'Koh-i-Noor'[2] private gasworks of the mid 1880s presaged a new interest in oil gas. In 1883 'Koh-i-Noor' gas at Stanley[3] near Perth cost only 1s 9d per 1,000 cu ft.

Scottish equipment manufacturers in the 1870s experimented with mineral oil, but concentrated upon "carburetted air"[4] for private gasworks, supplied mainly by the Glasgow Pneumatic Gas Company[5] In

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1. In 1873 A. Taylor of Edinburgh claimed that shale increased gasworks labour four times, and unsuccessfully urged the development of Dr Eveleigh's oil-gas process. A. Taylor (1873) "On Bitumens, Oil Shales and Oil Coals" Edinburgh Geological Society 1874 Vol. II, pp. 187-8.

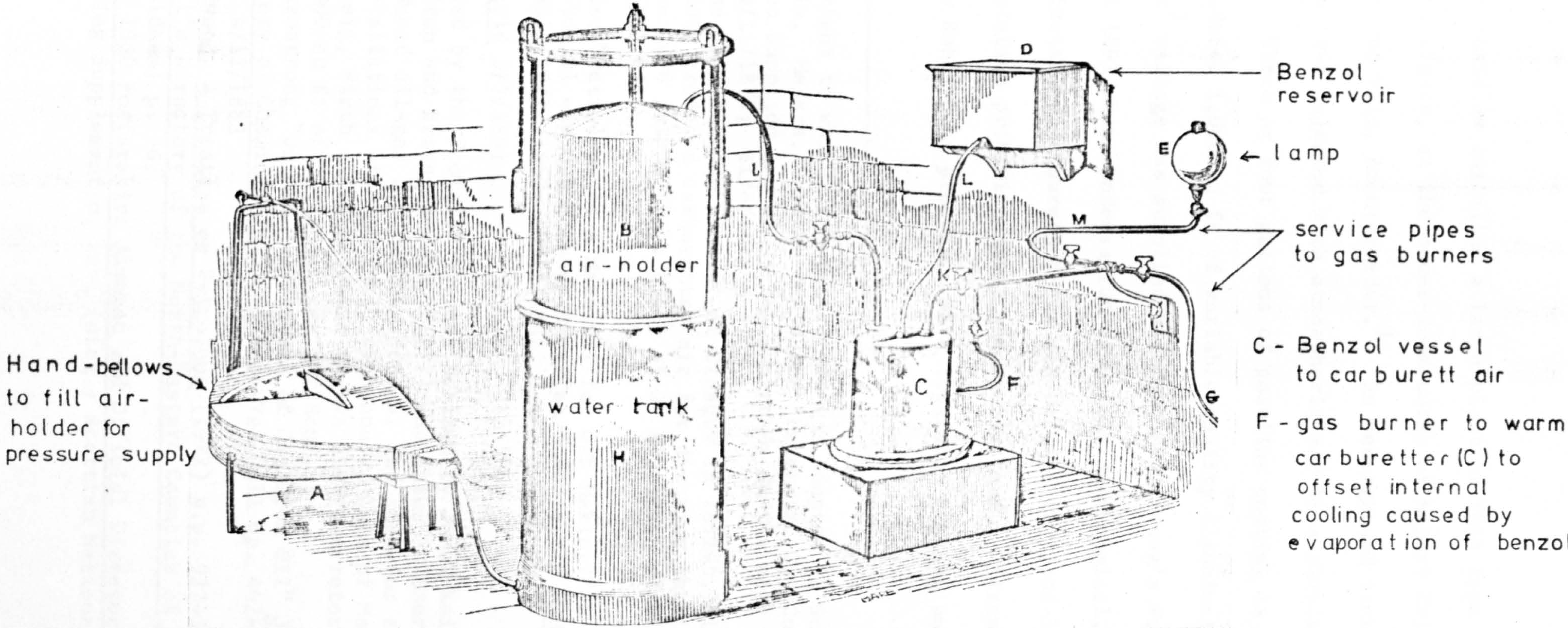
2. Manufactured by Messrs Rogers Brothers, Watford. Double retort generator. One gallon of oil (6d) gave 100 cu ft of sixty candlepower gas. Installed by e.g.
   Major Richardson at Ballathie, Perth, in place of his coal-gas works.
   Sir J. Richardson, Pitfour Castle, Perth (1886)
   E. Miller, Rosie Castle, Perth (1887)
   Vide Institute of Gas Engineers - Miscellaneous Documents Vol. 12 (18) ref. 5302/18 p. 270; Iron - An Illustrated Weekly Journal 1883 Vol. 21 p. 224 (diag. and Quantitative chemical analysis of 'Koh-i-Noor' gas).

3. J.G.L., 14/8/1883

4. Carburetted-air was first proposed by Charles Blanchford Mansfield in 1847 (Pat.11,960), but not widely developed, until 1862 when M. Mongruel and J.F.G. Kromschroder found that cheap mineral oil or petroleum as vapour in atmospheric air could produce a 30-candlepower mixture. This was the technical basis of the Photogenic Gas Company (£40,000) and Air Gas Light Company (£200,000) which both failed.
   C.B. Mansfield "The Application of Certain Liquid Hydrocarbons to Artificial Light" J.G.L. 10/5/1849, p. 62; Engineering and Mechanics Magazine 1/7/1863 p. 88; Minutes Proc. Institute of Civil Engineers 17/4/1849 Vol. VIII; W. Richards Practical Treatise (1877) op. cit., pp. 33, 321 (diag.); Ure's Dictionary of Arts, Manufactures and Mines (1875) 7th Edn. R. Hunt, ed. p.536; B. Redwood and G.T. Holloway, Petroleum (1896) Vol. II "Air Gas" pp. 686-95; King's Treatise (1882) Vol. III op. cit. pp. 351-5; Vol. I p. 55.

5. Their equipment was advertized at the 1875 Highland and Agricultural Show, for country estates. J.G.L. 3/8/1874.

Fig. 3.92 Carburetted - Air Gas Apparatus by C.B. Mansfield 1849



Source - Illustrated London News 1849 Vol.15 p.106

1874 Messrs. Laidlaw installed a large plant of this type costing £260 for 300 lights, at the power-loom works of Messrs Hally and Company at Ruthven Vale, Auchterarder.[1] An underground tank, for oil or gasoline, was injected with atmospheric air by a simple clockwork mechanism. Three or four gallons of gasoline costing 1s to 1s6d a gallon, produced 1,000 cu ft of variable quality illuminating gas. West Calder[2] village was supplied with gas from Young's Paraffin Oil works until 1891 when condensation made this uneconomical. The village then installed carburetted-air gas because the land-lease at the gasholder station prohibited coal gas manufacture. Elsewhere, the inexpensive Koh-i-Noor process,[3] with apparatus costing only £150,

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1. The extent to which carburetted air was adopted in Scotland is uncertain. Messrs. Laidlaw owned the 'Pneumatic Gas Co.', which in 1874 also supplied gas at 4s for Craigends Castle near Glasgow. J.G.L. 3/11/1874; 11/8/1874 p. 203.
   cf. the 'Air Burning Co Ltd' at Glasgow in 1872-5, with a nominal £60,000, produced carburetted air for dressing textile fabrics under the 1870 patent (Pat. 1746) of J. Robertson of Nitshill. S.R.O. (BT2/461).

   See also "Petroleum as a Material for Gas Making?" a provocative editorial exploring cheap American imports, in J.G.L. 21/10/1862, 16/12/1862, 30/12/1862.

2. Gas World 5/7/1891

3. Rivalled by the Scottish process devized by James Keith of Arbroath, Iron and Brass Founder, (1877) and later Edinburgh (1880), who produced oil-gas for private houses, and also for some maritime installations like Langness lighthouse, Isle of Man, and Ailsa Craig, Firth of Forth where twelve six-foot retorts could make 2,000 cu ft of 50-candle gas per hour.
   H.E. Armstrong "On the Manufacture of Gas from Oil" Journal of the Society of Chemical Industry 1884 Vol. III pp. 462-8 (diag.)
   J.G.L. 4/12/1883
   B. Redwood, A Treatise on Petroleum (1922) p.p. 922-3.
   Worrall's Directory of the North-Eastern Counties of Scotland (1877, Oldham) p. 36.
   Hood's 1880 Forfarshire Almanac and Official Directory (1880) advertizing Supplement p. xxvi (diag.) Scottish National Library.

enabled Letham[1] village to organize a gas company for the first time in 1884. Loanhead[2] gasworks also developed a mixture of coal gas and oil gas in 1887.

Alexander and Paterson,[3] gasfitters of Kirkintilloch, in 1887 introduced a new process whereby oil vapourized in a tube held in the centre of the retort, and then changed to permanent gas in the retort as it passed through. Shale oil prices had fallen to about 2½d a gallon, and eleven gallons gave 1,000 cu ft of sixty candlepower gas for only 3s 1d. This system was developed by the Patent Paraffin Gas Lighting Company[4] of Glasgow, and widely adopted by private mansions,[5] factories like J. and W. Dixon's Balbirnie Paper Mills, Mark-

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1. Registered for Limited Liability in October, 1884. Nominal capital £500 in £1 shares. Principal shareholders J.C. Brodie, solicitor in Edinburgh (£200) and J. Young (£50), bank agent in Forfar. 470 shares subscribed. Company liquidated with excessive liabilities in 1895.

Investment in Letham Oil-Gas Company

	Persons	£ Stock		Persons	£ Stock
Professional	2	250	Industry-employees	2	25
Gentry	1	5	Retail shopkeepers	8	140
Women	3	50			

SOURCE: S.R.O. (B.T.2/1389): Occupation groups vide supra p.188

By 1887 Letham had changed from Koh-i-Noor gas to using Keith's Patent Process; Gas World 16/4/1887; J.G.L. 17/2/1885, 4/10/1887.

2. Gas World 16/4/1887

3. Gas World 5/3/1887 p. 309; J.G.L. 23/2/1886 p. 356.

4. Gas World 21/4/1888. J. Talbot, Return of Joint Stock Companies 1888, (H.M.S.O.)
Registered 1888. Nominal capital £2,000 in £10 shares. 23 shareholders. £2 10s called up per share. Mr Patterson as manager vide Gas World 14/4/1888.

5. e.g. Col. C.M. King, Antermony House, Milton of Campsie; Sir Archibald Orr Ewing, Ballikirain Castle; Alex. White, Gartshore, Kirkintilloch; J.T. Hay, Blackhall Castle, Banchory;
Gas World 8/4/1893.

inch, and sanitoria like Woodilee Asylum, Lenzie. Successful trials were made at Dawsholm[1] gasworks, Glasgow, but the process was too expensive for city requirements. The largest installation was at Colinsburgh,[2] Fife, for Wm. Alexander[3] of Cowdenbeath who previously supplied the village from coal-gas apparatus. Instead of 1,200 cu ft per night, only 600 cu ft of oil gas was required. Only eighty cu ft was produced per gallon, but although the West of Scotland Association of Gas Managers[4] criticised the gas as impure and impermanent, a gas company[5] was formed in Cowdenbeath in 1891 and took over those oil-gas works as a successful venture.[6]

A crisis in cannel coal supply afflicted Scotland in 1892, with pithead prices at 35s a ton, and several gas engineers[7] warned that the only alternative to oil enrichment was a reduction in gas quality by about a quarter down to twenty candlepower. Experiments proliferated. J. Mackay of Peterhead,[8] unable to purchase good cannel in

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1. Gas World 14/4/1888. 2. Gas World 16/4/1887 pp. 500,503.

3. Alexander may have been connected with the oil gasworks at Cowdenbeath which in 1888 had two retorts producing 300 cu ft per hour. J.G.L. 23/10/1888

4. J.G.L. 18/8/1891

5. S.R.O. (BT2/2195) Registered August, 1891. Nominal capital £2,000 in £10 shares; 115 shares issued and paid-up. Little change until 1904 when 1800 new shares issued. Investment groups in 1891 - Professionals £60, gentry £20, Industrial employers £200, industrial employees £10, retail shopkeepers £140, merchants £720.

6. Some consumers tried to use oil gas as a basis for new, rival gas companies. In 1888, Mr Kerr of Ardeer Foundry, Stevenson, Ayrshire, tried to form an oil gas company to supply the Railway Station and New Street area in competition with coal gas. J.G.L. 16/10/1888

7. e.g. T.D. Hall (Montrose) 1892 presidential address to West of Scotland Assn. Gas Managers; A. MacPherson address to North British Assn. G.M. Gas World 16/4/1892, 30/7/1892.

8. J. Mackay "Enriching Coal Gas by Paraffin Oil or Liquid Hydrocarbons" N.B.A.G.M. Gas World 23/4/1892 p. 459. The experiments included data on optimal oil-pressure and quantity, naphthalene

December 1891, studied the Pintsch system at Glasgow before developing a high-pressure oil injection system for the lower retorts of a normal coal distillation oven. A charge of low quality coal was distilled for 3½ hours, before opening the retort to rake the coke level, and injecting about three gallons of oil over a fifteen minute interval at up to 250 lbs pressure. The oil nozzle entered through a stop-cock already used on retort doors, and fine oil spray was gasified immediately. John Laing,[1] a mineral oil chemist in 1893 developed a superheater using waste retort-oven heat to increase oil gas output, but the most successful oil gas process was developed in 1892 by William Young,[2] another oil engineer.

His 'Peebles Process' was named after the gasworks where early experiments[3] were made with the help of A. Bell, the manager, and Mr Fyfe managing director of James Young's 'Paraffin Light and Mineral Oil Company.' Iron retorts were necessary, and oil was used for the first time to wash condensable vapours out of the gas, and as a coat-

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condensation and benzol by-product yield. The coal gas duration, by jet photometer rose from 41 to 50 minutes after enrichment. No candlepower measurement.

1. J. Laing (Edinburgh) "Oil Gas and By Products from Mineral Oil" Gas World 25/11/1893, 9/12/1893

2. *Vide infra* pp. 572, 1733

3. Only 17 per cent of the oil made permanent gas during each distillation, but recycling raised this to 75 per cent, leaving 25 per cent as coke. The process was 'continuous', and oil-gas retorts were only opened once every 12 or 24 hours to remove coke.
"The Manufacture of Oil Gas - William Young's Process" Gas World 4/2/1893; 18/4/1896 p. 521: W. Young, "Further Developments of the Peebles Process" N.B.A.G.M. 1894. Patents by Wm. Young and Alex. Bell in 1892 (Pat. 12,421) and 1893 (Pat. 12,355). B. Redwood, *Treatise on Petroleum* (1922) Vol. III p. 930 (diag.)
Greenock Police Board (1894) No. 15, p. 72 (Greenock Ref. Lib.).
The patent also covered tar-gas, and at Peebles, one ton of tar gave 14,500 cu ft of 25-28 candle gas, and 14 cwt coke (worth 16s a ton).

ing of the retort-house pipes to prevent choking by carbon deposits. As at Peterhead, the oil gas was used to enrich gas from cheap splint coal which was distilled separately. One ton of Blue Oil, from which paraffin had been extracted, gave 22,157 cu ft gas and six cwt high quality coke. This raised the candle power of poor gas from sixteen or eighteen to thirty candles. The Scottish oil industry had high hopes of an expanding market which would reduce the depression caused by Russian and American competition.

The Oil Gas Enrichment Company[1] which was formed to promote this process, registered for limited liability in July 1893 with a nominal capital of £30,000 in £1 shares, and purchased the patent rights[2] from W. Young, A. Bell, J. Fyfe and H. Brown. The first directors were William Young (900 shares) and George Thomas Beilby[3] (1,400) consulting chemists, James Milne (500) gas-meter manufacturer of Edinburgh, Hugh Brown (500) of Glasgow, G. Harrison (700) merchant of Edinburgh, and W. Thorburn (400) M.P. of Peeblesshire. Many gas managers invested like A. Bell of Peebles (200), W. Mar of Stonehouse (10), F. Scott of Kelso (100), J. Turnbull of Lauder (10), and the managers of Briton Ferry, Gateshead, Hexham, Buxton and Middlesborough. Investors within the gas industry also included A.F. Craig (700) gas engineer of Paisley, R. and J. Dempster (200) and R.A. Hepworth (50) gas engineers of Manchester, D. Macfie (250) of Milton House gas-meter works in Edinburgh, and Mrs A.B. Glover (100) of St Helens, wife of a gas engineer-

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1. Gas World 26/7/1894
   S.R.O. (BT2/2544) Registered 22/7/1893; Liquidated 15/10/1907
2. 1892 Pat. 12,421; 1893 Pat. 12,355.
3. G.T. Beilby (1850 - 1924) shale-oil engineer.
   The Oil Shales of the Lothians (1927) 3rd Edn. p. 253

ing associate of W. Young. Others with a technical knowledge were J. Hepworth (200) C.E. of Carlisle, W. McCutchon (150) oil-works manager at Addiewell, and A.P. Aitken (150) Professor of Chemistry at Edinburgh. The Misses M. and R.A. Beilby of Edinburgh had 100 each. J. Dennis, contractor of Dalkeith, had the second largest investment (1,350). J. Dennis[1] built the Peebles installation at Galashiels for £834 10s, including £572 ironwork from A.F. Craig and Company of Paisley, despite rival tenders from J. Aimers and Son of Galashiels (£627) and Messrs R. and J. Dempster of Manchester at £640. It is unclear how Dennis exercised his influence. Within a year the Oil Gas Enrichment Company had built[2] plants at Alloa, Alva and St Helens in Lancashire.[3] Dumfries followed in 1894, Broughty Ferry[4] and Falkirk in 1895, and also Stirling where oil-enrichment enabled the price of gas to be reduced from 3s 7d to 3s 4d. Galashiels[5] became the most well-known[6] Out of sixty retorts, twelve were replaced by nine foot iron oil-retorts which reached dull-red temperature simply using waste heat from twelve normal coal retorts on the opposite side of the bench.[7] The oil storage tank was fed by gravity directly from rail-

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1. Galashiels Minute Book <u>op. cit.</u>, 14/2/1893. Galashiels installation preceded the application for Limited Liability by the Oil Gas Enrichment Company.

2. A different and cheaper small scale oil-gas enrichment system designed by McLusky, the Kelso manager, was installed at Kelso and Penicuik in 1894-5. <u>Gas World</u> 20/4/1895 p. 473.

3. S. Glover (St Helens) "Enrichment by Peebles Oil Gas Process" <u>Gas World</u> 2/6/1894. "Regenerative Furnaces and Oil Gas at Falkirk" <u>N.B.A.G.M.</u> 1895.

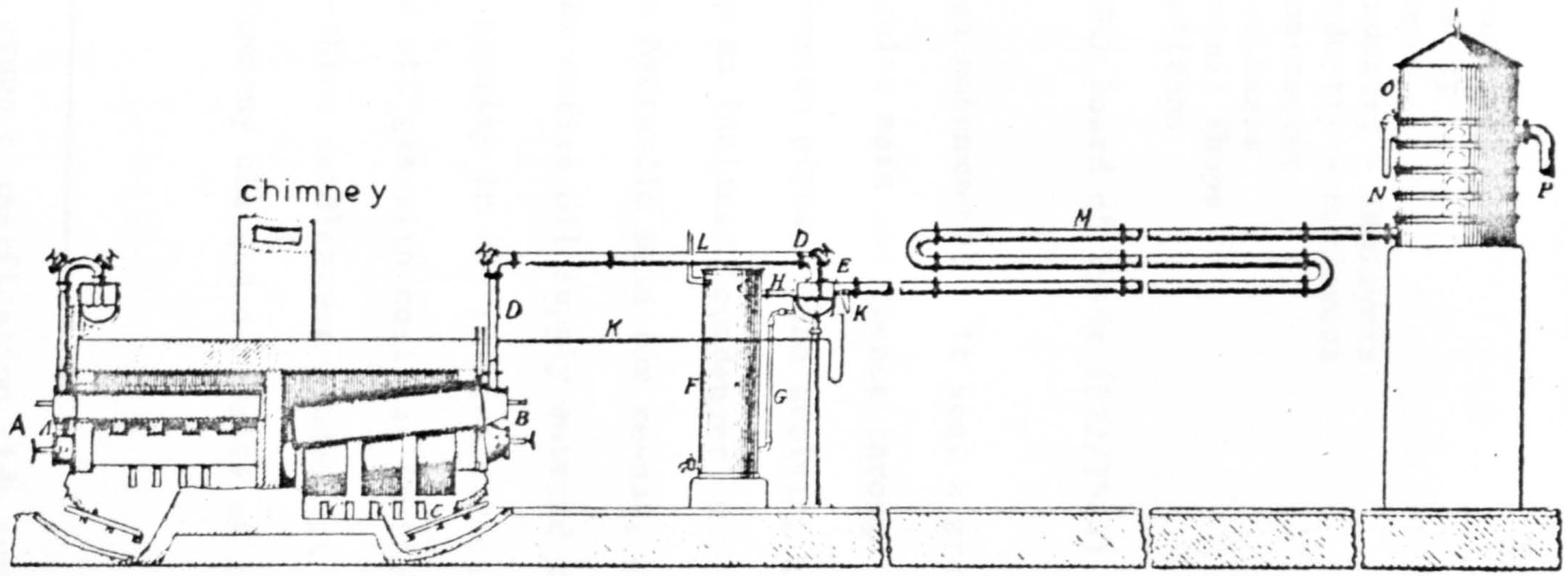
4. Broughty Ferry in <u>Gas World</u> 6/4/1895 p. 422.

5. Prof. V.B. Lewis, "The Enrichment of Coal Gas" describes both Peebles and Galashiels equipment <u>Gas World</u> 8/6/1893, 10/6/1893. B. Redwood and G.T. Holloway, <u>Petroleum</u> (1896) Vol. III p. 703.

6. In 1893 W. Young agreed to charge no royalty, and in return Galashiels directors were to allow visitors to inspect the installation. Galashiels Minute Book <u>op. cit.</u>, 3/1/1893.

7. i.e. stop-end retorts in back-to-back ovens.

Fig. 3.93a 'PEEBLES' OIL GAS INSTALLATION AT GALASHIELS GASWORKS 1893



Note - A coal-gas retorts; B oil-gas retorts; C waste heat ports from coal-retorts; D stand pipe and dip-pipe; E hydraulic main;

F compensating and settling tank; G oil outlet from hydraulic main;

H main oil feeding pipe; K regulating valve and syphon tube;

L fresh oil-supply and ball-cock; M horizontal condenser;

N oil-gas scrubber; O oil supply tank for scrubber;

P outlet from scrubber to oil-gas meter.

Source - J. Bell jn (Peebles) "The Production of Illuminating Gas from Liquid Hydrocarbons by the Peebles Process" J.G.L. 8/8/ 1893 pp. 264-6 (photo. Galashiels retort house)

Table 3.93 Investment Sources for the Oil Gas 'Enrichment' Company (1893)

Place	Persons	£ Stock	Place	Persons	£ Stock
Peebles	6	550	Edinburgh	33	6,075
Galashiels	7	895	Glasgow	12	4,100
Elsewhere in Scotland	23	6,925	England/Wales	13	1,345

Occupations[1] of Investors in Oil Gas Enrichment Company (1893)

	Persons	£ Stock
Professional	27	5,695
Gentry	14	2,495
Women	5	500
Industry - Employers	18	5,025
Industry - Employees	13	1,430
Contractor	1	1,350
Merchants	13	2,995
Retail Shops	1	50
Artizans	1	150

SOURCE: S.R.O. Board of Trade (BT2/2544)

way tankers on an embankment. It sent a graduated oil flow into a high-level hydraulic main and thence through feeding lines which pierced the ascension pipes. The evolving gas passed into the hydraulic main, up an inclined 'condenser' pipe which sent the condensate back to the hydraulic main for re-use, and through an oil 'scrubber'. The entire oil supply entered through the scrubber and descended under gravity in the reverse direction to ascending gas. After mixing the oil gas with coal gas in the gas holder, Galashiels sold the thirty-three candlepower product at a low price of 3s 9d. The Enrichment Company charged a royalty of 2s 6d per ton of oil[2] used.

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1. Occupation group classification vide supra p.188

2. 'Blue' or 'Intermediate' oil, from shale or the waste-gases of blast furnaces, had a specific gravity of 0.85 to 0.89 which was inadequate for lubrication but not sufficiently refined for use in oil lamps. Price £2 10s to £3 per ton delivered. Galashiels gas company in 1893 contracted for 885 tons Blue Oil from Young's

In 1893 Edinburgh and Leith Gas Commissioners[1] installed seven two-retort ovens on the 'Peebles' process, at a conversion cost of £140 per oven. By 1895 it was also used at Broughty Ferry,[2] and Alloa[3] where £433 was spent on five retorts set in two ovens. The Alloa iron retorts often cracked, but could be repaired with silicate mortar and salt. Oil was delivered there by railway, on a yearly contract at 2d a gallon or £2 3s 8d a ton, but the manager soon preferred blast-furnace oil to shale-oil. The high quality oil coke found a ready market at 18s a ton to bakers and tradesmen.

Greenock[4] municipal gasworks in 1894 invested £1,500 in twelve oil-retorts and ancillary apparatus, and Perth[5] spent £1,100 on nine retorts operated on twelve-hour charges. Oil, delivered to Perth at

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Paraffin Light and Mineral Oil Co. Ltd., at up to 600 tons per year for three years, paying £2 10s per ton the first year, then £2 12s the second and £2 15s the third year. Their expenditure was £366 in 1893, £563 in 1894, £59 in 1895, and £78 in 1896. During 1896 Galashiels refused to purchase Young's oil at £3 3s per ton, and after paying £29 to Broxburn Oil Co. that year, and £26 to Linlithgow Oil Co in 1897, abandoned the process as too expensive.
Galashiels Minute Book op. cit., 2/11/1893 to 7/1/1896, 5/5/1896, 1/12/1896, 5/1/1897.

1. F.T.C. Linton (Leith) "The Manufacture of Gas from Oil" Gas World 29/4/1893, 6/5/1893, 4/8/1894 p. 143.

2. A. Waddell (Broughty Ferry) "Gas Making from Splint and Shale and from Splint and Oil Compared" N.B.A.G.M., 1895.
Gas World 6/4/1895 p. 422

3. Gas World 6/4/1895

4. "Peebles Oil Gas Process for Greenock" Gas World 28/4/1894

5. Oil coke at Perth sold for 16s a ton, compared to 7s 6d for coke from splint coal.

Table 3.94

Comparison of 'Peebles' Oil Gas and Coal Gas at Greenock (1894)

A. Mixed Coals Alone

To produce 700,000 cu ft., the maximum daily output outside the season November to February.

				£	s	d
74 tons cannel, shale and splint, at 12s 6d per ton				46	5	0
9 ovens, requiring 27 stokers at 4s 6d				6	1	6
6 coke-barrowmen at 3s 4d				1	0	0
Coal-breaking on 74 tons at 5d				1	10	10
Purification (700,000 cu ft at 1d per 1,000)				2	18	4
Carting away 10 tons shale waste at 8d				0	6	8
12 tons coke fuel at 7s per ton				4	4	0
Wear and tear, barrow, tools and sundries				1	4	0
				63	10	4
Deduct By-Products:						
40 tons coke at 7s	£14	0	0			
Tar and Liquor on 74 ton coal at 3s	11	2	0			
				25	2	0
TOTAL COST: 13.20d per 1,000 cu ft at 26 candlepower				38	8	4

B. Peebles Oil Gas and Coal Gas

To produce 96,000 cu ft of 90 candlepower oil gas, and 600,000 cu ft 'splint' coal-gas per day.

Oil Gas -

4 'Peebles' ovens each with 12 retorts (making 8,000 cu ft each)

	£	s	d
4½ tons oil, yielding 100,000 cu ft., at £3 per ton	13	10	0
Wages of 1 man on 3 shifts at 4s 6d per shift	0	13	6
Lime for Purification at ½d per 1,000 cu ft	0	4	2
Coke fuel, 2 tons at 8s	0	16	0
Pumping oil, sundries	0	2	0
	43	10	0
Deduct Oil By-Products:			
22½ cwt coke at 16s ton	0	18	0
Oil gas at 2s 10.52d per 1,000 cu ft	14	7	8

Coal Gas

8 Klonne ovens making 600,000 cu ft of 16 candlepower gas

				£	s	d
64 tons splint coal, 9,500 cu ft per ton, at 9s				28	16	0
Wages of 3 men per oven, 13s 6d per oven/day				5	8	0
Purification lime (1d per 1,000 cu ft)				2	10	0
Fuel coke, 25 cwt per oven, at 8s ton				4	0	0
Coal-breaking on 64 tons at 3d				0	16	0
6 barrowmen at 3s 4d each				1	0	0
Wear and tear, barrows, tools				1	0	0
				43	10	0
Deduct By-Products:						
12 cwt coke per ton splint at 8s	£15	7	0			
64 tons tar and liquor at 2s 6d	8	0	0			
				23	7	0
Splint-coal gas at 8.06d per 1,000 cu ft				20	3	0
TOTAL COST of Oil and Coal Gas Mixture - 11.84d per 1,000 cu ft at 27 candlepower				34	10	8

SOURCE: Greenock Police Board April 1894 p. 73 *op. cit.*

NOTE: Some on-cost charges omitted in both calculations.

£2 16s 7d per ton, plus labour costs of 6s 6d, produced 21,750 cu ft plus five cwt coke.

Table 3. 95 Installations of 'Peebles' Oil Gas Process (1894)

Town	Number of Peebles Retorts	Daily Oil Gas Output (cu. ft.) Per Retort	Total	Volumes of Coal Gas mixed with 1 of Oil Gas
Perth	9	6,700	60,000	9
Galashiels	12	9,000	108,000	4
Peebles	2	10,000	20,000	3

SOURCE: Gas World 28/4/1894

At Dalkeith[1] the process was adopted in 1893 as a temporary alternative to purchasing a larger gasholder and selling larger quantities of poorer gas. The Dalkeith installation,[2] like those at Kelso and Musselburgh, used ovens with two clay coal retorts and one iron oil-gas retort. One disadvantage was immediately apparent, when consumption fell by £200 in 1894 because less of the richer gas was required for equal light. In 1897 Dalkeith ceased to use the process because best quality cannel coal was cheap enough to use by itself for enrichment.[3]

1. Gas World 18/4/1896

1894 Comparison of Oil Gas

Company	Gas per Ton Oil	Candlepower	Coke per Ton Oil	Coke value per ton
Peebles	22,000	90	5 cwt	20s
Perth	21,750	90	5 cwt	16s
Galashiels	22,000			

Source: Greenock Police Board 1894 No 15 pp. 72-3
By using a mixture of oil gas and splint coal gas, Greenock saved about 1½d per 1,000 cu ft., or £1,150 per year on 220 million cu ft.

2. Dalkeith Minute Book 11/4/1893, 7/5/1897. Total cost of two ovens at Dalkeith was £250. Most of the equipment was supplied by A.F. Craig and Co., Paisley for £170. Oil Gas Enrichment Co. charged royalty of 2s 6d per ton of oil used.

3. It is not clear how long the oil-gas enrichment apparatus at Temple Farm, Glasgow remained in use, after being designed by William Foulis and installed in 1896. J.G.L. 7/7/1903.

The Peebles process was in direct competition with water-gas enrichment[1] of coal gas, but was at first preferred by many Scottish managers because the degree of enrichment necessary, equivalent to about ten candlepower if splint coal was used, involved a larger quantity of "poisonous" water gas than was required to enrich coal gas in England. By 1896, thirty gasworks had 'Peebles' installations.[2] The Ayr gas manager reported that a carburetted water-gas plant for his company would cost £4,000 to provide 500,000 cu ft per day, whilst a Peebles plant to enrich the same quantity each day was only £1,800 and could produce a saving on coal of £600 per year. Nevertheless Ayr[3] did not adopt the system, because oil prices rose.

The full extent of 'Peebles' oil-gas adoption cannot be estimated, but it was rapidly superseded by cheaper methods in the early 1900s. Benzol[4] was particularly important. It fell in price from 4s 6d per gallon in 1890 and 1897, to only 9d or 1s per gallon after 1899 and was easily adopted. In the late 1890s cheap enrichment with

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1. C. Cowan, auditor of Ayr gas company, unsuccessfully urged the adoption of oil-gas many times in 1893, for the same reason that others favoured water-gas "to insure against the disastrous effects which may ensue from continued or prolonged strikes." Ayr Minute Book op. cit., 4/12/1893, 19/6/1893

2. Ayr Minute Book op. cit., 31/8/1896

3. The directors decided this despite the manager's support for the Peebles system since 1894. During 1894 the manager estimated that a Peebles plant costing £900, to raise the gas from cheap splint (10s 4d per ton yielding 16 candlepower) to 26.5 candlepower reduced working costs from 18.5d to 15.9d which could save the company £400 to £600 per year.

   Ayr Minute Book op. cit., 17/9/1894

4. Benzol was used in synthetic dyes and cost 5s per gallon in 1857, and 18s in 1860, but thereafter the price was reduced as larger quantities were processed for the market.

   L.F. Haber, Chemical Industry (1958) op. cit., pp. 86, 163, 256.

Benzol became possible with the 'Maxim Patent Carburettor' which became most popular during the coal crisis of 1900. After noting its use at Alloa, Coatbridge, Broughty Ferry and Alyth, the Banff company[1] installed one for only £55 in 1900 and reduced manufacturing costs by 5.97d per 1,000 cu ft. Consequently the price of gas was reduced 5d in 1902. At Banff the established mixture of cannel and poorer splint coals produced 9,346 cu ft per ton, or a prime cost of 3s 0.86d per 1,000 cu ft, whereas Benzol and splint coal gave 9,038 cu ft at 2s 6.89d per 1,000 cu ft.

Table 3.96 Banff - Benzol and Cannel Enrichment Comparison 1900 (Quarter Year)

Coal only -						
195 tons 19 cwt cannel at 33s	£323	7	0			
125 tons 16 cwt splint at 22s	138	1	10			
				£481	8	10
Coal and Benzol -						
65 tons 1 cwt cannel at 33s	107	6	6			
257 tons 10 cwt splint at 19s	238	18	11			
527 tons 1 cwt Benzol (10d gallon)	21	19	7			
				368	5	0
Cost Reduction				93	3	10

SOURCE: Banff Gas Company Minute Book op. cit., 12/9/1900

"Carburetted air",[2] and undiluted mineral-oil gas remained important for a number of small Scottish gas companies in the 1900s.

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1. Banff Minute Book op. cit., 12/9/1900

2. Vide "Petrol Air Gas Lighting" L. Gaster and J.S. Dow Modern Illuminants and Illuminating Engineering (1915) pp. 119-24 desc. apparatus.

   Over thirty types of carburetting apparatus were on sale in London in 1915.
   Maxim's patents were 703 and 2508 (in 1889); 2559 (in 1890); apparatus diagram in B. Redwood Petroleum (1922) p.917

Ecclefechan[1] gas company sold its unprofitable works in 1902 to T. Gass, who closed them entirely in 1905 when only twenty consumers and eleven public lamps were using the expensive coal gas at 8s 4d. An entirely new gasworks opened in 1907, supplying cheaper "petrol gas", or carburetted air. Ellon[2] company in Aberdeenshire supplied similar "paraffin" gas to sixty-five consumers at 8s 4d in 1901.

The Deanston[3] gasworks of J. Finlay and Co in 1901 sold one million cu ft of pure oil gas at sixty candlepower. Forty-seven tons of oil a year supplied the 175 consumers with gas at 7s 6d. Golspie[4] gasworks, owned and operated by the Duke of Sutherland since 1862, converted to oil at £4 10s a ton for gasmaking in 1905. The previous year 1,088,000 cu ft of twenty-six candle coal gas at 7s 6d was consumed by 102 residents, but in 1905 only 692,200 cu ft of the twenty-six candle gas was consumed at 10s. Harthill[5] gas company in Lanarkshire was supplied with gas in bulk by Whitburn Gas Company until 1907. That year, 500,000 cu ft was purchased at 5s and sold to forty consumers at 6s 3d. A new company was then formed which used gasoline, at 1s 6d a gallon, to manufacture gas, but by 1908 only 260,000 cu ft per year was being sold to thirty consumers, despite the lower price of 5s.

iv Water Gas

From the discovery made by Felice Fontana in 1780 that combustible gas could be produced by passing water through a tube of red-

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1. C.W. Hastings, Gas and Water Directory and Statistics (1902-7)

2. C.W. Hastings, Gas and Water Statistics (1901). 460,000 cu ft of sixty candlepower gas sold to sixty-five consumers and seventeen public lamps.

3. Ibid (1901)

4. Ibid (1904, 1905)

5. Ibid (1906, 1907, 1908)

hot coke, many innovators attempted to produce 'Water Gas'[1] commercially. A patent was taken by Ibbetson[2] in 1824 but the gas burned with little luminosity, and in 1830 M. Donovan[3] in Dublin made the first attempt to 'carburet' it for higher candlepower, using turpentine. J.B. Mollerat[4] in 1834 vaporised volatile oils with the gas, and Edward Manby[5] in 1839 produced a mixture of coal gas and water gas. The Count de Val Merino[6] introduced a system in which two retorts produced oil vapour and water gas separately and a third retort superheated the mixture. This was closely copied by Stephen White[7] (d. 1867) who added pulverized charcoal and iron filings to the retorts, and obtained a patent in 1849. Meanwhile an alternative system

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1. G. Maltasa Coal Tars (1920) pp. 146-7. The chemical reaction absorbed heat:-
   C (coke) + H_2O = CO (carbon monoxide) + H_2 - 29.7 calories

2. Gas World 26/6/1886 p. 683; E.C. Stewart Town Gas (1958) p. 20. J.H. Ibbetson 1824 Pat. 4954.

3. "Illuminating Gas" Practical Mechanic and Engineers Magazine 1851-2 pp. 172-3 Pat. 6003.

4. 25/9/1834 Pat. 11,960 Vide supra p.374

5. J.G.L. 10/1/1852 Patent on 8/5/1839 Pat. 8062

6. "History of the Manufacture of Water Gas" J.G.L. 10/1/1852 p. 244, 10/2/1852 p. 464, 10/3/1852 p. 282, 10/5/1852 p. 333.

7. Because of the similarity, White was refused an English patent on 15/4/1847, but obtained one on 26/3/1849, and an American patent on 22/1/1850. White's first pioneer installation was at Park-house, Aberdeen, which he described in detail in 1849. He claimed gas could be produced at 1s 3d to 2s per 1,000 cu ft., depending on the size of the installation. The water gas from one retort was carburetted by rosin gas from a second retort, and White advertized the mixture to give 20 per cent greater illumination than coal-gas. Methven Castle, Dunkeld, also used White's process successfully. Bo'ness gasworks manager observed it at Dunkeld in 1852, but was unsuccessful in urging his company to adopt water-gas.
   J.G.L. 10/7/1849; The Builder 1852 p. 710; Bo'ness Minute Book op. cit., 7/6/1852; Ure's Dictionary of Arts, Manufactures and Mines (1875) Vol. III op. cit., pp. 601-5 (diag.); King's Treatise 1878 Vol. I op. cit., pp. 53, 61; (1882) Vol. III p. 342. Manchester installations vide J.G.L. 10/3/1851 p. 50; List of installations vide J.G.L. 10/2/1852 p. 276; Obituary J.G.L. 25/6/1867 p. 524.

was developed by M. Gillard, which was used to light part of Paris in 1848, and Narbonne from 1856-65.

Heating the coke and carburetting the water gas cheaply were the main problems of operation.[1] White's process was, nevertheless, adopted in several parts of Scotland. Comrie[2] gas company when founded in 1851, spent £200 on such equipment from Manchester because the village appeared too remote to purchase coal for gas. After a one year trial, water gas was abandoned in favour of coal. Leith gasworks[3] also tried White's "Hydro-Carbon Gas", but two retorts produced only 900 cu ft each per day, or 335,076 in six months after which the trial was closed.[4] Andrew Fyfe[5] used the Leith results in his

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1. M. Sellingue in 1840 used vertical retorts in Paris and Dijon to mix water gas with oil-gas distilled from bituminous shales.
   Gillard's process was first used industrially in England, in Manchester and at Kurtz's Works, Cornbrook, London, to singe calico and melt iron; an incandescent platinum-wire 'basket' was necessary when it was burned for illumination and it became known as "Platina Gas".
   The Civil Engineer and Architect's Journal, Sept. 1840, p. 309; J.G.L. 10/11/1850, 10/9/1850, (disparaging comments) 11/6/1851; The Artizan, Sept. 1850 p. 210.
   When the coke was chilled by steam, gas output decreased. Gillard in 1849 used an intermittent system, in which gas production alternated with a blast of atmospheric air causing combustion of the coke to re-heat it.
   J.E. Dowson and A.T. Larter, Producer Gas (1909)
2. J.G.L., 9/8/1881 p. 262
3. Experiment directed by Mr Lyon, the manager. J.G.L. 10/6/1853
4. Similar trials at Bridport, Fareham, Ennisworthy and Keadly were also failures. Nevertheless, in 1853 S. Hughes reported that White's process was the only successful water gas method, and used on a large scale at Dunkeld, Ruthin, Southport and Warminster, and supplying many Lancashire mills.
   S. Hughes, A Treatise on Gasworks (1853) op. cit., p. 309; J.G.L. 10/8/1853.
5. Vide infra p.416
   Andrew Fyfe (Univ. Aberdeen) "On Resin and Water Gas" J.G.L. 10/7/1850; A. Fyfe "On Hydro-Carbon Gas" J.G.L. 10/3/1854.

opposition to water gas, published in the Journal of Gas Lighting.

Both of the Leith retorts had 4-hour charges. One held coke to decompose the water, and the other two cwt coal for carbonisation, before the gases were mixed. Fyfe maintained that it was a fraud against consumers. The water-gas raised output from Boghead coal from 16,093 cu ft per ton to 27,700, but diluted the candlepower by thirteen per cent, and operating costs were thirty-four per cent greater than coal gas alone.[1]

Further development was delayed for three decades[2] until cheap mineral oil became available to carburet the gas in the 1870s. T.S. Lowe[3] in 1874 sprayed oil onto the hot coke in the 'generator' to carburet the gas, and at the same time Strong[4] devized a method for using waste heat, produced by an intermittent air blast over the coke, to heat chequered brickwork which subsequently pre-heated the steam before it reached the coke. These two methods were combined in 1882, and a final superheater applied to the mixture of oil and water gases.

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1. Experiments with Boghead coal for 'Hydro-Carbon' Gas were made at Dunoon gasworks in 1850, under the supervision of Professor Anderson of Glasgow University. This produced 20,000 cu ft per ton. The process was modified at some gasworks to also make paraffin oil for sale, until James Young attacked Lancashire textile factories, which used water gas, for infringement of his paraffin patent in 1853.
   J. Butt, "James Young, Scottish Industrialist and Philanthropist" (1963) op. cit., pp. 187, 192. A.W. Lyell, Torbanehill Case - Report of the Trial (1853, Edinburgh), p. 89.
   Vide infra 'Coal' p.491

2. 1872 Ruck used petroleum to carburet water gas at Battersea Water Works.
   1874 First large scale water-gas plant at Phoenixville, Pennsylvania, USA.
   1875 Scott used water-gas enrichment in vertical retort experiments at Musselburgh. J.G.L. 25/5/1875. Nature 1872-3 Vol. VII p. 329. Vide infra 'Technology' p.371

3. E.G. Stewart, Town Gas (1958) p. 20

4. Ibid.

The process became immensely popular in America,[1] using mineral oil, and in Germany. It was the basis also for many British water-gas processes.[2]

The British Water Gas Syndicate Limited in 1886 built the Leeds Forge[3] plant where gas was used for welding, steel-melting, lighting and cooking. This became the main focus of British interest in water gas, but in 1889 a subsidiary firm, the North British Water Gas Syndicate, built a large factory at Uddingston[4] to manufacture and publicise the equipment. Foundries and workshops of the Caledonian Railway Company there, as well as the local railway station,[5] were lit by water-gas at half the price of coal-gas. In 1890 an experimental plant was also used at the Townhead works of Glasgow Iron and Steel Company, for iron puddling.[6]

W. Foulis for Glasgow municipal gasworks, examined Leeds Forge[7]

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1. In the United States, of 951 gas companies operating in 1889, 418 supplied coal gas, 296 water-gas, 116 coal and water gas mixed, 108 oil gas, 5 oil and coal gas mixed; 5 water-gas for fuel only; 1 rosin gas and 2 carburetted air. Out of 363 water-gas works, 312 used the Lowe system. G. Maltasa, Coal Tars (1920) op. cit. p. 147.

2. Normally abbreviated C.W.G. Plant i.e. Carburetted Water Gas Plant. Some Scottish managers, like R. Southerland of Falkirk, had personal experience of the system in America. R. Southerland "Notes on Water Gas" N.B.A.G.M. 1884; "Water Gas in the United States" Gas World 22/3/1890.

3. Gas World 19/12/1891. List of B.W.G. Syndicate installations.

4. In 1889 a show-room was arranged in Central Station Hotel, Glasgow, and some towns like Helensburgh commissioned a demonstration of water-gas. J.G.L. 14/5/1889; Gas World 27/12/1890, 18/5/1890 p. 547, 1/6/1889 p. 599.

5. Gas World 27/12/1890

6. Gas World 18/1/1890

7. W. Foulis "On Water Gas" Gas World 15/6/1889 p. 657.
A.H. Sexton, Producer Gas (c. 1903, Manchester) pp. 98, 96.

personally. A ten-minute blast of air into incandescent coke in a vertical retort heated both the coke, and some steam-boilers. The air supply was then closed, and a four-minute steam jet used to produce gas. Each 'generator' produced 52,800 cu ft per day. One ton of coke was used per 34,000 cu ft., and one ton of water per 84,000 cu ft. The total operating cost, including wages, depreciation and interest, was only 4d per 1,000 cu ft. Unlike America, no carburetting agent was used, and incandescent magnesium 'combs' lasting only 100 hours were placed on gas-burners to produce light. Because anthracite was required and the gas was unsuitable for normal burners, it was not adopted by Scottish gas companies, but variations achieved a wide private market in the north.

Messrs Humphreys and Glasgow,[1] and the Economical Gas Apparatus Construction Company,[2] rapidly superseded the B.W.G. Syndicate. They first sold units in America, and Dublin gasworks under Stelfox[3] in 1891 became the first British gasworks to distribute water-gas. Dawsholm[4] works in Glasgow in 1893 was the first in Scotland to adopt the

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1. A.G. Glasgow "Carburetted Water Gas" (detailed desc. and diag.) Proc. Cleveland Institution of Engineers 1896-7 pp. 43-76; G. Maltasa, Coal Tars and Their Derivatives (1920) p. 148; Gas World 7/8/1897, p. 288.

2. Operating the Merrifield, Westcott and Pearson process. A list of installations by this company up to 1903 shows no Scottish examples. Vide J.G.L. 10/3/1903 p. 653

3. Followed in 1892 by Beckton Station of Gas, Light and Coke Co. London. Gas World 26/12/1891
J. Stelfox (Belfast) "Experience with Carburetted Water Gas" Gas World 21/7/1894 (desc. Dawsholm).

4. Gas World 14/4/1894, 21/4/1894, 16/4/1898, 5/2/1898 p. 197.
Aberdeen gasworks in 1889 used water-gas only for heating purposes vide J.G.L. 4/6/1889.
A.M. Paddon "The Technology of Water Gas" (Inst. Gas Engineers) Gas World 4/6/1892, 11/6/1892

process and did so in preference to the Peebles oil-gas process. The plant could produce 350,000 cu ft in twenty-four hours, and in foggy weather could be in full operation within three hours compared to forty-eight hours with coal-gas retorts. Water gas was produced at 14d per 1,000 cu ft. in Glasgow.[1] The manufacturers claimed many advantages for the system: control over the coke market, little ground space required for the equipment, emergency supply available at short notice, control of candlepower, greater independence in a coal crisis, and a peak-demand supply[2] which reduced capital expenditure on coal-gas plant.[3] Several companies, like the South Metropolitan, were motivated by labour disputes in 1889 to develop water-gas which required less skill, and reduced labour costs from about 4½d to 1½d per 1,000 cu ft. 'Blacklegs' could operate water-gas

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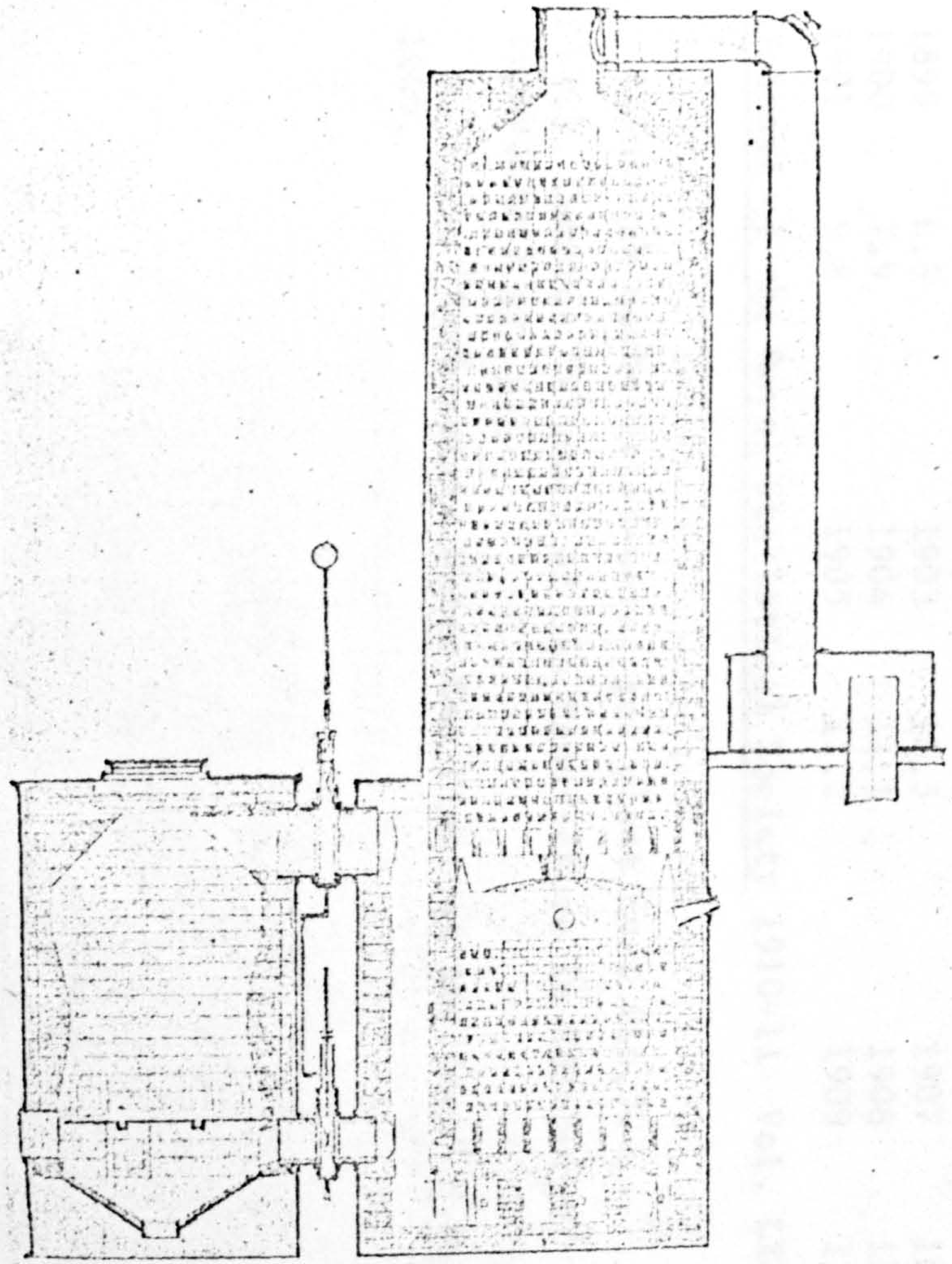
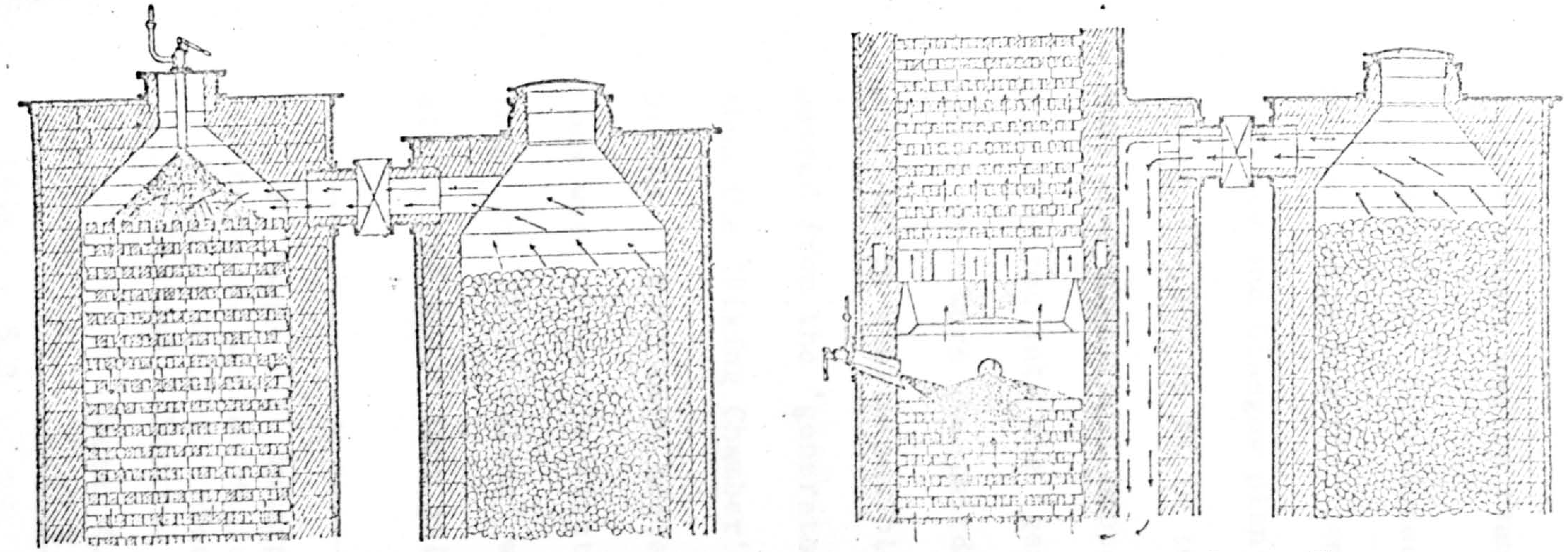
1. c.f. 14.31d per 1,000 cu ft in Dublin

2. Reduction in the capital equipment required for peak supply allowed more intensive use of capital and labour, and provided a market for coke which could not be transported because of high costs.
   G. Manners, The Geography of Energy (1964) pp. 92-100,128

3. However, the Carbon Monoxide in water-gas made it more 'poisonous' than coal gas, and public apprehension was raised by a number of accidents in America. A Home Office inquiry of 1898, however, placed no stringent provisions on water gas supply. Where water-gas alone was used, as at Llandridrod Wells in 1890, the Board of Trade enforced the use of mercapton and thioacetone as odour in the gas. By 1903, fifteen out of a total 140, thousand million cu ft gas produced in Britain, was water-gas.
   J. Mitchell, Presidential Address, Trans Inst. Mining Engineers 1890-1 Vol. II pp. 3-4
   "Proposed Restriction on the Supply of Carburetted Water Gas" Gas World 18/2/1899, 25/2/1899, 4/3/1899, 11/3/1899
   Digest of Evidence Given Before the Royal Commission on Coal Supplies (1901-5) Vol. I p. 370
   "Water Gas Fatalities" (in America) Gas World 13/6/1889, 22/3/1890
   Professor I. Macadam "Carburetted Water Gas" N.B.A.G.M. 1899
   V.B. Lewes "Water Gas - Past, Present and Future" Gas World 14/5/1898 p. 746



Cross Section of the Generator, Superheater, Fixing Chamber, and Washer of the Merrifield-Westcott-Pearson Carburetted Water-Gas Plant.



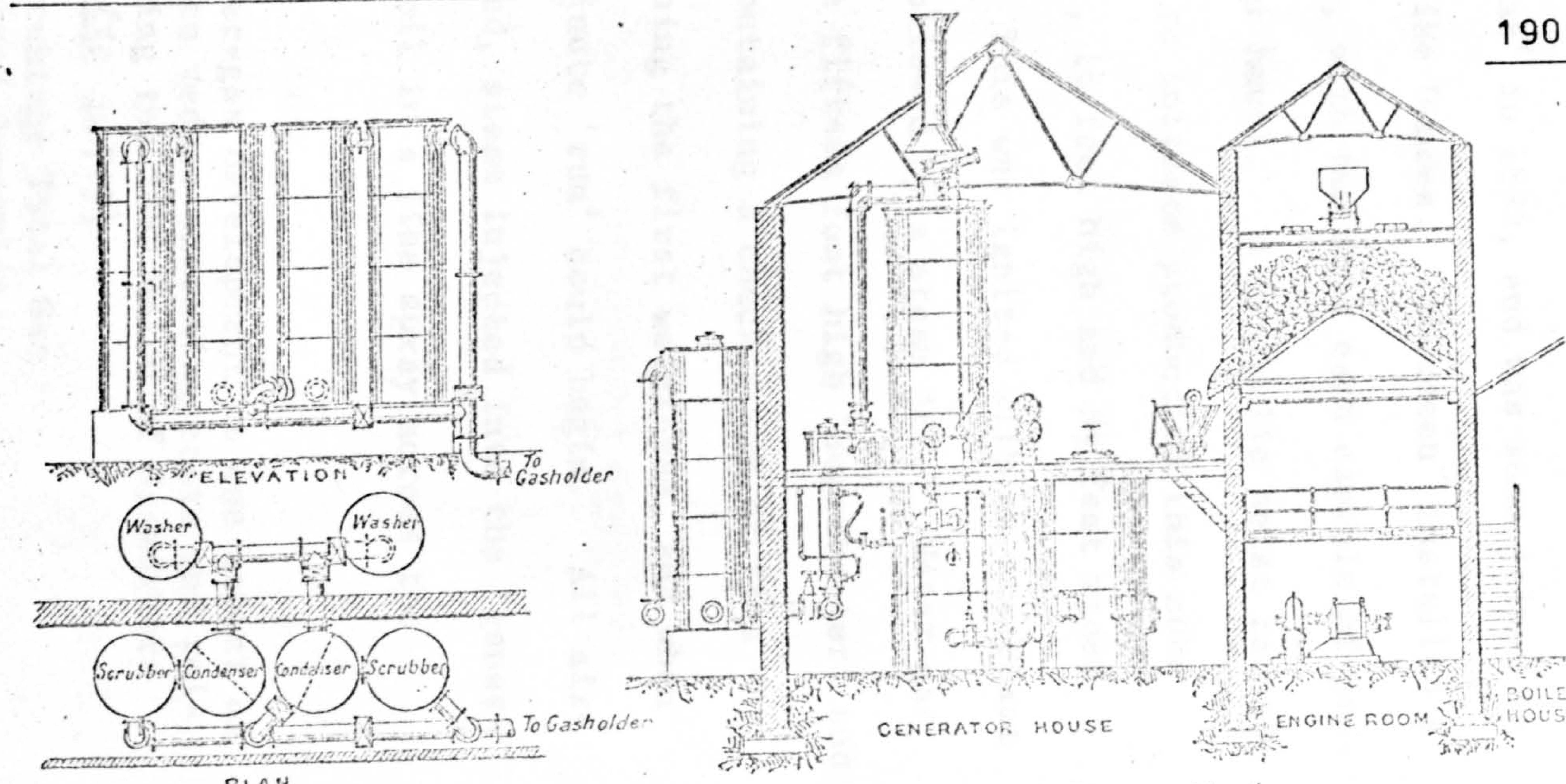
Ordinary Double Superheater Type. Merrifield-Westcott-Pearson Type.

Diagrams showing Comparison of Two Oil-Inspecting Systems.

Fig. 3. 97

CARBURETTED WATER GAS (M.W.P. SYSTEM) INSTALLATION AT ABERDEEN

1909



The General Arrangement of the Carburetted Water-Gas Plant at Aberdeen.

Source - N.B.A.G.M. 1909

equipment more easily than coal-gas.[1]

Edinburgh[2] introduced 'C.W. gas' in 1895, and was soon joined by several large Scottish companies like Dundee. Aberdeen[3] installed a Humphrey and Glasgow plant in 1901, with two sets each capable of producing 750,000 cu ft in twenty-four hours. A hydraulic hoist raised coke into high-level hoppers, and to initiate production this coke was directed into the 'generators', 16 feet high and 8½ feet wide, until they were two-thirds full. This was ignited with an air-blast provided by Sturtevant blowers, followed by a steam jet. Water gas passed from the 'generator' to the fifteen foot high 'superheater' and then the 'Fixing Chamber', both containing a checkerwork of fire - bricks. Both were heated by burning the first water-gas, and when they were ready the first seven minute 'run' could begin. All air-inlet or 'Blast valves' were closed, steam injected into the 'generator', and about four gallons of oil in a fine spray across the

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1. F. Popplewell interprets water-gas development as one aspect of increased mechanization aimed to reduce operating costs and reliance on skilled labour following the 1889 Union of Gasworkers and General Labourers (*vide infra* p.719)

Water Gas as Percentage Total Gas by U.K. Chartered Companies

1898	5.3	1902	10.4	1906	11.0
1899	6.8	1903	10.3	1907	10.7
1900	7.9	1904	11.1	1908	11.3
1901	9.8	1905	11.2	1909	12.1

Journal of the Royal Statistical Society 1910-11 Vol. LXIV

2. Edinburgh carburetted-water gas plant cost £16,501.

T.R. Cameron "History of Gas Manufacture in Edinburgh" (1951, typescript) *op. cit.*

3. S. Milne "Carburetted Water Gas Plant at Aberdeen" *N.B.A.G.M.* 1909.

'superheater'. Once the gas had passed through, and been sealed off, air vents to the superheater and generator were opened for another four minute "blow" before the next 'run'.

One set of equipment in full use required three shifts a day, each comprising one boilerman for pumps and machinery, one operator, and one assistant. From the 'superheater' the gas passed through a set of apparatus quite separately from the coal gas. Two twenty-two feet high scrubbers, water-cooled condensers, a 'cyclone' tar extractor, and an auxiliary 580,000 cu ft gasholder, all raised the capital cost.[1]

Table.3.98

Humphrey and Glasgow Water Gas at Aberdeen
(percentage volume)

	Coal Gas	Carburetted Water Gas
Heavy hydrocarbons	9	13
Carbonic Oxide	11	32
Methane	35	21
Hydrogen	40	28
Nitrogen	5	6

SOURCE: N.B.A.G.M. 1909

With oil at 55s per ton, the process at Aberdeen produced gas at a cost equivalent to good coal at 17s 1d to 18s 4d per ton. Good coal there cost 28s 2d per ton, so carburetted water gas was used in large quantities. The disadvantage was that small changes in oil price were equivalent to large changes in coal price. One penny per gallon rise in oil was equal to 3s rise in coal, and oil could easily become too expensive to use.[2]

1. Colman's 'Cyclone' tar extractor allowed gas to enter at a tangent, creating a vortex which left the tar as centrifugal condensation on the walls of the vessel. A separate gasholder was required because output was too rapid for the purifiers to handle immediately.

2. In 1909 Glasgow had temporarily ceased to use C.W. gas.

Table. 3.99 Water Gas Installations by Humphreys and Glasgow Ltd

Operational in 1912		Installed in 1913-21	
Town	cu ft per day	Town	cu ft per day
Dundee	1,500,000	Coatbridge	400,000
Edinburgh	2,000,000	Glasgow	3,000,000
		Glasgow (II)	2,500,000
		Stirling	400,000

SOURCES: J.G.L. 13/2/1912
Gas World Year Book 1921 p. 3

v **Producer, Suction and Acetylene Gases :**

As the Welsbach incandescent mantle replaced open-flame burners, Scottish gas companies after 1900 turned their attention increasingly to the production of large quantities of cheap gas of high calorific value, suitable for industrial use.[1] Nevertheless, private gasworks to produce fuel-gas at a lower price, were developed on a large scale. They used either intermittent water gas or the continuous 'producer gas' process in which atmospheric air entered the retort for combustion of coke at the same time as gas was being produced, thereby diluting the output with inert combustion gases. Cassel Gold Extracting Company[2] in Glasgow built a large water gas plant to rival Leeds Forge.

Bischof,[3] in Harz, built the first internally-fired gas 'producer' in 1839, but despite later experiments in Austria and France, the method was not perfected until F. Siemens'[4] combined gas producer and

1. Vide infra p.1307
2. Royal Commission on Coal Supplies (1901-5) op. cit., Vol I p.385
3. J.E. Dowson and A.T. Larter Producer Gas (1907) pp. 66, 73, 85, 94, 95
4. Vide infra 'Technology' p.357
Widely used for steel production after 1879 when a basic lining allowed use of phosphoric British iron supplies. P. Mathias, The First Industrial Nation (1969) op. cit., p. 411

regenerative furnace of 1857. This was developed for the heavy industries, like steel, in the 1870s, but in Scotland the rival Wilson's Gas Producer was more popular. A ten-foot vertical 'retort' filled with poor slack and waste coal was injected with steam and air at the base, and carbonic monoxide entered an ascension pipe at the top for direct delivery to a combustion chamber. There it was used for a great variety of operations, from annealing steel castings and metal wire, to heating core-drying stoves and moulds in foundries, chemical operations and firing steam boilers. A blow-pipe flame gave intense heat over a fifteen foot section for welding iron tubes. Unlike Siemens system, it produced gas under positive pressure which could be distributed by gas-mains, and it could be built of smaller dimensions, without regenerators, at lower cost.

Wilson's system[1] was first adopted in the Glasgow region during 1881, and soon used for the chemical furnaces of Messrs C. Tennant and Company and the charcoal kilns of Greenock sugar refineries. With a regenerator it was used by Dunnachie's Star Brick Works at Glenboig

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1. F.J. Rowan "A Description of Wilson's Gas Producer for Firing Furnaces, with some Applications" Trans. Inst. Engineers and Shipbuilders in Scotland 1880-1 Vol. XXIX p. 177; 1881-2 p. 25
F.J. Rowan "On Gas Firing, with a description of the Wilson system" Mining Institute of Scotland 1881-2 Vol. III pp. 194-210
L.F. Haber The Chemical Industry During the Nineteenth Century (1958) op. cit. p. 58.
J. Mayer "Dunnachie's Continuous Regenerative Gas Kiln" Trans. Inst. Engineers and Shipbuilders in Scotland 1885-6 Vol. XXIX
A. McLean Local Industries of Glasgow and the West of Scotland (British Assn., 1901)
A.H. Sexton, Producer Gas (c. 1903, Manchester) p. 145
Many producer-gas installations have passed unrecorded. One was apparently used in the automated production of whisky and beer bottles by J. Campbell and Son of Glasgow about 1890.
Stratten's Glasgow and Its Environs (1891, London) p. 221
For later installations vide Iron and Steel Bibliographical Series (No. 6) Gas Producer Practice 1902-36 (1936)

where the firing-time for bricks was reduced from over fifty hours to eighteen, and fuel costs halved.

Table 3.100

Constituents of Wilson's Producer Gas (volumes)

26 per cent carbon monoxide
11-13 per cent hydrogen
1.75 - 3 per cent methane
57 per cent nitrogen (inert)

SOURCE: Sexton, Producer Gas (c. 1903) op. cit.

Producer gas was apparently also used for gas-fired ceramics by W.F. Murray of the Caledonian Pottery, Rutherglen.[1] Conventional 'bottle-shaped' kilns were heated by nine fires around the circumference, which caused considerable smoke pollution and required many ventilators and ash-pits which reduced thermal efficiency. With gas firing, the temperature and airflow were easily controlled which reduced spoilage of saggars, ware and kilns. By arranging several kilns in sequence, waste heat from the one in use could warm up the next to be fired, and total fuel economy was estimated at eighty per cent in monetary cost. Experiments began about 1891, and the Patent Gas Kiln Company Limited[2] was formed in 1894, but conventional fifteen foot high kilns were wasteful of heat and this farsighted project was abandoned in 1900.

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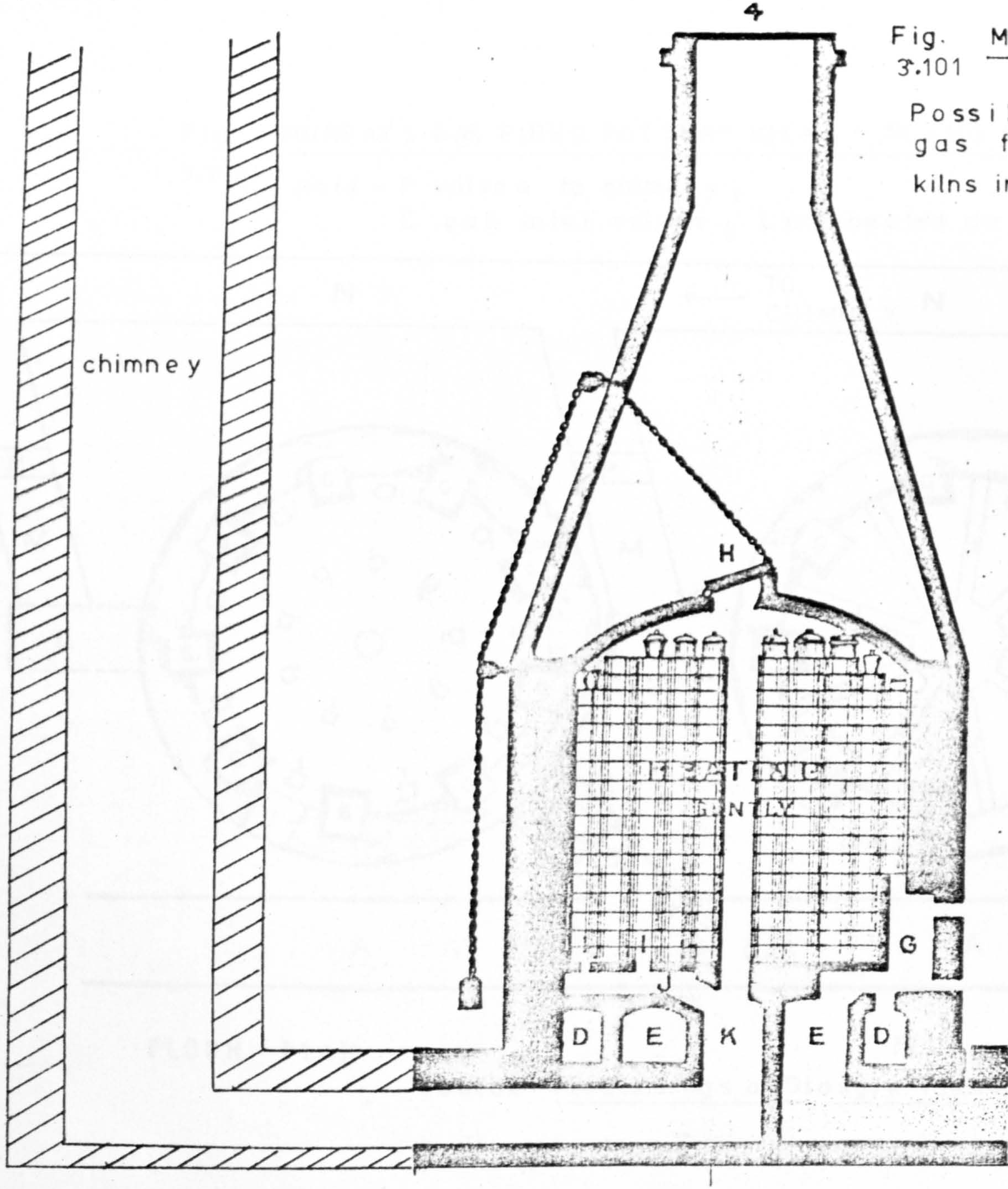
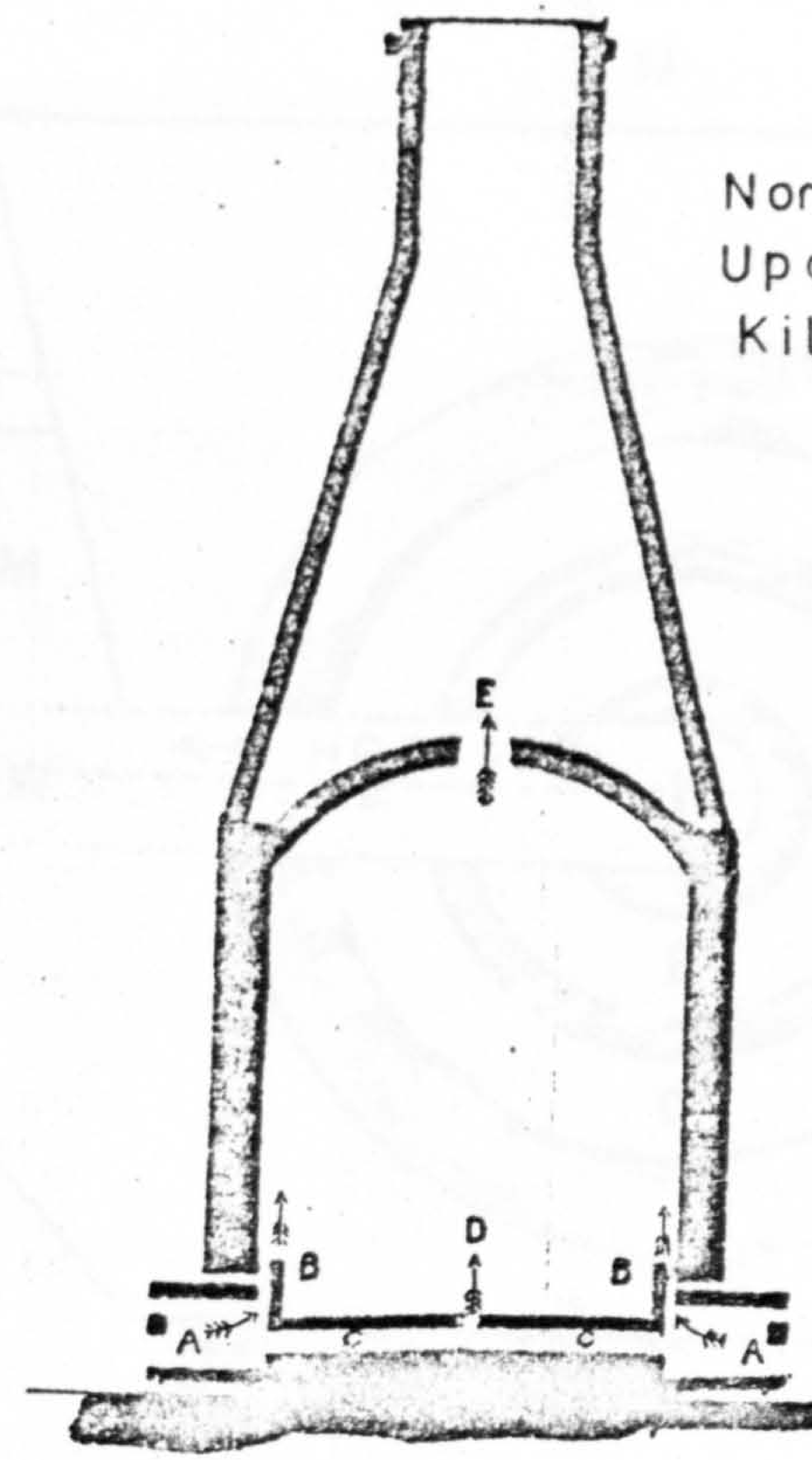
1. W.F. Murray "On a New System of Firing Pottery Ware by the use of Gaseous Fuel" Proceedings of the Philosophical Society of Glasgow 1892-3 Vol. XXIV.
   Coal firing lasted twenty-four hours, and each of the nine fires required fuel every forty minutes, producing temperature fluctuations which damaged the saggars and kilns. Gas firing was completed in about twelve hours.

2. Registered 1894 Board of Trade Records (BT2/2801). Nominal capital £100, of which £93 was subscribed by W.F. Murray and Co. Ltd. The process was patented by John Macintyre and William Fullarton Murray. Murray believed gas-firing would make it "possible to plant potteries in great markets like London" because the small fuel consumption would make it cheaper to transport coal from the coalfields rather than transport fragile pottery. A. McLean, Ed. Local Industries of Glasgow and the West of Scotland (1901, British Association) pp. 200,202.

Fig. 3.101 MURRAY'S GAS-FIRED POTTERY KILN 1892

Possibly the first gas fired pottery-kilns in Britain





Source - Proceedings of Glasgow Philosophical Society 1892-3 Vol.XXIV

Fig. 3.102 MURRAY'S GAS FIRED POTTERY KILNS - PLANS OF FLUE ARRANGEMENT IN THREE KILNS

Note - P valves to chimney;
C gas inlet valves; L pre-heated air flue

Source - Proceedings of Glasgow Philosophical Society 1892-3 Vol. XXIV

Table 3.103 Gas-Fired Stoneware Pottery Manufacture (1892)

Coal Fired				Gas Fired			
8½ tons coal (at 7s 6d)	£3	1	10	3½ tons dross for gas (at 3s 6d)	£0	12	3
180 saggars (at 6d)	4	10	0	40 saggars (reduced damage)	1	0	0
Wear and tear of Kiln	0	17	6	Wear and tear of Kiln	0	5	6
Cleaning Kiln	0	7	6	Cleaning Kiln	0	2	6
Breakage and Damage of Goods	1	0	0	Breakage and Damage of Goods	0	5	0
TOTAL COST	9	16	10		2	5	3

SOURCE: Philosophical Society of Glasgow 1892-3 op. cit.

The Mond Gas Producer[1] was also popular for private gasworks. Each ton of coal or carbonaceous material in a domed vessel was injected with 2½ tons of steam, and air which was pre-heated in a regenerator. The gas passed through a washer, and then a sulphuric-acid tower scrubber which extracted ammonia by-products as sulphate for sale. 140,000 cu ft gas was produced per ton of slack, with a calorific value[2] of 140 B.Th.U., or about a quarter of the value of coal gas. It was economical for works using over 4,000 horsepower of gas per day.[3]

Table 3.104 Constituents of Mond Producer Gas (volumes)

11 per cent carbon monoxide
29 per cent hydrogen
2 per cent methane
16 per cent carbon dioxide (inert)
41 per cent nitrogen (inert)

SOURCE: Royal Commission on Coal 1901-5 op. cit.

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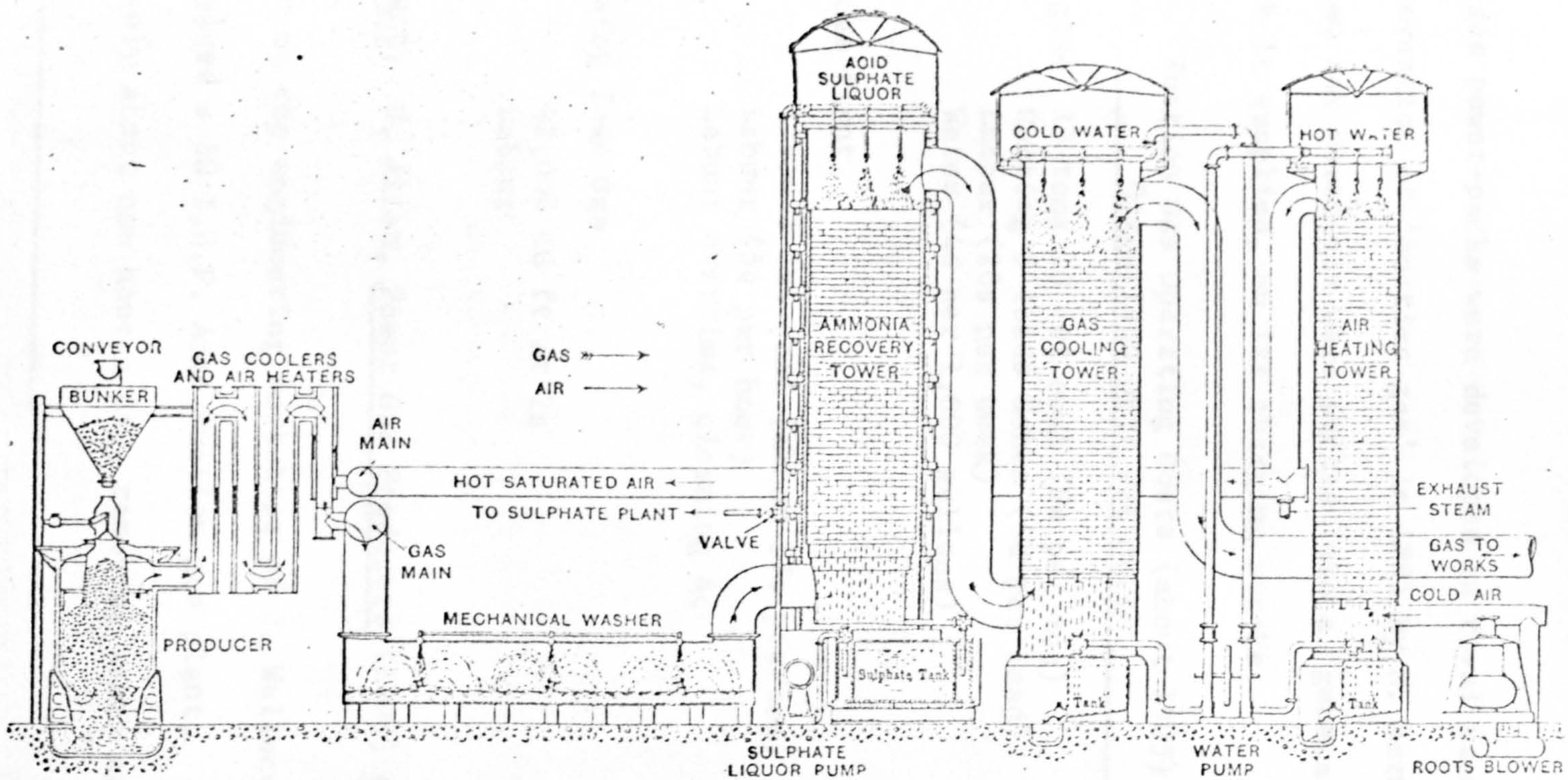
1. Royal Commission on Coal Supplies (1901-5) Vol. I op. cit., pp. 214, 215, 232. List of Mond installations throughout Britain.

2. British Thermal Units i.e. unit quantity of heat required to raise 1 lb. water by 1°F. The sulphate was worth up to 75 per cent the cost of coal-slack for distillation.

3. J.E. Dowson in 1879 produced the first gas-engine to run on producer gas. J.E. Dowson, "Producer Gas" Journal of the Society of Arts 1907-8 Vol. LVII p. 965

Fig. 3.105 THE MOND SYSTEM - Producer Gas and By-products Production



Source - A. Meade Modern Gasworks Practice 1916 p. 78

By 1903 the main Scottish Mond installations were at the United Turkey Red Co. Ltd. in Alexandria, D.W. Henderson and Co. Ltd., and Messrs Wm. Beardmore and Co., both of Glasgow. The last used gas for heating and power, equivalent to 20,000 horsepower or 200 tons of coal per day.

Small gas power-packs were developed to rival steam-engines after the invention of 'suction gas' in 1891 by M. Bernier of Paris.[1] Air and steam for water-gas were sucked into a 'generator' by the gas-engine which it supplied, on its charging stroke.

Table 3.106 Suction Gas Operating Costs (about 1905)
Comparison over One Month

Steam Engine	13 tons 10 cwt coal (6s per ton)	£4	1	0
	Carting 5 loads ashes (6d per load)	0	5	0
	Labour (20s per week)	4	0	0
	Water (4d per 1,000 gallons)	0	4	0
		8	10	0
Suction Gas Plant				
	1 ton 1 cwt coal (about 17s per ton)	0	18	6
	Labour (5d per hour)	0	10	0
	Labour overtime, cleaning &c	0	6	0
		1	14	6
Engine using Town Gas				
	42,000 cu ft at 2s	4	4	0
	Labour	0	6	0
		4	10	0

SOURCE: H. Allen, Power Gas Producers (1908) op. cit.

This example at the engineering workshops of J. Wallace and Sons, Glasgow involved a 30 I.H.P. Acme suction-gas plant. The labour required was only about one hour a day, removing ashes and placing coal

1. Dr J. Arboes of Barcelona unsuccessfully tried a similar method in 1862. Journal of the Society of Arts 1907-8 Vol. LVII pp. 965-6.
H. Allen, Modern Power Gas Producers, Practice and Applications (1908) p. 153.

in the small 'generator' at 6 a.m. and 4 p.m. Because it was cheaper than town gas and could be used to generate private electricity, suction gas was extremely popular in Scotland until the 1910s when electricity companies could provide a cheaper supply. Several Scottish companies[1] sold a variety of suction gas equipment.

Acetylene gas[2] was the last important special gas of the nineteenth century Scottish gas industry, when the raw material, calcium carbide, became more readily available in the 1890s. Several Scottish companies[3] were established to sell suitable equipment for private Scottish gasworks, and a number of small gas companies purchased larger versions after the 1900 coal crisis. Portsoy[4] municipal gas-

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1. e.g. Acme Engine Co. Ltd., Glasgow; Grices' Gas Engine Co. Ltd. which moved from Birmingham to Carnoustie in 1906 with a nominal capital of £20,000. Globe Gas Engine Co. Ltd., with a nominal £30,000 capital, which purchased the engineworks of Pollock, Whyte and Waddel at Johnstone in 1906. S.R.O. Grice Co. (BT2/6353); Globe Co. (BT2/6304).

2. $CaO + 3C = CaC_2 + CO$ (industrial manufacture requiring heat)

   CaC_2 (calcium carbide) + $H_2O = CaO + C_2H_2$ (acetylene gas)

   This reaction with water was discovered in 1836 by Edmund Davy, and expounded by Berthelot in 1862. After 1892, cheap calcium carbide was used to make acetylene gas for portable lights like bicycle lamps, and to light country houses. Calcium carbide was manufactured from lime and carbon in electric furnaces from 1892 by Moissan's process.

   F.W. Robins, The Story of the Lamp (and the Candle) (1939, Oxford) p. 119; L. Gaster and J.S. Dow, Modern Illuminants and Illuminating Engineering (1915) pp. 124-34 (diags.); Gas World 7/8/1897 p. 320.

3. e.g. the British Acetylene Gas Generator Co. Ltd. of Glasgow, 1897-9 with a nominal £5,000, using the 1896 patent (Pat.29554) of H.K. Spence (Edinburgh), W.G. Andrew and M. Beveridge (Kirkcaldy) S.R.O. (BT2/3585); Gas World 25/6/1898 p. 1037.

   The Home and Colonial Acetylene Gas Syndicate Ltd., 1899-1907, at Glasgow, with a nominal £10,000 S.R.O. (BT2/4309).

4. C.W. Hastings, Gas Works Directory and Statistics (1901).

   Portsoy village had a total population of 2,000.

works in 1901 used eleven tons of calcium carbide to sell 75,000 cu ft of fourteen candlepower gas at 6s to sixty consumers and sixty public lights. West Linton gas company in Peeblesshire changed from coal gas to acetylene in 1902, and Whithorn[1] in Wigtownshire, in 1903. The gas could be sold far cheaper than coal gas at these geographically isolated, small works, and of approximately the same candlepower. In 1902 Whithorn[2] sold only 400,000 cu ft of twenty-four candle gas from 100 tons of coal at 20s a ton. Only seventy-five consumers bought the gas, at 10s, and thirty-one public lamps. In 1904, five tons of calcium carbide costing £13 per ton, produced 50,000 cu ft of twenty-five candle gas which sold at 6s 8d to the same number of consumers. Several railway stations, like that at the Kyle of Lochalsh,[3] also used acetylene gas lighting, or merely threatened[4] to do so in order to obtain cheaper coal-gas from local companies.

Despite the proliferation of special gases for fuel and lighting, coal gas remained the cheapest and most suitable in most urban locations. Special gases only achieved importance for enriching coal gas, or for serving the requirements of small communities and large or isolated industrial premises.

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1. Ibid. W. Linton, (£327)capital) in 1902 supplied 200,000 cu ft of 27 candle coal gas at a very high price, 10s, to 40 consumers and 11 public lamps; in 1904 supplied acetylene of 27 candlepower to 70 consumers, 17 public lamps. Whithorn (£800 shares, £150 loans)

2. C.W. Hastings, Gas and Water Works Statistics (1902, 1904)

3. Gas World 25/6/1898; vide supra Chapter II p.118; also p.91

4. C.E. Cockburn, superintendent of the Glasgow and South Western Railway Company in 1904 threatened to introduce acetylene gas at Muirkirk station whilst demanding cheaper coal gas from the local company. Muirkirk gas company refused to reduce the price below 4s 7d only after consultation with other coal gas companies also threatened. New Cumnock allowed 5 per cent discount but charged 5s 5d, Auchinleck allowed 5 per cent on 5s, and Mauchline which charged the same as Muirkirk, also gave no reduction. Muirkirk Minute Book op. cit., 20/6/1904, 1/7/1904, 17/8/1904.

3 Coal and By-Products

(i) Coal

As the principal raw material in gas production, coal supplies and prices had a major impact upon gasworks management, technology and finance.[1] The coal industry's fortunes were a barometer of national prosperity, which at the same time affected that prosperity; expensive coal usually indicated high demand rather than price-fixing by associations of coalmasters since miners' wages, one of the chief overheads, often rose in sympathy with wage rates in alternative, outside industries.

Cyclical coal famines were probably the most important stimulus and financial hazard to the Scottish gas industry up to the late 1870s, with an impact exaggerated by the coincidence of higher wages for employees in the gas industry. Rising coal costs resulted directly in higher gas prices, as will be shown in a later chapter,[2] yet the demand for gas was elastic in relation to the price of gas. Total consumption did not decline immediately, because more illumination was required for the brisk trade during an industrial boom, but retardation in the rate of growth was frequently evident within the next twelve months and accentuated the reduction in sales caused independently by the cessation of a boom. This contradicts recent statements by Hobsbawm[3] on an "inelastic" demand for gas which supposedly sheltered the gas industry from the winds of economic change. By

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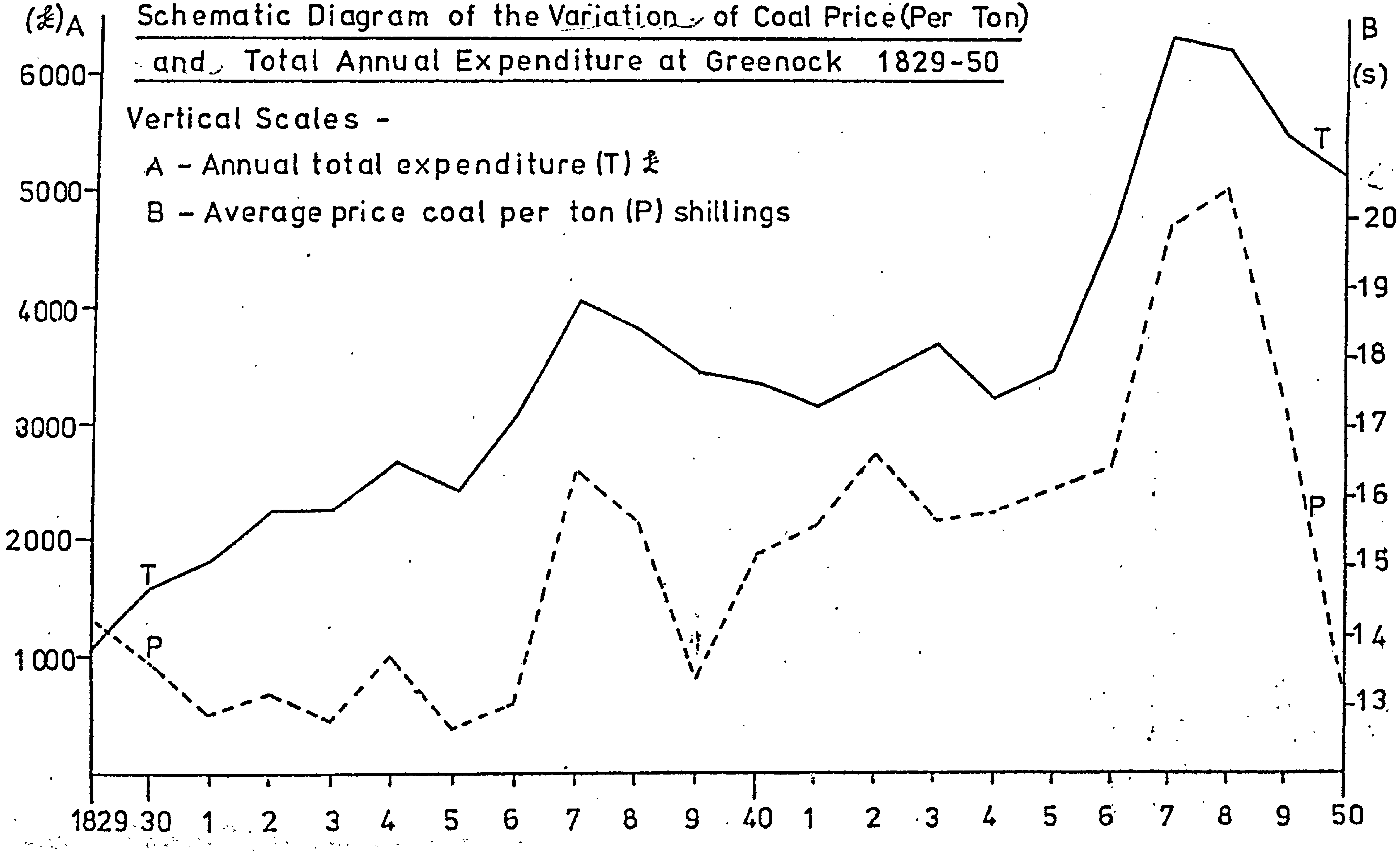
1. Vide infra pp. 789, 794, 847
2. Vide infra p. 878
3. E.J. Hobsbawm, Labouring Men - Studies in the History of Labour (1965) pp. 158-9

Fig. 3.107

Schematic Diagram of the Variation of Coal Price (Per Ton) and Total Annual Expenditure at Greenock 1829-50



Vertical Scales -

A - Annual total expenditure (T) £

B - Average price coal per ton (P) shillings

Fig. 3.108

Relative Importance of Coal and Wages Expenditure, as a Percentage of Total Expenditure at Greenock 1829-50

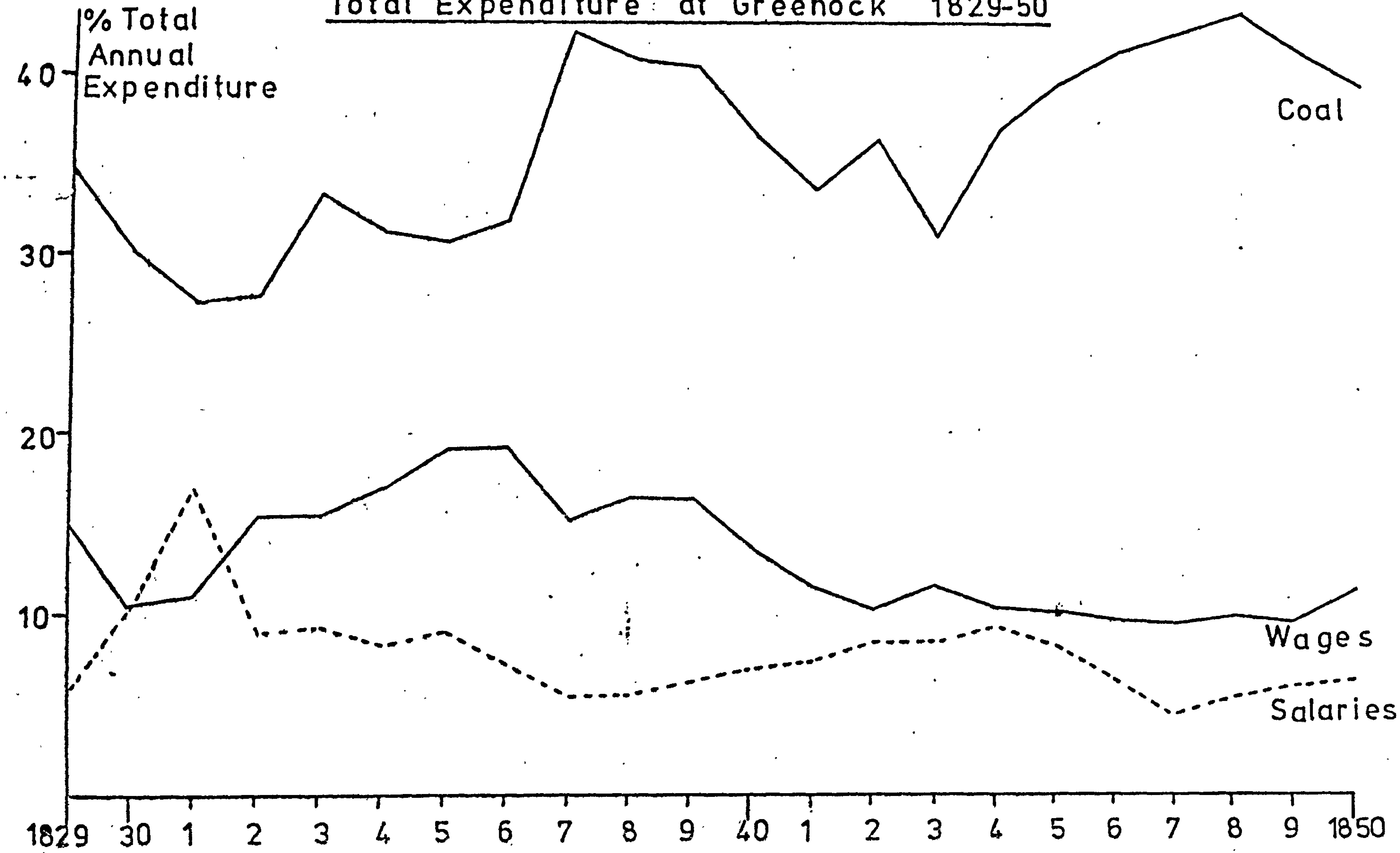
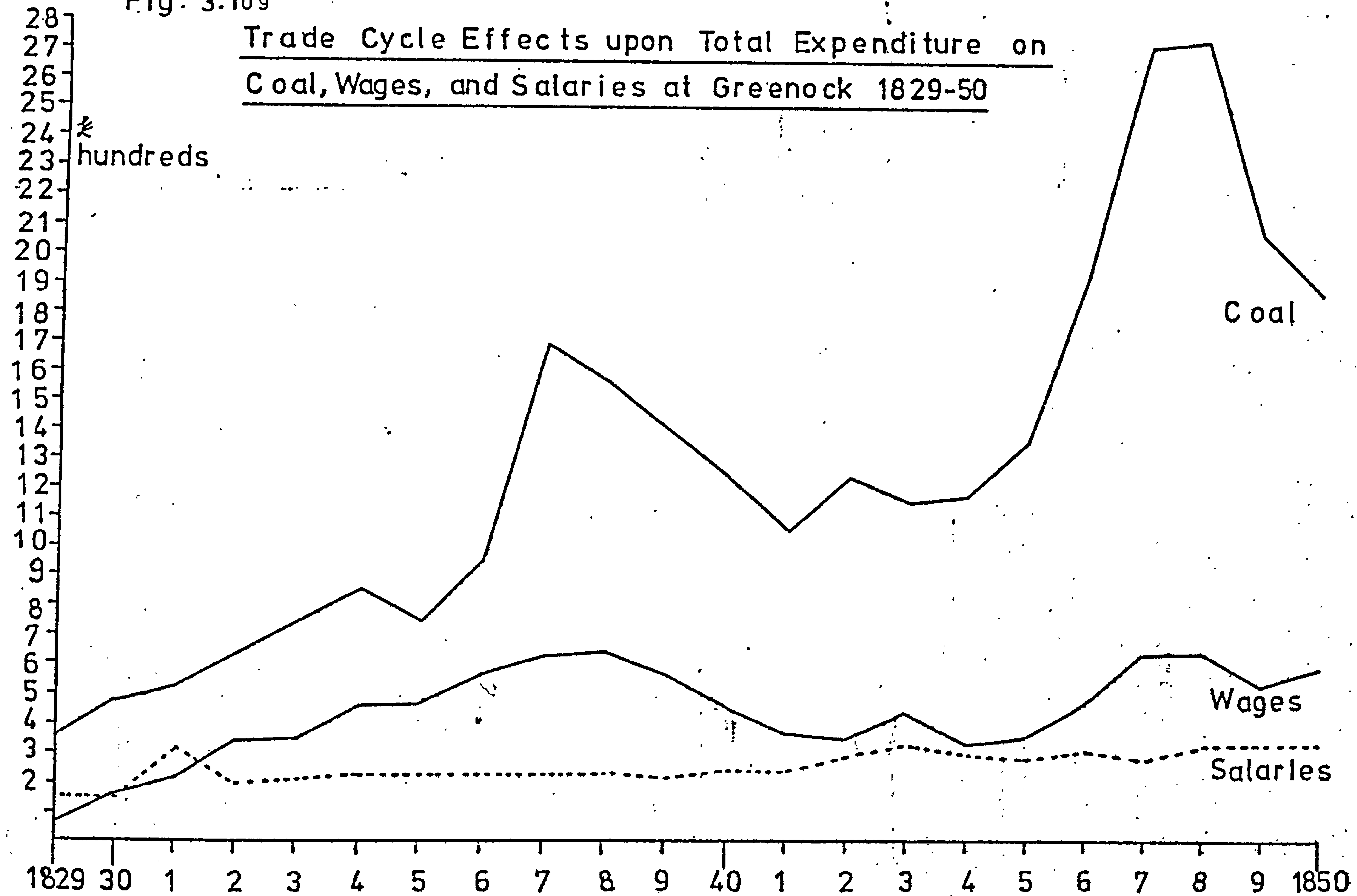


Fig. 3.109

Trade Cycle Effects upon Total Expenditure on Coal, Wages, and Salaries at Greenock 1829-50



reducing expenditure on repairs and extensions as soon as demand slackened, in order to reduce the high total outlay caused by coal and to improve profits despite reduced consumption, gasworks in fact contributed to the slump which followed each boom.

The long-term reduction in gas prices was a consequence of slow technological improvements in gaswork construction, and not of a progressive reduction in the tonage price of coal consumed, until the 1880s-90s when this also was achieved. In the early decades, as at Dundee in the 1830s-40s, cheaper gas was sometimes simply due to "increased consumption"[1] and the ensuing economies of scale, rather than cheaper coal or better technology.

On a national scale, the coal gas industry in Britain consumed[2] anything between 600,000 and 1,125,000 tons of coal in 1850, and gave employment to possibly 20,000 persons directly and another 20,000 indirectly, mainly in coal-mining. David Laidlaw of Glasgow, a prominent gas-equipment manufacturer, in 1861 estimated the total coal consumption of the British gas industry at 3.5 million tons per year.[3] A later comparison with coal consumption by other industries is summarised in Table 3.110

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1. Evidence of J. Russell, Manager of the Dundee Old Gas Company. H. Commons 1846 Vol. 98 25/3/1846 p. 123.

2. G.R. Porter, Progress of the Nation (1851) p. 624
   J.H. Clapham, An Economic History of Modern Britain - Free Trade and Steel 1850-1886 (1932, Cambridge) p. 105

   The Civil Engineer and Architects' Journal August 1850 p. 271
   The Practical Mechanic's Journal (1849-50, Glasgow) p. 167
   M.E. Falkus, "The British Gas Industry" op. cit., Economic History Review 1967 II Series Vol. XX

3. Laidlaw believed that about £30 million was invested in the industry, producing an annual gas revenue of £5 million. Mechanics Magazine 1861 Vol. V pp. 248, 272.

Table 3.110 Coal Consumption in Great Britain and Ireland (1869 - 1920) (Millions of Tons)

Industry	1869	1887	1903	1913	1920
Gas Works	6.3	11.5	15.0	18.0	18.6
Electricity	-	-	3.0	5.0	7.4
Railway Locomotives	2.8	6.2	12.0	13.6	13.8
Coastal Steamers	1.2	1.5	2.0	2.5	1.7
Coal Mines	6.7	10.9	15.0	18.0	17.3
Pig Iron Manufacture	14.0	15.3	18.0	21.2	17.2
Domestic	18.5	28.3	32.0	35.0	36.5
Miscellaneous	44.9	58.7	70.0	70.0	66.7
Total Consumption	94.4	130.4	167.0	189.1	185.8

SOURCE: A.M. Neuman, Economic Organisation of the British Coal Industry (1934), p. 98

A Select Committee on coal in 1871 estimated that in the late 1850s gasworks consumed "about one tenth of all the coal raised",[1] but by 1869 the proportion[2] was only about 5.9 per cent of 107.4 million tons output. Gas coal[3] was 3 per cent of Scottish coal output in 1891, and 4.2 per cent in 1901.

Cannel coal, the best type of gas coal, was available in far larger quantities in Scotland than elsewhere in Britain. From the coalfields of the Midland Valley, it provided considerable financial advantages to the market-oriented gasworks built in that populous region. Cannel output[4] reached a maximum about the late 1860s-70s, before the exhaustion of seams reduced supplies. The average annual

1. 1871 Report of the Commissioners Appointed to Inquire into the Several Matters Relating to Coal in the United Kingdom (1871, H.M.S.O.) Vol. III p. 204

2. Estimate only, since 1,024 gasworks which answered a questionnaire, used only 3.8 million tons per year. Ibid.

3. Vide infra Appendix VII p.1679

4. B.P.P 1871 (c. 435-11) XVIII Royal Commission on Coal, Committee E, p. 163.

output of Scottish cannel in 1865-9 was 322,000 tons, comprising 172,000 from Lanarkshire, 55,000 from East and Mid Lothian, 38,000 from Ayrshire, 29,000 from Fife, and 28,000 from Linlithgowshire. This cannel was about 2.3 per cent of total Scottish coal output[1] at that time, but until about 1870 its importance was such that restrictions in output or high prices of cannel supplies alone produced crises in the gas industry. At all times, however, cannel supplies and prices were intimately connected with the economics of the coal industry as a whole.

English gasworks normally used a single type of coal exclusively,[2] well into the 1850s. This was often the bituminous, caking Newcastle coals,[3] which produced far more valuable coke than did the Scottish cannels, but a much lower quality gas, about twelve candlepower. Moreover, they took about twice as long to distill and produced less gas per ton than did cannel, so that English gasworks had the capital and labour costs of operating more than twice as many retorts for an equal output as Scottish gasworks.

Four aspects of coal supply were of great importance to the gas industry. Analysis of the quality of coal[4] in terms of the illuminating power and quantity of gas which it produced, was essential in purchasing supplies and especially in assessing the value of distant

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1. Average Scottish coal output 13,705,610 tons in 1865-9, calculated from statistics in R.W. Dron, The Coalfields of Scotland (1902)

2. J.G.L. 10/4/1851 pp. 63-5

3. J.G.L. 31/8/1869 p.698; The Civil Engineer and Architect's Journal March 1848 p. 89; E. Ronalds and T. Richardson, Chemical Technology 1855 Vol. I Part II p. 566.

4. Vide infra Appendix XI.2 p.1639

sources which involved extra transport costs. Knowledge of the variety and quantity of available gas coals was equally important; and coal prices, the third factor, corresponded approximately to coal quality and to the obtainable quantity or degree of competition for markets. The value of by-products, solid and liquid, became a fourth consideration in purchasing coal. By-product revenue fluctuated fairly independently of coal prices, declining for example in 1850-7 although coal prices rose,[1] and its importance is considered in a later section.

Sources of coal supply for individual gasworks, the second major commercial factor, progressed through a number of indistinct phases. The initial local supply phase was characterised by difficult transport conditions; reliance upon a small number of coalmasters who operated locally in the case of gasworks built near the coalfields; concentration almost solely upon best quality cannel; and a fairly tight restriction in the number of national sources of suitable gas-coal. These conditions applied to all gas companies in the 1820s, and partially afflicted many new and inexperienced companies into the 1840s and later.

The second phase involved the development of mixtures of various coals for distillation, which became one of the most skilful aspects of management and was greatly assisted by improved photometric measurements. Better transportation, especially railways, increased the variety of available coals, and a distinction evolved between "enrichment" or best quality cannels which were economical

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1. "Popular Fallacies As To the Influence of the Price of Coal on the Cost of Gas" J.G.L. 28/8/1860 p. 574.

despite heavy freight charges, and second or third class cannels and other coals which added bulk rather than illuminating power to the gas being sold. An extension of pits providing these coals occurred as a result not only of growing demand by the gas industry in Scotland, but the development of blackband-ironstone in the 1830s for hot-blast furnaces, and the flotation of new companies to supply steam and household coal, these latter forming especially after the boom prices in coal famines.

Thirdly, the coal famines, and rising prices as a result of the exhaustion of best coal seams by the last quarter of the century, produced a search for emergency supplies for oil and water gas enrichment, and ultimately contributed to the reduction of candlepower. Finally, as coal gas became a source of fuel rather than illumination, an entirely new range of coals was exploited which, unlike cannel, provided valuable coke and thereby considerably raised by-product revenue.

In 1823, Andrew Ure[1] recorded only two Scottish sources of cannel coal, at Gilmerton and Muirkirk, probably supplying gasworks in the Edinburgh and Glasgow districts respectively. Glasgow gasworks obtained its original supplies entirely from William Dixon[2] (1753 - 1824) of Calder Iron Works, who also organised its transportation. In

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1. A. Ure, A Dictionary of Chemistry (1823) p. 337 Vide supra p.28
2. Glasgow City Archives (D.G.E.59) 12/8/1818
   P.L. Payne, "The Govan Collieries 1804-5" Business History 1960 Vol. III pp. 75-96
   P.L. Payne, ed., Studies in Scottish Business History (1967) p. 270
   W.H. Marwick, Economic Developments in Victorian Scotland (1936) p. 64 B.F.Duckham Scottish Coal Industry (1970) op.cit. pp. 138, 181
   Vide supra p.108; also pp. 1130, 1143, 1156

August 1818 he undertook to supply cannel from Woodhall Estate in "any quantity not exceeding 2,000 Tons" at 15s per ton (20 cwt) "laid down at their works in Crispen Place", together with 500 tons of common coals as furnace fuel, at 9s per waggon (24 cwt), paid Quarterly in cash. Deliveries commenced at twenty-five tons of cannel, and ten of furnace coal, delivered daily until the works had stocks of 200 and 100 tons respectively, and that level was to be maintained.[1]

A similar agreement was reached in 1829 between Halbeath colliery and the new gas company at nearby Dunfermline.[2] The one year contract there stated no specific quantity of coal, but fixed the price at 9s 6d per ton less 2½ per cent discount if paid monthly, and prohibited the gasworks from taking supplies from other collieries except for the purpose of experiments. The Vale of Leven[3] gas company relied heavily upon local coals from Messrs Wilson of Hurlet alum works up to the 1840s. Transport and organizational problems led small companies like Duns to prefer a single source of supply. Located near the south east border, Duns[4] in 1836 at first ordered fifteen to twenty tons through local merchants, Messrs Calder distillers, and J. Nisbet fish-curer of Eyemouth, and the following

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1. The demand for coal by the first Scottish gas companies came after the dissolution of Glasgow Coal Combine, in March 1817. The Combine of coalmasters had purchased important collieries at Govan and Faskine in 1813-14 to restrict output; and paid bounties on exports to Ireland, to raise coal prices in Scotland. Heavy depression of coal and iron industries in 1816 was followed by a trade revival in the spring of 1817, when Glasgow and Edinburgh gas companies commenced, and these were not hindered by artificially raised coal prices. H. Hamilton "Combination in the West of Scotland Coal Trade, 1790-1817" Economic History - A Supplement of The Economic Journal, 1930, Vol. II, No. 5, p. 136

2. Dunfermline Ref. Lib. Dunfermline Minute Book op. cit 18/9/1829. B.F.Duckham Scottish Coal Industry(1970) op.cit. p.192

3. S.R.O. Vale of Leven Minute Book op. cit. 31/5/1844

4. S.R.O. Duns Minute Book op. cit. 6/7/1836, 26/9/1836, 1/5/1838.

year through James Thomson who placed the entire order with Sir John Dalrymple's Edgehead colliery and charged 16s 8d per ton for overland carriage. In 1838 the company made direct contact with several collieries including Elphinstone (12s per ton at the pit) and Edgehill (19s per ton on ship), before placing the entire fifty tons order (at 19s on ship) with George Leach, manager of Prestongrange colliery, who organised the delivery to Eyemouth (23s per ton) from which port the gas company arranged carriage inland (another 6s per ton). In 1841 Duns[1] placed the entire order with the Earl of Stair's Oxenford colliery (13s 6d per ton), although the overland carrier they employed charged more for transport (14s) than the pithead cost of coal. On the advice of J. Richardson, gas manager at Dunbar which relied upon Cadell's coal, Duns[2] in 1842 and for many succeeding years obtained all of its coal from Henry Cadell's Tarry colliery near Dunfermline. The first year, Cadell charged only 11s 6d with 2½ per cent discount for cash sales, on top of which sea freight was 3s 6d to Dunbar and 4s to Eyemouth. As G. Leach emphasised to the Duns directors after supplying twenty tons in excess of their order in 1838, a full boat-load reduced freight costs[3] and this was an important reason for small gasworks favouring a single source of supply.

Gasworks in the prosperous textile towns of Ayrshire, like Dalry, and their metallurgical industry counterparts in the 1830s, relied upon local supplies of medium quality coal well into the 1840s. In

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1. S.R.O. Duns Minute Book op. cit., 2/11/1841
2. Ibid., 18/2/1842, 2/5/1843
3. At that date, the saving was 6d per ton. Ibid. 1/5/1838

the New Cumnock[1] coalfield there, Afton pits run by W. Hilbert and R. McWhir, commenced the sale of second-class gas coals in 1826. Dalry gasworks in 1835-40 used gas coal from James Jameson's nearby pits almost exclusively. The pattern of small local markets around coal pits, restricted in accordance with coal quality and carriage costs, was a traditional aspect of the coal industry.[2]

Large gas companies like Edinburgh, Glasgow which consumed 9,000 tons of coal per year by 1832, and Paisley which used 2,634 tons in 1835, led the development of mixed coals and 'enrichment' procedure. In Western Scotland, the Lesmahagow seam was undoubtedly the most important in this respect; as mined[3] by the Duke of Hamilton, and by James Ferguson near Auchinheath, this 22 inch seam gave the most prolific gas of the highest candlepower anywhere in the 1830-40s. The seam[4] was also worked, under different names and in descending order of quality, at Haywood, Cleugh, Wilsontown, Knightswood, Skaterigg and Govan. In 1835 Glasgow gasworks[5] mixed Lesmahagow 'enrichment' cannel at 16s per ton, with other coals costing 10s 6d, to reduce the average coal cost to 14s. During 1835-6 Paisley used a small quantity of Lesmahagow to enrich a large quantity of cheap coals from Ruchill, near Maryhill (Appendix XII.5). Ayr[6]

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1. J.L. Carvel and J.C. George, The New Cumnock Coalfield (1946, Edinburgh) p. 15; J.E. Shaw Ayrshire 1745-1950 (1953) p. 51

2. A. Slaven, The Development of the West of Scotland : 1750-1960 (1975) p. 114

3. J.G.L., 10/1/1851 p. 10, 10/2/1851 p. 40
4. Dr Wallace "Some Points on the History of Coal Gas" J.G.L. 31/8/1869 p. 698

5. New Statistical Account VI p. 162

6. Evidence of J. Haswell, lessee of Ayr gasworks, H. Commons 1846 Vol 102.
S.R.O. Ayr Minute Book op. cit., 3/7/1848

gasworks in 1846 used a small quantity of Lesmahagow, shipped via Glasgow at 29s 6d per ton, to enrich coal from the nearer Mansfield pit near Cumnock which cost 21s. In 1848 Ayr mixed £63 Lesmahagow with £119 Ayrshire coal from Mr Biggart's Perceton colliery, although the cost of freight for these coals was an additional £23. The Garnkirk railway, which opened in 1831 and reduced freight costs from 3s 6d to 1s 6d per ton between the Monkland coalfield and Glasgow,[1] was the first of many improvements to encourage the use of a wider variety of coals.

Besides Lesmahagow, the principal enrichment coals in western Scotland[2] during the 1840s were from Knightswood and Cowdenhillhead collieries in Dunbartonshire. Both were utilised by Glasgow City and Suburban company, in addition to the Lesmahagow, to enrich poorer coals which during the 1850s included the entire output of the Faskine and Palacecraig pits.[3] Glasgow old company,[4] however, in 1846 used up to seventy-five per cent Lesmahagow coal in the retorts mixed with Netherfoot (11s 6d) and Skellyton (12s) coals. Another medium quality coal, described in the 1850s as one of the "chief" gas coals in the Glasgow region, was the twelve inch Balbardie seam near Bathgate.[5]

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1. Ackworth estimated that, at that time, Glasgow City gasworks used 16,000 tons coal per year and St Rollox chemical works 30,000 but the origin of these statistics is not clear. W.M. Ackworth, The Railways of Scotland (1890) p. 19.

2. A.W. Lyell, Torbanehill Case - Report of the Trial. Mr and Mrs Gillespie of Torbanehill v. Messrs Russel and Son (1853, Edinburgh) pp. 92, 93, 185

3. R.D. Corrins "Wm. Baird and Company" (1974) op. cit. p.255

4. Evidence of George Miller, chemical manufacturer in Glasgow H. Commons 1846 Vol. 102 11/5/1846 p. 168

5. W. Moore "Observations on the Supply of Coal and Ironstone from the Mineral Fields of the West of Scotland" Proceedings of the Philosophical Society of Glasgow 1855-60 Vol. IV p. 303

In eastern Scotland, enrichment coals were available by the 1840s from the Marquis of Lothian's Newbattle pits (e.g. East Bryan's pit), nearby Arniston colliery at Gorebridge, Pirniehill pit at Methil, the Earl of Stair's Civility pit (Oxenford colliery), and the Capeldrae and Lochgelly collieries in Fife. From Lochgelly coal and iron works, John Henderson and Company[1] shipped large quantities of gas coal through Burntisland port by 1849. The Newbattle[2] pits commenced about 1820, and produced around 10,000 tons of gas coal by 1839, when Arniston, which sold domestic coal to Edinburgh, produced about 2,000 tons of gas coal a year. Wemyss colliery,[3] which may have originally supplied Messrs Neilson's private gasworks,[4] by 1838 was worked "level free" by twenty men selling gas-coal at 10s per ton compared to splint at 8s 6d; in the 1840s this was a high-quality supply of growing importance.

During one decade from 1849, until its value for paraffin production drove prices too high[5] for large scale gasification, Torbanite (also termed Blackbraes, Boghead or Bathgate coal)[6] from Bath-

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1. Advertisement J.G.L. 10/7/1849 c.f. B.F.Duckham Scottish Coal Industry (1970) op.cit.p.229
2. J.A. Hassan (Manchester) "The Gas Market and the Coal Industry in the Lothians in the Nineteenth Century", forthcoming article in Industrial Archaeology
3. New Statistical Account Vol. IX pp. 394-8.
4. Vide supra p.50
5. Torbanite rose in price from 11s per ton in 1850 to 25s in 1858 J. Butt "Technical Change and the Growth of the British Oil Shale Industry 1680-1870" Economic History Review 1964-5 II Series Vol. XVII. J. Butt "James Young, Scottish Industrialist and Philanthropist" (1963, Unpublished Ph.D thesis, University of Glasgow) p. 114.
6. Although Torbanite was accepted as a "coal" in nineteenth century law suits, especially Gillespie v. Russel (1853) and Binney and Co v. Clydesdale Chemical Co. (1860), the Torbanehill Mineral to which it referred was an unusual geological phenomenon, intermediate between cannel coal and oil shale. Contemporaries used 'Boghead' or 'Torbanite' to refer to this Mineral exclusively, and

gate provided a unique enrichment material of greater intrinsic value than even Lesmahagow. It was available in fairly large quantities, about 30,000 tons a year[1] by 1851-2. At the temperature used in gas retorts, Torbanite produced about 14,000 cu ft gas[2] per ton, and worthless coke[3] containing sixty-five per cent ash.[4] The mineral was retailed by Messrs Russel and Son,[5] coalmasters of Falkirk, who together with the estate owner William Gillespie,[6] travelled personally to gasworks throughout Scotland[7] to persuade them

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although B. Redwood (Petroleum - A Treatise 1922 Vol. II p. 593) stated that Torbanehill Mineral was worked out in 1862, R.W. Dron (The Coalfields of Scotland 1902 p. 196) recorded Torbanehill Gas Coal being mined in 1902 and implied that it was the same substance. Both Dron and R. Hunt (R. Hunt, ed. Ure's Dictionary of Arts, Manufactures and Mines 1878, 7th edn. Vol. I p. 409) described the substance as a cannel, whilst the Journal of Gas Lighting continued to record the market price of 'Boghead' until 1873.

In 1919 "Torbanite" was placed under the generic term "Cannel" (J.A. Green, ed. A Treatise on British Mineral Oil 1919, pp. 31, 41, 48,49). It was defined as an "algal coal", with specific chemical and physical characteristics, containing above twenty per cent of well-developed Kerogen globules. This usage has not been adopted in the present text (where the nineteenth century definition is employed) since "Torbanite" was expanded in 1919 to refer also to Wemyss Cannel, several other Scottish coals, Hoo Cannel in N. Staffordshire, and other deposits as at Autun in France, Kentucky 'shale' and New South Wales "shales". By the 1940s, Torbanite was defined as "a variety of cannel coal" vide W. Gardner and E.I. Cooke Chemical Synonyms and Trade Names (1948) Vide infra p. 1687

1. J.G.L. 10/1/1851

2. Kilmarnock gasworks obtained 14,300 to 15,800 cu ft per ton. A.W. Lyell, Torbanehill Case (1853) op. cit., p. 85

3. Kilmarnock and Dundee gasworks were unable to sell this coke even after mixing it with that from other coals. A.W. Lyell, Torbanehill Case (1853) op. cit., pp. 85, 187

4. Ibid. p. 190; J.G.L. 10/12/1850, 10/1/1851

5. James Russel senior, ironmaster and first town clerk of Falkirk, was a member of the legal firm Messrs Russel and Aitken. His son, James Russel junior, the sole partner in the coal firm by 1860, opened the second county branch of the Clydesdale Bank at Falkirk in 1839: J.M. Reid, The History of the Clydesdale Bank 1838-1938 (1938) p. 66; S.R.O. Bathgate Sheriff Small Debt Court (S.C.41/46/1) 11/4/1860 Case number 3.

6. Gillespie obtained a contract from Russel by threatening to supply Dundas Simpson, a gas manager instead. A.W. Lyell, Torbanehill Case (1853) op. cit., p. 229. Vide supra p. 42

7. e.g. Rothesay gasworks. Ibid. p. 184

of its value. Although James Young[1] (1811-1883) contracted for 10,000 tons of Torbanite in 1850, and continued to use large quantities for his mineral-oil works at Bathgate whence his 1850 patent (Pat. 13,292) prevented gasworks selling the valuable lubricating oil and paraffin oil or wax from Torbanite, most Torbanite was consumed by gasworks[2] until 1856.

Freight costs compared to the quantity and illuminating value of gas output per ton decreased as the quality of coal increased, and despite higher pithead prices for these coals they remained economical after transhipment throughout Scotland and even abroad. Gasworks located close to the coalfields used high quality enrichment coals mixed with low-grade local coals, but as distance increased from all coal supplies, an increasingly large proportion of best quality coal became the cheapest source of gas. Although collieries with best quality coals competed for markets throughout Scotland, the gas yield and quality of these coals, with the exception of Torbanite, was so closely similar that under conditions where there was no

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1. James Young (1811-83) studied chemistry in evening classes by T. Graham at Andersonian University; 1837 assisted Graham at University College, London; works manager to Messrs Muspratt at Newton le Willows (1839) and then to Messrs Tennant at Manchester (1844). On the suggestion of L. Playfair, opened a lubricating and illuminating oils business at Riddings Colliery, Derbyshire (1848-51). In January 1850 he received a sample of Torbanite from a former colleague, H. Bartholomew, manager of Glasgow C. and S. gasworks. At lower temperatures than those used in gas retorts, Torbanite produced large quantities of oils. With E. Meldrum and E.W. Binney, Young opened chemical works at Bathgate (1850, E.W. Binney and Co.) where he produced liquid and solid-wax paraffin from 1856; this became a major market by 1859. In 1865 opened his own, larger works at Addiewell. Fellow of the Royal Society (1873).
   J. Butt "James Young" (1963) op. cit., pp. 59-74; Dictionary of National Biography 1909 Vol. XXI p. 1292.

2. J. Butt "The Scottish Oil Mania of 1864-6" Scottish Journal of Political Economy 1965 Vol. 12

shortage to meet demand, transportation costs continued to produce zones in which a particular variety was more competitive than others. These zones were far less rigid than those imposed upon low and medium quality cannels like Lumphinnan, Bredisholm[1] and Bartons coal[2] in the 1850s, which were readily invaded if the local collieries relaxed their competitive position. Nevertheless in 1849[3] Edinburgh was supplied very largely from the Lothians and Fife, Glasgow from Lesmahagow, Kelvinside and Wilsontown, and Greenock from Monkland and Skaterig.

Dundee Old[4] gas company, with the largest works just beyond the north-east corner of the coalfield, in the late 1830s mixed poor quality Barrickness coal with almost the entire output of enrichment coal from Holback colliery near Inverkeithing in Fife. This was perhaps the closest supply of best-quality coals but Holback was approaching exhaustion by the mid 1840s. A new supply was found at Wemyss where a five-year contract was placed in 1843 at 10s 6d per ton for the rich coal which produced 10,000 cu ft per ton. Freight costs raised the price to 20s upon delivery, yet Dundee used about 2,000 tons a year, about half its total requirement. Although other coals could be delivered at Dundee far cheaper, including Lord Elgin's at 17s, and some coal as low as 13s from Wellwood colliery, the use of Wemyss

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1. Easy port access nevertheless led to the shipment of large quantities of medium quality Bredisholm to Irish gasworks in the 1850s.
   <u>Proceedings of the Philosophical Society of Glasgow</u> 1855-60 Vol. IV p. 297.

2. T.G. Barlow "The Comparative Value of Coals for the Manufacture of Gas" <u>J.G.L.</u> 10/4/1851 pp. 63-5

3. <u>J.G.L.</u> 10/2/1849 pp. 3-6

4. Evidence of James Russell, Dundee Old company manager. H. Commons 1846 Vol. 98 25/3/1846 pp. 29, 65, 66, 105, 108, 122.
   See also B.F.Duckham <u>Scottish Coal Industry</u> (1970) op cit p.229

coal to enrich those others was estimated in 1846 to be saving Dundee £1,000 per year. Indeed, as others appreciated the value of Wemyss coal its market price rose to 18s at the pithead by 1846.

Apart from Torbanite, Lesmahagow was the most widely used enrichment coal in Scotland. Aberdeen gasworks[1] in 1850 obtained it via the Forth and Clyde canal, to mix with other high quality[2] Lochgelly, Wemyss, and Capeldrae coals as well as those from Kinneil and Methil, and subsequently with Torbanite. By 1871 Aberdeen had reduced the proportion of first class coal to one-third, but still used much Lesmahagow for enrichment. Even some of the second class coal was being sent from Monkland, besides Fife. Freightage of Lesmahagow in 1871 was 3s 3d per ton to Glasgow, but 7s 6d to Aberdeen, whilst Cogan Hall coal was 2s to Glasgow but again 7s 6d to Aberdeen.[3]

Lesmahagow, shipped via Glasgow, was also dominant along the western seaboard as at Ayr. Stranraer[4] gasworks, in the south west, began in 1840 with samples of Lesmahagow, Dalquharrson, and English Wigan coals, but soon settled upon Ayr-coast furnace-coals, and Lesmahagow gas-coal shipped by P. Falconer of Glasgow. This was apparently already used for gas at Kirkcudbright, where enquiries were made to ensure that an equable price was being charged. Lesmahagow also served the far north west. James Ferguson began to send

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1. Aberdeen used Lesmahagow by the 1830s.
   Vide infra 'Consumer Relations'pp. 1125, 1135
2. A.W. Lyell, Torbanehill Case (1853) op. cit., p. 187
3. c.f. in 1881 Aberdeen paid 4s 1d per ton freight from ports along the Firth of Forth.
   J.G.L. 23/5/1871, 31/1/1882
4. S.R.O. Stranraer Minute Book op. cit. 31/8/40, 19/9/1840

supplies to Stornoway[1] gasworks about 1850, and retained that market despite a brief interlude in 1853-4 when eastern supplies were taken from J. Russel of Bathgate and from Wemyss Castle. In 1858 Ferguson received £143 from Stornoway company, which the following year contracted Mr McIver to ship Lesmahagow coals from Glasgow at 7s 3d per ton, roughly one-third extra on the Glasgow prices. Shipping charges were much higher in 1860, when Stornoway used seventy tons of Lesmahagow mixed with thirty tons of Bartonshill; tenders varied from 13s 6d to 15s 6d per ton for freight. Stornoway nevertheless relied mainly upon Lesmahagow supplies until about 1878 when a new mixture was introduced, copying that at Carlisle gasworks, with twenty per cent Lesmahagow and eighty per cent Newcastle Wallsend coal.

In the southern interior, Lesmahagow competed with Arniston and Newbattle coals which were of paramount importance along the south eastern seaboard. Galashiels gasworks in the 1840s relied almost entirely upon Mr Maxton's Arniston coals. These included about 350 tons in 1845, when the pit-head charge was 21s 8d, and overland carriage by a contractor 10s 7d per ton. In 1846-7 the coal rose to 24s and carriage to 11s 6d, and remained so in 1848 when 125 tons of Arniston was ordered. With a railway link in 1849, Galashiels retained allegience to Arniston despite the close competition from other eastern supplies, and for the first time also from Lesmahagow. In 1849 400 tons of Arniston (19s 6d) was taken in preference to Newbattle (20s) and Lochgelly (10s excluding carriage). Coalmasters, anxious to improve their competitive position, quoted prices f.o.b.

1. S.R.O. Stornoway Minute Book op. cit. 8/11/1850, 6/4/1854, 11/8/1860, 7/9/1877.

the local railway station, and undertook to organise intermediate transit. Galashiels in 1850 again took 400 tons Arniston (19s) despite offers from Newbattle (18s 10d), Auchinheath Lesmahagow (19s 2d), and Inverkeithing (12s 6d f.o.b. Edinburgh). The order was finally won by Newbattle in 1851, at 17s 6d delivered to the gasworks, compared with Arniston at 17s 6d to the railway station.

Later in the 1850s, Galashiels[1] frequently purchased Lesmahagow coals. The 200 tons ordered in 1853 cost 18s f.o.b. North British Railway Station in Edinburgh, plus 5s 8d extra carriage to Galashiels. In 1857, when the Galashiels manager persuaded his directors that its quality was "5s 4d per ton better than Arniston", Lesmahagow cost 26s per ton at the Caledonian station in Edinburgh, plus 1s 3d cartage to the North British station and 5s 8d freight to Galashiels, a total 32s 11d per ton.

Railway communications enabled other gasworks to gain similar advantages.* Hawick[2] gasworks from 1831 obtained coal overland from the Lothians, including Rigside and Mashock-Mill coals, but took advantage of the 1849 railway to test samples from twenty-eight English and Scottish pits. Thereafter, the principal supplies were of Arniston, Halbeath, Newcastle, Lesmahagow, Newbattle, and later Boghead coals. Selkirk gasworks was also restricted to a few types of very expensive coal until railways provided cheaper transport in the 1850s. In 1835, taking the advice of Galashiels gas company, Selkirk[3] paid 23s

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1. S.R.O. Galashiels Minute Book op. cit., 28/6/1853, 20/4/1857
2. R.E. Scott "The Story of the Hawick Gas Light Company" Transactions of Hawick Archaeological Society 1969 p. 26.
3. S.R.O. Selkirk Minute Book op. cit. 12/10/1835, 1/6/1842, 26/12/1855, 12/6/1873.

* See also the effect of lower rail-freight coal prices upon general trade at Paisley; infra p.957

per ton for Mophie gas coal, and 17s for Arniston furnace-coal; by 1842 seven coalmasters offered only three alternative coals, Melville (around 18s) Gardey (19s) and parrot (25s to 27s). In 1855 Selkirk placed an order with Mr Christie of Arniston, but in 1856 the railway allowed distant supplies to be taken for the first time from several collieries, including Torbanite, Newbattle and Kinneil as well as Arniston. Nevertheless, Arniston continued to send large quantities to Selkirk, including 550 tons in 1873.

Torbanite was the enrichment coal par excellance, and by 1854 was in use as such in gasworks as distant as Alsace, the Vosges and Switzerland.[1] From a location midway across central Scotland, it was widely used in both western and eastern Scotland. Glasgow obtained Lesmahagow at 16s 6d in 1850, but also took Torbanite at 15s, the same price as that paid at Edinburgh in the east.[2] Rothesay[3] gasworks on the Clyde used Torbanite extensively for some years; Kirkintilloch[4] used it mixed with Lesmahagow and Wilson's Muirkirk coal; and some small works like Montrose also used a large proportion of Torbanite by 1850.

The usefulness of enrichment coals was greatly increased by three factors in addition to better transportation:- consumers' complaints over gas quality and the threat of a rival gasworks; coal famines during which medium quality gas-coals rose excessively in price compared to third-class cannel which could be economically en-

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1. Dr Pernot "Report on Gas Lighting" (Societe Industrielle at Mulhouse) J.G.L. 10/1/1854
2. Cupar gasworks paid 15s per ton f.o.b. Edinburgh.
3. A.W. Lyell Torbanehill Case (1853) op. cit. pp. 185, 87
4. Ibid. p. 184

riched (despite higher best-coal prices); and new sources of cheap, low quality gas coals.

Paisley[1] in the late 1830s used about seventy per cent Skaterig coal and twenty per cent Kilburnie or other third-class coals, enriched by only ten per cent of Lesmahagow which was expensive because of thirty-one miles overland carriage via Glasgow, including two tolls and a pontage. When a competing company was threatened in 1843-4, the proportion of Lesmahagow and high quality Monkland coals was raised to twenty-five per cent each to improve the gas. (Appendix XII.5)

The large quantities of cheap coal purchased from Wilson and Company (of Hurlet?) in 1839-41 undoubtedly contributed to the dissatisfaction in Paisley, and this company's output also led to the demand for enrichment elsewhere.

The Vale of Leven[2] gasworks in 1851 took 100 tons of the Duke of Hamilton's Lesmahagow to enrich Messrs Wilson's coals, and following complaints in 1853 the directors also took thirty tons of Torbanite and ruled that "not less than one fourth of best coal be used at the works". Each ton of coal that year gave on average 7,645 cu ft gas, but this rate of output declined in the later 1850s because poorer coals (Table 3.111) were used in addition to the enrichment coal.

Besides J. Wilson's Bredisholm coal,[3] which was first sold to Paisley gasworks at 10s a ton in 1840 and in 1857 still cost only

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1. H. Lords 1844 Vol. 8 2/8/1844 pp. 58-78

2. S.R.O. Vale of Leven Minute Book <u>op</u>. <u>cit</u>., 6/6/1851, 9/6/1853, 15/8/1853.

3. S.R.O. Vale of Leven Minute Book <u>op</u>. <u>cit</u>., 31/8/1857

12s 6d on ship at Bowling,[1] a considerable variety of medium and low quality gas coals became available in most areas in the 1840s-60s.

Table 3.111 Lesmahagow Enrichment of Cheap, Local Coals - Vale of Leven 1856-9

Date	Coal	Tons	Average Gas per Ton (cu. ft.)	Gas Sold per Ton	Leakage %
1856	(Lesmahagow	100)			
	(Barclay and Co	250)	6,670	6,160	14.5
	(Bredisholm (J. Wilson)	300)			
	(Summerlee	50)			
1857	(Lesmahagow	125)			
	(Titwood Coal	125)	6,369	5,863	10.3
	(Bredisholm (J. Wilson)	150)			
1858	(Provanhall	150)			
	(Bartonhill	150)			
	(Bredisholm (J. Wilson)	150)	8,000	7,200	13
	(Tennant's Coal	100)			
	(Monkland Iron/Steel Co. Coal	100)			
1859	(Lesmahagow	150)			
	(Tennant's	150)	7,518	6,248	17
	(Wylies and Hills	150)			

SOURCE: S.R.O. Vale of Leven Minute Book *op. cit.*

N.B. Output figures taken from subsequent year.

In Ayrshire, Mr Biggart's Pearceton Colliery began to supply Dalry gasworks[2] in 1841, and the following year Mr Ramsay's Stevenston colliery and the Glengarnock Iron Company pits also sent samples to Dalry, as

1. John Wilson was one of three brothers who opened Wilsontown ironworks, Lanarkshire, in 1779; he was later a partner in J.B. Neilson's hot blast process, and a promoter of Tolcross Gas Company (1836). *Vide infra* p. 562
   A. Slaven, The Development of the West of Scotland: 1750-1960 (1975) pp. 115, 116.
   B.F. Duckham Scottish Coal Industry (1970) op. cit. p.185
2. S.R.O. Dalry Minute Book *op. cit.*, 19/9/1844

did Colonel Neill's Coalheughglen pits in 1844. In Lanarkshire a more intensive development of the iron industry, in the 1830s-40s, led to the sinking of iron-ore pits in which second-class gas coals were obtained, often within easy access of the Monkland Canal (1793) which increased their range of distribution. Ironmasters also played a major role in extending supplies of second-class gas coals in the east,[1] including the Kinneil collieries under G. Wilson and Company, pits around Bathgate by Shotts iron company, Elphinstone Tower colliery which began selling gas coal in the late 1850s under Messrs C. and A. Christie of Gladsmuir Ironworks, and an extension of the Grange Collieries by Henry Cadell[2] (1812-1888). The number of Fife[3] collieries grew considerably in the 1850s, whilst in the late 1860s Shotts Iron Company released large quantities of second-class gas coals from the Loanhead and Dryden areas. J. Hassan has also noted the increased gas coal output from Niddrie, Edmonstone and Woolmet collieries, leased to John Grieve from 1862, from Edgehead colliery under Joseph Whitfield from 1854, and from Elphinstone under Durie and Nisbet after 1862.

Bo'ness gasworks in the east used some of these supplies, including Cadell's coal (11s) and Wilson's coal (10s 6d) in 1848. Thus when average coal costs at Bo'ness rose to 20s in 1855, the company

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1. J.A. Hassan (Manchester) "The Gas Market and the Coal Industry in the Lothians in the Nineteenth Century", forthcoming article in Industrial Archaeology

2. The Cadell family purchased Grange estate in 1788; Hassan traced late-nineteenth century gas coal shipments from Grange to Aberdeen, Dundee, Perth, Forfar, Brechin and Montrose gasworks. Vide supra pp. 88, 432

3. W.H. Marwick, Economic Developments in Victorian Scotland (1936) p. 126.

delayed raising gas prices in the hope that a new railway to Bathgate would provide cheaper Torbanite and "admit of a considerable quantity of splint coal and Bastard parrot being used which will reduce the cost." In 1862 Bo'ness continued to use Torbanite (30s) and Balbardie coal (26s) to enrich a large proportion of local Kinneil coal (16s 6d) and splint (8s 2d). Incidentally, although Bo'ness gasworks sold gas to the Kinneil works, Wilson and his executors were expected to pay in cash, and the gas company protested strongly on the single occasion when they paid with coal[1] instead of cash.

High coal prices in Scotland occurred at roughly decennial intervals, often in coincidence with high cast-iron prices; within the trade cycle, booms in iron production created greater demand for coal and hence raised prices. The first major rise, in 1824-5, can only be inferred[2] since direct evidence is sparse[*]; nevertheless it may have stimulated the use of tar instead of coal as furnace fuel.[3] At Paisley,[4] Lesmahagow coal reputedly cost 22s per ton in 1826, compared with 21s in 1825 (the earliest extant record), and it fell to

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1. 103 tons (18s 10½d) in 1868
S.R.O. Bo'ness Minute Book op. cit. 5/10/1848, 11/6/1855, 5/6/1862, 26/6/1868

2. English iron rose from £7 to £14 per ton, partly as a result of high coal prices and high wages.
Mechanics Magazine 1824-5 Vol. 3 p. 414.
c.f. P. Mathias, The First Industrial Nation (1969) op. cit. p. 236

3. Vide supra pp.282, 298; also pp. 546, 438

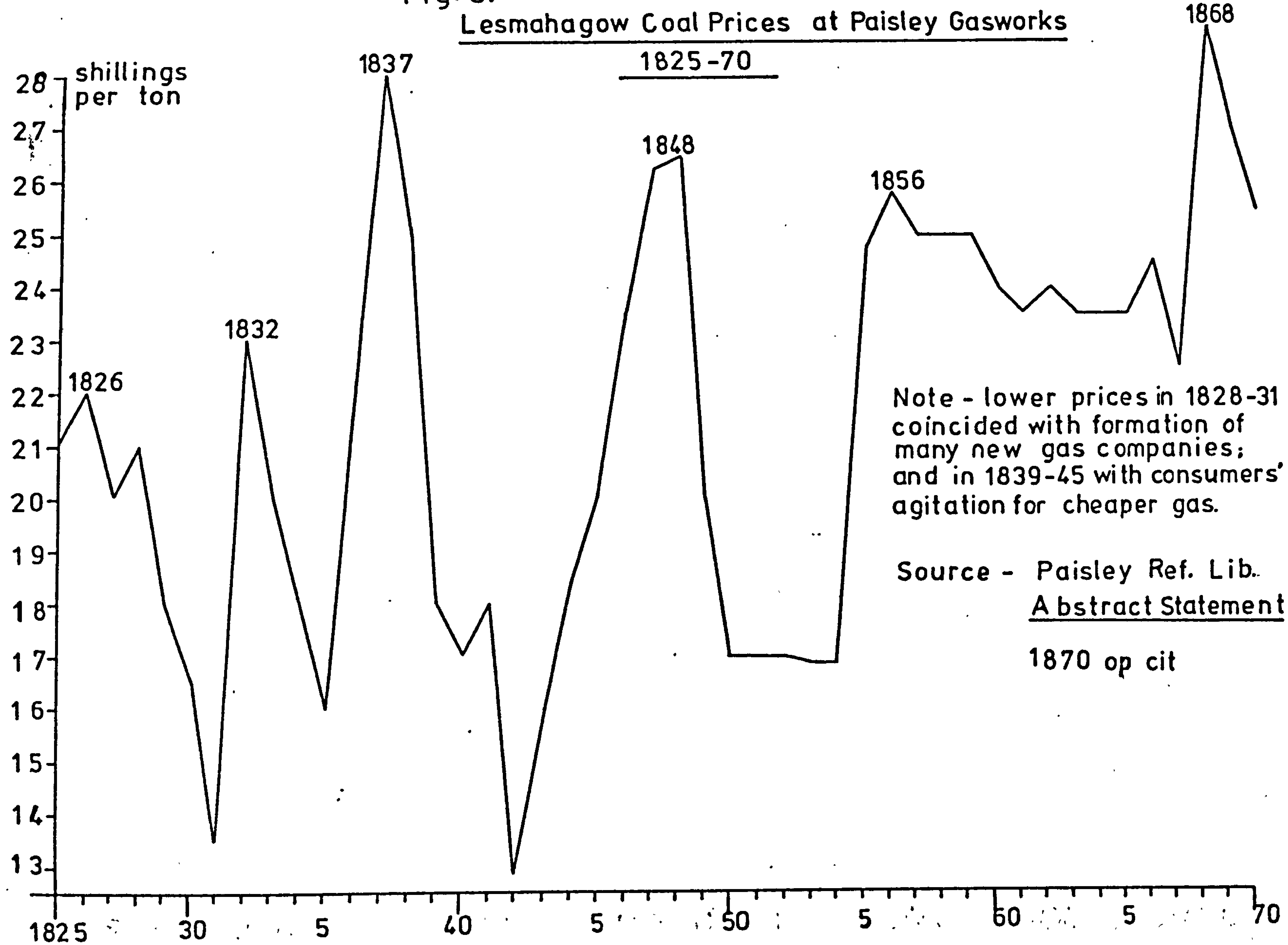
4. Paisley Ref. Lib. Abstract Statement of the Revenue and Expenditure of Paisley Gas Light Commissioners 1869-70 (1870, Paisley)
Note - 1826 was the first year in which exports to London may have contributed to a Scottish coal famine.
J.H. Clapham, An Economic History of Modern Briton - The Early Railway Age 1820-1850 (1950, Cambridge) p. 234

* Glasgow gas company in 1825 ascribed a reduction in profits to expensive coal and iron, and a great wastage of gas that year. Glasgow Mitchell Lib.(G.665.7*) 'Report of the Committee of Management' 1/6/1825. c.f. expensive industrial/domestic coal in Glasgow in 1825 recorded by the New Statistical Account(Glasgow): 1824 7/11d(cheapest), 1825 11/1d, 1826 9/7d, 1828 5/10d.

Fig. 3.112

Lesmahagow Coal Prices at Paisley Gasworks

1825-70

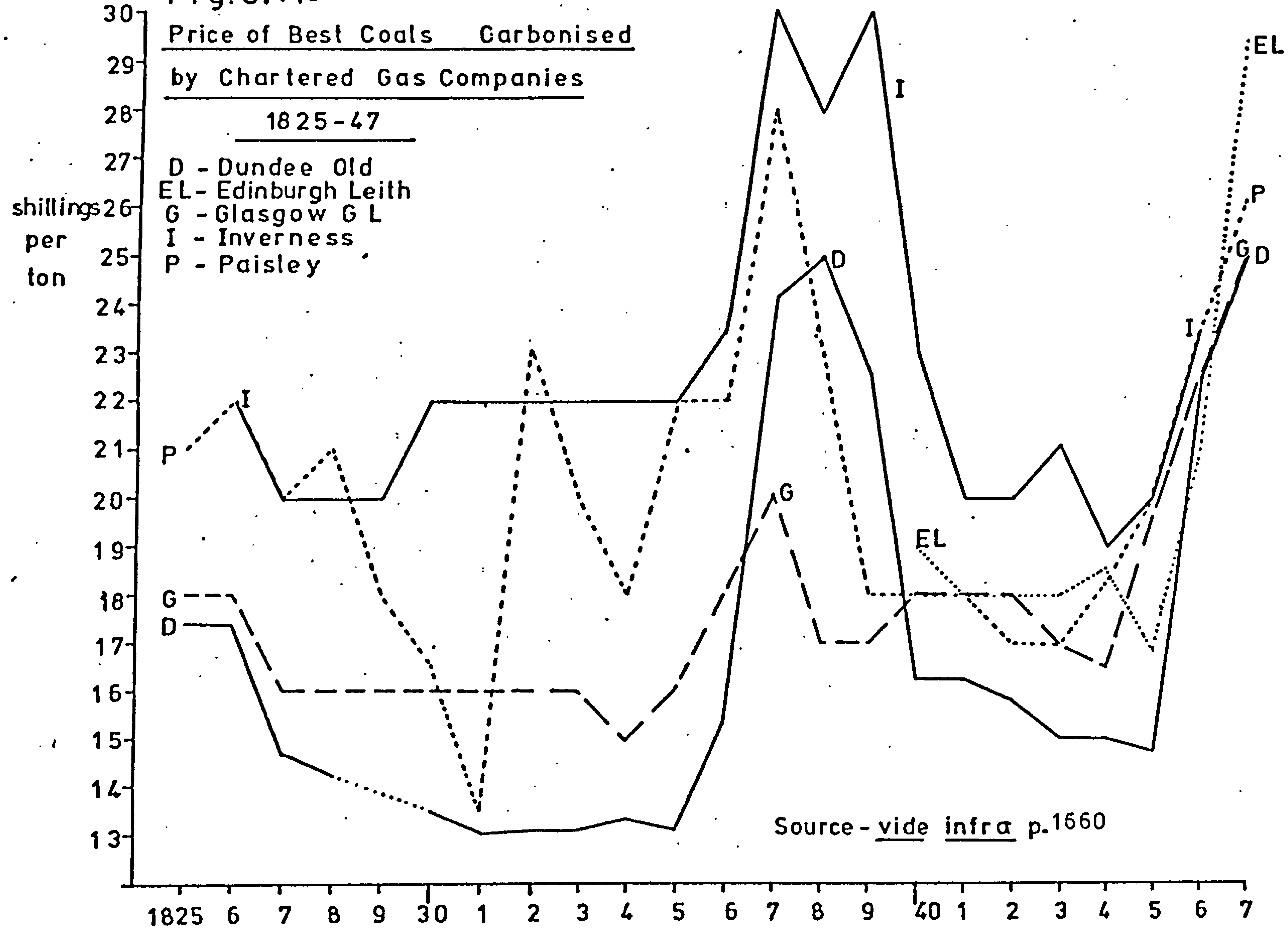


Note - lower prices in 1828-31 coincided with formation of many new gas companies; and in 1839-45 with consumers' agitation for cheaper gas.

Source - Paisley Ref. Lib. Abstract Statement 1870 op cit

Fig. 3.113

Price of Best Coals Carbonised by Chartered Gas Companies 1825-47



20s in 1827 and 13s 6d by 1831 (Fig. 3.121) The price was again high at Paisley in 1832-3 (23s and 20s), but figures are not available from other gasworks to verify that short peak.[1]

The national coal price rise of 1836-8 was the first for which detailed records have survived. Periods of high prices later recurred in 1844-8, 1854-7 and 1865-8. A quite exceptional peak arose in 1872-4, and was followed by less extravagant high prices in 1884-5, 1891-3, 1900-2 and 1907-8. A review of trends up to 1872, as reflected in Lesmahagow coal prices, and coals purchased by Chartered gas companies, appears in the following Figures (3.113 - 117)

The coal-famine of 1836-8 was a result of the general increase in consumption[2] by blast furnaces and steam ships, besides gasworks. It was more serious than any restriction of supplies in the 1820s, and in Edinburgh[3] coal prices reached their highest level for twenty years. At Paisley, Lesmahagow coal rose from 16s in 1835 to 28s in 1837. On the London coal market, Elgin Walls End[4] (Tyneside) cannel

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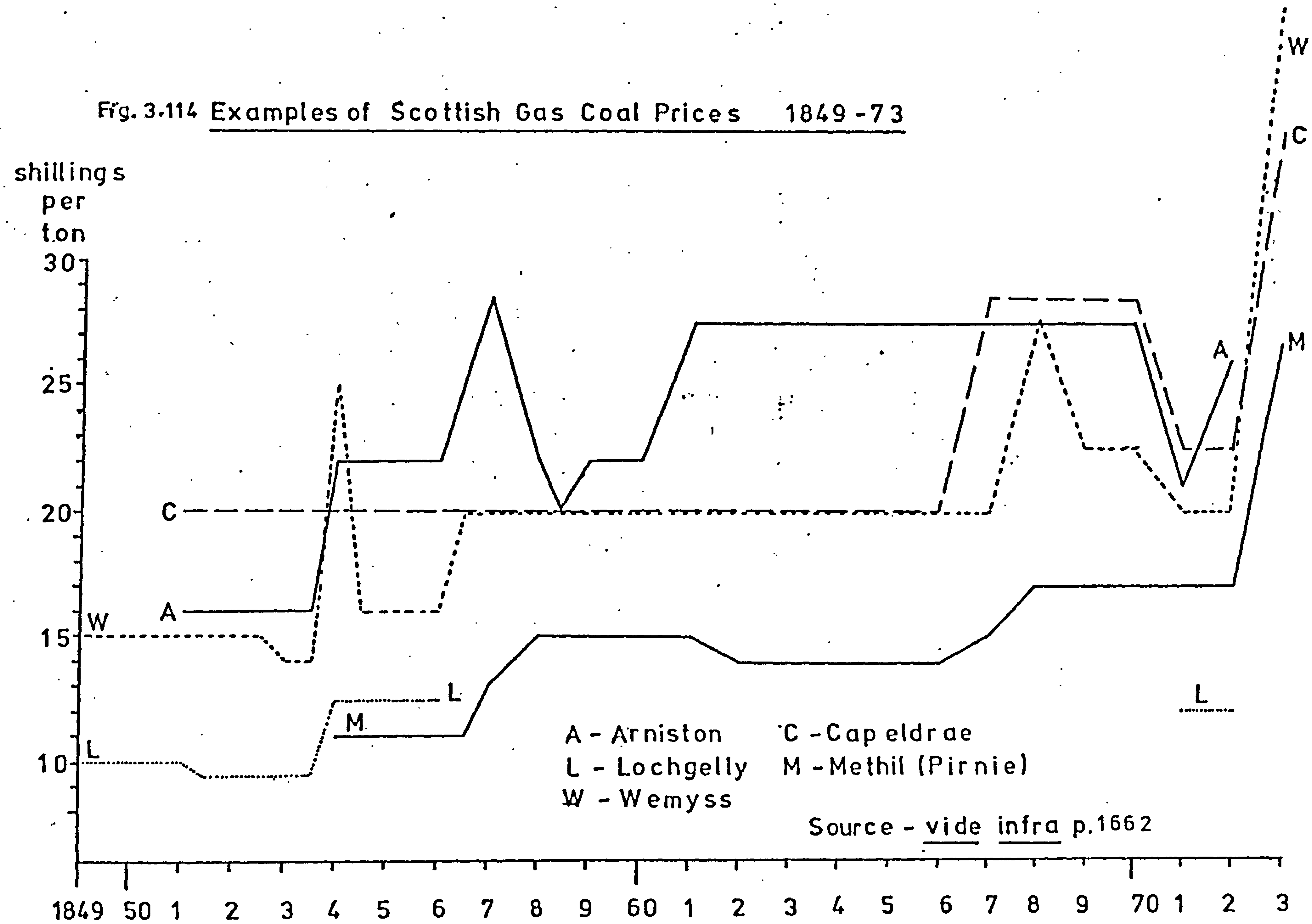
1. As in several other periods of coal shortages, however, this was a time of labour agitation among the colliers. After the repeal of the Combination Laws (1824), unions of colliers along the Tyne and Wear had been most active in seeking higher wages in 1825-6 when the Scottish miners were also successful in reducing the daily hours of labour below the 'darg'. In 1831 renewed strikes produced higher wages and shorter hours, until blacklegs were used to break a prolonged strike in N. England in 1832. In the winter of 1836-7 many miners reduced their working day by 33 per cent, until coal masters began to introduce blacklegs in April 1837, after coal prices had risen considerably. Labour unrest did not necessarily create the coal shortage, but did take advantage of (and thereby increased) such shortages, to improve the remuneration of colliers. R.L. Galloway, Annals of Coal Mining and The Coal Trade (1898, 1904) Vol. I pp. 464-8; Vol. II pp. 167, 169

2. W.H. Marwick, Economic Developments in Victorian Scotland (1936) p. 126.

3. J.A. Hassan "The Supply of Coal to Edinburgh, 1790-1850" Journal of Transport History 1972 Vol. 5 p. 140

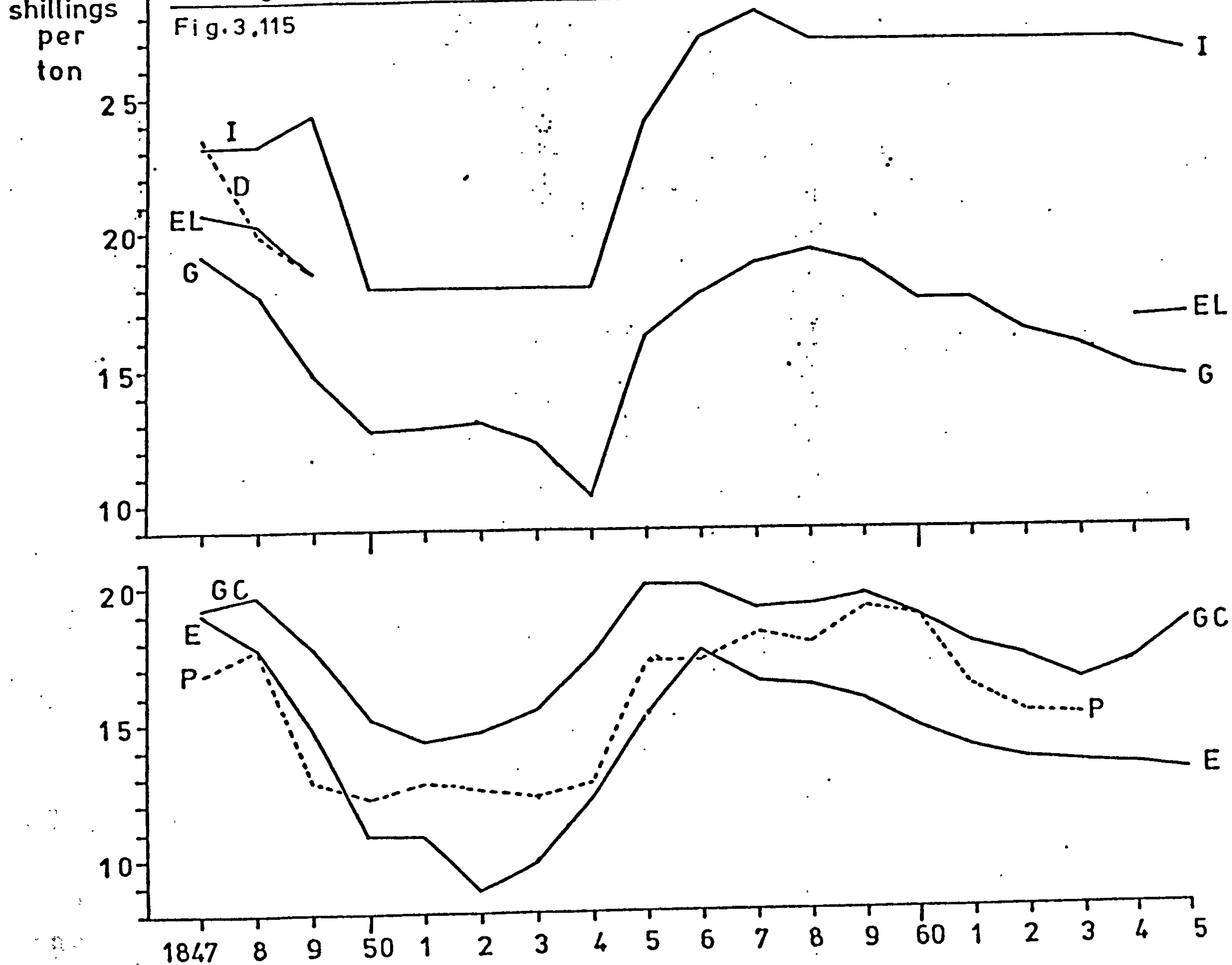
4. B.P.P. Select Committee on the Coal Trade (Port of London) Bill 1838 p. 62, Q. 1278-80

Fig. 3.114 Examples of Scottish Gas Coal Prices 1849-73



Average Prices of Coals Carbonised by Chartered Scottish Gas Companies 1847-65

Fig.3.115



D-Dundee Old
E-Edinburgh G.L.
EL-Edinburgh/Leith
G-Glasgow G.L.
GC-Glasgow C.&S.
I-Inverness
P-Paisley

Source - *vide infra* p.1661

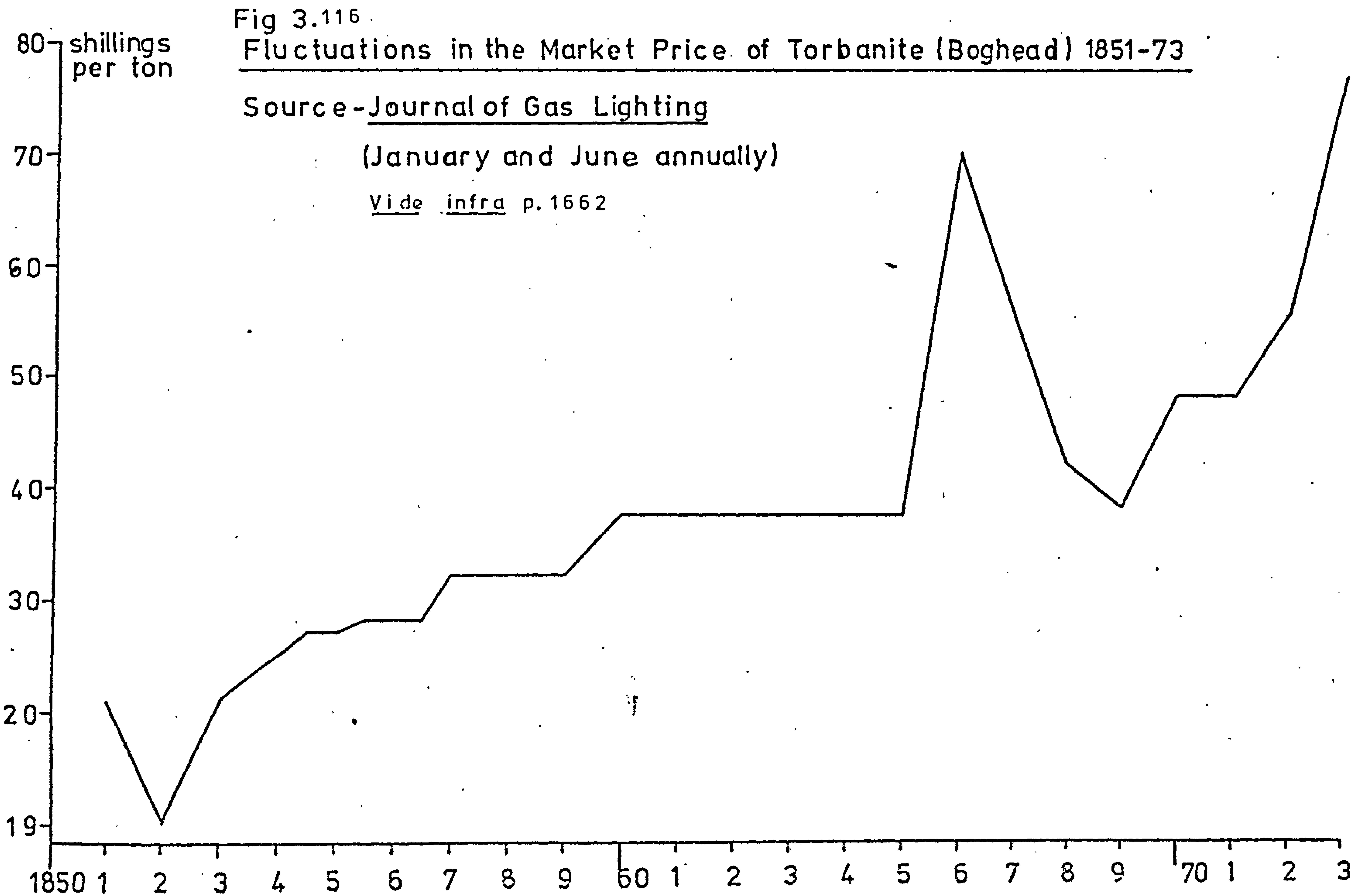


Fig 3.116
Fluctuations in the Market Price of Torbanite (Boghead) 1851-73

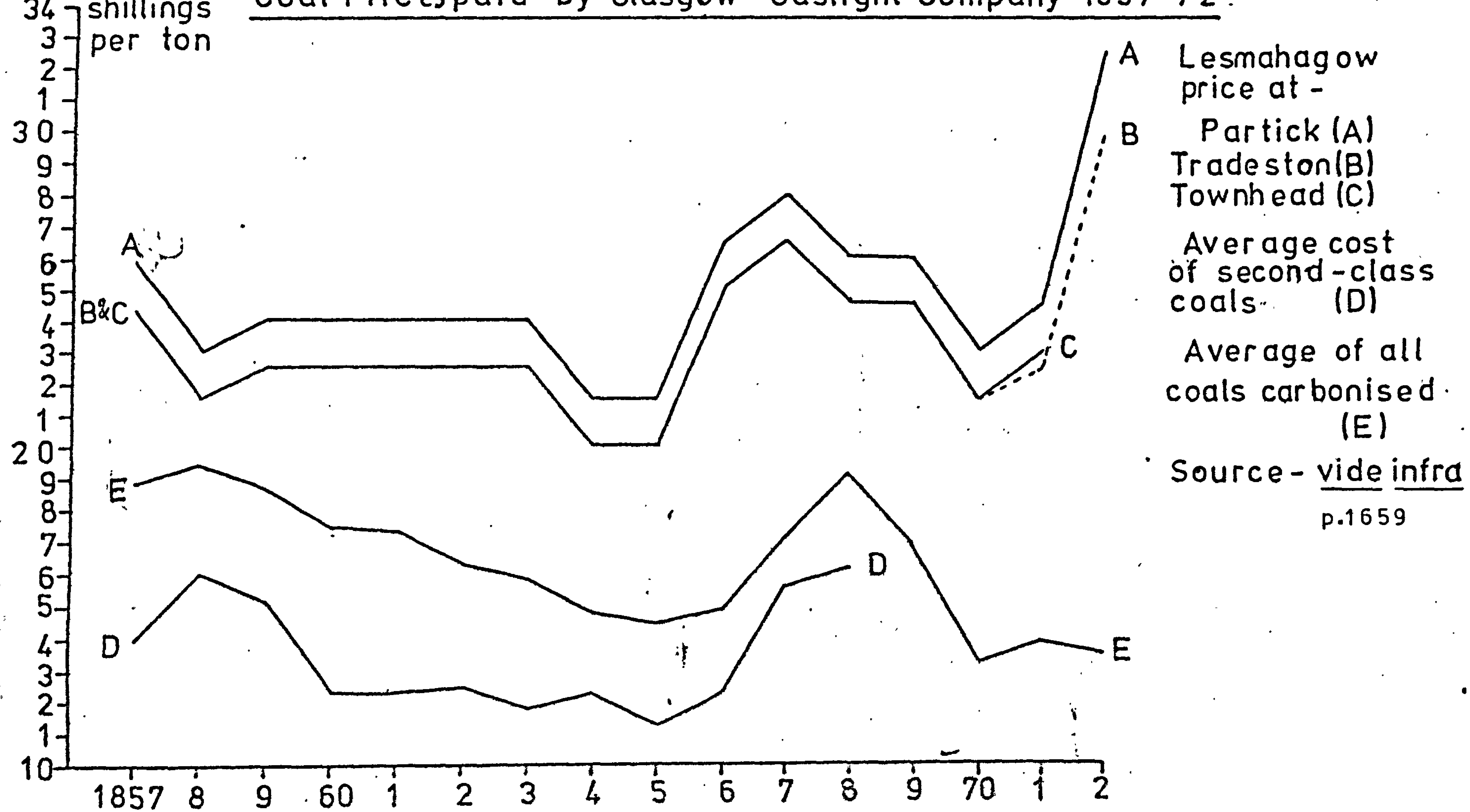
Source-*Journal of Gas Lighting*

(January and June annually)

Vide infra p. 1662

Fig. 3.117

Coal Pricespaid by Glasgow Gaslight Company 1857-72



rose from 9s in 1835 to 12s in 1837, whilst better cannels rose from about 15s to 20s. At Dalry[1] gasworks in Ayrshire total coal expenditure rose from £22 in 1835 to £56 in 1836, £75 in 1837 and £92 in 1838, before falling to £41 in 1839 and £67 in 1840. Despite possible variations in the quantity of annual purchases, this small company like others had to contend with a price rise of over 100 per cent.

The famine had two important long-term consequences. By hastening the adoption of tar-fired furnaces to save fuel coal expenditure it stimulated the adoption of cheap clay retorts[2] about 1838-9. Secondly, the high prices resulted in the promotion of a large number of new collieries both in Scotland and England. Unable to obtain best quality gas coals, gasworks purchased either large quantities of poor Scottish coals, as did Greenock[3] and Paisley,[4] or they imported poor gas coals directly from the English coalfields. The reduced quality of gas from coals used at this time may well have contributed to the dissatisfaction of consumers, as manifest in the Consumers Movement of the early 1840s.

Newbattle cannel in 1827 cost 13s per ton to Dalkeith[5] gasworks, and Aberdeen still obtained best cannel at this price in the mid 1830s. A severe scarcity of coal in 1836, however, forced Aberdeen[6] to import Wigan cannel at 36s per ton, though average prices fell to 28s by 1839. Dundee[7] had longer contracts for Scottish coals, but

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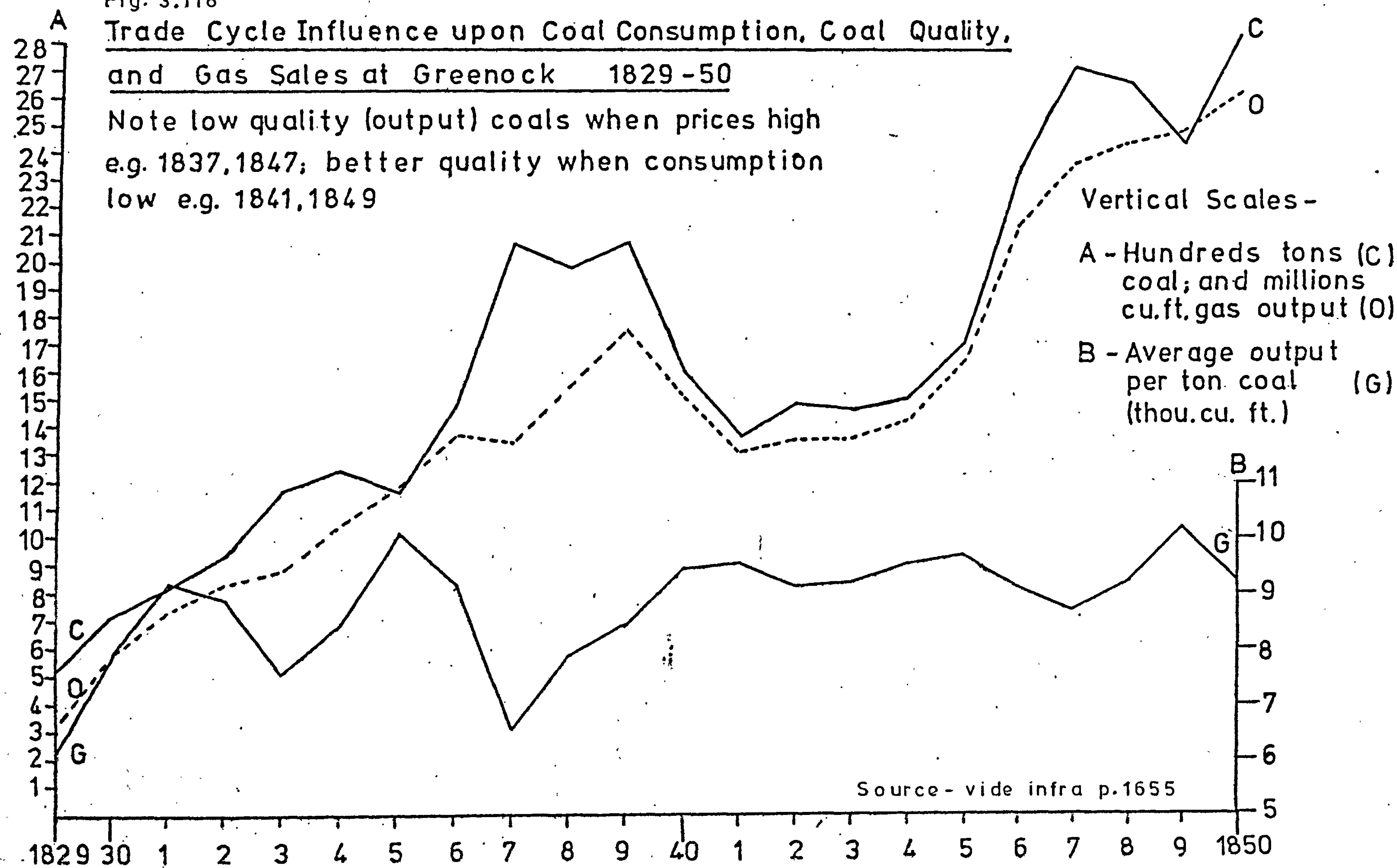
1. S.R.O. Dalry Minute Book _op. cit._
2. _Vide supra_ p.282
3. _Vide infra_ Appendix XII.4 p. 1655
4. _Vide infra_ Appendix XII.5
5. S.R.O. Dalkeith Minute Book _op. cit._
6. _New Statistical Account_ Vol. XII p. 78
7. Evidence of J. Russell, gas manager, H. Lords 1846 Vol. 98 25/3/1846, pp. 61, 108

Fig. 3.118

Trade Cycle Influence upon Coal Consumption, Coal Quality, and Gas Sales at Greenock 1829-50

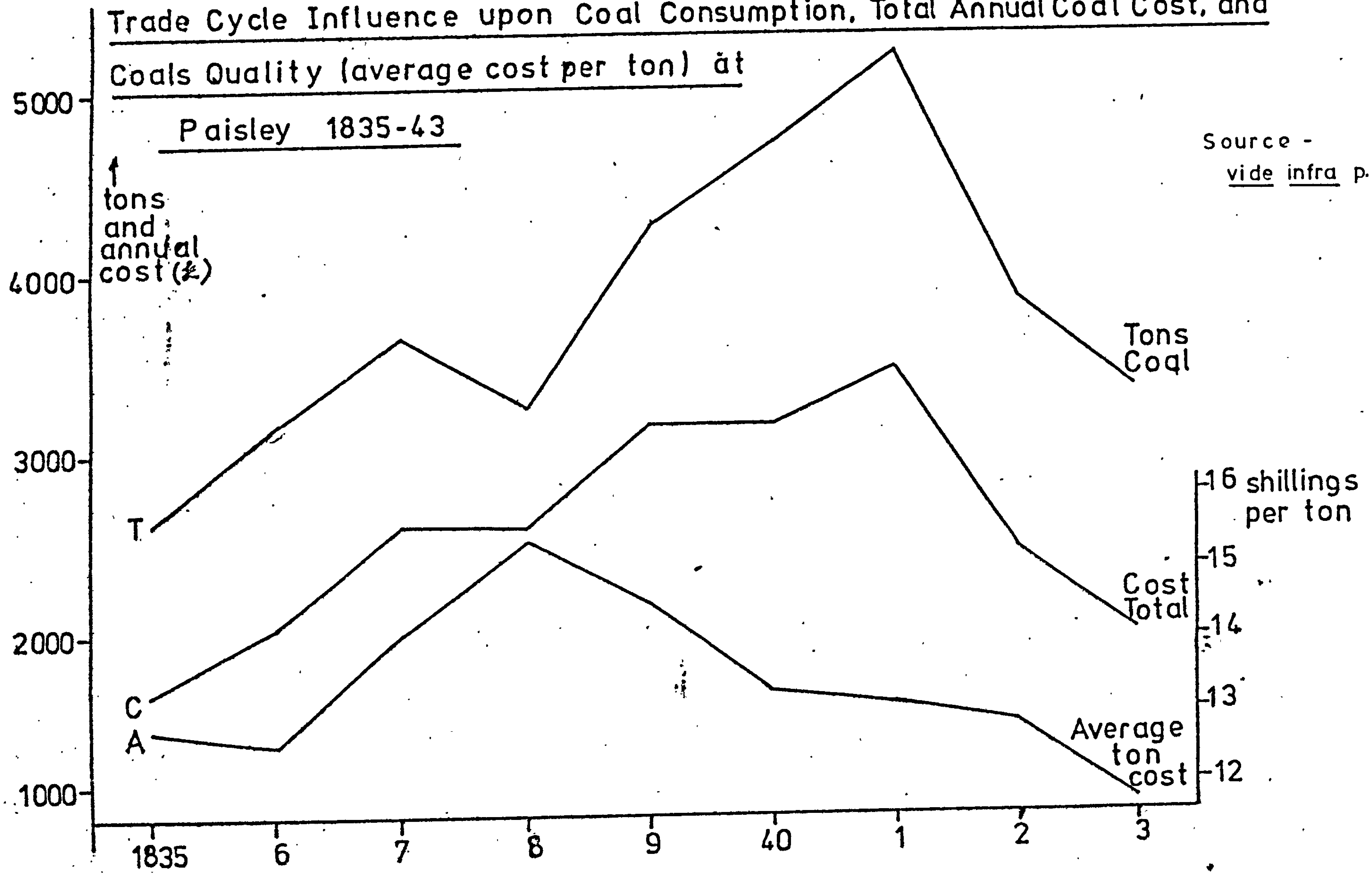
Note low quality (output) coals when prices high e.g. 1837, 1847; better quality when consumption low e.g. 1841, 1849



Source - vide infra p.1655

Fig. 3.119

Trade Cycle Influence upon Coal Consumption, Total Annual Coal Cost, and Coals Quality (average cost per ton) at Paisley 1835-43



Source - *vide infra* p. 1657

in view of the higher prices in 1837-8, English 'small coals' were purchased to carbonize for better coke, which could be used (like tar-fuel) to raise furnace heats in order to raise the gas output (at lower candlepower) from each ton of coal. Exports to Scottish gasworks were thus one cause for the "extraordinary activity"[1] on Tyneside in 1836-7 when individuals and companies opened many new pits for coking, gas and steam coals.

Coincidence of high coal costs, high labour costs, and a boom in output reflecting the regional or national economic boom, was evident at Greenock[2] gasworks both in the late 1830s and during the next peak of coal prices in the mid 1840s. At Greenock in 1835-7 coal expenditure rose from £747 to £1,697, and fell to £1,068 by 1841, whilst wages rose from £462 to £616, and fell to £373. Output reached a peak of 17.5 million cu ft in 1839, and declined to 13 million by 1841 (Appendix IX.4)

The next boom, according to R. Lamont[3] of Glasgow City and Suburban gasworks, commenced in 1844-5 due to the great demand for coal and labour in west central Scotland. The Duke of Hamilton's Lesmahagow coal rose from 15s 6d per ton in 1843-4, to 23s 3d the following year, but the use of alternative coals kept overall costs down for some time until the incipient boom diffused its influence through wider aspects of the economy.

Thus, total coal costs at Greenock did not rise dramatically

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1. P.M. Sweezy "Monopoly and Competition in the English Coal Trade 1550-1850" Harvard Economic Studies 1938 Vol. LXIII p. 122
2. J.G.L. 10/5/1851. Vide infra Figs 3.107-9
3. H. Commons 23/3/1846 p. 48

during the 1840s until 1846, perhaps two years after the English railway boom had commenced.[1] From a coal expenditure of £1,368 in 1845, Greenock faced a ninety-eight per cent rise to £2,707 by 1847, though by 1850 the total fell to £1,880; wages at the same dates were £351, £617, and £598; and gas consumption did not decline after the boom despite a rapid increase from 14.3 million cu ft in 1844 to 23.7 million by 1847.

A shortage of enrichment coals contributed to the high prices. In the east, Cupar[2] gasworks could only obtain irregular deliveries from Capeldrae colliery in 1842, after previously relying largely upon that source, and Newbattle had full order-books. By 1846 Cupar was obliged to purchase the bulk of its supplies, 200 tons, from Lesmahagow on the opposite side of the country. This cost 30s 6d delivered, including 22s 9d at the pit head, 1s coal dues, 4s freight to Guard Bridge and then 3s water carriage. In 1847, however, Cupar was able to obtain 300 tons of Arniston coals at 20s per ton. As on the previous occasion, high coal prices had by 1846 "led to the opening of a great many pits",[3] the output of which ensured that prices fell again.

Another coal famine[4] in 1854-6 was caused largely by inadequate supplies of best enrichment coals, and indicated the great importance of those coals. Exports of coal to England rose very

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1. S.G. Checkland, The Rise of Industrial Society in England 1815 - 1885 (1969) p. 36
2. Capeldrae cost 19s per ton in 1840. S.R.O. Cupar Minute Book op. cit.
3. Evidence of George Miller, chemical manufacturer in Glasgow H. Commons 1846 Vol. 102 11/5/1846 p. 168
4. Incorrectly dated as 1851-3 by G. Lunge, who claimed also wrongly that it resulted in widespread use of shale in Scottish gasworks. G. Lunge, Coal Tar (1882) op. cit., p. 12

rapidly in 1853-4 as a result of a great increase in gas consumption[1] at a time of high prices for natural oils and tallow for illumination. This increased the shortage - exports to London[2] alone rose from about 12,500 tons in 1853 to around 19,000 tons in 1855, including an increase of Torbanite from 5,700 to 10,700, of Methil from 1,200 to 3,500, and even of second-class Knightswood from 270 to 1,951 tons.[3]

By 1853, Arniston, Newbattle and Edgehead pits in the Lothians were believed to be approaching exhaustion.[4] Competition from Torbanite had depressed their gas-coal revenue in 1850-3, but the demand placed upon Torbanite in 1854-5 caused prices to rise alarmingly. At Haddington the delivery price of Torbanite was 20s in 1853 and 30s in 1854. Other enrichment coals rose at a similar rate. At Galashiels, Arniston cost 21s 3d in 1853 but 26s 8d in 1854, and Newbattle rose from 19s 6d in 1852 to 25s 10d in 1855 (Appendix XII.10) At Paisley, Lesmahagow rose from 16s 10d in 1854 to 24s 8d in 1855 and remained above that until 1859. Many coals fell in price after 1856-7, but a general rise in demand[5] for all coals kept prices above the early 1850s level until the early 1860s.

Three solutions were open to trial for reducing coal costs in the late 1850s. Distillation of peat was tried in some localities,

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1. J.G.L. 8/1/1856 p. 8
2. J.A. Hassan (Manchester) "The Gas Market and the Coal Industry in the Lothians in the Nineteenth Century", forthcoming article in Industrial Archaeology.
3. Several London companies raised gas prices by 6d in 1854, and coal prices there reached a peak of 38s in January before declining to 21s per ton by February 1854. J.G.L. 10/2/1854
4. Evidence of J. Robb, manager at Haddington. J.G.L. 10/7/1854 p. 477
5. J. Butt "James Young" (1963) op. cit., p. 114

but coal imports from England[1] provided a less adventuresome remedy which was widely adopted. It was a conservative, stop-gap solution which ignored many potential coal supplies within Scotland. Galashiels used Torbanite (28s) and Arniston (26s 8d) in 1854 to enrich large quantities of English coal (15s), but ceased to use English coal by 1860. Stornoway[2] in 1857 took eighty tons of Newcastle coal (19s) and fifty of Scottish splint (13s) to dilute eighty tons of Lesmahagow, but soon reverted to mainly Lesmahagow supplies.

Perspicatious managers devised a new strategy which was more widely adopted after later coal famines. Cupar gasworks, for example, had first experimented with new sources of second-class coals in 1850-3, enriched by Torbanite, in place of earlier reliance upon Capeldrae coals. Lochgelly Raith (9s 10d) was first used in 1851, and Russel's Wellwood Chews in 1853. In the late 1850s Lochgelly was used regularly, and a wide variety of poor new gas-coals were also used including Cowdenbeath (15s) and Cadell's Bridgeness (Grange) cannel (18s), Ladiddie in 1858-9, and Lumphinnans (12s 8d) in 1860. Mixtures of the new cheap coals were perhaps only economical at gasworks close to the coalfields in the 1850s, but when prices again rose steeply in 1865-6 (Table 3.120) and especially in 1872-4, this solution was very widely adopted. Newbattle pits were modernised in

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1. Only a few southern, coastal gasworks used English coals regularly e.g. Annan shipped gas coal from Carlisle and Runcorn from the early 1840s until the mid 1860s. S.R.O. Annan Minute Book op. cit., 10/2/1842, 15/12/1865

2. S.R.O. Stornoway Minute Book op. cit., 26/5/1857

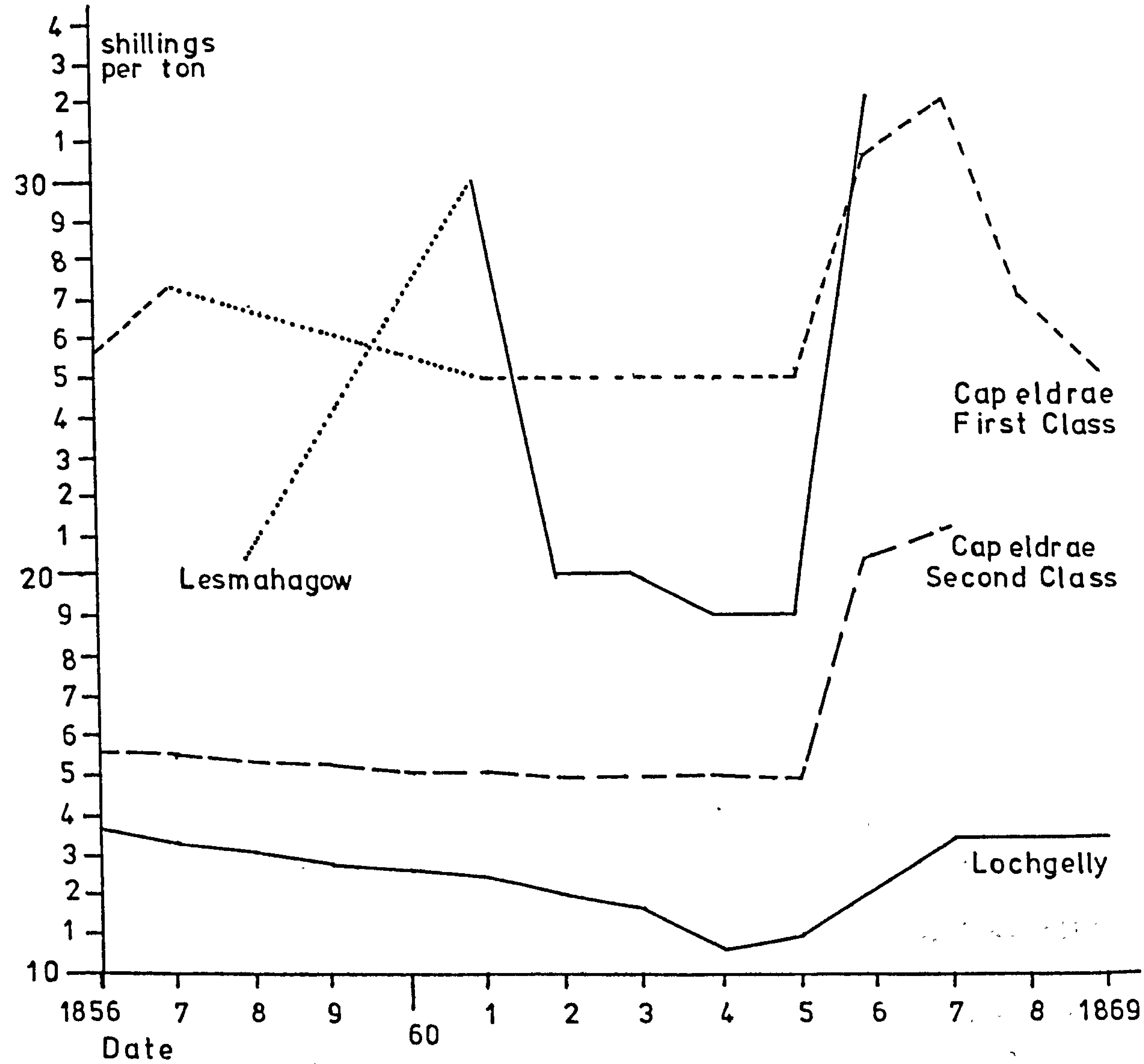
Table 3.120. The Coal Famine of 1865-8 : Coal Prices at Galashiels and Cupar

(1) Best Quality Coals used at Galashiels 1861-9 (Incomplete records)

	Arniston			Newbattle		
Date	Tons	Price s	d	Tons	Price s	d
1861	383	-		176	-	
1862	356	25	10	600	25	5
1863	400	23	4	600	23	9
1864	300	23	4	700	23	9
1865	600	23	4	200	24	2
1866	1,300	26	3	500	27	1
1867	1,000	28	8	400	29	2
1868	-	-		-	-	
1869	-	23	4	1,000	23	2
1870	-	22	2	1,400	22	1
1871	1,500	23	4	-	-	
1872	750	29	2	750	29	2

SOURCE: S.R.O. Galashiels Minute Book op. cit.

(2) Coal Prices at Cupar 1856-1869



SOURCE: S.R.O. Cupar Minute Book op.cit.

the 1850s by John Christie,[1] the new lessee (1850-74), and Lesmahagow[2] coal production rose from about 60,000 tons in 1857 to 80,000 by 1867. Consequently, prices fell again about 1859-61 and remained low until 1865-6.

Enrichment coals, despite their relatively small total quantity, were the cause of high gas-coal prices in 1866-8. A cabal of cannel coalmasters met in Glasgow[3] in November 1866 and agreed to raise coal prices by twenty-five per cent. They hoped to take advantage of the pending exhaustion of cannel seams, which observers[4] in 1865 believed would last under twenty years. They placed the immediate blame in 1867 upon London gasworks which purchased more Scottish cannel; prices certainly rose more rapidly than had been planned. Lesmahagow at Cupar gasworks in 1867 rose from 19s to 30s and ceased to be used there; at Paisley it rose from 22s 6d in 1867 to 29s in 1868. The high prices stimulated experiments with mineral-oil enrichment, as previously mentioned but coal price-fixing was soon undermined by new sources of enrichment coals. In 1867 oilworks[5]

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1. Assisted in 1868-74 by T. Coates, Paisley thread manufacturer. Christie apparently operated both Arniston and Newbattle pits in the 1850s-60s. J.A. Hassan, "The Gas Market and the Coal Industry in the Lothians in the Nineteenth Century", forthcoming article in Industrial Archaeology.

2. Ibid. quoting J.B. Greenshiels Annals of the Parish of Lesmahagow (1864, Edinburgh). Estimated 11,000 tons Lesmahagow output in 1837, and 24,000 tons in 1847.

3. J.G.L. 27/11/1866 p. 849.

4. In 1865, of the 14 million tons of gas-coal used in Britain only one million was believed to be cannel. J.G.L. 13/6/1865.

5. Several gas coals like Lesmahagow (78 gallons per ton), Methil (90) and Capeldrae (81) could be used for mineral-oil production. Oilworks in 1871 used 250,000 tons of cannel out of the entire British output of 1.4 million tons of cannel.
B.P.P. 1871 (c. 435-11) XVIII Royal Commission on Coal, Committee E. PP. 161-3.

began to release large quantities of rich Rochsoles[1] following the collapse of many oil firms[2] when the early 1860s boom was followed by intense American competition. At about the same time, second-class Lanemark cannel became available in Ayrshire.[3] At Catrine, a good new second-class coal termed Dalgain (20s) entered the market. Ayr[4] gasworks thus recorded a general fall in prices during 1868 - Muirkirk first class down from 23s 6d to 21s. Bartonholm (Eglinton Iron Co.) from 8s 6d to 7s 5d, and Lanemark (at 1,000 tons, the main coal used at Ayr) from 15s to 13s 6d.

A national economic boom[5] in the early 1870s produced an unprecedented increase in coal prices.[6] Most of the 100,000 tons of Torbanite[7] produced in 1871 was still used by oilworks; a further 400,000 tons of Scottish gas coal was being exported[8] annually by 1873 which increased the shortage since most of it was best quality cannel. At Galashiels (AppendixXII.10) Newbattle coal rose from

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1. The Artizan 1/8/1867 p. 191
2. J. Butt "The Scottish Oil Mania of 1864-6" Scottish Journal of Political Economy 1965 Vol. 12
3. Lanemark Coal Co. commenced 1865, organised by R. Brown and Wm. Hislop, whose father J. Hislop organised the vital railway branch line to Creoch in 1865 whereby the Lanemark and South Boig coals could be marketed.
   J.L. Carvel and J.C. George, The New Cumnock Coalfield (1946) pp. 23-6; P.L. Payne, ed., Studies in Scottish Business History (1967) p. 267.
4. S.R.O., Ayr Minute Book op. cit., 1/7/1868
5. S.G. Checkland, The Rise of Industrial Society in England 1815-1885 (1969) pp. 49-51, 164
6. Vide A.J. Taylor "British Coal Prices 1854 to 1913" Economic History Review 1961-2 Vol. XIV
7. Evidence of Mr Binney B.P.P. 1871 (c.435-11) XVIII Royal Commission on Coal, Committee E. p. 163
8. Evidence of R. Moore, Mines Inspector for East Scotland B.P.P. 1873 Select Committee on Coal Appendix p. 318

23s 4d in 1871 to 45s 6d in 1873, and over the same period at Cupar (Appendix XII.10) Capeldrae first-class rose from 25s 1d to 50s 6d, Lochgelly from 13s 6d to 24s, Lumphinnans from 12s 6d to 28s 6d, and Elgin/Wellwood from 9s 7d to 15s 6d. A similar rate of increase was registered in the west at Kilmarnock gasworks (Table 3.121)

Table 3.121 Coal Prices at Kilmarnock Gasworks (1861 - 74)

Coal	Average 1861-7		Average 1867-72		1873		1874	
Lesmahagow	25s	6d	28s	-	36s	6d	45s	-
Muirkirk I	15	-	20	-	26	6	42	6d
Muirkirk II	11	-	15	-	-		36	6
Lanemark	10	3	12	6d	20	6	30	-
Pathead	8	-	9	-	16	6	-	
Splints	5	6	-		-		18	-
Bartonholm	7	-	-		-		18	6

SOURCE: J.G.L. 20/10/1874

After 1873 Scottish gasworks for the first time began to use more second-class and third-class coals than best enrichment cannel. Selkirk gasworks[1] had relied largely upon Newbattle cannel but when the price of that reached 40s 7d in 1874, an equal quantity of poorer coals (e.g. Clydesdale and Auchlochan) was used to reduce the average to 31s 8d. By 1896, Selkirk used the same amount of Newbattle (500 tons) at 22s 2d, but had met the increased demand for gas entirely through poorer coals, 1,100 tons at 12s to 15s 8d per ton.

'Shale' or third-class coal, became the focus of attention for many managers in the 1870s-80s. Galashiels (Appendix XII.10) experimented with 200 tons of Benhar shale[2] in 1874, and regularly used

1. Vide infra Appendix XII.11

2. Benhar colliery vide W.H. Marwick, Economic Developments in Victorian Scotland (1936) p. 57
'Shale' was first mined commercially in about 1858-61 as raw material for oil works in Scotland e.g. by Robert Bell, coal and iron master of Wishaw. The Oil Shales of the Lothians (1927) 3rd Edn. Memoirs of the Geological Survey - Scotland p. 245

over 1,000 tons of shale[1] a year from 1880-91, with half as much again in 1882, 1884 and 1885, and 3,000 tons in the coal crisis of 1890. Although W. Foulis[2] refused to use shale at Glasgow gasworks after experiments in 1873 proved the gas to be of low quality, and naphthalene condensation as crystals blocked pipes in winter, others contested the view that condensation caused excessive loss of this gas. G. Hislop at Paisley carbonized mixed coals with twenty-five per cent shale in 1883-6, Dumbarton used eight per cent whilst Coatbridge[3] used fifty per cent. The Coatbridge works were stated to be unviable without shale, and blamed their seventeen per cent leakage on mining subsidence.

The use of shale and poor cannels prevented any serious coal famine through the relatively long period 1873 to 1890, and circumvented the incipient price-rise which appeared[4] in 1884-5. This was a very considerable achievement, since candlepower was not widely reduced until the 1890s, and best quality coal supplies were finally and unambiguously becoming exhausted. It was achieved partly by improved retort technology, and especially by the optimal temperatures achieved with regenerative settings in the 1880s, which were themselves inspired by the coal problem. The second factor was an abundance of

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1. Varieties of shale for Galashiels included Faskin Bonnet in 1887, Hartwoodhill (Benhar Co.) in 1878-80, 1882 and (10s 10d) 1888, Johnstone in 1888, Greenhill and West Longrigg (12s 6d) in 1890, Denboig in 1896 and Meiredge in 1900.

2. Gas World 24/7/1886 p. 110. 3. Ibid.

4. This price rise led to the formation of the Boghead Gas Coal company, in Glasgow early in 1885; and renewed explorations by James and William Wood's Bathville collieries.

J. Mayer "New Discovery of Rich Cannel Coal near Bathgate", Proceedings of the Royal Philosophical Society of Glasgow 1885-6 Vol. XVII cheap poor coals, as a result of a national decline in economic growth, and low miners' wages. In 1877 coalmasters were trying to export large quantities of second-class cannel to Holland,[1] in order to raise prices in Scotland. Rothesay[2] in that year used second-class Shieldmuir coal in two retorts and Glengarnock in ten retorts, enriched by Lesmahagow carbonized in only two retorts. Although some gasworks regularly purchased specific varieties of poor coals, like Ferniegair (1880-1900) and Allanshaw (1888-1900) at Galashiels gasworks, a rapid increase in the varieties[3] of coal carbonized occurred on a national scale throughout the 1890s.

High coal prices in 1891-3 were caused by external factors and not a failure of the new method of reducing coal expenditure. National labour agitation in 1889 resulted in higher miners' wages[4] in 1890-1, followed by a coal-famine[5] when the colliers took strike action in 1893-4 in an unsuccessful bid to retain those wage levels. Ayr gasworks recorded that in 1889-92 Muirkirk second-class cannel rose from 15s 6d to 24s 6d, Lanemark from 14s to 18s, and Bartonholm (Kilwinning) from 7s to 11s 6d. In the same period at Galashiels gasworks Allanshaw third-class coal rose from 12s to 18s, and even shale increased from 11s 3d to 17s. At Cupar gasworks, Niddrie

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1. J.G.L. 26/6/1877 p. 1056
2. J.G.L. 20/11/1877
3. Vide infra Appendix XII.10
4. H. Bumby "Iron and Steel in the West of Scotland" Journal of the Iron and Steel Institute 1901
5. An upswing in national prosperity from 1888-90 had already caused a coal shortage relative to demand, which contemporaries expected to reach the same levels as in 1872-3.
   J.H.Clapham, An Economic History of Modern Britain - Machines and National Rivalries (1887-1914) (1951, Cambridge) pp. 7, 13

Fig. 3.122

MAP OF COAL CARBONIZED 1891

Hundreds tons

Illustrating the Scale of Various Gasworks' Operations.

Source - vide infra p.1679

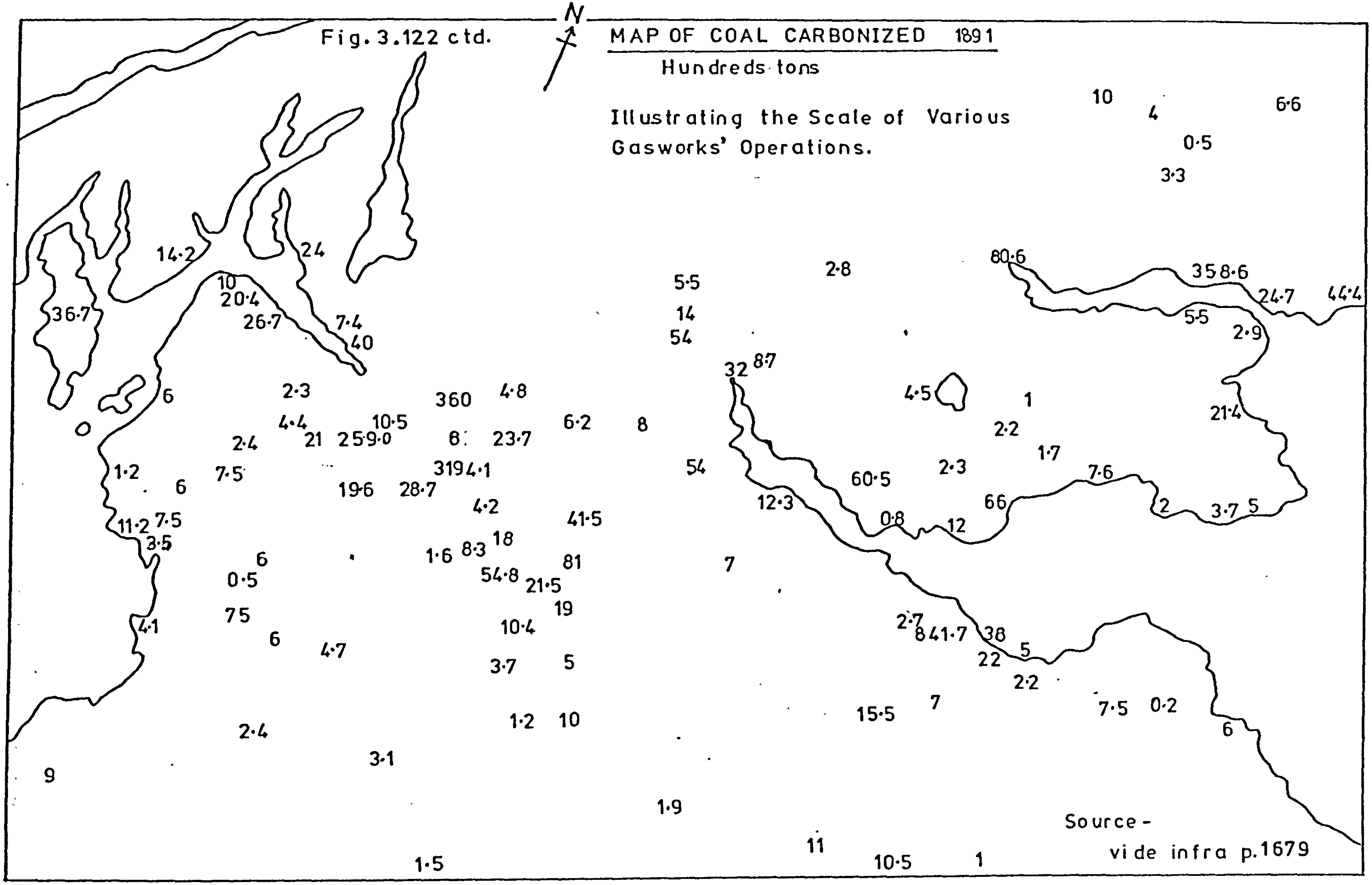

Fig. 3.122 ctd.

MAP OF COAL CARBONIZED 1891

Hundreds tons

Illustrating the Scale of Various Gasworks' Operations.

Source - vide infra p.1679

first-class cannel rose from 19s 6d in 1889 to 33s 3d in 1891.

The newly apparent anarchy in coal supplies encouraged several works, like Galashiels, to invest in the 'Peebles' system and similar forms of oil-gas enrichment, or in water-gas equipment as previously described. Other gasworks simply extended their sources of coal supply, like Ayr which during the crisis began to use Eglinton Park, Rosehall, Bellfield and Markinch coals, and soon adopted large quantities of splint on a regular basis.

Peat-gas was another possibility explored seriously during the 1890s. A. Cook.[1] at Paisley gasworks had used a mixture of tar and peat, carbonized with coal, from June 1842 to March 1843 but abandoned it because tar blocked the gas pipes. Stornoway[2] gasworks with easy access to peat, later made some important experiments, both in 1847 and in 1873-5 when Henry Cauter of Stornoway Paraffin Works[*] tried to develop a gasification process copied from an installation at McBrayne's residence, Nitts Hill near Glasgow. These trials were unsuccessful, but in 1893 Edinburgh and Leith Gas Commissioners[3] financed the first large-scale experiments in Scotland. Peat was obtained from Penicuik, Leadburn, and of a far better quality from Orkney, but the carbonization proved uneconomical. Because graphite particles did not form, to seal the pores in fireclay retorts, expensive iron-retorts were necessary which reduced the temperature that could be used for distillation and

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1. Evidence A. Cook. . H. Lords 1844 Vol. 8 2/8/1844 pp. 77-8
2. S.R.O. Stornoway Minute Book op. cit., 5/11/1847, 9/12/1873, 9/7/1875.
3. Gas World 25/11/1893

* Vide B.H.Paul "On the Manufacture of Hydrocarbon Oils, Paraffin, etc. from Peat" British Association Handbook (1862) Cambridge Part II p.50

Fig. 3.123

AVERAGE COAL COST PER TON 1911

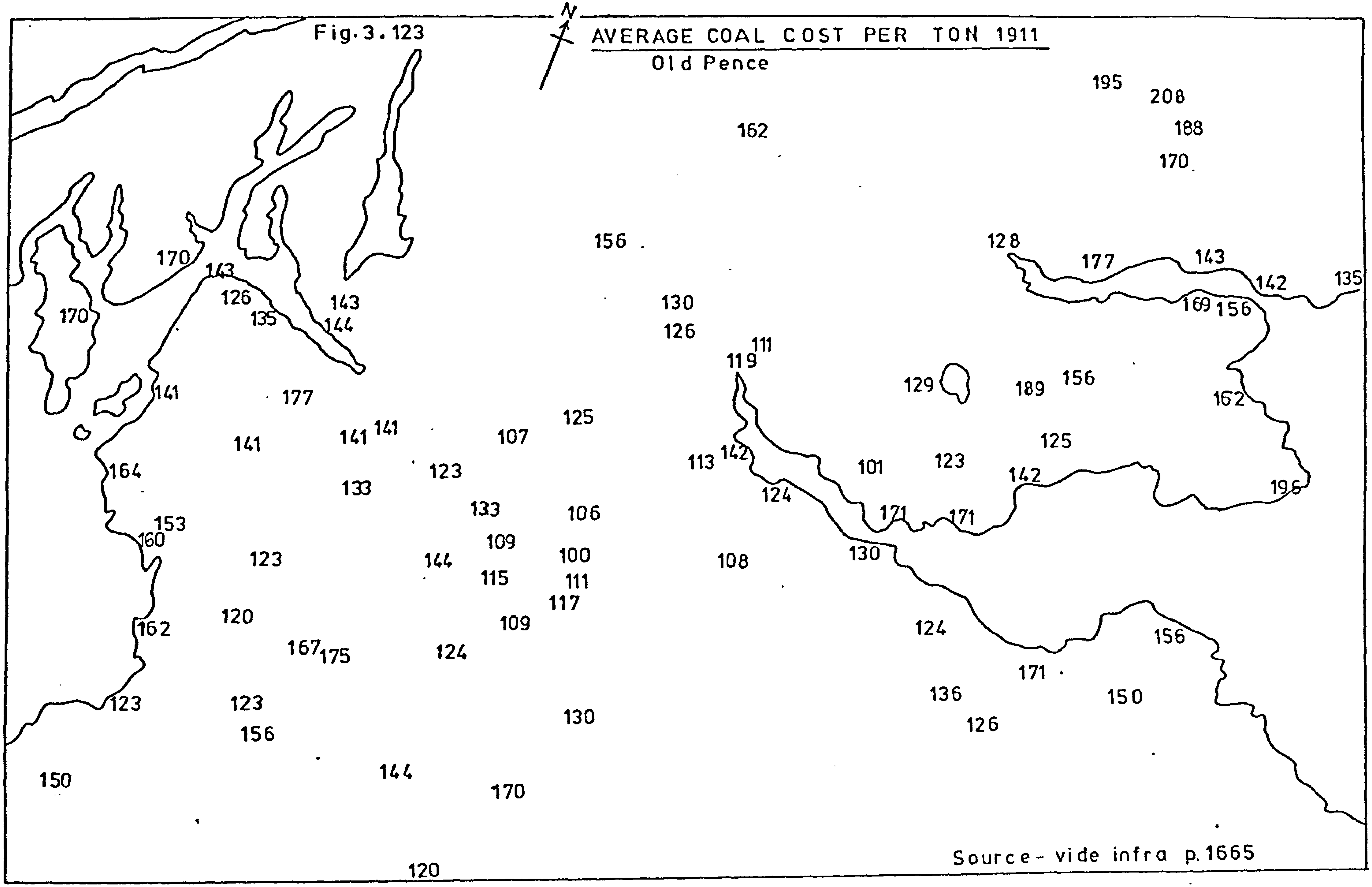
(Old Pence)

Source - vide infra p. 1665

Fig. 3.123

AVERAGE COAL COST PER TON 1911

Old Pence



Source - vide infra p.1665

consequently output was too low, whilst purification of the gas also proved expensive.

Coking coal was a more satisfactory alternative, and became the centre of attention by the mid 1890s. As the market for gas as fuel expanded, and incandescent mantles made this gas also suitable for illumination, candlepower was reduced and best-quality cannel became far less significant. Nevertheless, all coal prices rose very sharply in 1900-2.

Ayr gasworks used no first-class cannel in 1900, but recorded a rise of price amongst other coals, including Whitehill cannel from 15s 9d to 22s, Lanemark from 15s to 17s 6d, Cadzow from 14s 9d to 20s 11d. Apart from a minor rise[1] in 1907-8, this was the last significant rise in coal prices before 1914. It resulted in a growing emphasis upon the value of coke-sales, (Table 3.133), and other by-products, and led a growing number of companies to use benzol instead of cannel for enrichment. This change in emphasis resulted in the decline of several well-known cannel collieries which were unable to command prices adequate to meet their overheads. Lanemark[2] colliery, for example, despite a successful new pit in 1895 was forced to close its gas-coal operations in 1908. The long-term importance of by-product revenue in offsetting prime coal expenditure is examined in the next section.

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1. e.g. average coal costs at Banff rose from 18s 6d in 1906 to 23s 6d in 1908; at Bridge of Weir the rise was 12s 7d to 14s 9d. Many gasworks, however, avoided any rise at all in average costs. C.W. Hastings, Gas and Water Works Statistics (1906, 1907, 1908).

2. J.L. Carvel and J.C. George, The New Cumnock Coalfield (1946) op. cit., p. 29

Table 3.124 Adoption of Better Coking Coals 1891 - 1911

Town	1891 s	1891 d	1901 s	1901 d	1911 s	1911 d
			Coke Revenue per Ton			
Alva	5	-	10	6	10	-
Bathgate	5	-	8	4	9	2
Bothwell	5	10	18	-	10	9
Bridge of Allan	6	8	10	-	10	-
Coatbridge	5	-	7s to 12s		9	-
Dumbarton	6	-	6s 8d to 10s		8s 4d to 10s	
Dunfermline	4	-	10	-	10	6
Greenock	4	7	7	9	9	10
Hamilton	5	-	7	11	9	3
Inverness	7	-	13	-	9	6
Irvine	5	-	6s 8d to 8s 4d		8s 6d to 9s 6d	
Kinross	5	-	10	-	10	-
Lanark	5	-	10	-	8s 4d to 10s	
N. Berwick	2	6	6	8	9	2
Paisley	5	6	7	6	10	2
Peebles	8	4	11	8	10	-
Penicuik	6	8	10	-	10	-
Perth	7	6	9	0	9	10.6
Renfrew	4	0	10	0	9	1
Saltcoats	3	6	10	-	-	
Stevenston	3	6	10	-	10	-
Tranent	2	6	10	-	12	-
Whitburn	5	-	6	8	9	-

SOURCE: C.W. Hastings, Gas and Water Works Statistics (annual)

(ii) By-Products

Three types of 'residuals' remained after the distillation of coal. The solids were coke raked from the retorts, ash from the furnaces, and spent iron-oxide from the purifiers; liquids comprised tar, 'coal-oil' and ammoniacal 'liquor', which left the coal as vapours before re-condensing; and finally a noxious, semi-liquid paste termed "Blue Billy" consisting of wet lime in which impurities like hydrogen sulphide had been captured from the coal gas. Early gas company promoters, like F.A. Winsor[1] in 1804, had high hopes of considerable revenue from some of these chemicals, especially since industrialists like Dundonald profited from their production without selling any illuminating gas.

Archibald Cochrane, ninth Earl of Dundonald,[2] distilled coal for the sale of both coke and tar-chemicals from 1781, and his patent was extended until 1806. Vapours driven off the coal[3] were condensed to a liquid which was piped to a 'still' and there re-distilled or 'rectified' into several constituent mixtures of chemicals. Details of this are vague, but the products commenced with "volatile alkali"[4]

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1. A. and N.L. Clow, The Chemical Revolution (1952) p. 418

2. Vide supra p.11

3. e.g. at Dundonald's Upper Cranston tar-works in the 1790s, and at Muirkirk. A. and N.L. Clow, The Chemical Revolution (1952) p. 399; J. Butt and J.R. Hume "Muirkirk 1786-1802: The Creation of a Scottish Industrial Community" Scottish History Review 1966 Vol. XLV.
   Dundonald's internally fired coke oven of 1781 at Culross was copied by M.B. Faujas de St. Fond at Paris in 1785, from which a diagram appears in The History of Coke Making and of the Coke Oven Managers' Association (1936) p. 38

4. Definition of terms used in early chemical technology vide W. Gardner and E.I. Cooke, Chemical Synonyms and Trade Names (1948)

(ammoniacal liquor) which was syphoned off the top of other liquids, some being sold as hartshorne (ammonia, NH_3), some sold to James Hulton+ who manufactured sal-ammoniac (ammonium chloride, NH_4Cl) in Edinburgh, and some made into sal-ammoniac by Dundonald himself. This ammonium chloride was sold to artisans for use in 'tinning' cast-iron culinary utensils, and brass or copper goods. Dundonald's next product was a light "oil" used as a sheep-dip against maggots, or mixed with another distillate termed 'Rosin' to varnish ships' decks and spars (a form of creosote). Finally the boiled tar was sold as anti-corrosion varnish for iron, from railings to ships' fittings and ordnance; and to preserve cart wheels and wooden shingle roofs as well as ships' bottoms, although in the early nineteenth century copper-sheathing captured the last market. Some of the remaining pitch was sold as "hard black" to japanners in Edinburgh, as a lacquer, and some burned for 'lamp black', fine carbon powder used by chemists.

Before considering the technological restriction on markets for these products and for coke from gasworks, the complexity of coal tar must be appreciated. The "oil" produced by Dundonald was, until the mid-nineteenth century the most valuable part of the tar, and until 1823 was "called coal-oil, volatile-oil and spirits of tar".[1] By 1836 it was termed "naptha"* by gasworks engineers, though chemists like W.T. Brande and Dr Turner of London University insisted[2] that "naptha" only applied to products from the distillation of natural bitumens and petroleum. It remained a "loosely applied"[3]

1. Evidence of Mr Lowe of Chartered Gas Co. "The Patent Caoutchouc Case" Mechanics Magazine 1836 XXIV p. 490.

2. Ibid., pp. 473, 474, 491

3. W. Gardner and E.I. Cooke, Chemical Synonyms and Trade Names (1948) p. 351

* "Naptha" was later redefined as well as re-named "naphtha".

\+ James Hutton (1726-97), the well known geologist and philosopher L.F. Haber Chemical Industry in the 19th Century (1969) p. 32

term, and hereafter is used to refer to a substance which Scottish cannel coals were exceptionally prolific in producing, though now spelt naphtha.

Tar distillation or 'rectification' involved the separation of constituent chemicals[1] into 'fractions' which boiled at different temperatures.[2] The number of 'fractions' increased as purer chemicals were required by other chemical industries but six fractions became normal during the initial processing. "Naphtha" or 'first runnings' boiled at temperatures up to 110°C; "light oil" was obtained as vapour at 110 to 180°C; carbolic oil or "light creosote" at 180 to 230°C; creosote at 230 to 270°C; anthracene oil at 270 to 360°C; and pitch residue at higher temperatures.

Crude Naphtha, at one to two per cent of the total tar, contained several chemicals which were extracted individually by the late nineteenth century, including phenol (using caustic soda solution), pyridine (using dilute acid) and also benzene, toluene, xylene (using concentrated sulphuric acid and then alkalis) besides "solvent naphtha" (chiefly xylene, homologues boiling at 120 to 160°C) removed in a rectifying column. "Benzol" was segregated from benzene at 160°C. Light oil, eight per cent of the tar, comprised homologues of benzene with some phenol and pyridine. Treated in the same manner as crude Naphtha, using concentrated sulphuric acid and alkalis, the Light Oil gave toluene, xylenes, solvent naphtha, and "burning

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1. G.T. Morgan and D.D. Pratt, British Chemical Industry, Its Rise and Development (1938) p. 214
   W.A. Campbell, The Chemical Industry (1971)

2. As devised by H. Haskins in 1746.
   G. Lunge, Distillation of Coal Tar 1882 p. 84

naphtha" (boiling at 160 to 180^{o}C). Both Crude Naphtha and Light Oil were regarded as "coal oil" in the early nineteenth century.

Crude carbolic oil was solid at normal temperatures, and held up to forty per cent of naphthalene ("Tar Camphor", $C_{10}H_8$) together with most of the phenol (carbolic acid) and cresols (cresylic acid) from the tar. Anthracene formed a separate fraction of greater purity and could be collected as crystals to give a twenty per cent "cake" that could be reprocessed to fifty per cent strength. The remaining heavy fractions of crude tar, boiled tar, and pitch were utilised in the early nineteenth century, but not in any spectacular growth industry.

Seven factors affected the significance of by-products for early nineteenth century Scottish gasworks. Severe prohibitions against dumping provided a strong incentive to find markets for by-products, but tar output on a large scale swamped traditional markets. This situation only improved very gradually as chemists extended the use of tar products. Only naphtha, because of its use as a solvent, remained of value and it led to a close association between the gas industry and the new rubberized-fabric industry. Ammoniacal liquor posed a similar problem, solved in rural areas by publicity in favour of its value as a fertilizer, and in the West of Scotland by an important new market in the alum and textile-dyestuffs industries. Coke was perhaps the biggest disappointment. Dundonald[1] tried to sell coke to the iron-founding industry, but Carron company turned it down as being inferior quality, and although his sales were at first confined to salt-boilers and maltsters, he constructed[2] a new

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1. A. and N.L. Clow, <u>The Chemical Revolution</u> (1952) pp. 408, 413
2. B. F. Duckham <u>Scottish Coal Industry</u>(1970) op.cit.pp. 185, 186

tar-works adjoining Muirkirk ironworks in 1787 with the aim of selling coke there.

If Scottish coals had produced suitable coke, a close association between the gas and iron industries would have been possible. However, the "low yield" of fifty per cent coke from the best metallurgical coals in Scotland was a factor which retarded[1] the Scottish iron industry before the Hot Blast enabled raw coal to be used. By 1840 that industry used entirely raw coals. Moreover, gas output was far better in quantity and quality from different cannel coals. Yet again, cannel gave a poor coke which depressed by-product revenue well below that of the London gas companies[2] which in the 1840s obtained profits half as great as the original cost of coals.

Most coke was therefore consumed within the gasworks as furnace fuel, up to the 1880s when regenerative retorts were adopted. Torbanite coke was so poor that it was disposed of as ash without being used as fuel. As a bulky material, transport costs confined coke sales to the local region where railway companies were sometimes in direct competition for the market as at Annan[3] in 1857. A supply sent to small firms direct from the gasworks was typical, like nineteen shillingsworth of coke at five shillings per ton from Bo'ness[4] gas-

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1. The History of Coke Making and of The Coke Oven Managers' Association (1936) pp. 27, 46.
   R.D. Corrins "The Great Hot Blast Affair " Industrial Archaeology (1970) Vol. 7, p. 240
   H. Hamilton, The Industrial Revolution in Scotland (1932, Oxford) p. 174
2. Evidence of J. Headley, gas engineer in London. H. Lords 1844 Vol. 8 2/8/1844 p. 145
3. S.R.O. Annan Minute Book op. cit., 23/10/1857
4. S.R.O. Bo'ness Minute Book op. cit., 7/6/1860

works to Fleming's Kinneil Mill in 1860. Vale of Leven company[1] in 1858 obtained a one-year contract from a local coal merchant in Alexandria, who purchased coke at four shillings per ton. This was exceptional, however, since coke quality varied greatly; but it was a great advantage as so much time was wasted by gas-stokers in selling bags of coke to individuals who called at the works. For this reason, Galashiels[2] company sought a contractor in 1859, but had to reduce the price from 10s to 6s 8d per ton for the services of J. and W. Cochrane. After a year, the lower price seemed too cheap but when direct sales recommenced the market was slack and a new contractor in 1863 paid only 5s 6d, and 1s 9d the following year. Consequently direct sales were resumed in 1865-6, then contract sales until 1871, followed again by direct sales. Selkirk[3] gas company in the 1890s sold coke, and waste lime, direct to Mr Steel's important textile factory at nearby Philiphaugh.

TABLE 3.125 Coke Prices (Per Ton) at Galashiels 1859 - 71

1858	10s	0d
1859	6	8
1863	5	6
1864	1	9
1865	5	6
1866	5	7
1868	6	0
1869	7	6
1870	7	1

SOURCE: S.R.O. Galashiels Minute Book *op. cit.*

1. S.R.O. Vale of Leven Minute Book *op. cit.*, 9/8/1858
2. S.R.O. Galashiels Minute Book *op. cit.*, 12/7/1859, 2/8/1859, 30/8/1859, 6/9/1859, 1/12/1863, 5/1/1864, 1/11/1864
3. S.R.O. Selkirk Minute Book *op. cit.*, 15/12/1893

Large scale industrial markets for coke of the type originally envisaged, were mainly confined to west central Scotland where the Glasgow City and Suburban company, for example, in 1861 obtained more from coke sales than from ammonia. After installing regenerative retorts in 1881, Glasgow pioneered the adoption of lower-candlepower but improved coking coals which became typical by the late 1890s. Consequently, Messrs Dixon,[1] of Govan and Calder iron-works, signed a three-year contract from 1882 to take all coke from Dalmarnock and Tradeston gasworks. This was renewed from 1885-8 at 2s 6d per ton, though the Corporation was criticised for preferring such bulk sales to small sales at 5s per ton whereby "bagmen" could sell it to the city poor at 4d per cwt instead of the 8d charged for coal.[2] A further 20,000 tons from Dawsholm gasworks went to Messrs Merry and Cunningham at 2s 2d per ton, for use at Glengarnock blast furnaces[3] making phosphoric pig-iron. The new type of gas coke was highly suitable for making iron used in basic steel, but Merry and Cunningham[4] offered only 1s 9d per ton in 1888 and alternative markets had to be sought.

Ayr[5] gas company similarly charged less for bulk sales. In 1896 coke sales there comprised £50 to the County Hospital, £90 to six local bakers, £93 to five local firms, and £157 loose at the works. In 1897, however, a two-year contract was signed to supply

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1. J.G.L. 10/11/1885, 12/2/1887
2. J.G.L. 21/12/1886
3. Bessemer furnaces used from 1884.
W.H. Marwick, Scotland in Modern Times (1964) op. cit., p. 79
P.L. Payne, ed., Studies in Scottish Business History (1967) p. 272
4. J.G.L. 3/7/1888
5. S.R.O. Ayr Minute Book op. cit., 29/6/1896, 28/8/1898

the British Aluminium company at Larne, with one ten-tons waggon load per week, at 7s f.o.b. Ayr. This was 6d below current retail prices, but still allowed a saving over "wheeling and storing in winter."

Dry lime from gasworks purifiers gained a desultory market amongst farmers. After oxidation in the open air, it was offered for sale to make stiff, clay soils more friable, and to consolidate sandy soil.[1] Although suitable for clover, sainfoin, lucerne, peas, beans and turnips, the market price was very low. The Vale of Leven company in 1859 sold one year's output to R. Buntin, farmer of Cambusmoon, at 2s 3d per ton; the following year lime went to W. Murray of Strathleven at 2s 6d per ton. Muirkirk gasworks, however, received only 1s 4d per ton in 1888. Although this revenue was negligible, the market did relieve gas companies of cartage and disposal expenditure. Semi-liquid wet lime, "Blue Billy", in towns like Glasgow had to be evaporated to dryness on pans near the furnace,[2] before disposal; this labour gradually led companies to abandon wet-lime purifiers. In 1886, Glasgow corporation[3] disposed of 30,000 tons of dry lime at 1s 3d per ton through a contractor, A. Semple. Iron oxide, which was increasingly used for purifiers in the late nineteenth century, could be used repeatedly until it contained over fifty per cent free sulphur.[4] There is no record of this being

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1. "Value of Gas Lime for Agriculture" J.G.L. 10/7/1851; 23/10/1860
   A. Voelcheker (Prof. Chemistry, Royal Agricultural Society) "Use of Gas Lime in Agriculture" J.G.L. 4/4/1865 p. 210
   A. Simpson, Agricultural Chemistry (1892) pp. 328-30

2. J. Cleland, City of Glasgow Statistics 1832 (1832, Glasgow) p. 142

3. J.G.L. 18/5/1886

4. J.H. Chapman "Gasworks" Journal of the Insurance Institute of Great Britain and Ireland (1901) Vol. 4, p. 96

sold for sulphuric acid manufacture in Scotland, although another solid chemical residue, cyanide, was marketed.

The first Scottish demand for ferro-cyanide from coal gas was by the Hurlet and Campsie Alum Company[1] following the exhaustion of alum supplies in the early 1880s, though by 1900 most ferrocyanide in Europe[2] was obtained from coal gas. Prussian blue (Ferric-ferrocyanide) the first synthetic dyestuff from gaswork residuals, was devised from waste-lime by a London gas engineer, George Lowe (1788-1868)[3] in 1832 (Pat. 6276), but first manufactured, in a slightly different way, by Peter Spence,[4] a former employee at Dundee gasworks who used waste lime and ammoniacal liquor. This process was not economical in Scotland, where the Hurlet company pro-

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1. Hurlet and Campsie works were described in detail by K. Knapp in Chemical Technology or Chemistry Applied to the Arts and to Manufactures (1848) E. Ronalds and T. Richardson, eds., Vol.II pp. 181-3; J. Mackinnon, The Social and Industrial History of Scotland from the Union to the Present Time (1921) p. 121; W.H. Marwick, Economic Developments in Victorian Scotland, 1936 pp. 54, 110

2. The Mineral Industry, Its Statistics, Technology and Trade in The United States and Other Countries (1904, New York) Vol. IX p. 546

3. Son of a Derby brewer, Lowe published gaslight articles in Tilloch's Philosophical Magazine in the 1810s, became engineer to the Chartered Company 1821-62, and Fellow of the Royal Society in 1835 following his chemical work. Consulting engineer to the Imperial Continental European and Dublin Alliance gas companies, and Fellow of the Geological, Chemical and Microscopical Societies, he assisted Telford and Wm. Cubitt in founding the Institution of Civil Engineers.
J.G.L. 5/1/1869 p. 9

4. Apprentice grocer in Perth who worked at Dundee gasworks before opening a London chemical plant in 1834. In 1850 Spence commenced large-scale alum works in Manchester; by 1854 this enterprise, Messrs Spence and Dixon, consumed 800,000 gallons of liquor a year from Manchester gasworks and thus closely resembled the Glasgow arrangement. T.I. Williams, The Chemical Industry (1953) pp. 31,33; A. Clow "Scotland's Contribution to Chemical Technology" (1944, Aberdeen) op. cit., p. 87; C. Calvert "On Products Obtained from Coal" Mechanics Magazine 1854 Vol. 61 p. 531.

duced Prussian Blue by a secret process,[1] and made potassium ferrocyanide at Campsie into the 1880s. Their experiments in the 1880s inspired a far more successful process for recovery of cyanide directly from coal gas, as perfected by the Glasgow gas manager Wm. Foulis[2] at Dawsholm works in 1892. Iron chloride was made in slate-vats from scrap iron and hydrochloric acid. Sodium carbonate added to this gave an iron carbonate precipitate, and sodium chloride which was removed as waste. The iron carbonate, with extra sodium carbonate was then mixed with water and used in rotary-scrubbers to absorb hydrocyanic acid from the coal gas, thereby producing sodium ferrocyanide. This solution was subsequently removed and evaporated to dryness, producing a solid 'cake' of seventy-five per cent sodium ferrocyanide ready for storage and sale. A second installation was built at Provan[3] gasworks in 1911. The principal Scottish market for cyanide was the Cassel Gold Extraction Company[4] which commenced in 1884 using electrolysis, but in 1887 acquired the cyanide process patented by MacArthur and the brothers Forrest. From Glasgow this company exported sodium cyanide to goldfields throughout the world, though the patent was declared void in 1896. Another outlet, the Scottish Cyanide Company, commenced in 1894.

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1. A. and N.L. Clow, The Chemical Revolution (1952) pp. 240,243

2. A. Meade, Modern Gasworks Practice (1916) p. 370
   C. Hunt, Gas Lighting (1900) pp. 107-9
   Gas World, 17/10/1896

3. Transactions of the Institute of Gas Engineers 1911, p. 48

4. S.G. Checkland, The Mines of Tharsis - Roman, French and British Enterprise in Spain (1967) pp. 126, 130
   T.I. Williams, The Chemical Industry (1953) p. 51
   W.H. Marwick, Economic Developments in Victorian Scotland p. 81
   W.H. Marwick, Scotland in Modern Times (1964) p. 85

Liquid and semi-liquid residuals at first represented an expensive problem of disposal, as did furnace ash. Parliament imposed very heavy fines upon chartered companies[1] which polluted surface water supplies, so that Edinburgh at first carted waste to the sea "stealthily at night"[2] and Glasgow[3] tipped it into deserted quarries and pits. Riparian owners elsewhere ensured that unincorporated companies did not despoil fishing rights, or industrial and potable water supplies. Stirling town council[4] forbade the gaswork built on their lands from polluting the river, and Ludovic Houston who sold land to Johnstone[5] gas company in 1829 obliged them not to drain residuals into the River Cart or onto adjoining land. Bathgate company in 1835 carted tar away to "be consumed /burned/ at a distance from the Town, and not injure the neighbouring proprietors".[6] An accidental tar leakage at Dalkeith[7] in 1847 led, under threat of a law suit, to the payment of £40 damages to Sir John Hope and the Musselburgh magistrates to compensate for damage inflicted on the salmon fishery and oyster beds. Subsequently, papermakers and landowners along the North Esk appointed a bailiff to guard against further pollution. An accidental leakage from Galashiels[8] gasworks in 1856 similarly led to damage of £26, paid to the local manufacturers' Dam Committee.

Several companies resorted to digging pits for waste disposal,

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1. Vide infra 'Chartered Companies' p.999
2. "The Uses of Gas Tar" The English Mechanic 1868 Vol. VII
3. G. Macintosh, Biographical Memoir of Charles Macintosh, F.R.S. (1948, Glasgow)
4. Stirling Town Clerk's Office "Records of the Minutes of Committees appointed by the Town Council," 25/6/1825
5. S.R.O. (P.R.532.278) Renfrewshire Sheriff Court - Sasine 9/12/1829
6. S.R.O. Bathgate Minute Book op. cit., 16/7/1835
7. S.R.O. Dalkeith Minute Book op. cit., 4/9/1847, 25/6/1847, 2/11/1847
8. S.R.O. Galashiels Minute Book op. cit., 6/5/1856, 3/5/1856

and thereby fouled the unprotected sub-surface water. Arbroath[1] did so from 1826, and a well used from that year was soon tainted and by 1848 gave water suitable only for quenching coke. In most towns, underground pollution of this type was probably far more serious than that of surface water supplies. A partial solution to this expensive problem was the use of tar as furnace fuel in addition to a coal and coke mixture. J.B. Neilson was the innovator of this technique, which he used, at Glasgow[2] gasworks in 1826, but its popularity was closely linked with the development of clay retorts which could withstand the greater temperatures as the proportion of tar to other fuels increased. In this, Perth gasworks took the lead, having been forced to cease polluting the River Tay in the early 1820s, and to dig pits from which liquid refuse stubbornly refused to soak away. Besides tar as furnace fuel, a separate furnace and tall chimney was built to burn the remainder. When iron retorts were damaged by high temperature in 1828-9, Perth[3] installed some of the earliest Scottish clay retorts. Small gasworks like Moffat and Annan[4] still consumed all their tar as furnace fuel in 1841.

"Coal-oil" and more refined forms of naphtha, were the basis for a coal-tar chemical industry in Scotland supplying industrial solvents and lamp-oil for local use and for export to England and especially to London. Andrew Thomson[5] was the first to take advantage of

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1. J.G.L. 15/1/1884 2. Glasgow City Archives (D.G.E.64)
3. J.G.L. 28/6/1887 p. 1166; Gas World 1885 p. 482 Vide supra p.282
4. S.R.O. Annan Minute Book op. cit., 14/5/1841
5. Andrew was the brother of John Thomson, banker and agent to Glasgow gas company. Contract commenced 1/1/1819. Parties bound to observance under a penalty of £500. Thomson was not allowed to take water from the purifiers. One witness was Henry Creighton "civil engineer", a consultant at the gasworks. Pencil alterations were

gasworks' supplies and contracted to remove all tar ammonia and waste products gratis from Glasgow gasworks in 1818-20 in return for his obligation to use sealed barrels, to cause no nuisance on the roads, and never allow more than 2½ feet depth in the tar pit upon a penalty of £1 per day. Thomson used only the "coal oil" for mineral paints,[1] to hold the pigment in suspension,[2] whilst the remainder was "carted out into the country some miles and put upon the land."

Little effort was involved in separating the "coal oil", since it was immiscible with other distillation products from the gasworks. In the gasworks' tar cistern "the tar falls to the bottom; the ammoniacal water is above; the tar- and coal-oil float on the surface".[3] Even when carted away in a single vessel, this gravity segregation soon reasserted itself, so that the tar oil could be "ladled off - skimmed off".[4]

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made as a draft for Macintosh's later contract. John Thomson's interest in organic chemistry may have assisted his brother; in October 1816 John contributed an article on Turkey-red dyes to the Annals of Philosophy.
Glasgow City Archives (D.G.E.60) 1/12/1818, (D.G.E.4) 27/4/1819; Glasgow Chronicle 12/4/1817; Annals of Philosophy 1816 Vol. 8 p. 463; A. and N.L. Clow, The Chemical Revolution (1952) p.220.

1. Evidence of J.B. Neilson, Mechanics Magazine 1836 XXIV p. 491

2. G.T. Morgan and D.D. Pratt, British Chemical Industry (1938) op. cit., p. 143

3. Evidence of Mr Fleming, employee of C. Macintosh from 1804-25. Recently, D. Hardie has incorrectly stated that Macintosh distilled the tar portion to obtain ammonia, a misconception which appeared earlier in Chambers Biographical Dictionary.
Mechanics Magazine 1836 Vol. XXIV p. 427
E.A. Musson, Science, Technology and Economic Growth in the Eighteenth Century (1972) p. 186

T. Thomson, Ed., Chambers' Biographical Dictionary of Eminent Scotsmen (1875) Vol. 5, p. 42

4. Evidence of W.T. Brande Mechanics Magazine 1836 Vol. XXIV p. 475. Eminent chemists like Andrew Ure mistakenly believed in 1824 that gasworks' coal-oil, naphtha, and natural "petroleum" were identical substances. A. Ure, A Dictionary of Chemistry (1824) 2nd Edition, p. 345.

Charles Macintosh (1766-1843) soon developed an interest in the gasworks residuals, though more in regard to the ammonia constituents, as will be described later. In September 1819 Glasgow gas-company advertised the sale of tar and liquor,[1] and in December Macintosh contracted[2] to remove the entire output of tar and ammonia liquor for seven years, subject to the same penalties as Thomson, and paying either £50 per year or 3/20 old penny Sterling for each gallon (English wine-measure). This contract was extended[3] for ten years, at the same price from 1823.

'Coal oil', from distillation of natural tar, was used at Coalbrookdale in Shropshire as early as 1805 as "a solvent for caoutchouc ... used as a varnish for cloth".[4] Although turpentine was used from 1791 to dissolve caoutchouc or India Rubber,[5] to varnish and waterproof fabrics, turpentine and other natural solvents failed to evaporate sufficiently to give a dry and odourless finish. James Syme (1799-1870),[6] Professor of Surgery at Edinburgh and later Aberdeen, was not the first to use the far superior tar-naphtha[7] and rubber solution

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1. Glasgow Chronicle 6/9/1819 p. 3
2. Contract dated 3/12/1819; pencil alterations state 1/1/1820 Glasgow City Archives (D.G.E.64)
3. Extension dated 25/12/1823; Glasgow City Archives (D.G.E.64)
4. J. Plimley "A Brief Account of the Mineral Productions of Shropshire", The Philosophical Magazine A. Tilloch, Ed. 1805 Vol. XXI, p. 311.
5. cf A. and N.L. Clow, The Chemical Revolution (1952) p. 252
6. Another Scottish medic engaged in practical technology; a colleague of Dr Christison, and of Prof. Lizars who was a founding member of Edinburgh and Leith Gas Company (1840). H. Douglas, Burke and Hare - The True Story of the Bodysnatchers (1973) pp. 14, 66; A. Finlay, A Hundred Years of Chemistry (1937) p. 155; Dictionary of National Biography 1909 Vol. XIX p. 266 Vide infra pp. 422, 1128
7. H. Shurer has noted the attempt to use expensive natural-petroleum naphtha to dissolve caoutchouc in 1779, but incorrectly suggested that Syme was the first to use distilled-tar naphtha. H. Shurer "The Macintosh - The Paternity of an Invention" Transactions of the Newcomen Society 1952 Vol. XXVII pp. 79, 81

for coating cloth, though his published work[1] inspired Macintosh's successes.

The interval between 1819 and 1823 when Macintosh patented his double-layered cloth,[2] was a time of experimentation. The double-layer, and about six thin coatings of rubber in naphtha brushed onto the interior side of both layers to allow thorough solvent evaporation and 'drying' before sealing them with a final sandwich of solution, was the only novel aspect of Macintosh's process. It solved the problem of a clammy, non-durable finish which others had produced using a thick layer of naphtha and rubber on single sheets of material.[3]

It is not clear how pure the naphtha had to be before use.[4] N. Wray,[5] who supervised the dissolving of rubber until about 1821, claimed that raw "coal oil" was used just as it was delivered, but Mr Fleming[6] who worked with Macintosh stated that "manufacture was chiefly carried on by purified coal-oil", meaning rectified naphtha. Certainly a naphtha-still was operated, by Robert Sutherland and John Thompson,[7] and the solvent used with rubber was probably a mixture of crude "coal-oil" with purer naphtha distilled from the heavier tars.

Manufacture commenced in 1823 with several large government

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1. Philosophical Transactions 1818, Vol. 12 p. 112
2. 1823 Pat. 4804. The rubber company is dated from 1821 by A. and N.L. Clow, The Chemical Revolution (1952) p. 252
3. Mechanics Magazine 1823-4 Vol. I p. 55; 1824 Vol. II p. 291
4. Andrew Ure stated in 1824 that it was "rectified into a colourless liquid" before being used to dissolve caoutchouc. A. Ure, A Dictionary of Chemistry (1824) 2nd Edn. p. 296.
5. Mechanics Magazine 1836 XXIV p. 469
6. Ibid., p. 427
7. Ibid., p. 470

orders including[1] £600 from the Colonial Office and £500 from the Ordnance Office in 1824. This seemed like the beginning of a boom industry,[2] and the Glasgow works[3] were soon looking to Edinburgh for further supplies of raw material. In May 1824, Edinburgh gas company signed a contract for twelve years supply of tar to Dr John Wilson Anderson[4] of Edinburgh, for whom C. Macintosh stood as security. Anderson paid 2d per barrel of thirty gallons, in two annual payments, plus twenty per cent interest if payment was late and a £200 penalty in the case of non-fulfilment. He faced a fine of £1 per day if above 100 barrels accumulated at the gasworks.

Dr Longstaff, a colleague[5] of J.W. Anderson who assisted Professor T.C. Hope with practical classes at Edinburgh University in 1823-8, joined Dr Dalston in operating a tar-distillery at Leith, the first in eastern Scotland.[6] There, rectified naphtha was prepared for carriage to Glasgow, and was probably sent together with unrefined "coal oil". The remaining tar probably swamped traditional markets, and only lamp-black is recorded as having been sold.

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1. Ibid., pp. 532, 427

2. In reality, the demand for rubber goods grew slowly and an output boom during the Crimean War of the early 1850s reached levels not repeated until 1872.
W. Woodruff, The Rise of the British Rubber Industry during the Nineteenth Century (1958, Liverpool) pp. ix, 87, 93.

3. T. Hancock, Personal Narrative of the Origin and Progress of the Caoutchouc or India Rubber Manufacture in England (1857) pp. V, 22, 23.

4. S.R.O. Books of Council and Session - Deeds 14/5/1824 Vol. 267 Folio 697.

5. Ambix 1969 Vol. XVI pp. 70-1.

6. Possibly the second in the world; not the first as previously recorded. Vide H.E. Roscoe, Presidential Address, Journal of the Society of Chemical Industry 1881 p. 7; G. Lunge, A Treatise on the Distillation of Coal Tar, Ammoniacal Liquor, and the Separation from them of Valuable Products (1882) p. 371; S. Miall, A History of the British Chemical Industry (1931) pp. 197-205.

In 1826 Macintosh was preparing the Glasgow rubber factory for mechanised-brushes by Mr Ewart,[1] instead of varnishing by hand, when he found the Glasgow gas company were "secretly ... applying large quantities of tar ... for their own use"[2] as fuel. The company directors considered that J.B. Neilson's innovation[3] saved more on coal than Macintosh paid for the tar, coal-oil and ammonia liquor. Hence they placated Macintosh by allowing him all "the ammoniacal water and other liquids"[4] gratis. By the late 1820s this amounted to about 230,000 gallons of liquor and 6,000 gallons of "coal-oil" per year.[5]

Macintosh, however, saw new opportunities in Manchester, and decamped there[6] about 1825. Glasgow tar works were relegated to a simple out-station, like Edinburgh, which sent naphtha to Manchester "ready for use".[7] Hancock (1786-1865), who operated a secret

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1. Mechanics Magazine 1836 XXIV p. 427

2. Letter from J. Wardrop, Macintosh's procurator dated 5/2/1826 Glasgow City Archives (D.G.E. 64)

3. The tar-fired furnace was promulgated by C. Macintosh to H. Birley, a director of Manchester gas company in 1826 but was not devized by him. A. and N.L. Clow, The Chemical Revolution (1952) p. 254

4. Glasgow City Archives (D.G.E. 68) 28/2/1826, (D.G.E. 65) 28/2/1826

5. Evidence of J.B. Neilson Mechanics Magazine 1836 XXIV p. 491.

6. Evidence of Mr Ewart; N. Wray, however, claimed later that he was sent to the Manchester plant in 1821 where he assisted for ten years. Certainly S. Miall is wrong in stating 1834 for the Manchester installation; Woodruff states 1824, and on the basis of an unauthenticated MSS, states that much of the capital was from J. and H.H. Birley, (d. 1845) cotton spinners.
   Mechanics Magazine 1836 Vol. XXIV pp. 508, 469; S. Miall, A History of the British Chemical Industry (1931) p. 197; W. Woodruff, The Rise of the British Rubber Industry During the Nineteenth Century (1958, Liverpool); T. Hancock, Personal Narrative of the Origin and Progress of the Caoutchouc or India Rubber Manufacture in England (1857; reprinted 1920) p. 49.

7. Mechanics Magazine 1836 Vol. XXIV p. 470

"masticated" or sliced rubber process[1] in London from 1821, obtained a licence to use Macintosh's naphtha process in 1825 after experimenting with turpentine solvent, and with tar in 1823. Hancock was unwilling to enter a formal partnership with Macintosh,[2] although from 1826 he produced the waterproof cloth apparently under sub-contract. He had a greater technical interest in rubber, and in 1830 helped to re-plan Macintosh's Manchester factory[3] which began to produce his sheet-rubber and webbing. That year, Glasgow[4] ceased to send naphtha to Manchester, and indeed by 1834 Manchester distillery sent all the rubber and naphtha to London for Hancock's own works[5] there.

The expiry of Macintosh's original rubberised-cloth patent in 1837 allowed this material to be produced more widely using coal-tar naphtha, which was manufactured on a large scale in Glasgow by Messrs George Miller and Company,[6] who supplied a large government order during the Crimean War (1854-6) and became the principal naphtha distillers in Scotland.[7] Messrs. Miller in 1855 also tried to produce lubri-

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1. Hancock in 1843 (Pat.9952) like C. Goodyear in 1839, devized a method to 'vulcanise' rubber, using sulphur and heat treatment, to eliminate the continued problem of stickiness in all rubber goods.
   Dictionary of National Biography (1908) Vol. VIII p. 1160; Vol. XII p. 557; W. Woodruff, British Rubber Industry (1958) op. cit. pp. 5,8; G.P. Bevan, ed., British Manufacturing Industry - Tobacco, Hides, India-Rubber and Cordage (1877) 2nd edn., p. 121 et seq; C.A. Burghardt "The Indiarubber Manufacture", Journal of the Society of Chemical Industry 1882 Vol. II pp. 119-22.
2. T. Hancock, India Rubber Manufacture (1920) op. cit., pp. 8 - 10, 23.
3. Ibid., p. 32
4. Evidence of J.B. Neilson, Mechanics Magazine 1836 Vol. XXIV p. 491.
5. T. Hancock, India Rubber Manufacture (1920) op. cit., p. 33
6. Vide infra pp. 101, 547, 568, 585, 964
7. Messrs Miller also supplied solvent to paint manufacturers; and purchased burning oil and naphtha from James Young's oilworks for export to Germany. J. Butt "James Young" (1963) op. cit., pp. 132, 158.

cating oil for which there was great demand by many mechanised industries,[1] but the high temperatures used at gasworks dissociated these oils[2] and Luther Atwood's coup-oil which Messrs Miller[3] made under licence from gasworks tar, was unsuccessful and malodorous even when mixed with animal-oils. Gas-tar never became an important source of industrial lubricants.

Elsewhere, naphtha as a solvent, and occasionally as a lamp-oil,[4] provided the main profit for small distilleries which commenced in the 1830s-40s. A decade earlier, one of the last remaining eighteenth century coal-tar works run at Muirkirk by John Loudon McAdam

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1. Although natural oils like spermaceti and castor oil remained important into the twentieth century, the change from wooden to metal machinery in the early nineteenth century demanded finer, less combustible mineral-oils for many processes like high-speed steam-powered looms, and printing presses. J. Butt, "Technical Change and the Growth of the British Oil Shale Industry 1680-1870" Economic History Review 1964-5 II Series, Vol. XVII; "Sources of Lubricants" in A.W. Nash and A.R. Bowen The Principles and Practice of Lubrication (1929)

2. In the United States, Abraham Gesner in Jan. 1850 patented high-temperature distillation of Trinidad bitumen to produce "Kerosene Gas" but in 1854 he patented low-temperature "Kerocene" oil in an unsuccessful attempt to evade James Young's lubricating oil patents. J. Butt "Legends of the Coal-Oil Industry (1847-64)" Explorations in Entrepreneurial History 1964 p. 16 et seq.

3. Messrs Miller hoped to supply lubricants to textile mills, and obtained the services of William and Luther Atwood to build the Glasgow plant in 1855, with the consent of the patent holder, S. Downer whale-oil and candle manufacturer of Boston, U.S.A. Luther later falsely claimed to have produced the first water-white paraffin lamp oil from James Young's naphtha whilst in Glasgow; in reality Young had been selling lamp oil since 1847.
K. Beaton "Dr Gesner's Kerosene: The Start of American Oil Refining" The Business History Review (1955, Harvard) Vol. 29; A. Clement and A. Robertson, Scotland's Scientific Heritage (1961) op. cit., p. 83.Williamson and Daum American Petroleum (1959) op cit. p. 45

4. Gas-tar naphtha was used in oil lamps from the 1820s, but was both dangerous, and malodorous due to the sulphur content; James Young produced a less noxious oil, far cheaper than naphtha, but was unable to expand this market until the late 1850s when his company introduced improved oil lamps of German design into Scotland. J. Butt "Legends of the Coal-Oil Industry (1847-64)" op. cit.; A. Ure, A Dictionary of Chemistry (1824) 2nd Edn. p. 345.

(c.1756-1836)[1] was forced to close in 1829 because of the low revenue; even by 1817 London gas-tar sold more cheaply than simple wage-costs in Scotland. The new distilleries relied, probably entirely, upon gasworks residuals which had already undergone primary distillation. An extra market for naphtha opened in Edinburgh in 1856 when the North British Rubber Company[2] purchased the former Castle Silk Mills and began to produce cheap rubber shoes. This company also took large quantities of coal tar and lamp-black, initially from Leith tar distillery. The Scottish Vulcanite Company, also financed by American investors, opened in Edinburgh in 1861.

Distillation to increase naphtha yield from the tar, as opposed to "coal oil" produced a variety of minor products which were saleable. Residual "crude tar" produced an anti-corrosion paint[3] used to cover iron, wood and brick work, especially in chemical works, and also to preserve fishing gear and boats. Thus Stornoway[4] gas company in 1854 supplied the tar "boiler" in Mr Cook's nearby shipyards, and Macduff[5] gasworks in 1891 supplied local fishing boats. "Boiled

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1. R. Devereux, John Loudon McAdam (1936)

2. Promoted by American capitalists, especially J.R. Ford (1817-96) who recognized the under-developed market in Britain which had resulted from an agreement in 1847 between C. Macintosh and Company and the Haywood Rubber Company of Connecticut which was given a monopoly of vulcanised rubber footwear sales in Britain. The North British company imported machinery from America and net profits were £28,000 in 1857, £12,600 on £180,000 sales in 1866, and £43,000 on £223,000 sales in 1871.
   W. Woodruff "The American Origins of a Scottish Industry" Scottish Journal of Political Economy 1955; W.H. Marwick, Scotland in Modern Times (1964) pp. 97, 98

3. G.T. Morgan and D.D. Pratt, British Chemical Industry (1938) op. cit., p. 214

4. S.R.O. Stornoway Minute Book op. cit., 21/11/1854

5. J.G.L., 8/9/1891

tar" was used for footpaths and roadways,[1] and also for roof felt. The latter idea, with millboard or felt boiled in wood-tar, originated with Faxa of Sweden in the eighteenth century.[2] Coal tar to preserve railway sleepers was first used in 1838 by J. Bethell. Amongst the lighter fractions, anthracene was sold cheaply as waggon grease and as fuel, and creosote[3] was used by the late 1840s to preserve wood, like the Memel timber used for Leith Harbour. Henry Aitken[4] of Falkirk later devized a timber-preservative based upon naphthalene. Apart from paraffin oil, for which James Young had sole manufacturing patent rights, these were the limits within which tar distillers operated until the advent of coal-tar dyestuffs and a variety of new products in the late nineteenth century.

Dundee[5] gasworks was perhaps the first in Scotland to operate a tar distillery, in 1836, and specialised in the export of naphtha to London. Naphtha content varied with the type of coal distilled. Lesmahagow, Newbattle (Marquis of Lothian), Arniston and Benhar coals[6] produced about eight per cent of naphtha and benzene homologues, though this proportion fell to three per cent after the 1880s when higher temperatures were used for carbonization. Glasgow City and Suburban company under H. Bartholomew[7] built another tar still in the early 1840s, and an adjacent ammonia works. Both tar and ammonia

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1. A. Bird, Roads and Vehicles (1969, Newton Abbot), pp. 61-3
2. G. Lunge, Distillation of Coal Tar (1909) pp. 280, 281
3. J. Clift "On the Preservation of Timber by Creosote" J.G.L. 10/12/1851; G. Lunge, Coal Tar (1882) op. cit., pp. 200-43
4. J.G.L. 24/2/1891, p. 393
5. H. Commons 1846 Vol. 98 25/3/1846 p. 28; J.G.L. 10/6/1851 p.16
6. G. Lunge, Coal Tar (1882) op. cit., p.12
7. J.G.L., 12/2/1861 p. 96, 24/2/1885 p. 354

were frequently processed at the same by-product works. The attention of chemists, like Dr W. Gregory (1803-58),[1] was increasingly focused upon coal-tar chemistry in the 1840s, and for the first time a number of small-scale distillers established their operations in several parts of Scotland. A simple Coffey's Still, as described in the Journal of Gas Lighting[2] of 1852, was adequate to produce naphtha and a residue of asphalte. A "distilling apparatus" purchased by Greenock gasworks[3] to treat tar in 1852 cost only £20. In 1848 Ayr[4] gas company leased some ground to John Gamble who purchased their tar at 4s per 100 gallons and built "a place for the manufacture of asphalte, &c".

In 1845, James Ross commenced the Lime Wharfe (or Falkirk) Chemical Works[5] at Grahamston on the Forth and Clyde canal, where he later obtained the advantage of proximity to the North British and Caledonian Railways. This became the principal distillery in east central Scotland, but in the 1850s had many competitors. Mr McKinlay of Avon Bridge Chemical Works also operated in the east, and in 1847 obtained surplus tar from Cupar[6] gasworks, which by 1850 instead supplied Mathew Henderson of Kirkcaldy at 1s 6d per 100 gallons. In

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1. A. Clow "Scotland's Contribution to Industrial Development through the Application of Chemical Science since the Sixteenth Century" (1944) op. cit., p. 89
2. J.G.L. 10/9/1852 p. 413; Diagram vide J.E. Forbes, A Short History of the Art of Distillation (1948, Leiden), p. 349
3. J.G.L. 10/9/1852 p. 422
4. S.R.O. Ayr Minute Book op. cit., 25/5/1848
5. J. Stewart, Falkirk, Its Origin and Growth (1940, Falkirk) p. 160. Gas World 7/3/1914 p. 318
   Obituary of R. Orr, a senior partner N.B.A.G.M. 1906
6. S.R.O. Cupar Minute Book op. cit., 14/12/1847, 8/10/1850, 11/5/1854, 4/7/1854

1854, Cupar obtained better prices for tar and ammonia liquor from John Z. Kay of Dundee New Gas Company who also operated a still. In west central Scotland by 1851 some gasworks using Lesmahagow coal were receiving by-product revenue equal to thirty-five or forty per cent of the cost of coal.[1] Paisley gasworks sold tar to the British Asphalte Company at 8s 9d per 100 gallons, compared to ammonia liquor at 2s to 2s 6d per 100 gallons and coke 5s a ton. Hamilton obtained 6s per 100 gallons for tar.

As tar (and "coal oil") became more valuable, less was used as furnace fuel; but the principal stimulus to the growth of distilleries was the use of Torbanite or 'Boghead' for gas production. A flood of naphtha became available in place of the former scarcity. At Cupar,[2] each ton of Torbanite gave residuals reputedly yielding up to thirty gallons of "naphtha". William McLintoch,[3] a former manager of Wilson's Hurlet Alum works who opened works to manufacture naphtha, asphalte and artificial manure in Glasgow, Perth and Irvine, claimed more plausibly in 1853 that every fifty gallons (one ton) of liquid obtained from a gasworks using Torbanite produced 12½ gallons of naphtha, twenty-six gallons of paraffin oil; and also 11½ gallons of ammonia liquor so weak that it was wasted. This was less than the yield of an oil-works which used lower temperature, dull red heats, but it was still a very profitable raw material. The distiller spent £2 18s 9d processing each ton, or £1 7s 9d if primary distillation was made at the gasworks, but he obtained £5 14s per ton

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1. J.G.L., 10/1/1851 p. 10

2. Evidence of R. Douglas, gas manager at Cupar; probably a gross over-estimate. A.W. Lyell, Torbanehill Case - Report of the Trial (1853, Edinburgh)

3. Ibid., p. 89

forthe finished products. Despite a depreciation of equipment at 15s per ton processed, profit was as high as £3 11s. Crude naphtha, purchased at 10d per gallon, sold at 4s to 5s after being refined. Although James Young monopolised the production and sale of paraffin products, tar distillers profited handsomely from the growing market for lamp-oil and solvents.

Competition between distillers increased as transport facilities improved, and this raised the price paid to gas companies and encouraged larger quantities of tar to be released for sale. By the early 1850s, if not the late 1840s, an approximation of a national price market for residuals was established, and Robert Ford of Perth purchased tar from southern towns like Galashiels[1] by 1856. The Vale of Leven[2] gas company in the early 1850s received only 3s per 100 gallons for tar supplied to the British Asphalte Company, but then obtained 4s 3d from James Ross of Falkirk in 1855, and 6s 8d from him in 1858. In 1860 Ross paid 7s, in competition with offers from Geo. Shand and Company of Stirling at 6s 7d, and James Greenshiels and Company of Glasgow at 6s 10d. Shand's operations had commenced before 1856, when he competed with McBogie of Kirkcaldy for residuals from Cupar[3] gasworks. Advertisements placed by Cupar gas company in the Fifeshire Journal and Fife Herald[4] during 1857 brought offers not only from Shand, and from Messrs Walker and Bogie of Kirkcaldy,[5]

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1. S.R.O. Galashiels Minute Book op. cit., 4/3/1856
2. S.R.O. Vale of Leven Minute Book op. cit., 9/10/1855, 8/3/1858, 9/8/1858, 10/12/1861
3. S.R.O. Cupar Minute Book op. cit., 8/7/1856
4. Ibid., 11/6/1857, 7/7/1857
5. Messrs Walker, who became distillers at Kilmarnock and Ayr, may have been connected with this firm, and with a Dr Walker of Cupar who purchased tar, liquor and waste lime from Cupar gasworks in 1855; S.R.O. Cupar Minute Book op. cit., 11/1/1855

but also from Perth Old gas company, J.Z. Kay of Dundee gasworks, R. Ford of Perth New gasworks, and both D. Martin and J. Cairns of Cults Lime Works.

Lime works operated some of the early tar-distilleries because gas companies which required lime for purifiers sometimes preferred to combine these two aspects of business. Cupar[1] gasworks in 1856 supplied all tar, ammonia liquor and waste lime to John Cairns of Cults Lime Works in return for £10 plus adequate fresh lime supplies. In 1858, Messrs Bogie of Kirkcaldy, Dundee gas company, and Perth New gas company, all offered to send free lime to Cupar, plus a cash payment, in their competition to obtain the by-products contract.

The degree of competition is evident despite variations in the methods used for payment, and by the late 1850s it resulted in a new type of tar-distillery which was semi-portable. This innovation, which persisted until the end of the century, enabled distillers to undercut their rivals by eliminating much of the overland freight costs through capital investment on equipment which was built adjoining a gasworks, and then largely written off at the termination of a residuals contract of perhaps only three years duration.

When G. Shand and company offered 6s 6d per 100 gallons of tar to Cupar[2] gasworks in 1858, this was only a penny different to their tender made to the Vale of Leven gasworks. The Dundee and Perth gas companies offered £24 and £22 respectively to Cupar for

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1. Ibid., 12/7/1858, 6/7/1858
2. S.R.O. Annan Minute Book op. cit., 6/7/1858, 12/7/1858

one year's residuals, and £28 and £29 respectively for a long-term contract. Perth Old gas company offered on a different scale, at 1s 3d per ton of coal carbonized.

As far south as Galashiels,[1] Shand and company of Selkirk who were probably a subsidiary of the Stirling firm, offered 5s per 100 gallons for tar in 1858. That source was, however, lost to James Ross of Falkirk who paid 3s 9d for both tar and ammonia liquor together. In 1859-60 both distant distillers failed to outbid Robert Hall who built a naphtha works adjacent to Galashiels gasworks and thus eliminated most of the freight costs; Ross nevertheless regained this source in 1861.

Another small distillery was built adjoining Cupar[2] gasworks in 1859, by John Z. Kay of Dundee who obtained a five year contract for all tar, liquor and waste lime, for £35 plus free lime for the purifiers. The bargain included convenience for the gas company besides cash revenue, since James Bogie of Kirkcaldy had offered £40 per year without free lime. Although Kay's plant was "carried on at his own risk", a roadway was built that year connecting both premises, at £1 rent per year to the gasworks, and by 1860 one of the gas employees assisted part-time at the distillery. Kay obtained another contract, at £40 plus lime, in 1864. Later contracts were of short duration, of only one year in 1866, and although Kay sold his plant to J. Ross of Falkirk in 1869, the advantages of

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1. S.R.O. Galashiels Minute Book op. cit., 2/5/1858, 4/1/1859, 1/2/1859, 7/5/1861

2. S.R.O. Cupar Minute Book op. cit., 11/7/1859, 7/12/1859, 8/3/1860, 1/6/1864, 9/6/1866, 15/8/1867, 13/8/1868, 19/7/1875 8/7/1873

local distilling prevented outsiders from obtaining chemicals from Cupar gasworks until 1873 when W. Briggs of Arbroath obtained the contract. Ross obtained a final contract in 1875-6 and thereafter the naphtha works was abandoned.

Ross of Falkirk obtained many contracts for residuals from Galashiels[1] gasworks up to 1899 when W. Metcalf Ltd of Church, near Accrington, constructed a tar and ammonia chemical works on land leased from that gas company, using the slender basis of a three-year contract. Metcalf successfully obtained another three-year contract in 1902. John Dobbie and Company of Leith in similar fashion built a small subsidiary works at Elliot[2] near Arbroath in 1890, to compete more effectively in the north east.

The value of tar distillates rose rapidly in the 1860s, largely as a result of the well-documented synthetic dyestuffs industry founded by W.H. Perkin (1838-1907).[3] His experiments in the 1850s used tar distillates supplied by G. Miller and Company of Glasgow, and he had assistance from Messrs Pullar of Perth who proved the aniline-purple dye on silk in 1856 to produce better colour than cudbear vegetable dye.[4] Messrs Miller financed further early re-

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1. S.R.O. Galashiels Minute Book op. cit., 28/6/1899, 1/8/1899, 8/4/1902

2. The North British Chemical Works: J.G.L. 14/10/1890

3. F.J. Moore, A History of Chemistry (1939) p. 301; G. Lunge, Distillation of Coal Tar (1882) p. 84; W.M. Gardner, Ed., The British Coal Tar Industry: Its Origin, Development and Decline (1915) pp. 149-51, 236, 253.

4. With financial assistance from his father, G.F. Perkin a London builder/contractor, W.H.Perkin took an entrepreneurial role in taking commercial advantage ofchemicals already observed to produce colours by his tutor, August Wilhelm Hofmann (1818-92). Hofmann had commenced his post-graduate research in 1843 at Justus Liebig's laboratory in the German University of Giessen, on the analysis of coal-tar from Offenbach distillery. For two

search on dyestuffs by C. Grenville Williams,[1] a former assistant of Professor Thomas Anderson in Glasgow. Perkin's research continued in association with Dalmarnock Print Works, and Messrs Jones, Black and Company of Glasgow used the first aniline dyes for calico printing.[2] In 1869 he produced the first alizarine for commercial sale.

The initial boom in tar-dyes ended in a slump during 1868 when J. Ross of Falkirk, for example, reduced his offer for Galashiels tar from 15s per ton in 1865 to only 2s, whilst elsewhere Ross paid as little as 1s, and received tar gratis in return for carriage at Innerleithan. Messrs. T. Pearson and Company of Glasgow[3] circularised many gas companies in a campaign to sell naphtha stills. Galashiels considered purchasing one, and sent their manager to inspect similar stills, sometimes associated with ammonium sulphate plants, at Dundee, Glasgow, Paisley and Perth gasworks. However, tar rose again to 15s 6d in 1869, and naphtha distillation was not widely undertaken at gasworks.

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years, assisted by J.S. Muspratt (1821-71) an English student, he extracted pure benzene, nitrated and reduced it to aniline, and investigated the formula and chemical properties of aniline. In 1845 Hofmann became Principal of the newly formed Royal College of Chemistry in London, which aimed to popularise science in England as Liebig had done in Germany. With pupils like Charles B. Mansfield, and W.H.Perkin in 1854, this was achieved and the College was a focus of early knowledge on synthetic dyes even though Hofmann did not take their economic advantages seriously as late as 1858. J.J. Beer, The Emergence of the German Dye Industry (1959, Urbana) Illinois Studies in the Social Sciences, Vol. 44, pp. 5-8, 14, 19, 21, 26

1. C.G. Williams had also been a pupil at the Royal College of Chemistry.
   J.G.L. 20/8/1889; J.J. Beer, The Emergence of the German Dye Industry (1959) op. cit., p. 40

2. W.M. Gardner, ed., British Coal Tar Industry (1915) op. cit., pp. 151, 155, 178

3. S.R.O. Galashiels Minute Book op. cit., 19/6/1868, 4/5/1869, 1/6/1869

Despite the suitability of Scottish gasworks tar for dyes, the Scottish printers considered early aniline dyes inferior to those from madder root, especially with the problem of fading on cloth exported to the tropics. Consequently, Perkin's manufactory commenced in London, though it used impure benzene[1] at 5s a gallon transported from Messrs Miller of Glasgow. Subsequently, through superior research facilities, continental European chemists took control of the dyestuffs industry.[2] The mauve aniline dye, made from benzene and concentrated sulphuric and nitric acids, was followed by a wide range of colours based upon toluidine and quinoline. In 1869 the synthesis of alizarine[3] was achieved independently by Perkin, and by Caro in Germany who obtained the important patent for a dyestuff previously obtained from madder plants. Madder was the basis of Turkey Red dyes, as produced at Dalmarnock[4] from 1785, and thus of an industry which had financed many important sponsors of the early coal-gas industry, like Henry Monteith. By the 1880s, Messrs John Orr Ewing and Company of Alexandria Turkey-Red Works,[5] one of the

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1. First extracted from naphtha in the 1840s by C.B. Mansfield. W.A. Campbell, <u>The Chemical Industry</u> (1971) <u>op</u>. <u>cit</u>.

2. E.E. Williams, <u>Made in Germany</u> (1896; reprinted 1973, Bath) p. 103.

3. T.I. Williams, <u>The Chemical Industry</u> (1953) pp. 64-5; W.A. Sylvester "Dyestuffs" in R.B. Pilcher and F. Butler-Jones, eds. <u>What Industry Owes to Chemical Science</u> (1945, Cambridge) 3rd edn., p. 114; Green, Miall, Thorpe, Ruchter and Marshall (Yorkshire College) <u>Coal - Its History and Uses</u> (1878) pp. 212-23

4. A. and N.L. Clow, <u>The Chemical Revolution</u> (1952) pp. 215-8

5. W.M. Gardiner, <u>British Coal Tar Industry</u> (1915) <u>op</u>. <u>cit</u>., p. 502
J. Mackinnon, <u>Social and Industrial History of Scotland</u> (1921) pp. 124-5
G. Lunge, <u>Distillation of Coal Tar</u> (1909) p. 502
L.F. Haber, <u>The Chemical Industry During the Nineteenth Century</u> (1958) p. 86

principal Scottish dyeworks, obtained the bulk of their alizarine from Germany and the remainder from England. Large quantities of distillates, especially anthracene for alizarine, were nevertheless exported profitably. Of 1,400 tons of anthracene processed by German distillers[1] in 1880, 1,200 tons were from Britain, and by 1893 several Scottish gasworks like Peterhead[2] shipped partially distilled tar oils from their own stills direct to Germany.

Other markets for Scottish gas tar distillates also developed in the 1850s-60s. Naphthalene[3] was used in England for carburetting gas,[4] for fuel, to repel insects and moths (after 1868), and later for azo- and indigo dyes. Carbolic acid was employed in disinfectants and soaps after its use by Lister in 1865. Perfume manufacture began with coumarin, isolated by Perkin in 1868, and sweetening agents developed from the discovery of saccharin in 1879. Light creosote was used in the Lucigen[5] pressure lamps of the 1880s. Tar

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1. By 1883, the only British firm producing alizarine was the North British Alizarine Co., formed in anger by Scottish Turkey Red Dyers at a time when raw material prices fell fifty per cent, but alizarine import prices rose fifty per cent. The company made only 700 of the 3,026 tons consumed annually in the United Kingdom. I. Levinstein "The Development and Present State of the Alizarine Industry" Journal of the Society of Chemical Industry 1882 Vol. III pp. 213-26; P.L. Payne, ed., Studies in Scottish Business History (1964) p. 52 Bibliography; R.B. Pilcher, ed., What Industry Owes to Chemical Science (1945) p. 114.

2. Gas World 12/8/1893

3. Torbanite was exceptionally rich in naphthalene and toluene, but poor in benzene and anthracene. J.G.L. 10/6/1851, p. 16

4. Vide infra p.1252

5. Manufactured by Messrs. Lyle and Hannay of Glasgow (1885 Pat. 7165; 1886 Pat. 1626; 1887 Pats. 1632, 3113). Used dry steam or compressed air to boost combustion. First installed at Messrs Bow, McLachlan and Co., of Paisley. For outdoor illumination on railways, dockyards, etc. Experimentally used to smelt iron at Gartsherrie - creosote was produced in far greater quantities than could be used for preserving timber. J.B. Hannay "On the Lucigen: A New Industrial Light" Proceedings of the Royal Philosophical Society of Glasgow 1885-6 Vol. XVII p. 393; J.G.L 26/4/1887; B. Redwood Petroleum - A Treatise (1922) 4th Edn. p. 907

and lime steam-rolled roads also became popular in the 1880s, and this use of gasworks tar expanded rapidly after 1907 when T. Aitken of Cupar[1] devized the pressurised spray-bar which allowed easy application of tar.

Ammoniacal "liquor" was the second major liquid by-product from gasworks, and like naphtha it was first used on a large scale in Scotland at two projects run by the Macintosh family; dyestuffs and alum manufacture. George Macintosh (1739-1807) in association with J. Glassford, a wealthy merchant, and G. and C. Gordon who patented cudbear dye[2] (1758 Pat. 727), produced natural dyestuffs near Glasgow using imported lichens. Human urine was collected locally in large quantities to provide the necessary ammoniacal reagent, at a cost which rose from about £800 per year in 1777 to £1,500 for 2,500 gallons[3] by 1795. Charles Macintosh's contract with Glasgow gasworks in 1819, previously mentioned, provided a mixture of tar and "liquor" for less than one-sixth of an old penny per gallon; over half of the mixture was ammonia liquor, a massive price reduction compared to about 12s per gallon in 1795. Edinburgh gas company sold their "liquor" separately to tar (and "coal oil") but in

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1. A.G. Bryant "Road Tar, Problems and Progress" Coke Oven Managers' Year book (1967) p. 101

2. Cudbear manufacture at Macintosh's Glasgow works continued until 1852.
D.W.F. Hardie "The Macintoshes and the Origins of the Chemical Industry" in A.E. Musson, Science, Technology and Economic Growth in the Eighteenth Century (1972) p. 174; G. Stewart, Curiosities of Glasgow Citizenship (1881, Glasgow) p.68 et seqq.

3. A. Brown, History of Glasgow (1795, Glasgow) p. 253.
Incidentally, before gasworks "liquor" became available, human urine was important in several textile operations, like the woollen fulling mills at Leeds; W.B. Crump, Leeds Woollen Industry (1931) op. cit., p. 155.

the absence of any local industry using that less valuable material, the charge made to H.L. Pattinson of Newcastle-upon-Tyne[1] in 1824 was only £2 10s for the output with each one million cu ft gas. This contract lasted until 1836.

Alum manufacture using aluminous shale at Hurlet[2] near Paisley commenced on a commercial scale about 1795, when Charles Macintosh entered a partnership with John Wilson, John Finlay[3] J. Knox and C. Stirling. This was so successful that additional works commenced at Campsie in 1808. After long exposure to atmospheric air, the shale oxidised to aluminium sulphate, which was made into a solution to which was added potassium chloride purchased from local soapmakers. The reaction produced potash alum, a mixture of potassium and aluminium sulphates in water. As a mordant, alum increased the brilliance of vegetable dyestuffs and "fixed" them in the cloth for greater durability. In the late 1830s, ammonium sulphate was preferred[4] to potassium, and was best prepared from gasworks ammoniacal liquor.

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1. Pattinson had to ensure that accumulation at the works did not exceed 4,000 gallons, under a penalty clause of £200. Hugh Lee Pattinson (1796-1858) of Alston, in 1821, became assistant to a soap-boiler in Newcastle; member of the Literary and Philosophical Society there in 1822; and as a result of his self-education, assay-master at Alston in Cumberland for Greenwich Hospital in 1825. Built chemical works at Felling in 1833, and later at Washington near Gateshead, to extract silver from lead ores. F.R.S 1852. S.R.O. Books of Council and Session, Deeds (17/11/1824) Vol. 262 Folio 57; Dictionary of National Biography (1909) Vol. XV p. 501.

2. A.E. Musson, Science Technology and Economic Growth in the Eighteenth Century (1972) op. cit., p. 181; S.G. Checkland, The Mines of Tharsis - Roman, French and British Enterprise in Spain (1967) p. 95; A. and N.L. Clow The Chemical Revolution (1952) p. 237

3. Major John Finlay, the brother of Kirkman Finlay, cotton magnate. W.H. Marwick Economic Developments in Victorian Scotland (1936) p. 63 Vide supra p.155

4. T. Thompson "On the Most Important Chemical Manufactures Carried on in Glasgow and the Neighbourhood" British Association, 1840, Glasgow Part II, p. 61

The earliest extant contract from Glasgow gas-company is dated 1849 when John Wilson[1] obtained the entire ammonia liquor output from Tradeston and Partick gasworks, at prices on a sliding scale related to the strength of the liquor as measured in degrees Twaddel.[2] This scale stimulated improved gasworks practice in washing ammonia from the gas, to increase the strength. The contract was renewed[3] for ten years in 1852, and apparently also in 1862, though after 1859 the contractor was George Wilson of Dalmarnock. The Wilsons[4] had several connections with heavy industry especially coal-mining.

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1. A resident at Aucheniden, Wilson was father-in-law to Charles Tennant. He had to ensure that liquor accumulations in the gasworks did not exceed 6½ feet depth, and any disputes over the contract were to be settled through J.B. Neilson and John Tennant.

   Glasgow City Archives (D.G.E. 66) 3/8/1849.

2. The Twaddel hydrometer, invented by Charles Macintosh indicated 1°T when one gallon of liquor was a strength which required two ounces of sulphuric acid to precipitate salts. To convert °T to Specific Gravity, it was necessary to multiply by five, divide by 1000, and add one, e.g. 6°T is 1.03 S.G.

   A.E. Musson, Science, Technology and Economic Growth in the Eighteenth Century (1972) p. 186; T. Newbigging, The Gas Manager's Hand book 1870, p. 86

3. Glasgow City Archives (D.G.E. 67) 11/6/1852. Pencil alterations show it was used as a draft for an 1862 contract also. John assigned his contract to George Wilson from 16/4/1859.

4. John Wilson (1782-1851), a Lanarkshire ironmaster, leased coal mines and blast-furnaces on the Duke of Hamilton's Kinneil Estate in 1846, and these passed under the control of George Wilson and Company in 1851. In partnership with Colin Dunlop of Clyde Ironworks (1810) the Hot-Blast sponsor, John opened Dundyvan ironworks at Coatbridge in 1833. He later became sole partner at Dundyvan; worked coal at Arden near Airdrie (1838); and acquired Lugar ironworks (1846-50).

   W.H. Marwick, Economic Developments in Victorian Scotland (1936) p. 65.
   P.L. Payne, ed., Studies in Scottish Business History (1967), p. 265.

   Vide infra pp. 574, 599

TABLE 3.126 Ammonia Liquor Prices at Glasgow on a Scale related to Quality (1849)

Liquor Strength °Twaddel	Tradeston per 100 Gallons		Partick per 100 Gallons	
	s.	d.	s.	d.
3	1	11	1	6
4	2	11	2	6
5	3	11	3	6
6	4	8	4	3
7	5	2	4	9
8	5	8	5	3
Every 1° extra	Extra	6	Extra	6

SOURCE: Glasgow City Archives (D.G.E. 66) Contract 3/8/1849

Artificial manures using ammoniacal liquor or sulphate were the main outlet for gasworks liquor in other Scottish regions until the 1880s, and production was usually a side-line of tar distillers' operations. Paisley gasworks sold small quantities of ammoniacal liquor in 1827 and 1838 to Robert Smith and Company, and in 1832 sold it worked-up as sulphate crystals. Liquor rose considerably in value during the industrial boom of the late 1830s.

TABLE 3.127 Ammoniacal Liquor Revenue at Paisley Gasworks 1823 - 43

Date	£	Date	£	Date	£
1823-6	0 ?	1833-5	0 ?	1839	87
1827	8.65	1836	25	1840	150
1828-31	0 ?	1837	27	1841	202
1832	9	1838	77	1842	175
				1843	162

NOTE: By-products of minor total importance compared to gross profits of £604 in 1825 and £4,855 in 1843.

SOURCE: H. Lords 31/7/1844, p. 22

Greenock[1] ran ammoniacal liquor to waste until 1839 when A. Ritchie first obtained a commercial market by advertising it for sale.

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1. J.G.L. 10/5/1851; Greenock Advertizer 9/4/1847, 16/4/1847

The agricultural value of ammonia was recorded in Justus Liebig's Organic Chemistry in its Application to Agriculture and Physiology,[1] edited by Lyon Playfair and first published in Britain in 1840. Subsequently, the value of gasworks liquor as fertilizer was emphasized by many experiments in the 1840s, as in Johnstone's lectures,[2] and in the work of T. Bishop,[3] the land steward at Methven Castle in 1843, though most publicity was given to results obtained by Mr Wilson[4] at Largs in 1841. J. Reid, gas manager at Montrose, maintained that as late as 1855 "most of the small gasworks in Scotland dispose of their ammonia water to the neighbouring farmers as manure."[5] Mixed with an equal quantity of water, Reid advocated its use for barley, grass and oats. Tar from small works could also be used, mixed with animal manures.

Reid, however, also produced twelve ounces of the more valuable ammonium sulphate fertilizer from each gallon of liquor using a simple chemical reaction with sulphuric acid. Milk of Lime (calcium hydroxide in water) was added to the liquor before heating it in a 'still'

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1. Although Liebig claimed that "the nitrogen of vegetation is furnished by the atmosphere and not by the soil", he accepted that, in the presence of other essential minerals, ammoniacal manures produced "acceleration of the development" of plants. Liebig ran experimental laboratories at the University of Giessen from 1824. J. Liebig, Chemistry in Its Applications to Agriculture and Physiology 1847 4th Edn. L. Playfair and W. Gregory, eds., pp. 210-11; Liebig and After Liebig - A Century of Progress in Agricultural Chemistry, F.R. Moulton, ed. (1942, Washington), American Association for the Advancement of Science p. 49 (comprehensive bibliography).

2. J. Johnstone, Lectures on Agricultural Chemistry and Geology (1844) Part III p. 508

3. Prize Essays and Transactions of the Highland and Agricultural Society for Scotland 1843 Vol. XIV, p. 357.

4. J.G.L. 10/6/1851; T. Newbigging, The Gas Manager's Handbook (1870) p. 85.

5. J.G.L. 10/1/1855. Much was still lost as refuse. Vide W.C. Kerby "The Waste of Ammoniacal Products" J.G.L. 28/4/1857, p. 192.

to drive off ammonia gas which was absorbed in sulphuric acid, and this solution neutralised to precipitate ammonium sulphate as crystals.[1]

Other gasworks, like Bo'ness[2] in 1859-60, also operated small ammonium sulphate plants. This was the period of an improvement movement in agriculture characterised as "high farming", with profitable mixed farming in the Scottish Lothians and southern Perthshire.[3] The popularity of imported South American guano,[4] as retailed throughout Scotland by Peter Lawson and Son of Edinburgh,[5] depressed the market for ammonium sulphate which was mainly used mixed with other manures.

Ammonia liquor rose rapidly in value in the early 1860s, though Scottish shale-oil works began to compete in sulphate production after Robert Bell[6] discovered this possibility in 1865. Nevertheless Gray sulphate (twenty-five per cent strength) rose from £11 to £15 f.o.b. Hull between January and July 1868, and £19 by 1875 (Table 3.132). A new, seven-acre Forth Bank Chemical Works at Stirling by George Shand and Company[7] in 1864 which began to handle liquor

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1. G.T. Morgan and D.D. Pratt, British Chemical Industry (1938) op. cit., p. 233; E. Thorpe, Dictionary of Applied Chemistry (1928) op. cit., Vol. I p. 208 et seq.
2. S.R.O. Bo'ness Minute Book op. cit., 9/6/1859, 7/6/1860
3. J.D. Chambers and G.E. Mingay, The Agricultural Revolution 1750-1880, (1966) pp. 170,184.
4. "On Guano - Its Value and Uses" The Scotsman 31/8/1844; W.H. Mathew "Peru and the British Guano Market 1840-1870" Economic History Review (1970) II Series, Vol. XXIII, p. 112
5. List of Lawson's retail agents vide The Scotsman 31/8/1844
6. I.I. Redwood, Mineral Oils and their By Products (1897) p. 170
7. J. Butt "The Scottish Oil Mania of 1864-8" Scottish Journal of Political Economy 1965 Vol. 12

from shale-oil works besides gasworks, was typical of the new prosperity. By 1872 human urine was again collected in Glasgow, by G. Chapman[1] who by 1876 processed 60,000 tons a year.

These were the early stages of a boom in sulphate production which lasted until 1884. Like the rising value of tar distillates, the boom was caused by an absence of competition from two industries which wasted vast quantities of ammonia and tar both in Britain and, to a lesser extent in the case of coking, abroad - the coke ovens and blast furnaces. By the mid 1880s two-thirds of British ammonium sulphate was exported, either to central Europe as a fertilizer,[2] or to Russia and America for the Solvay soda process. Ernest Solvay (1838-1922) allowed Ludwig Mond (1839-1909) a licence in 1872 to operate his ammonia-soda process whereby sodium carbonate was extracted from concentrated brine using ammonia. With J. Brunner, Mond established Northwich chemical works[3] in 1874 and soon obtained ammonia liquor from Liverpool gasworks for the process which gradually supplanted the Leblanc alkali industry in which John Tennant (1796-1888)* at St Rollox in Glasgow was a leading manufacturer. In the early 1880s ammonium sulphate for the Solvay process was thus being exported from Scotland to Cheshire in large quantities,[4] including 3,000 tons worth £56,000 in 1882.

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1. Notice of Some of the Principal Manufactures in the West of Scotland (1876, Glasgow)
2. L.F. Haber, The Chemical Industry During the Nineteenth Century (1958) op. cit., pp. 105-6.
3. Ibid., pp. 15, 87, 101, 157
4. R.R. Tatlock "Address to the Chemical Section", Proceedings of the Royal Philosophical Society of Glasgow (1882-3) Vol. XIV p. 263 et seq .

* Successor of Charles Tennant (1768-1838), the founder of St. Rollox. J.Butt The Industrial Archaeology of Scotland (1967,Newton Abbot)p. 13[8]

Gasworks which tried vertical integration by operating ammonium-sulphate equipment, gained the advantages of no annual contracts or middlemen to erode general market profits, the absence of transport costs, and the possibility of stock-piling for greater stability of prices. Malodorous atmospheric pollution was the main drawback, and this prevented companies like Ayr purchasing chemical equipment in the 1880s. Kilmarnock[1] gasworks opened one of the early sulphate works to become a long-term success in 1863. As sulphate prices rose, further capital was invested in more efficient purification of gas. Thus the single 'scrubber' at Kilmarnock[2] in 1872, twenty feet high and four feet in diameter, recovered liquor equivalent to sixteen pounds sulphate per ton of coal; in 1873 it became worthwhile to instal a second scrubber which raised the yield to twenty-one pounds, and by doubling the condensers in 1875, yield rose to twenty-six pounds equivalent per ton of coal. By reducing retort temperatures output of ammonium sulphate reached fifty tons from 5,434 tons coal.

Although many small gasworks used no scrubber, or one which was ineffective through the lack of steam power for a water-spray, some like Lanark devized gravity feed systems and by 1878 the president of the West of Scotland Gas Managers' Association[3] advised small works that by-products revenue was the best solution to meet the competition from electricity. Larger works thought likewise, and

1. S.R.O. Ayr Minute Book op. cit., 27/12/1886

2. S. Dalziel (Kilmarnock) "The Treatment of Residuals" N.B.A.G.M. 1880.

3. S. Stewart, Presidential address J.G.L. 29/10/1878; c.f. J. Eldridge "Apparatus for Manufacturing Sulphate of Ammonia Suitable for Small Gasworks" J.G.L. 18/7/1871

Coatbridge[1] installed sulphate plant in 1880. Rothesay[2] installed washers in 1883 which increased liquor recovery by £200 per year, and reduced lime expenditure by £25. In 1884 three small Scottish gasworks[3] were reported to have reduced distillation temperatures, to raise by-product output even though this involved a reduction in gas output from 11,000 to 6,000 cu ft per ton and hence more retorts in use, and wear and tear increased.

Most gasworks selling residuals experienced such a large rise in by-product revenue in the 1870s and early 1880s that this became of major importance, equivalent in some cases to thirty-six per cent of coal costs, twenty per cent of gas revenue, and seventeen per cent of total revenue, as shown in Table 3.128. The rise of by-product income, especially of tar and liquor, is demonstrated at Glasgow in Table 3.129. At Aberdeen,[4] which piped liquid residuals to Messrs Miller's adjoining Sandilands chemical works, tar and liquor rose from £348 in 1871 to £5,141 in 1883. At Arbroath[5] the increase was from £377 in 1878 to £789 in 1883. Dundee[6] in 1883 received £10,458 for tar and ammonia, equivalent to 35.9 per cent of the cost of coal at 18s 4½d per ton (Table 3.130)

The two boom markets for ammonium-sulphate and tar-distillates did not pass unnoticed by the coke and blast-furnace entrepreneurs, who faced considerable technical problems in recovering

1. J.G.L. 31/7/1888
2. J.G.L. 17/7/1883
3. Evidence of Mr Mitchell, Edinburgh gas manager, J.G.L. 19/2/1884
4. J.G.L. 23/5/1871 p. 402; 10/7/1883
5. J.G.L. 10/7/1883
6. J.G.L. 26/6/1883

TABLE 3.128 Value of By-Products in Various Towns (1882 - 6)

Date	Town	Coal Cost	Gas Revenue	Total Revenue	Total	By-Products % Coal Cost	% Gas Revenue	% Total Revenue
		£	£	£	£			
1882	Johnstone	-	3,933	-	445	-	11.3	-
1883	Arbroath	-	-	9,458	789	-	-	8.3
1884	Dundee	36,786	-	66,596	8,934	24.3	-	13.4
1884	Arbroath	-	7,661	10,640	1,323	17.2	-	17.3
1884	Renfrew	962	1,439	-	290	30.0	20.1	-
1885	Perth	5,589	-	-	1,571	28.0	-	-
1885	Dundee	37,876	-	-	6,362	16.8	-	-
1885	Hawick	3,122	-	7,237	1,128	36.1	-	15.6
1885	Forfar	-	5,176	6,743	988	-	19.1	14.7
1886	Forfar	2,779	4,941	-	1,007	36.2	20.4	-
1886	Perth	6,354	-	14,405	1,708	26.9	-	11.9
1886	Johnstone	-	4,354	5,155	528	-	12.1	10.2

SOURCES: J.G.L. 24/7/1882, 10/7/1883, 10/6/1884, 8/7/1884, 28/10/1884, 9/6/1885, 23/6/1885, 28/7/1885, 20/7/1885, 8/6/1886, 2/8/1887.

TABLE 3.129 Rising Value of By-Products at Glasgow Gasworks (1870-85)

Date	Gas Revenue £	Total Revenue £	Coke Income £	Tar and Ammonia Liquor Income £	Total By-Products % Total Revenue	Total By-Products % Gas Revenue
1870	210,736	235,701	9,557	13,972	10.0	11.2
1871	225,095	252,357	8,275	17,902	10.4	11.6
1872	238,048	269,976	9,274	21,189	11.3	12.8
1873	255,726	289,620	13,917	18,788	11.3	12.8
1874	325,105	357,702	10,798	20,702	10.9	12.3
1875	345,641	378,393	8,547	22,923	8.3	9.1
1876	326,660	364,896	9,735	27,286	10.1	11.3
1877	306,001	342,909	7,730	27,679	10.3	11.6
1878	290,816	327,430	7,114	27,907	10.7	12.0
1879	299,517	337,964	7,880	27,909	10.6	11.9
1880	295,930	341,274	7,669	35,219	12.6	14.5
1881	302,793	353,811	8,238	40,015	13.6	15.9
1882	326,399	378,133	7,100	41,986	13.0	15.0
1883	350,112	406,977	9,915	44,355	13.3	15.5
1884	353,529	418,775	13,828	48,908	15.0	17.7
1885	364,203	428,227	15,306	46,798	14.5	17.1

SOURCE: Gas World 24/10/1885

TABLE 3.130 Value of By-Products at Dundee 1872-81

Date	Total Revenue	Coke Revenue	Other By-Products	Total By-Products	Coal Cost	Total By-Products as Percentage Coal Cost
1872	43,873	1,153	3,220	4,373	22,265	19.6
1873	46,950	1,633	2,959	4,592	29,305	15.7
1874	67,864	1,862	2,430	4,292	44,902	9.6
1875	64,763	797	2,763	3,560	43,248	8.2
1876	61,588	1,337	2,985	4,322	35,806	12.1
1877	57,380	679	3,338	4,017	31,477	12.8
1878	60,615	1,441	4,314	5,755	33,738	17.1
1879	57,985	888	3,943	4,831	31,172	15.5
1880	57,759	1,034	4,137	5,171	31,867	16.2
1881	58,609	1,326	4,280	5,606	32,561	17.2

SOURCE: J.G.L. 3/1/1882; vide infra p. 1570

residuals. In 1765, coke ovens supplying blast-furnaces at Saarbrücken[1] supplied tar for miners' lamps, but most British coke in the early nineteenth century was from open heaps. The rising value of tar-distillates in the late 1850s-60s inspired several experiments like Lord Dundonald's horizontal D-retorts for coke, and modification of open-coke heaps by S. Blackwell, to recover liquid by-products.[2]

1. W. Smith, "The Earliest Records of Methods for Coking of Coal in Coke ovens for Metallurgical Purposes with Recovery of Tar and Ammonia" Journal of the Society of Chemical Industry 1884 Vol. III pp. 601-4
The History of Cokemaking and of The Coke Managers' Association (1936) p. 36

2. Dundonald's ovens vide E. Rogers "Manufacture of Charcoal and Coke" Proceedings of the Institute of Mechanical Engineers 1857;
S.H. Blackwell (Dudley) "On a New Process of Open Coking" Proceedings of the Institute of Mechanical Engineers 1860

Henry Aitken[1] pioneered coke-oven by-products in Scotland with ovens built to his own design at Almond Iron Works, Falkirk, in 1875. By 1880, more of Aitken's ovens at Blaenavon recovered even gas for illumination. Nevertheless, continental European competitors developed the first profitable by-product coking ovens, and conservatism against adoption of the Carvès[2] ovens in Britain resulted in an annual loss, by 1877, of about 36,000 tons of ammoniacal liquor worth almost £2.8 million as sulphate.[3] The Bairds of Gartsherrie[4] were the first in Scotland to import this technology with 40-chamber Bauer ovens in 1887, 50 Semet-Solvay ovens at Dumbreck

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1. H.A. Aitken (d. 1902) son of a Falkirk solicitor, trained as mining engineer. Manager of Torbanite mines in West Lothian, and of Almond Iron Works from 1860. Chairman of the Niddrie/Benhar, Lochore/Capeldrae Cannel, and Cadzow coal companies, and of Kithill tin mines in Cornwall. Connected with Spanish mines; early research on recovery of blast-furnace gases. His 1874 patent (Pat. 2587) was used with that of Wm. Young in 1875 (Pat. 2725) to design a coal-gas "Analyzer" as previously described, which was marketed through the Universal Gaslight Improvement Co. 1877-8 (S.R.O. (B.T.2/782)) which paid Aitken £1,800 expenses and 5,000 £10 shares. Henry's brother John (1839-1919) trained as an engineer at the University of Glasgow and with Messrs Napier, shipbuilders, before becoming a notable scientist.
   Obituary of H. Aitken <u>Transactions of the Mining Institute of Scotland</u> 1903-4 Vol. 26 p. 27; articles in <u>Transactions of the North of England Institute of Mining and Mechanical Engineers</u> 1874-5 Vol. XXIV p. 97, 1879-80 Vol. XXIX p. 81; <u>Transactions of the Mining Institute of Scotland</u> 1883-5 Vol. 5 p. 298; C.G. Knott, <u>Collected Scientific Papers of John Aitken, L.LD., F.R.S.</u> (1923, Cambridge).

2. Carvès, the manager at St Etienne coke works, improved Knab's 1856 ovens, and his design was used at Bessèges in 1866, and at Paris gasworks by 1870.
   <u>Journal of the Society of Chemical Industry</u> 1884 <u>op. cit.</u>

3. F. Jourget "Manufacture of Coke" <u>Fourteenth and Fifteenth Annual Reports of the Alkali Inspector 1877-8</u> pp. 48-81; J. Clapham, <u>An Economic History of Modern Britain - Free Trade and Steel 1850-1886</u> (1932) p. 106.

4. R.D. Corrins "Wm. Baird and Company" (1974) <u>op. cit.</u>, pp. 248-53.

in 1897 and more at Bedlay in the early 1900s. Merryton Colliery Company also built ovens at Bannockburn,[1] and Coppeeovens were built at Plean in 1896, but most Scottish coke in the early 1900s was from traditional beehive ovens[2] and only 290,000 tons out of the British total 11 million tons of coke was made in 1905.

Blast furnace gas proved the most serious rival to gasworks' by-products, especially that produced in Scotland where the resistance to crushing, and non-caking or non-swelling property of coals[3] enabled them to be used in place of coke, so that furnaces became large, vertical gas-retorts. Early experiments were designed to recover the "green gas"[4] as fuel for steam raising, and the main problem for ironmasters like Budd and Levick in South Wales,[5] and at the Gartsherrie and Dundyvan ironworks in the early 1850s, was to obtain the gas without reducing furnace efficiency. In 1848-54 Alexander Christie financed extensive experiments at Devon Iron Works,[6] while

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1. Twenty-five ovens built in 1911, by James Bain, copying designs in Westphalia, were described by J.L. Carvel One Hundred Years in Coal - The History of the Alloa Coal Company (1944, Edinburgh) p. 96; see also C.H. Lauder "The History of Coal Carbonization" in Historical Review of Coal Mining (1924, Mining Association of Great Britain).

2. A. McLean, Ed. Local Industries of Glasgow and the West of Scotland (1901, British Association) p. 15.

3. W. Aiton General View of the Agriculture of Ayr (1811, Glasgow) p. 50; A. Slaven The Development of the West of Scotland 1750-1960 (1975) p. 117; V.B. Lewes The Carbonization of Coal (1912) pp. 205, 206, 265.

4. Prof. Bunsen of Marburg and Dr Lyon Playfair "Gases Evolved from Iron Furnaces" British Association - 1845, Cambridge p. 142; S. Muspratt Chemistry in Arts and Manufactures (1861) op. cit., Vol. II, p. 426; Wemyss Reid Memoirs and Correspondence of Lyon Playfair (1899) p. 63

5. S.H. Blackwell "Materials in the Blast Furnace, and Application of Waste Gases" Proceedings of the Institute of Mechanical Engineers 1852.

6. J. Mayer "Iron Manufacture in Scotland" Journal of the Iron and Steel Institute 1872 Vol. II pp. 36-8.

partner John Wilson made similar trials at Dundyvan.

Experiments continued at Summerlee, and with greater success at Glengarnock, and although it has been claimed[1] that Scottish ironmasters ceased recovery-trials by 1860, later in that decade their attempts were again publicised.[2] Walter Neilson[3] (1807-85) ran the experiments at Summerlee, where in 1868 the Addenbrook system allowed the recovery of furnace gas for use as fuel. Each ton of coal[4] gave 120,000 cu ft gases at 300°F, containing 28-30 per cent carbonic oxide, 3-8 per cent carbonic acid, 5-7 per cent hydrogen, 2-4 per cent methane and 52-60 per cent nitrogen (of which 14 per cent was ammonia). Soon, liquid by-products like tar and ammonia were successfully recovered at Monkland ironworks[5] in 1874, by H. Aitken of Falkirk.

The conservatism of ironmasters who feared a reduction of iron quality, inhibited further development throughout the 1870s, and in 1877 a reputable chemist, Dr Wallace, advised Messrs Bairds that by-product recovery was uneconomical.[6] Nevertheless, experiments were conducted by Messrs Bairds on the initiative of one partner, William Ferrie,[7] who was also a gas company director. Their equip-

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1. R.H. Parsons, A History of the Institution of Mechanical Engineers 1847-1947 (1947) p. 133; Proceedings of the Institute of Mechanical Engineers, 1860, 1865.
2. W. Fairburn, Iron, its History, Properties and Processes of Manufacture (1869, Edinburgh) pp. 84-94.
3. Obituary Journal of the Iron and Steel Institute 1885 Vol. II
4. Gas World 1885 p. 322
5. Ibid.
6. R.D. Corrins " Wm.Baird and Company." (1974, unpublished Ph.D thesis, University of Strathclyde) pp. 44-9.; R.D. Corrins "Entrepreneurship in the British Iron and Steel Industry, 1870-1914 - The Case of William Baird & Co." Journal of the West of Scotland Iron and Steel Institute 1971-2 Vol. 79, p. 138.
7. W. Weldon, "On the Present Condition of the Soda Industry" Journal of the Society of Chemical Industry 1882 Vol. II, p. 5.

ment, devised by John Alexander and A.K. McCosh,[1] heralded a dramatic fall in the market prices of ammonium and tar-distillates. The first recovery of anthracene and benzol was made at Gartsherrie ironworks in 1880, and compared with identical coal distilled at Coatbridge gasworks.

Dr Siemens in 1882 drew the attention of furnace managers to by-products,[2] with an apparently "unlimited" demand for ammonium sulphate. Siemens claimed that the dyestuffs industry in Britain and abroad used almost the entire British output of benzene, naphtha, anthracene, and also some naphthalene, from gasworks tar. The Alexander and McCosh process (1879 Pat.4117), 1880 Pat. 1433, 1881 Pat.3785), was adopted on a large scale[3] at Gartsherrie, Lugar and Muirkirk in 1882-4. James Addie of Langloan (1882 Pat. 4758) and W. Neilson at Summerlee[4] also adopted recovery processes in the early 1880s, and Carron[5] used furnace gas as fuel by 1884 and later recovered liquid products.

The sixty million cu ft gas processed daily at Gartsherrie contributed significantly to the by-product slump experienced by gasworks in 1884-6, a date which varied with the duration of existing chemical contracts. Over-production of aniline and alizarin dyes

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1. P.L. Payne, ed., Studies in Scottish Business History (1967) p. 256.
2. Journal of the Iron and Steel Institute 1882 pp. 714-5.
3. Detailed description vide Gas World 1885 p. 322
4. Gas World 1885 p. 322; J.G.L. 21/4/1885 p. 734, 9/3/1886 p. 505.
   Comprehensive review vide W. Jones (Langloan Works) "The Present Position and Prospects of Processes for the Recovery of Tar and Ammonia from Blast Furnaces" Journal of the Iron and Steel Institute 1885 Vol. II pp. 410-47
5. Journal of the Iron and Steel Institute 1884 Vol. I, p. 195

TABLE 3.131 Total Value of By-products from United Kingdom Gasworks (1882)

Crude Product	Output (Millions Tons)	Refined Product	Value Refined Products (£ Thousands)
Ammoniacal Liquor	1	Ammonium Sulphate	1,947
Tar	0.5	(Dyestuff	3,350
		(Pitch	365
		(Creosote	208
		(Carbolic Acid	100
Coke sold	4	-	2,400
Sulphur	0.12	(wasted)	-
		TOTAL (£ Thou.)	8,370

SOURCE: Journal of the Iron and Steel Institute 1882, pp. 714-5.

TABLE 3.132 Prices and Competition between Ammonium Sulphate and Nitrate Fertilizers in Britain (1868 - 89)

Date	Gray Sulphate (25%) F.O.B. Hull	Nitrate (95%) F.O.B. Liverpool	Tons Sodium Nitrate into Europe
	£		
Jan. 1868	11	-	-
July 1868	15	-	-
1875-6	19	-	-
1879-80	20	16	140,000
1881	20	15	225,000
1882	20	13	340,000
1883	17	11	450,000
1884	14	10	500,000
1885	11	10	380,000
1886	11	10	-
1887	12	10	-
1888	12	10	-
1889	12	9	-

SOURCE: Gas World 9/1/1886, 18/1/1890, 1/2/1890

coincided with an agricultural depression which reduced the demand for ammonium sulphate at a time when the price of American exports of sodium nitrate into Europe had fallen from £16 per ton in 1880 to £9 15s by 1884 making them strong competitors.[1] Moreover the chief market, Germany, imported less sulphate and tar-distillates from Britain as coke-ovens were providing more local supplies. The sulphate fertilizer market is shown in Table 3.132 above.

The severity of the slump affected all Scottish gasworks selling residuals and resulted in a rise in gas prices in many towns,[2] Aberdeen raised gas from 3s 10d to 4s, Forfar from 4s 4d to 4s 7d, and Prestonpans from 4s 7d to 5s 5d. A fortuitous fall in coal prices absorbed only part of the impact, as at Rothesay[3] in 1886. The by-product slump appears to have been the main motivation for the promotion of gas cooking and heating after 1884.

Dundee[4] gasworks distilled tar and also produced sulphate, but suffered a fall in by-product revenue from £10,458 in 1883 to £8,766 in 1884 and £6,362 in 1885. The naphtha market fell from 2s 9½d per gallon in 1882 to 4d; sulphate fell from £20 10s per ton to £10 10s. The revenue decline at Dundee was from 6s 7d to 1s 10d per ton of coal carbonized. Dumbarton[5] in 1885 made a trading loss of £950 because by-products had fallen seventy per cent. The tar and liquor revenue at Aberdeen[6] fell £4,000 in 1884-5 and a sliding-scale of payment was developed by Messrs. John Miller. Miller paid

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1. Lunge incorrectly claims that incandescent mantles reduced benzol consumption by gasworks for enrichment purposes in the early 1880s. G. Lunge, <u>Coal Tar and Ammonia</u> (1909) pp. 155-7, 247; L.F. Haber, <u>The Chemical Industry during the Nineteenth Century</u> (1958) <u>op</u>. <u>cit</u>., pp. 105, 106; "Disastrous Fall in the Price of Residuals" <u>Gas World</u> 4/4/1885.
2. <u>J.G.L.</u> 24/8/1886, 3/11/1885, 3/8/1886
3. <u>J.G.L.</u> 20/10/1885
4. <u>J.G.L.</u> 23/6/1885, 17/11/1885, 11/6/1886
5. <u>J.G.L.</u> 20/10/1885
6. <u>J.G.L.</u> 1/9/1885, 15/9/1885, 14/9/1886

2s 3d per ton of coal (1s tar and 1s 3d liquor) whilst ammonium sulphate was £12 per ton on the market, 2s 6d when £13, 2s 9d when £14, and only 2s when sulphate was £11. The last figure was reduced by 6d in 1886. The small Kirkintilloch[1] municipal gasworks which received 12s 6d per 100 gallons tar and liquor in 1884, obtained 4s 6d in 1885 and 2s 6d in 1886. That year, Arbroath[2] received 2s 8d per 100 gallons from Mr Briggs and similar prices were universal. Dumfries[3] began to burn tar as furnace fuel when Maxwell's nearby distillery offered only 3s per 100 gallons, and elsewhere small gasworks were advised to install ammonium-sulphate[4] plant to obtain as much by-product revenue as remained possible.

Large distilleries which expanded in the boom of the early 1880s were badly hit by the slump and many relied upon rebates from gas companies to maintain their liquidity. Only a few, like Maxwell of Dumfries and Messrs. Miller[5] of Glasgow who purchased tar and creosote from Gartsherrie in 1886, took immediate advantage of the new supplies. The Gas Residual Products Company Limited,[6] formed with £60,000 stock in 1884, absorbed Messrs J.B. Lindsay of Irvine and Messrs Galloway of Coatbridge, Pollokshaws and Glasgow, intensified the competition in which Messrs J.B. Robertson of Dunbar Chemical Works[7] became bankrupt with £3,622 debts mainly to Dalkeith and Burntisland Gas Companies.

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1. J.G.L. 18/5/1886.
2. J.G.L. 18/4/1886
3. J.G.L. 18/5/1886
4. J.T. Lewis "The Utilization of Residual Products in Gasworks" J.G.L. 12/6/1886 p. 787.
5. J.G.L. 5/1/1886
6. S.R.O. (BT 2/1348)
7. Gas World 25/4/1885; S.R.O. Dalkeith Minute Book op cit., 31/3/1885.

Messrs. W.G. Walker and Sons of Ayr chemical works had obtained tar and liquor from Ayr gasworks[1] from 1875-83 at 10s per 100 gallons. Despite reductions to 8s in 1885, 3s in 1886 and 1s 6d in 1887, they were £580 in debt by February 1887. Although Ayr placed the next contract with rival distillers in October 1887, Walker's debt remained open until 1889 when £300 was written off the remaining £374. Messrs Walker, incidentally, sold pitch in London and in 1887 repaid £100 as a Bill from D. Stover and Sons there.

This allowance to distillers, repeated at most Scottish gasworks, saved them from wholesale bankruptcies. Galashiels[2] company which had dealt periodically with J. Ross of Falkirk since 1858, allowed him a rebate of 3d per ton coal in May 1885, followed by £400 in the spring of 1886, and a further £200 a year later. The small Annan[3] company in 1886 halved the contract price to Maxwell of Dumfries.

From 1887 to 1891 sulphate output from Scottish blast furnaces[4] stabilised at about 5,000 tons per year, before doubling in 1892 and rising steadily from 1895 to 16,000 tons by 1900. The ammonia-soda process provided a growing market which reinstated worthwhile prices for sulphate. Messrs R. and J. Dempster, coal-gas engineers of Manchester, devised blast-furnace gas apparatus in 1884

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1. S.R.O. Ayr Minute Book _op. cit._, 1886-1890
2. S.R.O. Galashiels Minute Book _op. cit._, 8/4/1884, 6/5/1884, 5/5/1885, 2/3/1886, 3/5/1887
3. S.R.O. Annan Minute Book _op. cit._, 8/3/1886, 15/4/1886
4. Annual statistics reproduced in _Journal of the Iron and Steel Institute_ 1901.
   Gartsherrie statistics for 1887-1919 _vide_ S.R.O. (C.B. 4/521) 953/67.

(Pat. 10,790) which within a decade was used at Shotts,[1] Govan,[2] Carnbroe, Calder and Glengarnock ironworks. In association with Messrs Merry and Cunningham, ironmasters, Messrs Dempster operated the £52,500 Carnbroe Chemical Company from 1891 to process the by-products.

Andrew Gillespie, a coal gas engineer who designed the new Ardrossan[3] gasworks of 1900-3, introduced a third recovery system for blast furnace gas at Clyde ironworks Tolcross and for Summerlee and Mossend company[4] in the mid-1890s. By 1895, by-produce recovery was second only to Neilson's Hot Blast in economic importance to the Scottish iron industry,[5] though in England coal-quality restricted such operations entirely to Staffordshire.[6]

In the new by-product environment where output periodically exceeded demand, instability did not deter gasworks and shale-oil works from renewed efforts to recover tar and ammonia for sale (Table 3.133)

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1. J.G.L. 26/5/1891
2. Govan recovery plant installed 1888, exploded 1891 killing five employees. J.G.L. 22/5/1888, 17/3/1891
3. Ardrossan Burgh Centenary 1846-1946 (1946) op. cit.
4. A. Gillespie "Recovery of Tar and Ammonia from Blast Furnace Gases" Proceedings of the Institute of Engineers and Shipbuilders of Scotland 1895-6, Vol. xxxix.
   A. McLean, Ed., Local Industries of Glasgow and the West of Scotland (1901, British Association).
5. Evidence of A.H. Sexton, Proceedings of the Royal Philosophical Society of Glasgow 1895-6, Vol. XXVII
6. e.g. Messrs Dempster's 1885 installation for Messrs. R. Heath and Son, Stoke on Trent.
   Gas World 1885 p. 322
   G. Lunge, Coal Tar and Ammonia (1909) p. 1107
   Journal of the Iron and Steel Institute 1884 Vol. I p. 216, Vol. II p. 486.
   J.C. Carr and W. Taplin, History of the British Steel Industry (1962, Oxford) p.

TABLE 3.133 Competition from Shale-Oil Works in Ammonium Sulphate and Naphtha Markets (1877-1891)

Date	Production from each Ton of Shale						Income from Sulphate (per Ton)		
	Crude Oil (Gallons)	Naphtha (Gallons)	Sulphate of Ammonia (lbs)	Total Value of Products per Ton Shale					
				£	s	d	£	s	d
1877	30.49	-	17.37	1	3	2	17	5	6
1882	29.84	-	13.77	0	14	4	18	2	5
1887	27.86	-	28.95	0	11	2½	10	5	0
1891	25.09	1.73	27.23	0	13	2	10	7	1

SOURCE: R.T. Moore "The Mineral Oil Industry of Scotland" Transactions of the Federated Institute of Mining Engineers 1892-3, Vol. IV

Most gasworks recovered from the by-product slump during 1887 when, for example, Hamilton[1] received from J. Ross 4s 3d instead of 2s 3d per 100 gallons, Paisley[2] obtained 3s instead of 1s 4d per ton of coal carbonized, and Forfar[3] sold tar to Messrs Dobbie at 7s when it had previously fetched 3s 7d. Rising values could not be relied upon, however, and gasworks were not tempted to develop by-product sales as an alternative to selling large quantities of 'calorific' cooking gas which proved to be the long-term key to prosperity.

"Reckless competition going on among tar distillers"[4] in the 1890s led to the bankruptcy of more distillers. Messrs Weir and company,[5] who built a tar still adjoining Ayr gasworks on the basis of a one year contract in 1888, successfully obtained a similar

1. J.G.L. 9/8/1887
2. J.G.L. 25/6/1889
3. J.G.L., 25/6/1889
4. S.R.O. Ayr Minute Book op. cit., 27/2/1893
5. S.R.O. Ayr Minute Book op. cit., 19/12/1887, 5/6/1888, 31/3/1890, 6/6/1890.

contractin 1889 but went bankrupt the following year with debts of £150 to Glasgow and South Western Railway, probably for carriage of the refined products. Booms in liquid by-product prices occurred during the furnacemen's strike[1] of 1890-1 and colliers' strike of 1893-4. In the summer of 1890, Ardrossan received 20s per 100 gallons for tar, Kilmarnock received 17s 6d, and Dumfries 16s (and 3s 5d for ammonia liquor).[2] In these unsettled conditions, it was too easy for distillers to take on excessive committments in order to obtain supplies, and in 1892 Glasgow Alum and Ammonia Company[3] was liquidated with assets of £7,394 and liabilities of £11,136 including a debt of £523 to Galashiels gas company. This collapse led to a reduction in revenue for gasworks like Bathgate[4] from 8s 1d to 3s per 100 gallons of tar and liquor.

The long-term prospects for ammonium sulphate sales nevertheless remained encouraging. Several gas companies embarked upon capital expenditure for sulphate plant in the late 1880s, and the instability of the early 1890s persuaded many other Scottish gasworks to take the same step. Although more ammonia 'liquor' than tar was obtained from a given quantity of coal, liquor was often only one-third to one-fifth as valuable as an equal quantity of tar because the chemicals were less concentrated until prepared as sulphate crystals. Once a sulphate plant was successful, gasworks often installed a tar-still to be operated by the same staff. The financial

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1. Journal of the Iron and Steel Institute, 1901.
2. J.G.L. 17/6/1890, 10/6/1890, 13/5/1890
3. S.R.O., Galashiels Minute Book op. cit., 5/4/1892
4. S.R.O. Bathgate Minute Book op. cit., 14/6/1892, 4/2/1892

advantages were considerable. At Tillicoultry[1] a sulphate plant in 1887 raised the value of by-products from 5½d to 2s 10d per ton of coal carbonized. Nine tons of sulphate from 836 tons of coal sold for £101, a trading profit of £59. Inverness[2] gasworks in 1888 built a sulphate and tar works for £500; the output of sulphate, naphtha and tar in one year sold for £1,113, a trading profit of £703 which tripled the previous £208 by-product revenue from external contractors. In 1893, Ayr[3] gasworks received only 1s 5d for tar and liquor per ton of coal carbonized, compared to between 2s 6d and 3s at Dundee, Coatbridge, Kilmarnock, Perth and other works processing sulphate. Ayr made enquiries about a sulphate plant, but was discouraged by a slump in the sulphate market from £13 to £8 7s 6d per ton in 1886, which reduced the contract price of tar and liquor from 4s 4d to 3s 4d per 100 gallons.[4]

A renewed boom in sulphate prices from about 1896-1902, and in 1911-14, led again to installation of sulphate plant at many gasworks and an importance of liquid by-products similar to the early 1880s. Peterhead[5] gasworks in 1899 received 9½d per ton coal carbonized by the sale of residuals to a small adjacent chemical works, run by a single man whose "intermittent plant" was used alternately to make sulphate and tar distillates, specially boiled tar. In 1900 Peterhead council purchased a "continuous" sulphate plant (£400) and a still for tar and naphtha (£311) which was operated by one man and raised by-product profit to 3s per ton of coal carbonized compared

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1. J.G.L. 31/7/1888
2. J.G.L. 9/7/1889
3. S.R.O. Ayr Minute Book op. cit., 18/12/1893
4. Ibid., 24/2/1896
5. G. Keillor (Peterhead) "The Manufacture of Sulphate of Ammonia" N.B.A.G.M. 1903

to the national average of 2s 1½d where liquid by-products were sold raw. Each ton of sulphate (twenty-five per cent strength) used 2,600 gallons liquor and one ton of 144 per cent Sulphuric Acid; consequently each ton of coal gave only twenty to thirty pounds of sulphate.

Also in 1900, Hamilton[1] gasworks purchased sulphate plant from Messrs E. Scott and Company of London. Andrew Gillespie turned his attention from blast furnaces to coal-gas to produce improved sulphate plant in the late 1890s for Motherwell, Alloa, Rothesay and Kilmarnock gasworks, and also an installation at Ayr[2] costing £807 in 1901. By 1903 about eighteen Scottish gasworks[3] manufactured ammonium sulphate. Although sulphate prices (Table 3.136) remained at least one-third lower than in the early 1880s, the 1900s boom occasioned important capital expenditure at many works. Greenock, for example, in 1913 replaced an old sulphate plant producing thirty cwt per day, with one for sixty cwt by Messrs C. and W. Walker (£1,535) besides a liquid ammonia plant (£1,000) producing up to ten tons a week, and improved extraction facilities including a Livesey washer and four water-cooled tower-condensers* (£2,495) from Messrs Clapham Bros.

Edinburgh gas companies, and the gas Commissioners, relied upon outside contractors for the sale of residuals[4] up to the early 1900s when a large chemicals plant was built adjoining Granton gasworks. Glasgow corporation also sold residuals to independent

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1. S.R.O. Ayr Minute Book <u>op. cit.</u>, 24/12/1900
2. Gillespie's fee, five per cent of profits, was later altered to £77. <u>Ibid.</u>, 19/8/1901, 25/8/1902
3. <u>N.B.A.G.M.</u> 1903.
4. <u>J.G.L.</u> 31/7/1877

* <u>Vide supra</u> p.246 Fig. 3.7

distillers, after an unsuccessful trial at operating a distillery at Dawsholm[1] in 1873-9. Tradeston[2] gasworks from 1868-1903 sold almost exclusively to local distillers, first Glasgow Alum and Ammonia company and later Messrs Robertson and Hunter; J. Ross was the only distant contractor to obtain supplies, in 1889-94, and paid £4,000 carriage to Falkirk on the Caledonian Railway above his contract price of £9,000 per year. Messrs. George Miller continued the Dalmarnock distillery until 1913; the West of Scotland Chemical Company leased Dawsholm distillery; and at the new Provan gasworks a distillery was leased to Messrs Brotherton[3] from 1909-13. Nevertheless, Glasgow achieved a by-product revenue greater than comparable undertakings with their own chemical plants (Table 3.134)

TABLE 3.134 By-Product Output at Large Scottish Gasworks (1913)

Town	Coal Carbonized (Tons)	Tar/Ammonia (Tons)	By-Product Revenue (Per Ton Coal)	
Dundee	87,056	17,714	4s	0d
Edinburgh	187,254	41,698	4	5
Glasgow	687,542	180,898	5	3
Greenock	38,543	8,345	4	3
Paisley	42,202	9,005	4	3

SOURCE: Glasgow City Archives Glasgow Reports Vol. 6 p. 664

The price of sulphuric acid, for which ammonium sulphate works were a major market, variedlike naphtha prices according to geographical and transport factors (Table 3.137). Nevertheless, by the 1900s by-products made in total up to twenty-nine per cent of gross revenue at

1. J.G.L. 25/6/1887.
2. J.G.L. 1/5/1888, 28/5/1889; N.B.A.G.M. 1903
3. Glasgow City Archives Glasgow Reports Vol. 6, p. 664.

Broughty Ferry (Table 3.138), and in the early 1910s thirty-six per cent of gross revenue equivalent to sixty-one per cent of gas revenue at Hamilton (Table 3.139). In 1907 total Scottish gasworks output of ammonium sulphate (Table 3.140) was about 6,000 tons worth £70,000, and ammoniacal liquor worth £8,000, both equal to thirteen per cent of the total by-products worked up at gasworks.[1] This sum total of £602,000 per year was equal to 23.5 per cent of total gas revenue in Scotland, and a far more significant factor[2] in the prosperity of the gas industry than has recently been claimed.[3]

Vertical gas retorts, especially when steaming was used, produced a thinner tar[4] with forty to fifty-five per cent pitch instead of over sixty per cent; and also an increase in ammoniacal liquor from that equivalent to about twenty-two to thirty pounds sulphate up to the equivalent of forty-five pounds. In the absence of any synthetic-ammonia works in Britain by 1914, unlike the Haber nitrogen-fixation process in Germany, the gap in output by these world leaders in sulphate production slowly widened. Thorpe's quotation of British output[5] at 331,000 tons in 1907 may be a misprint for 231,000 tons, compared to Germany at 287,000 and world output of 895,320 tons. By 1913 Britain produced 438,932 and Germany 549,000 tons.

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1. Census of Production (1907) - Preliminary Tables Summarizing Returns Under the Census of Production Act 1906 (1910, H.M.S.O.) Category 116.
   Note - The Introductory volume, pp. 21-2, 57, provides misleading statistics on coal tar chemicals production.
2. Britain in Depression - A Record of British Industries Since 1929 (1935, British Association) p. 177
3. E.J. Hobsbawm, Labouring Men - Studies in the History of Labour (1965) pp. 158-9.
4. E. Thorpe, A Dictionary of Applied Chemistry (1928) Vol. III p. 341, Vol. I p. 201
5. Ibid., Vol. I, p. 203.

TABLE 3.135 United Kingdom Output of Ammonia (calculated as Sulphate) 1889 - 1913

	1889	1913	1917
Gasworks	87,000	182,180	188,478
Iron Works	5,500	19,956	13,621
Shale Works	22,000	63,061	60,560
Coke Ovens	-	133,816	166,354
Producer Gas &c	3,000	33,605	29,604
TOTAL	117,500	432,618	458,617

SOURCE: E. Thorpe, Dictionary of Applied Chemistry (1928) op. cit., Vol. I, p. 202

In 1907, about 231,000 tons of ammonium sulphate, eighty-nine per cent of total output,[1] was exported for £2,300 million compared with 6,300 tons of carbolic acid (£154,000), 5,000 tons anthracene and naphthalene (£28,000), and other coal-tar distillates (excluding dyes) worth £1,064,000. Most of the last were exports of crude products, to be processed abroad.

The low cash value of coal-distillates produced by Britain in the late nineteenth century and early twentieth century was a result of the technological superiority of Germany[2] which exercised economic imperialism,[3] in obtaining semi-processed chemicals from

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1. Census of Production 1907 (1910) op. cit. Category 116, p. 19.

2. J.J. Beer views this as a result of the loss of German emigrés (who returned to highly paid jobs in Germany), after they had contributed greatly to the initial British lead; the disinclination of British capitalists to finance high-risk experiments which could not be evaluated in advance; and primarily due to the low prestige of the chemical profession.
   J.J. Beer, The Emergence of the German Dye Industry (1959, Urbana) op. cit., p. 44; D.H. Aldcroft and H.W. Richardson, The British Economy 1870-1939 (1969) pp. 147, 149; A.G. Green "The Relative Progress of the Coal Tar Industry in England and Germany during the past Fifteen Years" British Association Handbook - 1901, Glasgow p. 252.

3. The economic power exerted by a technologically advanced country over a less developed nation, from which it obtained raw material and to which it exported the manufactured articles, has been

Britain as raw-materials[1] for its more highly advanced and hence more remunerative industrial output.

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explored by J. Gallagher and R. Robinson in "The Imperialism of Free Trade" Economic History Review 1953 II Series, Vol. 6.

1. From the 1870s, Britain increasingly exported raw materials and semi-finished goods, as noted by S.G. Checkland, The Rise of Industrial Society in England 1815-1885 (1969), p. 64. This was only one aspect of a more general lack of initiative vide P.L. Payne, ed., Studies in Scottish Business History (1967) p. 257 et seq

TABLE 3.136 Sulphate, Tar and Acid Prices at Ayr Gasworks 1902 - 12

Date	Sulphate (25%) Revenue per Ton		Tar Revenue (100 gallons)		Sulphuric Acid Expenses (per Ton)		Sulphate Revenue	Expenditure (including Wages)	Profit on By-Products
	£	s	s	d	s	d	£	£	£
1902	11	5	9	0	32	6	-	-	-
1903	11	15	10	0	32	6	913	325	678
1904	11	12	10	0	32	6	1,050	218	832
1905	12	7	7	6	35	0	-	-	-
1906	11	10	7	0	35	0	969	223	746
1907	11	2	-		-		923	203	719
1908	10	12	7	0	35	0	958	225	736
1909	11	0	9	3	33	0	807	224	583
1910	10	15	10	0	33	0	713	166	548
1911	11	10	12	0	35	0	943	171	772
1912	13	0	16	0	35	6	-	-	-

SOURCE: S.R.O. Ayr Minute Book *op. cit.* (annual statements)

TABLE 3.137 Variations in By-Product Revenue at Gasworks with Chemical Plant (1903)

Town	Coal Carbonized Annually (Tons)	Sulphate Annually (Tons)	Sulphate (lbs) per ton Coal	Sulphate Revenue per ton Coal			Expenditure on Sulphate plant per ton Coal		Tar/Naphtha Revenue per Ton Coal	
				£	s	d	s	d	s	d
Dundee	68,410	765	25	1	17	5	1	10.75	1	9.75
Coatbridge	16,747	240	32.1	2	2	0	2	8.8	1	2.6
Kilmarnock	16,000	215	30	2	12	0	-		-	
Hamilton	15,200	200	29.47	3	13	0	-		-	
Bothwell/Uddingston	10,120	120	26.56	2	4	0	2	9.1	1	3.1
Arbroath	7,558	73	21.63	4	19	0	1	4.5	1	3
Peterhead	3,437	38	24.75	4	19	7	1	4.2	1	7.71

NOTE: Tar disposed raw in all cases except Peterhead and Arbroath

SOURCE: N.B.A.G.M. 1903

TABLE 3.138 By-Product Revenue (£) at Broughty Ferry Gasworks (1870 - 1911)

Date	Gas Revenue	By-Products and Meter Rent	Total Income	By-Products and Meter Rent as Percentage Total Revenue
1870	2,676	134	2,812	4.8
1880	3,880	471	4,351	10.8
1885	4,341	1,009	5,350	18.9
1890	4,650	420	5,070	8.3
1895	5,420	1,098	6,518	16.8
1900	6,391	1,707	8,099	21.1
1901	6,825	2,790	9,615	29.0
1902	7,193	2,116	9,309	22.7
1903	8,140	1,420	9,560	14.9
1904	8,549	1,658	10,207	16.2
1905	9,044	1,875	10,918	17.2
1906	9,178	2,234	11,412	19.6
1907	9,516	2,278	11,795	19.3
1908	8,960	2,531	11,491	22.0
1909	8,503	2,512	11,016	22.8
1910	8,345	2,507	10,852	23.1
1911	8,250	2,725	10,975	24.8

NOTE: Meter Rent not shown separately, but this was not a major variable

SOURCE: N.B.A.G.M. 1912

TABLE 3.139 By-Product Revenue at Hamilton Gasworks (1894 - 1914)

Date	Total Revenue £	Gas Revenue £	By-Products - Revenue £	Percentage Total Income	Percentage Gas Income
1894	-	8,558	1,774	-	20.7
1895	-	6,711	2,729	-	40.7
1896	-	8,084	2,767	-	34.2
1897	-	8,589	2,720	-	31.7
1898	-	9,018	2,450	-	27.2
1899	-	10,507	2,396	-	22.8
1900	-	11,631	3,119	-	26.8
1901	17,329	12,512	4,437	25.6	35.5
1902*	23,730	18,378	5,268	22.2	28.7
1903	22,322	15,898	6,121	27.4	38.5
1904	19,859	13,012	6,441	32.4	49.5
1905	19,965	13,517	5,865	29.4	43.4
1906	20,908	14,357	6,208	29.7	43.2
1907	20,946	14,307	6,093	29.1	42.6
1908	23,501	16,112	6,941	29.5	43.1
1909	22,748	15,930	6,181	27.2	38.8
1910	20,787	14,491	5,680	27.3	39.2
1911	22,119	14,309	7,235	32.7	50.6
1912	21,389	13,632	7,156	33.4	52.5
1913	23,695	14,423	8,607	36.3	59.7
1914	25,538	15,014	9,192	36.0	61.2

NOTE: * 14 months period.
Because of unstated "working costs" and depreciation, gross 'total revenue' is a less reliable standard for comparison than exact statistics on gas revenue or coal expenditure.

SOURCE: Hamilton Ref. Lib. Hamilton Council Record (annual)

TABLE 3.140 Comparison of By-Products and Gas Output, and Revenue, in Scotland and U.K. (1907)

	U. K.	Scotland	Scotland (%)	U.K. (£)	Scotland (£)	Scotland (%)
(1) Gas Companies' Statistics						
Coal and Water Gas	-	-	-	15,324,000	435,000	2.8
Coke/Breeze (tons)	4,706,000	100,000	2.1	2,968,000	51,000	1.7
Crude Tar (tons)	366,000	8,000	2.2	363,000	7,000	1.9
Ammonia liquor	-	-	-	140,000	4,000	2.9
Crude Tar and Ammonia liquor	-	-	-	18,000	12,000	66.6
Ammonium Sulphate(Tons)	73,000	1,000	1.4	729,000	10,000	1.4
Anthracene (lbs)	280,000	0	0	2,000	0	0
Benzol/Toluol (Galls)	38,000	0	0	2,000	0	0
Carbolic Acid (Cwt)	14,000	0	0	21,000	0	0
Naphtha (Galls)	57,000	0	0	3,000	0	0
Naphthalene (Cwt)	29,000	0	0	11,000	0	0
Pitch (Tons)	64,000	0	0	88,000	0	0
Refined Tar and Varnish (Galls)	154,000	1,000	0.6	2,000	*	?
Tar Oil, Creosote &c (Galls)	6,247,000	6,000	0.1	67,000	*	?
Other Products	-	-	-	151,000	2,000	1.3
Total Value				19,889,000	521,000	2.6
(2) Municipal Statistics						
Coal and Water Gas	-	-	-	7,833,000	1,629,000	
Coke/Breeze (Tons)	2,884,000	590,000	20.5	1,466,000	255,000	
Crude Tar (Tons)	287,000	32,000	11.1	304,000	32,000	
Ammonia Liquor	-	-	-	182,000	4,000	
Crude Tar and Ammonia liquor	-	-	-	161,000	152,000	
Ammonium Sulphate (Tons)	32,000	5,000	3.1	349,000	60,000	
Anthracene (lbs)	16,000	0	0	*	0	0
Benzol/Toluol (Galls)	8,000	0	0	*	0	0
Carbolic Acid (Cwt)	4,000	0	0	4,000	0	0
Naphtha (Galls)	224,000	7,000		5,000	0	0
Naphthalene (Cwt)	15,000	0	0	1,000	0	0
Pitch (Tons)	21,000	0	0	22,000	0	0
Refined Tar and Varnish (Galls)	488,000	359,000	73.6	4,000	3,000	
Tar Oil, Creosote &c (Galls)	1,630,000	16,000	1.0	17,000	0	0
Other Products	-	-	-	48,000	10,000	
Total Value				10,396,000	2,145,000	20.6
Sum Total Value				30,285,000	2,666,000	8.8
Sum Total (Excluding Gas)				7,128,000	602,000	8.5

NOTE: * Under £500

SOURCE: Census of Production 1907 (1910) op. cit. (Category 116)

TABLE 3.141 Total Annual Output of Coal-Carbonization Products in U.K. 1907

	(1) Quantity		(2) Value £	
	All Gasworks	Gas, Iron Coke and Distilling Works	Gasworks	All
Coal and Water Gas	-	-	23,157,000	23,157,000
Coke/Breeze (Tons)	7,590,000	19,762,000	4,434,000	14,607,000
Crude Tar (Tons)	653,000	846,000	667,000	833,000
Ammonia Liquor	-	-	322,000	361,000
Ammonia Liquor and Crude Tar	-	-	179,000	179,000
Ammonium Sulphate (Tons)	105,000	260,000	1,078,000	2,823,000
Anthracene (Lbs)	296,000	3,126,000	2,000	9,000
Benzol/Toluol (Galls)	46,000	6,212,000	2,000	182,000
Carbolic Acid (Galls)	18,000	688,000	25,000	208,000
Naphtha (Galls)	281,000	4,188,000	8,000	141,000
Naphthalene (Cwts)	44,000	283,000	12,000	42,000
Pitch (Tons)	85,000	647,000	110,000	795,000
Refined Tar and Varnish (Galls)	642,000	6,251,000	6,000	64,000
Tar Oil, Creosote &c (Galls)	7,877,000	65,613,000	84,000	672,000
Other Products (not dyes)	-	-	199,000	565,000
TOTAL			30,285,000	44,638,000
Total Excluding Gas			7,128,000	21,481,000
By-Products as percentage Gas Value			23.5	

SOURCE: Census of Production 1907 (1910) op. cit. (Category 116)

TABLE 3.142 Proportion of Gasworks' staff (wage-earners) employed in U.K. in Tar and Ammonia Plants (1907)

	Scotland	England/Wales	U.K.	Scotland as Percentage U.K.
(1) Gas Companies				
Gasworks employees	912	45,964	48,253	1.9
Tar/Ammonia Plant employees	11	1,204	1,232	0.9
Percentage of Gasworks employees	1.2	2.6	2.6	
(2) Municipal				
Gasworks employees	5,060	18,975	25,121	
Tar/Ammonia Plant employees	45	308	361	
Percentage of Gasworks employees	0.9	1.6	1.4	

NOTE: No separate information available on independent tar distilleries.

SOURCE: Census of Production 1907 (1910) op. cit. (Category 116)

(4) Management and Labour

(i) Managers and Consultant Engineers

The Scottish gas industry began with consultant engineers poached[1] from London and Birmingham, but company Directors were responsible for the choice of engineers and thereby for the level of skills employed in the initial construction work.[2] During the 1820s skilled mechanics from other industries were trained by the consultants, and themselves became gas engineering consultants employed in the design of new works. Civil engineers with only a book knowledge of gasworks and a few practical observations, also built works and trained "Managers", who were the chief resident engineers. Self-taught engineers with private gasworks were also employed for large-scale constructions.[3] Propagandists for small works grossly understated the role of the manager. In 1815 Accum[4] claimed that gasworks could not be damaged by mis-management, and "with a common degree of care and attention" could be operated with "no more skill than a few practical lessons can teach to the meanest capacity". "The workman was not called upon to exercise his own judgement", but merely to follow a few simple rules.

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1. c.f. S. Pollard, Genesis of Modern Management (1968) op. cit., p. 199. James Watt's fears were realized, vide infra p. 64

2. Vide infra pp. 900, 938

3. Vide infra pp. 83, 84, 132
Shortage of competent gas engineers in the 1820s, vide supra p. 132

4. F. Accum, "On the Method of Illuminating the Streets with Coal Gas", Annals of Philosophy 1815, Vol. VI, p. 16.

James Beaumont Neilson[1] (1792-1865) was a gifted mechanic who trained for gas engineering on the job. In 1814 he had been engine-wright at Irvine colliery, but was appointed foreman at Glasgow gasworks in 1818, under the supervision of the design engineers Hutton and H. Creighton.[2] Neilson at first had no understanding of the industrial chemistry involved, but was able to attend lectures on chemistry, physics and mathematics at the nearby Andersonian University, in his free time.[3] By 1821, when he was officially designated "Manager or

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1. J. B. Neilson was born at Shettleston village, the son of Walter Neilson a millwright who became engine-wright at Govan Colliery. J.B. Neilson saw a private gaslight display at that Colliery celebrating the Peace of Amiens (1802). Educated at Strathbungo parish school and Gorbals' Chapel School, J.B.N. tended a condensing steam engine at Govan Colliery and in 1806-8 was gig-boy on the winding engine. 1808-11 he was apprenticed to his elder brother, John, engineman at Oakbank near Glasgow, where J.B.N. remained some time after becoming a journeyman. In 1814 J.B.N. became engine-wright at Wm. Taylor's collieries at Irvine. Walter Neilson had once been works' engineer to Dr. John Roebuck at Bo'ness colliery, which may have served as a recommendation for J.B.N.'s acceptance at Glasgow Gasworks, on a 5 year contract at £90 per year. Other early details are not extant, and although J.B. Neilson reputedly worked on the construction of Glasgow gasworks in 1817 this cannot be verified. R. Chambers, A Biographical Dictionary of Eminent Scotsmen (Revised by T. Thomson Ed.) (1875), Vol. V, p. 215. S. Lee Ed., Dictionary of National Biography (1909), Vol. XIV. S. Smiles, Industrial Biography (1876), pp. 141, 150-60. T.B. Mackenzie, Life of James Beaumont Neilson (N.D., West of Scotland Iron and Steel Institute). Proceedings of the Institute of Civil Engineers 1870, Vol. XXX, p. 451. W.H. Marwick, Economic Developments in Victorian Scotland (1936), pp. 19, 39. A. Clow, "Scotland's Contribution to Industrial Development", Blackwell Prize Essay (1944, Aberdeen), op. cit., pp. 64-7, 71. Memoirs and Portraits of One Hundred Glasgow Men (1886), op. cit., p. 245. R.D. Corrins, "The Great Hot Blast Affair", Industrial Archaeology (1970), Vol. 7, op. cit., p. 236. A.H. Stirling, A Sketch of Scottish Industrial and Social History in the Eighteenth and Nineteenth Centuries (1906, Glasgow), p. 157. S. Pollard, Genesis of Modern Management (1968), pp. 171, 183.

2. The Gas Supply of Glasgow (1935, Glasgow Corporation Gas Dept.) op. cit.

3. Neilson lived at a tied-house owned by the Company, in Kirk Street until 1834, and in Weaver Street near the Rottenrow gasworks from 1834 until his retirement in 1847.

Engineer and Superintendent of Works",[1] he was already acting in that capacity. He was forbidden to undertake any business "for his own behoof" which "diverted" his time or attention from the works. A later contract permitted him "to give advice as a Civil Engineer or furnish drawings and designs, to parties about to erect Gas Works, but with the express stipulation that he is to have no charge of the execution of any of these works, or on any plea whatever to visit them while they are erecting".[2]

Restrained from more active participation in the development of new gasworks, J. B. Neilson applied his ingenuity to a new gas-burner, the Union Jet,[3] experiments with iron sulphate purifiers,[4] the invention of tar-fired furnaces; and adaptation of other innovations originating in the large London gasworks.[5] He designed[6] large extensions of the original

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1. The 6 years employment contract of 15/3/1821 is extant, and carried a non-fulfilment penalty of £200. Neilson's salary of £200 per annum, was paid "at such times and in such sums as he may have occasion to require the same". The Company provided his dwelling house, free gas, free coals, and also paid "the whole government and city taxes" and water rates for him. Pencil alterations, as draft for a new contract, show a new 7 years contract from 1824 at possibly £350 per year. Glasgow City Archives (D.G.E. 10).

2. Undated 7-year contract, awarding Neilson 300 guineas a year (possible date 1824). Neilson was permitted to invest his savings "as a dormant partner, in any branch of business" but was forbidden to join the Management of such a company; if he invested in any Company manufacturing gasworks equipment, the Glasgow gas company would purchase no goods from that company. Neilson's salary later rose to £400, a very high rate compared to other gas managers. Glasgow City Archives (D.G.E. 10).

3. Vide infra pp. 142, 1250

4. Iron sulphate was later deemed impractical, though in 1842 Graham approved of its use, and in 1848 M. Martens of the University of Louvain independently suggested iron-sulphate purifiers. T. Graham, Elements of Chemistry Including the Application of the Science in the Arts (1842), p. 423. Civil Engineer and Architects Journal, April 1848, p. 128.

5. Tar-burning furnaces originated in Glasgow Vide supra p. 290

6. J.B. Neilson possibly designed Irvine gasworks in 1828. J.G.L. 15/7/1890

Townhead gasworks, and new gasworks at Tradeston and Partick to serve other areas of the city, besides gasworks in several other towns. His chemistry experiments resulted in the Hot Blast Process[1] of 1828 which revolutionized the Scottish iron industry, thus indirectly stimulating a great increase in the construction of gasworks at lower capital costs. Like later gas engineers, Neilson trained his son to a high standard in the field, and Walter Montgomery Neilson[2] (1819-1889) became consultant engineer for many new gasworks.

John Leslie, an Edinburgh civil engineer who designed Dundee harbour and waterworks, was typical of the alternative consultants. For practical research he "visited most of the Gas Works in London, Liverpool, Glasgow and other places",[3] and in 1844 designed a new gasworks in Dundee with modern features including an iron roof, good ventilation, and improved retorts, costing £23,800. The vast majority of Scottish gasworks were, however, designed by consultant gas engineers who had themselves been trained on the job. In England, Parliamentary survey officers[4] in 1847 reported that most works had originally been badly constructed and much capital wasted in renovating them. Managers lacked scientific training and were usually "persons who have acquired a knowledge of the operations, which on ordinary occasions is sufficient". Their inability to plan extensions or make technical decisions prompted a request for permanent Government Officers to supervise all large construction work undertaken by chartered companies, and to provide whatever other technical advice was requested; but this was never implemented.

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1. In 1824 an ironmaster asked Neilson if it was possible to extract 'sulphur' out of atmospheric air, in the same way as removing it from coal gas, because it was believed to spoil the iron. Neilson proved sulphur was not the culprit, but tried to extract water-vapour from the air because iron made in summer was better quality than that in winter. Meanwhile/

Meanwhile, J. Ewing of Muirkirk ironworks requested a remedy for the deficient blast from a blowing engine, half a mile from the furnace. To increase the blast, Neilson planned to heat and expand the air, but experimented first with hot air on a gas flame to find if expansion reduced the oxygen available for combustion. Instead, the illuminating power was greatly increased, and in partnership with Charles Macintosh (1766-1843), Colin Dunlop and John Wilson, Neilson proved that the cold-air blast used by superstitious ironmasters had produced poor iron and vast fuel losses. At 600° F, the fuel consumption of a furnace was reduced 66%, and the total air-blast necessary was halved. The new process enabled black-band ironstone in Lanarkshire and Ayrshire to be used profitably and Scottish pig-iron output rose from 37,500 tons in 1830 to 500,000 in 1840s. Neilson received royalties of 7/6d to 15/- per ton of iron, and the patent (Pat. 5701) lasted from 1828-42, providing him with £90,000. In 1846 J.B. Neilson was a shareholder in the Glasgow, Airdrie and Monkland Railway. T.B. Mackenzie, Life of James Beaumont Neilson, op. cit. W.H. Marwick, Economic Developments in Victorian Scotland (1936), op. cit., pp. 19, 39, 68. J.R. Kellett, "Glasgow's Railways 1830-80", Economic History Review 1964, II Series, Vol. XVII, p. 360.

2. W.M. Neilson spent his apprenticeship in the gas industry under J.B. Neilson, though J. Thomas has claimed that he joined an engineering firm (called 'Mitchell and Neilson' from 1836) at the age of 14. In 1851 Neilson and Company of Finnieston Foundry and Boiler Works and Hyde Park Engine Works, Glasgow, produced "every description of apparatus and pipes for gas and water" (4 years before the date given by Thomas). At this time, most small engineering firms undertook a wide range of work. In 1845 Hay and Addis, brassfounders of Edinburgh, advertized gasworks plant for mansion houses and small towns, as had Messrs. J. & R. Laidlaw, brassfounders in 1831, whilst Reid and Hanna of Paisley in the 1840s produced boats and smith work besides gas apparatus. Neilson's works produced marine engines up to 1859, and also the first steam locomotives for Garnkirk Railway; only with the new Hyde Park Locomotive Works at Springburn in 1861 did Neilson concentrate solely upon locomotive engineering. In 1862 R. Douglas of Dunnikier Foundry in Kirkcaldy still made "Steam engines, Water Wheels, Turbines, Corn Mills, Cranes, Gas Works" and agricultural castings. J. Thomas, The Springburn Story - The History of the Scottish Railway Metropolis (1964), pp. 84, 89, 130, 142. Hay and Addis, vide The Scotsman, 8/10/1845, p. 3. Laidlaw, vide The Scotsman, 21/12/1831. Neilson and Co., vide J.G.L., 10/3/1851, p. 61. Hanna, vide J.G.L., 10/3/1853, p. 281. Douglas - Westwood's Parochial Directory for the Counties of Fife and Kinross (1862, Edinburgh), p. 35.

3. Dundee New company planned to produce up to 300,000 cu.ft. per day. In 1860 Ecclefechan gasworks in Dumfriesshire were designed by A. Scott, C.E. of Dumfries; towns like this often supplied engineers for their hinterlands. H. Commons 1846, Vol. 98, 23/3/1846, pp. 142-9. J.G.L., 24/4/1860. Other examples vide infra pp.144, 967

4. B.P.P. 1847, Vol. XXII, op. cit. Vide infra p.1148

The gas 'Managers'/

The gas 'Managers' and consultants were supervised by, and responsible to, Company Directors,[1] whose technical knowledge and intervention varied from company to company. A few companies in fact termed some directors "managers" in the early nineteenth century. The first Glasgow 'Managers' were John Thomson,[2] banker, and Walter Ferguson a former Magistrate; and the Edinburgh 'Manager' from 1818-59 was John Watson,[3] a successful merchant. Bathgate[4] gas company in 1837 termed its Treasurer "Manager of the whole of the Company's business", and called the chief engineer a "Foreman". The first four 'Managers' at Fraserburgh[5] were similarly financiers - Robert Stephen, Mr. Lawson and Alexander Watson, successive agents of the North of Scotland Bank, and Thomas Park, shipowner.

Beneath the 'Manager' and supervised by him were four categories of employees,[6] the 'Firemen' or 'Stokers' who fed the retorts and furnaces and were sometimes aided by labourers; the Clerks and

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1. Vide infra p.900

2. In 1817, Thomson acted as Clerk to collect the calls made on shares. Glasgow Chronicle, 12/4/1817, p. 2. P. Mackie, Reminiscences of Glasgow (1890, Glasgow), Vol. II, p. 163. Vide infra p. 1008

3. Born 1790; educated in Edinburgh and London; merchant in Leith 1812-18. Stated to be the son of George Watson (1767-1837) first President of the Royal Scottish Academy. Gas World, 10/7/1886, p. 42. Dictionary of National Biography 1909, Vol. XX (no record of John Watson).

4. S.R.O., Bathgate Minute Book, op. cit., 1/5/1838, 15/5/1843.

5. J. Cranna, Fraserburgh Past and Present (1914, Aberdeen), p. 450. c.f. Boness 'Manager' J.M. Gardner in 1846 was apparently a director. J. Naismith, who was termed the 'Gas Maker' in 1854, was not "invested with the authority and powers of Manager" until 1857 when the Directors raised his status upon the advice of a consultant engineer, Mr. Young of Dalkeith. S.R.O., Boness Minute Book, op. cit., 8/1/1846, 13/4/1854, 12/6/1854, 30/7/1875.

6. Only a few of the very largest works had a Foreman as well as an Engineer or Manager. Glasgow company in 1836 employed George Sutherland as foreman under J.B. Neilson. By the 3 year contract he was forbidden to take outside work, in return for a salary of £100 paid "at such times and in such sums as he may have occasion to require". Penalties - £50 for breach of contract, and £100 for breaking contract. Glasgow City Archives (D.G.E. 22), 5/8/1836.

Collectors of gas rents; the Lamplighters if these were not employed by the town council; and 'Plumbers' or gasfitters who only appeared on company payrolls after the mid nineteenth century.

The first decade of operations was a critical period for the Directors learning their role and arranging a sufficient labour force at reasonable wages. Stranraer company began in 1840 with a single full time employee, John Young the manager,[1] helped only by one labourer "during the winter months". In 1843 when the revenue was not increasing, the Directors resolved to reduce labour costs, and a Committee of three directors wrote for information to gas managers "throughout the country" at works which they "supposed to be similarly situated" regarding revenue and expenditure.[2] Only four replies were obtained, on which basis Young was denied any assistance except for occasional pipe laying. He was over-worked and arrears developed in the collection of gas rents, so a Director[3] acted as unpaid interim Collector and threatened to disconnect those who refused payment.

In 1844 Young requested better purifiers, and when the Directors[4] refused on financial grounds only, he threatened to resign. One Director accepted the case, however, and obtained evidence from J.B. Neilson of Glasgow gasworks, and the Catrine manager, that the alteration was "indispensable". This persuaded the others, and Young was permitted to design improved purifiers and retort benches. The Directors remained anxious, however, to institute a wage level based upon national standards for gasworks of a similar size. In 1845 they

1. S.R.O., Stranraer Minute Book, op. cit., 28/11/1840. Vide infra p. 1733

2. Ibid., 21/3/1843, 10/4/1843, 29/6/1843.

3. This Director was later awarded a salary, and remained collector for several years. S.R.O., Stranraer Minute Book, op. cit., 5/10/1843.

4. Ibid., 12/6/1844, 25/6/1844, 6/3/1845.

obtained statistics from the works at Pollokshaws, Annan, Inveraray and Brechin and resolved to reduce the manager's salary from fifty pounds to forty pounds per year, with free house, gas and coal. Young resigned, and an advertisement was made for his replacement at only thirty five pounds. Although applications were received from a distance, including Glasgow and Castle Douglas, the new manager[1] chosen was a local resident with far less skill than Young. He was unable to complete the purifiers, which were purchased to specifications provided by the manufacturers, Messrs. Robertson and Wilson.

With the aid of consultant engineers, early companies tried to operate with a minute labour force.[2] Ayr new gas company in 1847 appointed only two employees, T. Clark as manager and collector, and W. Pollock as Treasurer and Secretary.[3] They relied heavily upon Mr. Ritchie, a Glasgow engineer,[4] who designed extensions of the works from a new gasholder and mains pipes, to public lamp-posts. Ritchie[5] designed new purifiers in 1848, and was again employed during extensions

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1. The Stranraer manager did not have a permanent assistant until 1850. S.R.O., Stranraer Minute Book, op. cit., 8/3/1845, 25/6/1845, 2/7/1845.

2. Assistance was minimal even in the busiest winter season. Bathgate in 1847 paid the manager £39 15/-, but spent only £10 on winter assistants. Gasworks in the small village of Birnam, on the river Tay in Perthshire, in 1886 were still run entirely by one man, G. Ogilvy, who devised his own system of dampers to conserve heat in the furnaces overnight. J.G.L., 3/8/1886; S.R.O., Bathgate Minute Book, op. cit., 23/5/1848.

3. S.R.O., Ayr Minute Book, op. cit., 29/3/1847.

4. Probably J. Ritchie, Glasgow Gaslight Company manager from 1847. S.R.O., Ayr Minute Book, op. cit., 15/1/1847, 28/1/1847, 29/3/1847, 22/5/1847, 7/6/1847. Vide infra pp. 134, 632

5. In 1849 Ritchie received £92 for his ehgineering services. Ibid., 7/8/1848, 25/6/1849, 7/7/1856.

in 1856. By August 1847 the company found extra labour necessary, and employed two lamplighters who were to "work about the Gas Yard &c" when not lighting or cleaning lamps, and a clerk[1] for book-keeping soon followed in March 1848.

Bathgate company,[2] acting upon the advice of their consultant engineer in 1834, first employed D. Houston instead of a local man who was their original choice. He was assisted only by a paid clerk who also acted as Treasurer until 1835 when a separate Treasurer was appointed. Houston was not a skilled gas engineer, and during 1835 the Company required advice from a consultant, Mr. Blaikie probably from Shotts Ironworks, for installing a third retort and extending the hydraulic main.

A Manchester mechanic, John Irving, was the first choice of Annan[3] directors, several of whom knew him personally, in 1838. They offered thirty five pounds a year, but Irving required seventy eight pounds, and the job was given instead to Heron Smith, a mechanic at Annan cotton factory who had assisted during the construction of the gasworks. In 1845 the third Manager at Annan, W. Ewart, was also a mechanic from the cotton factory. At Hawick in 1831 the first manager[4] was a local mill-wright, John Young Scott, who was sent by the Directors to Paisley where Mr. Cook, their contract engineer, provided his "information and instruction" on the "Management of Brick and Iron Retorts". When Andrew Muir, mason from Ayr, became the first manager at Dalry in 1834,

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1. Lamplighters 12/- a week; clerk 4/- a week. S.R.O., Ayr.Minute Book, op. cit., 30/8/1847, 2/3/1848.

2. S.R.O., Bathgate Minute Book, op. cit., 5/10/1834, 5/5/1835, 4/12/1835.

3. S.R.O., Annan Minute Book, op. cit., 13/7/1838, 12/5/1838, 25/3/1845.

4. Transactions of Hawick Archaeological Society (1969), op. cit., p. 26.

he was sent "for a few days" to Beith gasworks, "at the Company's expense in order to qualify himself for making gas".[1]

The choice of consultant engineers was made by company Directors, and in the early stages of the industry such engineers came from nearby larger gas companies, or equipment manufacturing companies. Dalry[2] works in Ayrshire in 1838 employed Mr. Coupar, the Kilmarnock manager, to explain the defective gas supply to Biggart's Mill. Cupar[3] company in 1847 employed William Foulis, gas manager at St. Andrews, to design a new gasholder, and also employed a local mason, D. Wilson, to supervise independently the construction of the gasholder tank. Boness[4] in 1847 took advice from Mr. Sanderson, the Dunfermline manager, on tracing leaks, and in 1856 commissioned a full survey of the works for five guineas from J.R. Fussell, manager of Shepton Mallet who had advertized his services in the <u>Gas Gazette</u>. Fussell confused the Directors by his ignorance of the special conditions of gas manufacture in Scotland[5] and his opposition to tar-fired furnaces, but they obtained better advice on extending the works in 1857 and 1861 from J. Young,[6] gas manager at Dalkeith.

Before large alterations at Dalkeith[7] in 1842, the Directors employed Mark Taylor, engineer of the Edinburgh gas company, to survey

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1. S.R.O., Dalry Minute Book, <u>op. cit.</u>, 25/10/1835.
2. S.R.O., Dalry Minute Book, <u>op. cit.</u>, 20/6/1838.
3. S.R.O., Cupar Minute Book, <u>op. cit.</u>, 2/9/1847, 12/10/1847.
4. S.R.O., Boness Minute Book, <u>op. cit.</u>, 29/7/1847, 18/1/1856, 29/3/1856.
5. <u>Vide infra</u> p.298
6. S.R.O., Boness Minute Book, <u>op. cit.</u>, 30/7/1857, 20/8/1857, 10/6/1861.
7. S.R.O., Dalkeith Minute Book, <u>op. cit.</u>, 13/6/1842, 29/6/1842, 29/3/1844.

the works. He was later paid thirty two pounds to design a new gasholder there. Employing consultants was a normal procedure when Directors were uncertain about the technical ability of their own manager, especially since new managers often wished to try new ideas. When the new manager at Selkirk,[1] for instance, requested extensions of the retort house costing £2000 in 1854, the Directors first instructed him to consult with the Kelso manager, and to obtain plans and estimates both from that man, and from a consultant in Galashiels. The Kelso manager inspected Selkirk works, and travelled with the Selkirk manager to examine the technology of Hawick works. Selkirk manager then visited Berwick gasworks also for further advice. The final designs were completed by specialist manufacturing companies, A. & J. Robertson for the gasholder, and Hooper and Miller of Kelso for the retort house.

Manufacturers' agents remained active consultants from the initial construction of works until after the close of the century. Mr. Anderson of Durie Foundry inspected Boness works and designed purifiers for them in 1875, at a fee of five pounds which was rescinded when his company obtained the contract. Mr. Brand of Airdrie Iron Company planned large extensions of the retort house there in 1877, under the same conditions for ten pounds, but the fee was paid because Messrs. Laidlaw obtained the contract after submitting the lowest offer by sealed tenders. Retort-bench design from the late nineteenth century was also a specialist field and two men gained very high reputations for building benches:[2] C.M. Hamilton of Hamilton, who installed one

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1. S.R.O., Selkirk Minute Book, op. cit., 3/4/1854, 10/3/1854, 9/5/1854.

2. R.S. Workman specialized on regenerative settings and received £2300 for a bench at Newton Ayr in 1905, £1100 for one at Barrhead in 1906, and £1124 for that at Ayr in 1907. S.R.O., Ayr Minute Book, op. cit., 26/2/1906, 11/7/1906, 29/4/1907.
S.R.O., Stornoway Minute Book, op. cit., 13/5/1890.

at Stornoway in 1890, and R.S. Workman of Saltcoats, who designed and installed that at Ayr in 1907. R. Workman repaired the retort ovens at Muirkirk[1] annually in the early 1900s, and supplied retorts.

The probity of consultant engineers was usually checked by company Directors, in advance of their employment. Muirkirk gasworks were inspected in 1895 by W. Fairweather of Kilmarnock, who recommended several improvements but had insufficient time to supervise them and instead suggested that the company should employ the assistance of Mr. Myers, manager of Saltcoats. Before accepting Myers, at a fee of five per cent of the new construction costs, Muirkirk directors wrote to "ask Mr. Campbell, Agent of the Bank of Scotland, Saltcoats, his opinion as to Mr. Myers' qualifications".[2]

Although a relatively small number of Scottish engineers acquired a reputation for consultancy work, gas companies rarely relied upon the judgment of a single consultant over long periods of time. Muirkirk company[3] had earlier employed J.A. Watson, C.E. of Glasgow, in 1888 to draw a detailed plan of the works and pipes, and in 1889 used their former manager, Mr. Morton to superintend alteration of mains pipes, besides consulting with Messrs. Laidlaw of Glasgow in 1889 over the condition of the gasholder, and again in 1895 on the advantages of oil-gas enrichment. Dalry[4] works employed McCrae of Dundee gasworks

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1. S.R.O., Muirkirk Minute Book, op. cit., 29/6/1903, 1/7/1904, 4/7/1905, 4/7/1906.

2. Myers received £50 for plans and specifications. S.R.O., Muirkirk Minute Book, op. cit., 26/11/1895, 21/1/1896, 1/2/1896, 10/3/1897.

3. Watson received 5 guineas for plans drawn over a 25 inches to the mile Ordnance Survey map. S.R.O., Muirkirk Minute Book, op. cit., 18/6/1888, 17/6/1889, 13/12/1889, 26/11/1895.

4. S.R.O., Dalry Minute Book, op. cit., 16/10/1873, 28/6/1875, 7/3/1878, 7/7/1881, 10/4/1882, 7/4/1884, 15/2/1892, 23/6/1892, 22/2/1894, 15/7/1894, 24/7/1894, 24/3/1897, 1/12/1897. (In 1897, Mr. Fairweather, the Kilmarnock manager, also inspected Dalry works).

to design a gasholder in 1873, to evaluate the works in 1875, and to advise upon an improved retort house in 1878. This Ayrshire company placed considerable reliance upon McCrae for those years, but in 1881 the works were inspected by Mr. Brodie of Paisley, a manufacturing engineer who designed new purifiers; in 1882 and 1884 improved retort benches were designed by Mr. Walker, gas manager of Irvine; and in 1892 a new retort bench was designed by Mr. Hislop, the manager at Paisley, but altered in 1894 upon the advice of Mr. Henderson, manager at Newton-on-Ayr. Improvements to the tar sump and purifiers in 1894 followed an inspection of the works by Mr. Brodie again, and also by Mr. Myers the manager of Saltcoats. Whilst a company would re-employ a satisfactory consultant like McCrae, in the event of problems like those with Hislop's retort bench, there was no hesitation to seek alternative advice.

Personal experience of a manufacturing process was often essential before it could be evaluated, and managers were often sent to visit other gasworks in order to gain experience and information. The Cupar manager[1] travelled to St. Andrews gasworks in 1842 to collect data on the quality and price of coals, and of retorts. Sometimes skilled stokers or "firemen" were enticed from other gas companies to teach special processes. Cupar[2] employed one stoker from Dunfermline gasworks for a short period in 1844 to teach its firemen how to burn tar correctly in the furnaces.

Mr. Mackenzie,[3] Dunfermline manager (1865-93), was dispatched in 1876 to examine eight leading English gasworks, from Newcastle on Tyne

1. S.R.O., Cupar Minute Book, op. cit., 9/8/1842.
2. Ibid., 31/4/1844.
3. "Dunfermline Gasworks - Centenary Celebrations", Dunfermline Press, 9/11/1929.

and Middlesborough to Rochdale and Manchester, before formulating a plan to modernize Dunfermline works. In 1889 the Partick and Hillhead company[1] sent manager L. Monk, with consultant engineer William Young, to examine the advantages of the 'Clauss' purifiers used at Belfast gasworks.[2] Consultants, like Young, had the great advantage of receiving payment for gaining experience which could then be sold as a service to other companies. Some consultants provided men to give practical lessons as well as written instructions. Mr. Hislop, the Paisley gas manager, received eleven pounds in 1897 for the services of Mr. Crone, one of his employees who travelled to Dalry[3] and received one pound for instructing the stokers there improved methods which reduced damage to retorts, and also provided advice on a better choice of coals.

Table 3.143 Examples of The Work of Consultant Engineers

Date	Company	Consultant Engineer Employed	Engineer's Regular Employment	Alterations Made
1860	Vale of Leven	Mr. Foulis	Manager, Paisley	Improvements
1860	Ayr	J. Z. Kay	Manager, Dundee	"
1867	Boness	G.R. Hislop Mr. Donald	Manager, Paisley Of Messrs. Hanna, Donald & Wilson	Assess subsidence damage to gasholder
1877	Wishaw	G.R. Hislop	Manager, Paisley	Extensions
1879	Stornoway	Mr. Thomson	Manager, Inverness	Overall inspection
1880	Johnstone	G.R. Hislop	Manager, Paisley	Overall inspection
1883	Fraserburgh	A. Smith	Manager, Aberdeen	New purifiers
1883	Blairgowrie	J. McCrae	Manager, Dundee	Major extensions; 18 new retorts
1883	Renton	J.McGilchrist	Manager, Dumbarton	Major extensions
1883	Kirkintilloch	J.McGilchrist	Manager, Dumbarton	New gasholder
1884	Kilsyth	J. Hislop	Manager, Partick	New retorts
1885	Johnstone	J.McGilchrist	Manager, Dumbarton	New purifiers
1885	Millport	J.McGilchrist	"	Extensions

1. J.G.L., 30/7/1889.

2. Belfast was run by a distinguished engineer, James Stelfox (1842-1910). Obituary, The Institute of Gas Engineers Transactions 1910, p.461.

3. S.R.O., Dalry Minute Book, op. cit., 28/9/1897, 6/10/1897, 29/10/1897.

Table 3.143 (contd)

Date	Company	Consultant Engineer Employed	Engineer's Regular Employment	Alterations Made
1885	Linlithgow	R. Mitchell	Manager, Edinburgh	Extensions
1886	Bathgate	G.R. Hislop	Manager, Paisley	4 regenerative ovens
1887	Stornoway	Mr. Thomson	Manager, Inverness	Overall survey
1887	Perth	S. Stewart	Manager, Greenock	Overall survey
1888	Arbroath	R. Mitchell	Manager, Edinburgh	Overall survey
1888	Selkirk	R. Mitchell	"	Overall survey and evaluation
1891	Renfrew	J.McGilchrist	Manager, Dumbarton	Large alterations
1892	Ayr	G.R. Hislop	Manager, Paisley	Advice on hours of work
1902	Dalkeith	W. Herring	Manager, Edinburgh	Advice on £6000 extensions planned by Dalkeith manager
1907	Banff	S. Milne	Gas engineer, Aberdeen	New chimney

Sources:- (1) S.R.O., Minute Books - Vale of Leven 16/6/1860; Ayr 2/7/1860, 26/12/1892; Boness 30/10/1867; Bathgate 7/12/1886; Dalkeith 19/6/1902; Banff 12/6/1907; Stornoway 9/7/1879, 10/6/1887; Selkirk 11/7/1888.

(2) J.G.L., 3/4/1877 Wishaw; 3/6/1884 Kilsyth; 25/9/1883 Fraserburgh; 25/9/1883 Blairgowrie; 21/8/1883 Renton; 1/5/1883 Kirkintilloch; 20/10/1885 Johnstone; 1/9/1885 Millport; 3/2/1885 Linlithgow; 20/9/1887 Perth; 17/7/1888 Arbroath; 22/9/1891 Dumbarton.

(3) Journal of Artificial Light 7/2/1880 Johnstone.

Former managers were sometimes preferred as consultants because of their knowledge of that particular works. J. Hislop who left Ayr company to become manager at Maryhill in the early 1870s, was employed as consultant at Ayr[1] in 1883. John Young,[2] former manager at Dalkeith, together with his son William, redesigned the retort bench there in 1891. Some consultants took advantage of their position to purchase shares in prosperous companies. J. McGilchrist of Dumbarton[3] inspected

1. S.R.O., Ayr Minute Book, op. cit., 4/7/1883.
2. S.R.O., Dalkeith Minute Book, op. cit., 11/12/1891.
3. S.R.O., Stranraer Minute Book, op. cit., 23/3/1892, 2/4/1901, 12/6/1896, 20/4/1903.

Stranraer works in 1892, and had become a Director by 1896. He made further surveys of Stranraer in 1901 and 1903.

Gas managers as consultants continued to design new works during the late nineteenth century. J. Hislop, manager at Partick, formulated that at Dullator[1] alongside the Edinburgh and Glasgow railway in 1877. Lochgelly[2] new works in 1886 were designed by McKenzie, manager at Dunfermline, and Monifieth[3] works in 1898 by the Cupar manager.

Even in a moderately large town like Galashiels, consultant engineers played a large initial role, and the skills of the resident gas Manager were developed slowly. The size of the works, however, enabled such companies to retain their qualified staff over long periods of time, often until the manager retired. Many managers were succeeded by their sons who were trained at the gasworks and provided further continuity of skills. Such managers required the aid of consulting engineers only for new, specialized equipment, but acted themselves as consultants to small companies.

Galashiels[4] manager, Mr. Kemp, designed a new gasholder and tank for the works in 1845, but several manufacturers including Messrs. Robertson of Berwick, Hooper and Miller of Kelso, Moore & Co. of Berwick, and Mushet of Dalkeith, were requested by the Directors to comment upon the design, making them virtually unpaid consultants. Instead of an expensive cast-iron tank, the Directors ordered one of freestone after obtaining free advice from "Mr. Nelson" [sic] of Hyde

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1. A commuter dormitory town serving Glasgow, on the Edinburgh and Glasgow Railway, which expanded rapidly in the late 1870s. J.G.L., 18/12/1877.

2. J.G.L., 10/1/1886.

3. S.R.O., Cupar Minute Book, op. cit., 22/6/1898.

4. S.R.O., Galashiels Minute Book, 2/7/1844, 16/4/1846, 15/6/1847, 2/7/1847.

Park Foundry in Glasgow, and Mr. Ford the manager of Perth new gasworks. Faults in the masonry led to an iron tank being purchased after the Directors obtained further free advice from Mr. Taylor, the Edinburgh gas manager, and Mr. Bootle, the Glasgow sub-manager. The Directors maintained close supervision of technology at that stage. Even in 1851 the Manager read consumers' gas meters and wrote out the accounts personally, with only a temporary assistant in winter,[1] and by 1860 these were still the manager's duties although a collector was also employed.

In 1856 Galashiels gasworks were inspected by a consultant engineer, Bartholomew of the Glasgow City and Suburban company,[2] who reported to the Directors on the overall condition and efficiency, and recommended larger mains pipes, and a reduction of the winter labour force to four labourers. Galashiels[3] new manager in 1860, J.C. Adamson, had formerly been manager at Leven gasworks. When he resigned in pursuit of a better position in 1864, the company replaced him by a local resident, A. Scott, who was given a far lower salary.[4] Scott had probably been a semi-skilled labourer at the gasworks, and was preferred for his reliability. He remained manager until 1903, with his son, F. Scott, as assistant manager from 1894. Throughout that period his skills increased considerably, though in 1866 he was unable to plan large-scale alterations of the works[5] unaided. Information was obtained from

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1. *E.g.* J. Dickson, shoemaker, assisted in the winter of 1851-2. S.R.O., Galashiels Minute Book, 21/10/1851, 27/3/1860.

2. *Ibid.*, 3/6/1856.

3. Kemp was apparently manager from 1834-60, and the Directors awarded him a pension of £20 per year. S.R.O., Galashiels Minute Book, *op. cit.*, 6/4/1860, 3/7/1860, 5/9/1859.

4. *Ibid.*, 6/9/1864.

5. *Ibid.*, 27/12/1866, 15/11/1868, 4/12/1868.

consultants, Robertson & Co. of Berwick on technical improvements used in their recent constructions for Paisley gasworks, which Scott visited to obtain plans and ideas. Warrington gas manager, W. Paterson, advised on the site for Galashiels new gasworks, while James Donald of Messrs. Hanna, Donald and Wilson provided much free information on the suitable location of gas-mains and influence of altitude. That company provided a complete ground plan[1] for the new gasworks, free of charge; and although they obtained a £3000 contract for the gasholder, this was only by competition with other manufacturers through sealed tenders.

The manager increasingly took responsibility for the financial evaluation of technology, and Directors became less capable of such evaluation without the expense of a special survey conducted by a committee of Directors.[2] Thus in 1869 Scott examined the naphtha and ammonia by-product recovery equipment installed at Dundee, Glasgow, Paisley and Perth, to advise the Directors on its feasibility at Galashiels.[3] In 1883 he visited the International Electric and Gas Exhibition at Crystal Palace, London,[4] to broaden his knowledge, and in 1889 the company financed his visit to the Paris Exhibition. During 1889 Scott examined water-gas at Leeds Forge,[5] and the Directors accepted his judgement that it could not compete with coal gas. In 1892 he examined oil-gas at Peebles, and persuaded the Directors to also meet William Young and to install oil-gas enrichment at Galashiels.[6]

1. S.R.O., Galashiels Minute Book, op. cit., 21/1/1867, 18/3/1867.
2. The entire Galashiels works removed to a better location. Vide infra pp. 387, 862
3. S.R.O., Galashiels Minute Book, op. cit., 1/6/1869.
4. Ibid., 3/3/1883, 2/7/1889.
5. Ibid., 2/4/1889, 4/6/1889.
6. Ibid., 6/12/1892, 3/1/1893.

Francis Scott succeeded his father[1] as manager in 1903. His skill was displayed in 1904 when he supervised the installation of modern retort ovens costing £2200, supplied by specialist manufacturers, R. Dempster and Sons Ltd. of Elland, Yorkshire. Instead of the standard covered subway in front of the retorts, F. Scott designed a travelling platform for the stokers to stand on. This was so successful that Messrs. Dempster[2] not only built two for Galashiels, but patented the device in association with Scott.

Small companies were unwilling to employ consultants so frequently, despite the lower quality of Managers which they could afford. When combined with a rapid turnover of management, and consequent loss of skills, this resulted in high prices and low profits for companies like Lesmahagow.[3] W. Miller, a local wright who assisted the consultant[4] building those gasworks in 1845, remained 'Gas Keeper' only until 1847, and was succeeded by R. Gordon, a blacksmith, and in 1849 by J. Miller a nailer. Miller remained until 1860, and was succeeded by J. Young until 1881. Miller assisted Young to design a gasholder in 1860, and both men commenced with negligible knowledge of the industry. Profitability was low or non-existent, but as the town grew in size, a consultant was eventually called in during 1870 when Mr. Bartholomew[5] planned the new retort bench and enlarged mains. Again

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1. A. Scott was awarded a retainer and pension of £100 per year to act as consulting engineer when required. 'Frank' Scott had previously been manager at Kelso; his brother Mr. Scott, was manager at Kilmalcolm until his death in 1883. S.R.O., Galashiels Minute Book, op. cit., 3/2/1903, 3/3/1903. J.G.L., 14/8/1883.

2. S.R.O., Galashiels Minute Book, op. cit., 3/5/1904.

3. Vide infra p.787

4. Acceptance of relatively unskilled men as gas managers in small works prevented any retardation of Company formation being caused by a lack of managers. S.R.O., Lesmahagow Minute Book, op. cit., 19/10/1845, 26/2/1847, 3/3/1849, 12/8/1860.

5. Ibid., 20/1/1871, 20/3/1871, 25/5/1871.

in 1879, Clement Hamilton,[1] a specialist retort-bench engineer, assisted with improvements.

Problems continued for the relatively small company, however. W. Marr, the new manager in 1881, was a skilled Whitburn engineer who improved the plant, but soon left in 1884 for a better position at Mallow gasworks in Ireland. Again the Directors chose a skilled replacement, J. Weir the manager at Auchinleck, yet they found him to be incompetent and forced his resignation in 1886. They made personal enquiries before choosing the next new manager, A. Bell, who improved the works but soon sought a better position and left in 1888. Another new manager, J. Miller of Edinburgh, had soon antagonized consumers with a defective supply, and during 1889 a Director acted as Manager to supervise Miller, who was dismissed when supplies twice failed. The Directors then sought the personal advice of the Hamilton manager and appointed A. Brown, a journeyman plumber who worked part-time at Hamilton gasworks. Brown resigned after only a few months, but a reliable manager was at last found in J. McKerracher who remained until 1914, though advice continued to be sought from Hamilton gas managers, Mr. Johnston in 1890 and Mr. Ewing in 1900, for the design of a retort bench and gasholder respectively.

At Boness, a slightly larger works than Lesmahagow, Mr. Young the Dalkeith manager supervised considerable improvements in 1859. Gas output was raised from 2537 cubic feet to 7710 cubic feet per ton of coal and the "confused appearance" of the works eliminated. Lime was stored in a separate shed, instead of using part of the retort-house, and that space used for drying thirty tons of coal prior to carbonization. Coal sheds were erected to hold a six weeks supply, so that wet winter

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1. S.R.O., Lesmahagow Minute Book, op. cit., 22/4/1875.

deliveries were unnecessary after mid November, and steps taken to reduce mains gas pressure from thirty tenths inch to fifteen tenths. Leakage had previously been thirty three per cent, or over 1.1 million cubic feet on an annual output of 3,334,200 cubic feet.[1]

Many early nineteenth century gas managers in small companies were employed on a year by year basis,[2] as at Lesmahagow in 1849-51 and at Dalry until at least 1844; their self-taught skills gave minimal advantage over others competing for the job. This retarded the technical development of small and possibly also medium-sized companies, which resulted in long-term problems that led later employees to seek alternative work, producing rapid labour turnover and progressively greater management problems. The duration of capital equipment, and reluctance or inability of small companies to replace workable but inefficient plant, meant that engineering errors could not be corrected for two, three or more decades. This was equally true of some large companies, and placed a limit upon a manager's ability to improve gasworks. Ayr company in 1906 had three retort benches, the newest twenty four years old, and although the manager raised output from 3000 to 7000 cubic feet per retort/day during that period, a new bench[3] of better design could alone raise it further.

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1. The leakage was partly caused by the large extent of mains pipes, and periodic "earthquakes" occurring locally; probably mining subsidence. S.R.O., Boness Minute Book, op. cit., 12/7/1859, 20/7/1859, 6/10/1859, 11/6/1860.

2. E.g. R. Gordon at Lesmahagow. S.R.O., Lesmahagow Minute Book, op. cit., 3/3/1849, 12/3/1850, 29/3/1851. S.R.O., Dalry Minute Book, op. cit., 12/6/1837, 9/2/1844. c.f. Stornoway in 1853 employed A. Fraser on a 3-year contract. S.R.O., Stornoway Minute Book, op. cit., 3/3/1853.

3. Ayr new retort bench built 1907 for £1124 gave annual £80 saving, raised output by over 1000 cu.ft. per retort/day, and 20% extra coke. S.R.O., Ayr Minute Book, op. cit., 26/2/1906. Vide infra p.863

Companies soon recognized that the residence of the manager and other staff close to the works was essential in case of emergencies.[1] Most managers were therefore provided with a "free" tied house,[2] with gas and coal, in addition to their stated salaries. Cupar company soon constructed such a house following a minor fire at the works in 1844. It comprised "a room for meetings of Directors, a Parlour, two bedrooms, kitchen and cellar for the Manager, a room for the principal fireman, and a Cellar for the use of the Works".[3] The multi-functional house was normal at many works, since the Directors were obliged to hire a room for meetings, usually paid for by free gas to the proprietors,[4]

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1. The Vale of Leven Company spent £20 for a "dwelling room" for their manager at the works in 1841. Leven Minute Book, op. cit., 8/3/1841.

2. E.g. Stornoway, Stranraer, Cupar, Boness, Selkirk, Bathgate, Ayr, Dalry. S.R.O., Stornoway Minute Book, op. cit., 12/8/1851, 10/9/1885. S.R.O., Vale of Leven Minute Book, op. cit., 23/3/1849, 27/8/1880, 23/3/1846. S.R.O., Stranraer Minute Book, op. cit., 28/11/1840, 26/6/1860, 23/3/1866, 30/3/1899. S.R.O., Dalry Minute Book, op. cit., 15/3/1838. S.R.O., Cupar Minute Book, op. cit., 1/7/1844. S.R.O., Boness Minute Book, op. cit., 14/7/1844, 30/11/1869, 13/8/1874. S.R.O., Selkirk Minute Book, op. cit., 8/7/1835, 11/7/1853. S.R.O., Bathgate Minute Book, op. cit., 15/10/1889. S.R.O., Ayr Minute Book, op. cit., 28/9/1908. Note - In 1908, besides a "free" house, the Ayr manager still received free coal, gas, water, and payment of taxes. Being within the vicinity of the works, the houses sometimes became insanitary. At Cupar the Manager was given a new house in 1899 because the old building was permeated by smells from the purifiers; Dalkeith manager was given a new house in 1838, and the old house, "infested with snails" and insects, was made over to the labourers. Vide S.R.O., Cupar Minute Book, op. cit., 14/9/1899; Dalkeith Minute Book, op. cit., 14/9/1838.

3. S.R.O., Cupar Minute Book, op. cit., 2/7/1844. (By 1850 the chief fireman, his wife, and 4 children all occupied one room). C.f. In 1831 the Hawick manager received 14/- a week and use of the ground-floor flat in a house at the gasworks; the Directors alone could use the remainder. Transactions of Hawick Archaeological Society 1969, op. cit., p. 26.

4. e.g. Boness gas company in 1845 supplied free gas to the Beneficent Society Hall in return for the use of the Hall for company meetings. S.R.O. Boness Minute Book op cit 2/6/1845

unless they could meet in their Manager's house.[1] Ayr[2] company Directors in 1877 insisted that the foreman stoker and meter inspector had to reside at the works as well as the manager, and converted the disused gas-holder house into a dwelling house at the top and a laboratory and meter-store below. Like the manager, these men received free gas from the company. Galashiels[3] provided a dwelling house for employees at the works from 1868, which was still used in 1902. Glasgow corporation[4] built several houses for workmen near the Dawsholm works, to have men on hand in an emergency.

Duties imposed upon the Manager varied with the size of the gasworks. He was frequently delegated full power to employ labourers and others out of his own wages, and where the Manager was on an annual contract this resembled the sub-contracting or 'butty' system used in other industries.[5] Early contracts gave very simple instructions. The Vale of Leven 'Superintendent' in 1839 was "to make gas on the most approved and economic principle", read and adjust consumers' meters regularly, examine reported leakages as soon as possible, and to "devote his whole time and attention...to manage and direct the company's works".[6] From his annual salary of ninety pounds in 1849 the manager was to "pay the wages of workmen employed under him", and be responsible for purchasing materials, laying service pipes, repairing meters, and

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1. E.g. Dalkeith Directors met in the Manager's house up to 1837. S.R.O., Dalkeith Minute Book, op. cit., 18/2/1837.

2. S.R.O., Ayr Minute Book, op. cit., 29/4/1895, 4/7/1877.

3. S.R.O., Galashiels Minute Book, 28/2/1868, 13/4/1868, 7/6/1887, 7/1/1902.

4. Gas World, 25/6/1887.

5. E.g. coal mining, building, ship and railway construction. S.G. Checkland, The Rise of Industrial Society in England 1815-1885 (1969), p. 220.

6. S.R.O., Vale of Leven Minute Book, op. cit., 5/3/1839, 12/11/1860.

supervising any extensions of the works.[1] The company only paid for labourers employed outdoors, laying pipes, during the busy season of September to April; all other pipelayers and repairers were paid by the manager. The Vale of Leven company did not pay the extra workmen directly[2] until 1860.

When short of staff Managers sometimes hired men out of their own wages, as at Stranraer[3] in 1871. Conscientious managers even purchased equipment for the works out of their own salary.[4] Annan company in 1840 paid the wages of an assistant, but any labourer employed in the four summer months had to be paid by the manager personally.[5] By 1856 the Annan manager had to pay also for his assistants in winter, which cost fifteen pounds to twenty pounds out of his salary of ninety pounds. To reduce the cost of assistance the Manager was working "eighteen or twenty hours daily" for seven days a week during eight months of the year, and seventeen to eighteen hours a day the rest of the year. The Company[6] only paid extra stokers directly after 1865.

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1. Until 1849 the Vale of Leven manager had to whitewash the works, and accompany the Treasurer whenever meters were read. S.R.O., Vale of Leven Minute Book, op. cit., 23/3/1849, 19/4/1849, 17/9/1849.

2. This followed the manager's request for a higher allowance of 1/- per week towards labour costs. The manager had to keep detailed records of hours worked by the labourers. Ibid., 9/4/1860, 27/8/1860.

3. Stranraer manager was later compensated by a bonus of £5. S.R.O., Stranraer Minute Book, op. cit., 3/7/1871.

4. E.g. When John Young retired as manager at Dalkeith (1853-67), the Directors purchased from him several items used for the benefit of the company, including a letter press £1, a Testing Gasholder to check meters £14 10/-, and a Photometer £3 15/-. The Directors at Cupar in 1847 purchased from their retiring manager, Mr. Buist, a turning lathe at £8. S.R.O., Dalkeith Minute Book, op. cit., 18/6/1867. S.R.O., Cupar Minute Book, op. cit., 6/7/1847.

5. Annan works expanded from supplying 85 consumers with 600,000 cu. ft. in 1845, to 202 consumers using 1,100,000 cu.ft. by 1855. S.R.O., Annan Minute Book, op. cit., 21/2/1840, 25/5/1855.

6. Ibid., 24/4/1865.

At Cupar[1] the Manager's salary of £110 a year in 1844 included fifty pounds wages for his two firemen. In 1844 he accepted a salary reduction to ninety five pounds on the understanding that he, instead of the Directors, had full control over the hiring and dismissal of firemen. But the Company placed excessive responsibility upon him to always have sufficient men and "any loss or damage that may accrue to the Company through his unskillful and insufficient servants must fall upon himself". He resigned in 1845, and was succeeded by an inexperienced Perth brassfounder, G. Buist, who signed detailed regulations governing his duties.[2]

'He had to "reside on the premises and devote his whole time and attention" to the business. For this he was to "superintend the making of Gas, the laying and repairing of pipes and survey the meters, keep the Books and accounts", and take charge of the men, one fireman throughout the year and another in the winter season. Further, "he must have the Books up and Balanced and present a list of arrears at each of the ordinary monthly meetings [of Directors] and ... be answerable for the due conduct of every part of the Business". Buist resigned in 1847 to emigrate to America, and a new manager was appointed who, as the son of a blacksmith, had little technical knowledge of gaslight.[3] Besides the original regulations, the new manager could "upon no account whatever, make any alterations upon the works of the Company" without the Directors' approval. The same regulations applied to the fourth manager, appointed in 1853 who was "custodian of the Books" and all Company

1. S.R.O., Cupar Minute Book, op. cit., 2/7/1844, 15/11/1844.

2. From 1845 the new manager's salary was £52, and labourers were hired and paid separately by the Company. S.R.O., Cupar Minute Book, op. cit., 10/6/1845.

3. S.R.O., Cupar Minute Book, op. cit., 2/7/1847, 5/7/1847, 5/11/1853. c.f. Details of Stornoway manager's duties in 1859. S.R.O., Stornoway Minute Book, op. cit., 14/6/1859.

documents, and was to "write the minutes of the Directors [meetings], and conduct the correspondence" of the Company. Frequently the gas manager had to weigh all raw materials delivered at the works, and sometimes each charge used in the retorts also had to be individually weighed.[1] The manager took daily, or more frequent, records off the Station-Meter showing output.[2]

Blacksmith work was often part of a gas-manager's duties and smiths were frequently preferred as Managers in early companies. Selkirk[3] in 1853 offered the position to one local blacksmith, J. Mitchell, who refused, and subsequently employed W. Robson, another blacksmith working at Messrs. J. & H. Brown & Company's factory. Dalkeith[4] company erected a smithy and portable forge at their works in 1848. The Bathgate company[5] built a smithy for their manager in 1835, and allowed him to do blacksmith work there "for his own benefit" in return for paying interest on the cost of the equipment. Annan[6] company in 1845 insisted that the manager did all blacksmith work himself. Larger companies employed specialists, and Dundee New company[7] gasworks

1. E.g. Vale of Leven manager from 1847. S.R.O., Vale of Leven Minute Book, op. cit., 14/6/1847, 15/1/1852.

2. E.g. Muirkirk Manager took daily records from 1861. Dalry manager's duties in 1892 included a daily record of the station meter, of the times when purifiers were changed, and of each charge of coal used in retorts (for which a Pooley weighing machine was purchased in 1892). S.R.O., Muirkirk Minute Book, op. cit., 19/6/1882. S.R.O., Dalry Minute Book, op. cit., 28/12/1892.

3. The Selkirk blacksmith received only a few weeks of training in gas management by his predecessor. S.R.O., Selkirk Minute Book, op. cit., 11/7/1853, 14/7/1853, 20/7/1853.

4. S.R.O., Dalkeith Minute Book, op. cit., 6/1/1848, 6/4/1848.

5. S.R.O., Bathgate Minute Book, op. cit., 4/12/1835.

6. S.R.O., Annan Minute Book, op. cit., 24/2/1843. c.f. Boness company had a smithy at the gasworks in 1848, as had Dalry in 1872. S.R.O., Boness Minute Book, op. cit., 6/1/1848. S.R.O., Dalry Minute Book, op. cit., 11/4/1872.

7. Evidence of J. Leslie. H. Commons, 23/3/1846, p. 142.

in 1846 had both a blacksmith's and a carpenter's shop.

Engineering designs for renovations and small scale extensions were also the responsibility of managers in most companies,[1] though the Directors often shared the initiative for promoting new ideas. The Cupar manager, for example, in 1870 designed the first scrubber used there but the Directors had previously gathered information on the advantages of such equipment.[2] Selkirk[3] manager in 1873 designed extensions for the works costing £5000, and work on this scale was frequently in the hands of gas-managers in medium and large gasworks. Managers were also responsible for reading trade journals to both observe and forecast price changes in all items of expenditure from iron pipes to coal,[4] and to keep the Directors informed upon events. Where companies developed their own by-products chemical works, this included sulphate of ammonia prices. Managers like that at Ayr[5] in 1900, were required to gain not only a working knowledge of such chemical works, but to undertake the costing and advise upon the best process before their company purchased such equipment.

In 1883 the Stranraer manager's duties[6] included weighing all coal carbonized, and the gas produced, in a daily ledger from which a monthly report was sent to the Secretary. Like other employees, he was allowed no extra outside occupation, and was responsible for

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1. E.g. Stranraer manager Stewart designed regenerative retorts and a chimney in 1893, and his successor Watson in 1901 engineered new purifiers, exhauster and retort bench. S.R.O., Stranraer Minute Book, op. cit., 19/4/1893, 21/5/1901. Masonry skills of gas managers vide King's Treatise (1879), op. cit., Vol. II, pp. 65-8.
2. S.R.O., Cupar Minute Book, op. cit., 7/7/1870.
3. S.R.O., Selkirk Minute Book, op. cit., 8/5/1873.
4. E.g. S.R.O., Ayr Minute Book, op. cit., 13/6/1907.
5. Ibid., 24/12/1900.
6. S.R.O., Stranraer Minute Book, op. cit., 15/8/1883.

repairing leakage or fittings reported by consumers, though he could not make "any alteration" at the works without consulting the Chairman or Secretary and "at no time go from home" without warning of his absence. The regulations[1] were tightened in 1898, including a day to day cash book, and the presentation of all petty cash receipts to the Treasurer once a fortnight. All wages and disbursements were also to be entered on a pay sheet sent weekly to the Treasurer. Running accounts for tradesmen were abolished, and cartage had to be paid monthly. The Manager had to record the hours of labour by all temporary men on jobbing work, and was forbidden to make any contracts above three pounds without the Secretary's consent. He also had to record the waggon number, pit, and correct weight of all coals delivered at the station, and reweigh all steamship deliveries.

A new manager[2] appointed in 1899 was "bound to execute any small incidental jobbing" like repairing meters or laying and correcting pipes, "free of cost for his own labour".[3] He undertook to "plan and superintend the erection of new works ... such as Gas Holders", for which the Directors could pay a bonus but undertook no legal obligation to do so. He had personally to read consumers' meters three times a year, and arrange for the wet meters to be watered that frequently, and he was to collect gas rents in person. Besides keeping the books tidy and always open to inspection by the Directors or Secretary, and other duties imposed in the 1880s like re-weighing all coals before carbonizing them, the new manager was to have the gasholders and all outdoors ironwork painted annually, the works kept tidy, and the purification

1. S.R.O., Stranraer Minute Book, op. cit., 23/8/1898.

2. Ibid., 30/3/1899. (Repeated for another new manager on 1/12/1903).

3. Laying service pipes from gas-mains to consumers' meters was usually the Manager's responsibility. E.g. S.R.O., Stranraer Minute Book, op. cit., 5/3/1855.

improved.

Part-time outside jobs were sometimes open to Managers. At Dalkeith[1] in 1847 the manager was given a higher salary on condition that he ceased to do gas-fitting work in his free time. Boness[2] in 1845 refused to allow the manager to take outside jobs, but allowed him to take in lodgers and provide them with free coal and gas, to supplement his small income. The small company at Stornoway at least in 1851-9, shared the services of its gas manager and his assistant[3] with the local Water Company, each paying part of his salary. He acted as both Manager and Secretary in the Gas Company,[4] and from 1855 was allowed to act as Inspector of Poor[5] in the town, provided he employed an assistant at the gasworks during the busiest season, out of his own pocket.

Table 3.144 Stornoway Managers Employed by Both Gas and Water Companies

Date	Manager	Remuneration from	
		(1) Gas Company	(2) Water Company
1851	J. Anderson	16s 8d per week	8s 4d per week
1853	A.C. Fraser	£46 13s.4d per year	£23 6s 8d per year
1856	Mc Fraser	£33 6s 8d "	£16 13s4d "
1859	R. Wilson	£20 0s 0d "	£10 0s 0d "

Note - Until 1859, Manager also acted as Secretary.

Source:- S.R.O., Stornoway Minute Book, op. cit., 4/10/1851, 3/3/1853, 28/10/1856, 2/6/1859.

Kilsyth[6] gas supply once failed because the gas-manager was preoccupied on his farm smallholding, and at Hawick[7] the manager received

1. S.R.O., Dalkeith Minute Book, op. cit., 10/6/1843.
2. S.R.O., Boness Minute Book, op. cit., 2/6/1845.
3. S.R.O., Stornoway Minute Book, op. cit., 27/4/1852.
4. Ibid., 3/3/1853.
5. Ibid., 10/4/1855.
6. R. Anderson, A History of Kilsyth (1901, Edinburgh), p. 129.
7. Transactions of Hawick Archaeological Society 1969, p. 26.

an increase in salary to sixty pounds per year in 1844 provided he ceased the part-time occupation of farming and stock rearing. J. Briggs, the manager of a small gasworks at Colinsburgh[1] in 1862 was also an auctioneer, inspector of the poor, and collector of poor rates. Muirkirk[2] directors refused to allow their manager to rear poultry in the works after 1888.

The Manager was often employed also as the Collector[3] at an extra wage, or as Clerk and Secretary to the company.[4] Selkirk[5] managers had to read meters and collect gas rents personally up to 1875. Bathgate[6] manager in 1881 had to examine and service all meters personally every three months, and test the accuracy of ten per cent of all wet meters and twenty per cent of all dry meters each year. Stornoway[7] manager in 1885 still read and watered the meters. At early companies like Annan[8] in 1843, the manager was also lighting and

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1. Westwood's Parochial Directory for the Counties of Fife and Kinross (1862, Edinburgh), p. 127.

2. S.R.O., Muirkirk Minute Book, op. cit., 7/4/1888.

3. Dalkeith manager surveyed meters and collected rents up to 1837; Vale of Leven manager was also Collector from 1851; Ayr manager was Collector in 1847; Boness manager in 1844 was book-keeper and meter reader. S.R.O., Dalkeith Minute Book, op. cit., 4/12/1830.
S.R.O., Vale of Leven Minute Book, op. cit., 10/6/1851.
S.R.O., Ayr Minute Book, op. cit., 29/3/1847.
S.R.O., Boness Minute Book, op. cit., 14/7/1844.

4. E.g. Cupar in 1896 and Banff in 1912 appointed their managers as Secretary when taking Limited Liability. S.R.O., Cupar Minute Book, op. cit., 16/7/1896. S.R.O., Banff Minute Book, op. cit., 9/10/1912.

5. S.R.O., Selkirk Minute Book, op. cit., 17/6/1875.

6. Detailed 'Agreement' of duties signed by Bathgate manager is extant. S.R.O., Bathgate Minute Book, op. cit., 12/1/1881.

7. S.R.O., Stornoway Minute Book, op. cit., 10/9/1885. c.f. Stranraer manager in 1899 still read meters three times a year, and acted as collector; a temporary collector was appointed in 1903 while the manager supervised construction of a new gasholder. S.R.O., Stranraer Minute Book, op. cit., 4/6/1856, 30/3/1899, 20/4/1903.

8. Annan manager was at liberty to hire a Lamplighter at his own expense. S.R.O., Annan Minute Book, op. cit., 24/2/1843, 25/3/1845.

cleaning public lamps. From 1856 Stranraer[1] company paid their manager an extra fifteen pounds per year to act as Collector. Annan[2] employed a local solicitor as Secretary and Treasurer until 1858, but thereafter the Manager took that office at an extra twenty five pounds per year.

A combination of secretarial and managerial functions was not always successful. The sub-committee of three Banff[3] directors who visited Huntly, Keith and Buckie gasworks in 1913 found them more efficient than Banff because the manager was not involved in book-keeping. Banff therefore appointed their former auditor, a local accountant, as a separate Secretary/Treasurer. As early as 1850, Stranraer was obliged to employ an assistant for the manager who had neglected the repair and examination of gas meters because of overwork.[4]

Fidelity guarantees[5] were widely used as security against intromissions by Managers and other officials, though few companies were as stringent as Dundee[6] which in 1824 required £1000 securities from the manager. The manager normally had to provide the Company with a letter from respectable men willing to pay that money if he absconded. Cupar manager provided £200 security in 1844 in the form of letters from a china merchant and a blacksmith, both of Cupar, and D. Scott an Edinburgh engineer.

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1. S.R.O., Stranraer Minute Book, op. cit., 23/6/1856.

2. S.R.O., Annan Minute Book, op. cit., 28/5/1842, 8/1/1858, 18/6/1858.

3. S.R.O., Banff Minute Book, op. cit., 30/7/1913.

4. In 1849 Stranraer paid £18 for a winter labourer and part-time pipe-layer; the full time assistant of 1850 cost £25 a year. S.R.O., Stranraer Minute Book, op. cit., 25/6/1850.

5. Vide infra p.940

6. S.R.O., Books of Council and Session, Vol. 265, op. cit.

Table 3.145 Fidelity Guarantees by Employees

(1) Fidelity Securities provided by Gas Managers

Company	Date	Amount £	Persons providing security letters
Cupar	1845	200	James Russell of Cupar and Mr. Frew of Perth
"	1847	200	Manager's father, J. Douglas, blacksmith, and J. Douglas ironmonger in Cupar
"	1853	?	A. Fullarton, gas meter manufacturer in Edinburgh
"	1866	?	T. Russell, ironfounder in Cupar, and A. Morrison, inspector of poor at Perth
"	1884	50	?
Stornoway	1856	100	J. Morason, merchant, and J. McFraser baker, of Stornoway
Banff	1889	350	Bailie Hay, and Mr. Mackay, gas manager at Peterhead

(2) Fidelity Securities provided by Company Treasurers

Stornoway	1859	100	£50 from two separate persons
Vale of Leven	1848	200	-
"	1849	150	-

Sources:- S.R.O., Minute Books - Cupar, 4/7/1842, 9/1/1844, 3/11/1853, 27/4/1866, 13/11/1884; Stronoway, 28/10/1856, 14/6/1859; Banff, 11/10/1889, 22/11/1889; Vale of Leven, 19/5/1848, 22/8/1848.

Mr. Oliphant,[1] temporary manager at Dunfermline, acted as Treasurer also in 1830 and provided a letter from J. McDonald, an Edinburgh merchant, for his £250 security. When J.B. McIntosh[2] became clerk and collector to the Boness company at twenty five pounds per year in 1857, he had to provide a relatively large security of £100. Glasgow Gaslight Company took £500 letters of security separately from two cautioners[3]

1. Dunfermline Ref. Lib. Dunfermline Minute Book, op. cit., 7/1/1830.
2. S.R.O., Boness Minute Book, op. cit., 9/6/1857.
3. James Graham writer, and Alexander Murdoch cotton broker of Messrs. Ritchie and Murdoch, acted as cautioners; Hamilton personally undertook not to act as securitor to any other person whilst employed by the gas company. Glasgow City Archives (D.G.E. 31).

on behalf of Dundas Hamilton, accountant, before appointing him as secretary/treasurer in 1860.

Letters of security were not returned until some time after Managers had resigned. R. Douglas resigned at Cupar[1] in October 1853, but the letters were witheld until the following April. W. Mackenzie resigned there in April 1866 and his letters were returned in September. Meanwhile the new manager rechecked the company's books to detect intromissions. G. Buist,[2] the new Cupar manager in 1845, for example, reported several irregularities by his predecessor who had not charged his father for gas, and had received revenue for one stair light and two office lights which had not been entered in the Books. Minor embezzlement like this was rarely found and the system of cross-checking was apparently effective.

From the 1880s personal guarantee letters were increasingly superseded by insurance with Companies,[3] which was paid for by the gas-company itself; at the close of the century, gas companies took similar insurance against claims made under the Workmen's Compensation Acts.

Table/

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1. S.R.O., Cupar Minute Book, op. cit., 3/11/1853, 13/4/1854, 13/9/1866, 27/4/1866.

2. Ibid., 15/8/1845.

3. Fidelity guarantee insurance began in 1840, and included the 1840 Guarantee Society of London, 1845-62 British Guarantee Assn. of Edinburgh, 1845-8 West of Scotland Guarantee Assn. of Glasgow, 1863-1914 National Guarantee and Suretyship Assn. Ltd., and 1873-84 Guarantee Association of Scotland. The Scotsman, 2/4/1845.
W.A. Dinsdale, History of Accident Insurance in Great Britain (1954) pp. 41, 79.
H.A. Balston, "Fidelity Guarantee", Journal of the Insurance Institute of Great Britain and Ireland (1911), Vol. 14, p. 376.

Table 3.146 Employees Fidelity Guarantee Insurance

Gas Company	Date	Official Insured	Amount (£)	Annual Rate	Assurance Company
Galashiels	1887	Treasurer	200	£2 2/-	
"	1888) 1898)	Treasurer	500	£3 15/-	N.G.S.A.
"	1889) 1905)	Collector	200		N.G.S.A.
Banff	1890) 1892)	Manager	350		N.G.S.A.
"	1895	"	100		
"	1897	"	110		
"	1911	"	350	£1 15/-	C.I.C.
"	1913	"	500		C.I.C.
Bathgate	1900	Collector	100	15/-	N.G.S.A.
Ayr	1909	(Manager (Clerk (Collector	300 200 100		L.L.

Note - N.G.S.A. is National Guarantee and Suretyship Assn. Ltd.
C.I.C. is Century Insurance Co. Ltd.
L.L. is London and Lancashire Co.

Sources:- S.R.O., Minute Books - Galashiels, 29/11/1887, 7/2/1888, 5/7/1888, 5/3/1889, 5/5/1898, 7/3/1905; Banff, 7/3/1890, 22/3/1890, 8/7/1895, 7/7/1897, 5/4/1911, 30/7/1913; Ayr, 27/1/1909; Bathgate, 13/6/1900.

The heavy responsibility of management[1] not infrequently led to intemperance,[2] and on rare occasions even insanity. When Mr. Watson retired, after managing Banff works[3] from 1831-1889, the gasworks were quite antiquated and the new manager, P. Macdougal, assisted by a

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1. The work of the Greenock manager in modernizing that works in 1850, despite factious civic politicians, is described elsewhere.* Vide infra pp. 1028, 1561

2. E.g. W. Robson, manager at Selkirk from 1853-93, was forced by the Directors to take a pledge of abstinence, or to resign in 1877. D. Young, manager at Dalkeith (1874-90) was dismissed after continued intemperance, apparently following complaints of impure gas which led the Directors to employ a regular analyst. S.R.O., Selkirk Minute Book, op. cit., 18/1/1877.

3. Watson received an annual pension of £70. S.R.O., Banff Minute Book, op. cit., 7/9/1889.

consultant engineer, A. Smith of Glasgow,[1] was immediately involved in designing extensive alterations. At the same time the Collector was dismissed for inaccuracies and allowing arrears to accumulate. In 1891 the Manager[2] was made Collector also, and three months later went insane and was sent to the Royal Lunatic Asylum in Aberdeen.[3] Stornoway[4] employed Mr. McFraser as manager in 1856, but when the directors refused to renew his contract in 1859, he also went insane and was committed to jail. He was subsequently found to have embezzled £100 from the gas rates and goods delivered to the works. His successor, R. Wilson,[5] absconded abroad with the Company books in 1871 but later returned them.

By the mid nineteenth century potential managers could obtain a better training than trial-and-error or rule-of-thumb methods, and the small new Scottish companies of the 1830s and 1840s which began by employing smiths and amateur mechanics, demanded the services of men with experience in the industry, at least as leading stokers or journeymen gasfitters, once their scale of operations had expanded. The transmission of new knowledge was at first the prerogative of consultant engineers who became familiar with the faults and improvements of each works they visited personally, and also of company Directors applying the "method of comparisons". Even small introverted companies were forced to examine improved technologies when consumers applied the "method of comparisons" themselves and raised complaints.

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1. S.R.O., Banff Minute Book, op. cit., 7/9/1889, 2/7/1890.
2. Ibid., 18/7/1891, 4/8/1891.
3. Ibid., 5/11/1891, 17/11/1891, 10/2/1892.
4. S.R.O., Stornoway Minute Book, op. cit., 28/10/1856, 16/5/1859, 2/6/1859, 10/9/1861 (Fraser's referees who gave securities forfeited their money).
5. Ibid., 27/10/1871, 22/12/1871.

Textbooks on gas manufacture were available to managers from the late 1810s, but until the 1850s they were most infrequent and managers relied upon short articles in general periodicals[1] like the Mechanics Magazine, and to a greater extent upon personal visits to other gasworks in the immediate vicinity. Many gas engineers learnt the skills of their fathers,[2] but ambitious outsiders could advance to the position of manager through apprenticeship and frequent removals, climbing the gradual ladder from management in a small gasworks, probably in Ireland or abroad, to larger works as their competence increased. Gasworks financed by British capital abroad, especially in South America, provided many opportunities for advancement.

The Journal of Gas Lighting[3] from 1849 provided the first forum for a rapid exchange of ideas on gas technology, from equipment to the quality of coals. The publication of technical books, for example by S. Clegg and S. Hughes, increased rapidly from the 1850s as self-help and technical progress increased. Yet no formal training or educational syllabus was devised. Consumer complaints[4] in the early 1840s illustrated the divergent views of managers on many technical issues, and Professor Wilson of the Andersonian University in Glasgow, with Angus Croll, promoted an Institute of Gas Engineers[5] in 1848 to rationalize the industry. By preventing "extravagant and ill-directed

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1. Technical dictionaries and encyclopaedias were a medium used also for expounding advanced designs in a wide range of early nineteenth century industries.

2. E.g. W. Fox, the manager of Lerwick who considerably improved those gasworks in 1887, was the son of B. Fox, manager at Carnoustie and a former employee of Dundee council. J.G.L., 27/9/1887. c.f. S. Pollard, Genesis of Modern Management (1968), pp. 182-3.

3. This was the only regular periodical on the British gas industry until the Journal of Artificial Light (1878-80, Edinburgh) and Gas World (initially Gas and Water, 1879 et seq., London).

4. Vide infra p.1149

5. The Builder 1848, Vol. VI, p. 250.

expenditure", Wilson believed that the Institute could considerably reduce gas prices after organizing "the collection and discussion of all data relative to the manufacture, price, purification and distribution of gas". The Institute was also expected "to reduce to one uniform system and science" the training of gas managers, but the ambitious scheme was not fulfilled.[1]

The high salaries offered by very large English gasworks, especially in London, created in some measure a "brain-drain" of the brightest managers out of Scotland even during the 1840s when their skills were most needed. The Imperial Gas Light and Coke Company[2] of London, for example, had a Scottish consulting engineer and director, Mr. Foulis, who in 1845 acquired John Kirkham,[3] chief engineer of Leith gas company, as their engineer. The new sub-engineer was also Scottish, James Reid the former manager at Montrose.

David Hunter was typical of the elite who migrated southwards. When Dalkeith gasworks commenced in 1827 a local millwright, G. Drysdale, was employed to install all service pipes, but the Company considered that only one "Stoker" was required to operate the completed works.[4] After advertising for applicants in the Edinburgh Evening Courant, they appointed Hunter from Leith Walk Foundry. By

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1. Nevertheless, the Andersonian University continued to play an important role in teaching applied technology; Dr. Penny's associations with the gas industry for coal analysis have already been mentioned, and in 1857 Penny's Chemistry Class visited Glasgow gasworks and many other Scottish industrial premises; the Andersonian in the late nineteenth century frequently housed meetings of Gas Managers' associations. Glasgow Herald, 29/4/1857.

2. S. Everard, The Gas, Light and Coke Company (1949), op. cit., p. 174.

3. Vide infra p.158

4. Hunter was granted the assistance of a Lamplighter later in 1828, and a clerk in 1830. S.R.O., Dalkeith Minute Book, op. cit., 10/9/1827, 23/8/1828, 30/8/1828, 20/9/1828.

1831 Hunter was sufficiently proficient to submit plans for the design of a gasworks for the new Musselburgh company,[1] and in 1832 he travelled to Inverkeithing to compare the quality of their firebricks with those made in Portobello. In 1833 he planned extensions of Dalkeith[2] gas mains, followed by a new gasholder the next year, and a gasholder-house and new dwelling house in 1838. But in 1840 he resigned to join the Metropolitan Gas Company in London, and was succeeded by G. Aitken,[3] the former manager at Musselburgh whom he had probably helped to teach.

James Ritchie,[4] gas manager at Ayr and consultant engineer who designed several works in the 1830s, used his design of Maybole gasworks as his key to a more highly paid position in the south, at Sheffield gasworks. Robert Morland[5] of Stranraer was another self-taught man who became the inexperienced manager of the local company in 1845, visited the 1851 Great Exhibition, and by 1853 had designed an enlarged retort bench for Stranraer works. He travelled to Glasgow and Inverkeithing to inspect the quality of castings and retorts, and during 1854 designed a new gasholder for the company and received an increased salary to decline applying for the management of Airdrie works. By 1857 he was manufacturing by-products in his spare time, with ammoniacal liquor purchased from the company, but in 1866 he resigned to become

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1. S.R.O., Dalkeith Minute Book, op. cit., 13/2/1831, 15/6/1831.

2. Ibid., 21/6/1833, 6/6/1834, 24/5/1838, 14/6/1839.

3. Aitken left the Company in 1853 to migrate to Australia. S.R.O., Dalkeith Minute Book, op. cit., 23/7/1840, 12/6/1840, 3/8/1840.

4. Brother of John Ritchie, of the glass and china warehouse in Ayr. James designed the original Stranraer gasworks. After the Sheffield United Gas Company, James succeeded J.B. Neilson as gas manager for Glasgow old company in 1846. Died 1876. Glasgow City Archives, (D.G.E. 25). Security guarantee 8/2/1847. North British Railway and Shipping Journal, 28/11/1846, p. 2. S.R.O., Stranraer Minute Book, op. cit., 27/1/1836, 4/6/1836, 16/7/1836. J.G.L., 15/8/1876. Vide infra p.134

5. S.R.O., Stranraer Minute Book, op. cit., 8/3/1845, 29/6/1852, 7/5/1853, 23/3/1854, 30/6/1857, 14/2/1866, 10/4/1866.

manager at Gloucester which offered a far higher salary.

In 1854 William Esson,[1] manager at Inverness, moved to a similar post at Cheltenham gasworks. R. Douglas,[2] gas manager at Cupar, resigned in 1853 to join the Phoenix Company in London. The lure of English works left some Scottish gasworks as mere training grounds, and forced others to raise the remuneration of skilled staff. Competition between gas companies for the services of engineers produced a national market in skills, and an approach to national wage levels. The new Cupar manager[3] in 1853, W. Mackenzie from Greenock, was paid seventy pounds a year, but in 1857 he applied for the management of Gosport, Hampshire, until Cupar raised his salary to eighty pounds. In 1860 he was offered the management of Montrose gas company at £130 but agreed to stay at Cupar when his salary rose to £110. In 1865 he applied for Burton on Trent which offered "very superior inducements", but instead accepted a rise to £120, and was finally seduced by the Dunfermline company in 1866.

John Young manager at Selkirk and later Dalkeith, was one of the highly skilled early engineers, but he too tried to move south and applied in 1852 for a job at Salford near Manchester.[4] Hugh Bartholomew, (1815-1885)[5] who studied chemistry under Thomas Graham at the Andersonian University, in the same class as David Livingstone and

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1. J.G.L., 10/2/1854, p. 353.

2. S.R.O., Cupar Minute Book, op. cit., 31/10/1853.

3. Ibid., 19/6/1857, 21/4/1860, 25/2/1865, 9/4/1866.

4. S.R.O., Selkirk Minute Book, op. cit., 11/10/1852. (Father of William Young). Extant copy of Selkirk Directors' letter of recommendation. Vide infra p.1733

5. H. Bartholomew introduced 'Paraffin' Young to Boghead coal and later purchased 100 shares in Young's Paraffin Light and Mineral Oil Company; he became Chairman of Kelvin Valley Railway, and partner in Haywood Gas Coal Company. Gas World, 21/2/1885. J. Jeans, Western Worthies (1872, Glasgow), p. 65. J. Butt, "James Young" (1964), op. cit., pp. 73, 74, 305. Vide infra p.1727

James Young, travelled to Liverpool gasworks to receive training as assistant to Mr. King,[1] a reputable engineer. In 1844 Bartholomew engineered and subsequently managed the gasworks of Glasgow City and Suburban company.

Dundee[2] was managed from 1826-52 by James Russell, whose origins are obscure, but his successor from 1852-66 was John Z. Kay who had been trained by J.B. Neilson at Glasgow gasworks. He was followed by Boyd M. McCrae, a skilled engineer and formerly manager at Airdrie, who was succeeded by his own son John. The younger McCrae studied drawing at High School, worked for two years as clerk to the Treasurer of Dundee Old Company, followed by a course in Natural Philosophy and Chemistry at St. Andrews University. For five years he assisted his father in Dundee gasworks before becoming manager at Bury St. Edmunds in 1875, and returning to Dundee as manager in 1880.

The manager at Edinburgh Gaslight Company, Mr. Watson[3] who died in 1860, was succeeded similarly by his eldest son, John Kippen Watson who had joined the company in 1834. John was principal assistant to his father by 1840, and treasurer and manager of the works from 1860-86. The Melrose[4] manager from 1860-85, W. Hogg, was succeeded by his son W. Hogg jn. J. Richmond[5] succeeded his father as manager of Whitburn gas company in 1888. Mr. Reid,[6] manager at Perth from

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1. <u>Vide supra</u> pp. 410, 276

2. J.Z. Kay left in 1866 to become a partner in the Phoenix Iron Works Co. in Glasgow. <u>Gas World</u>, 25/7/1885.

3. T.R. Cameron, "Gas Manufacture in Edinburgh" (1951 typescript), <u>op. cit.</u>

4. <u>J.G.L.</u>, 17/3/1885.

5. <u>J.G.L.</u>, 24/1/1888.

6. <u>Gas World</u>, 3/10/1885, p. 482.

1827-84, was succeeded by his son John.

The duration of company loyalty[1] by some managers, and perhaps some Directors, retarded the adoption of new technology and more efficient management at many small gasworks. W. Robson,[2] manager at Selkirk from 1853-93, was finally forced to resign by the Directors when in failing health, following a comparison made by them with the better management shown at Galashiels company. His successor at Selkirk, J. Smith[3] from Hawick, found the entire works antiquated. The output was only 20,000 cubic feet per man, using five retorts and two furnaces per oven. Smith recommended four retorts per oven which with an exhauster could raise daily output from 130,000 to 230,000 cubic feet per day or 30,000 cubic feet per employee. The works used lime purifiers but had no washer or scrubber to remove ammonia for sale; there were no by-pass valves to cut-out faulty sections for repairs or allow alternative purifiers to be used, the entire output passed to the mains through one small gasholder instead of a "distributive chest" to allow a supply from any gasholder in emergencies; and mains pipes were far too narrow. A four inch pipe to Selkirk Bridge supplied only half the potential demand, and despite an excessive $^{8}/10$ inch pressure on the mains, important consumers like the Philliphaugh and Deanbank mills obtained only $^{4}/10$ inch. Faults like these considerably reduced the revenue of a badly managed company.

A similar situation may also have arisen where sons succeeded

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1. Not infrequently Managers retained their position for more than twenty years with a Company. E.g. T. Inches, manager at Coupar Angus from 1855-78. J.G.L., 16/7/1878; Wm. Monroe remained manager at Alva from 1846-1882. J.G.L., 4/4/1882; Andrew Aikman remained President of Directors at St. Andrews from 1872-1889. J.G.L., 12/3/1889.

2. S.R.O., Selkirk Minute Book, op. cit., 28/8/1893.

3. S.R.O., Selkirk Minute Book, op. cit., 28/8/1893.

their fathers as Managers, without additional outside training. Such men were unlikely to experiment with new techniques, and many small companies relied upon such managers. Thus, R. Robertson,[1] manager at Bathgate from 1879 to 1896, was succeeded by his son J.B. Robertson, whose working experience was confined to assisting his father.

Nevertheless some families became well known[2] for their skills at gas engineering, which was learned as a craft by several sons of a gas manager. Mr. Blair[3] who became manager at East Wemyss in 1883, had a grandfather, father and four uncles in the gas industry at Airdrie, Alexandria, Kilbarchan and Girvan. T. Wilson,[4] manager at Newmilns in the late 1870s, was trained by his father who remained manager at Stewarton for forty years, and his own son, A. Wilson, became manager at Perth in 1895. R.B. Thomson[5] (1865-1893), manager at Broughty Ferry in the 1880s, was the son of the gas manager at Inverness; and John Terrance (1874-1955) the son of D. Terrance, chief engineer at Dawsholm works in Glasgow.[6]

Two families were famous in late nineteenth century Scottish gas industry, the Youngs of Bonnyrigg, and the Hislops. James Hislop[7] (1832-87) was the son of a gas engineer at Biggar, who became manager at Lanark and there taught James and his brother George as apprentices. George became manager at Paisley, and James became manager at Falkirk

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1. S.R.O., Bathgate Minute Book, op. cit., 10/3/1896.

2. Malam at Dumfries was a member of one such early nineteenth century family. Vide infra p.333

3. Gas World, 22/4/1899. Vide infra p.1728

4. Gas World, 30/7/1898. Vide infra p.1732

5. Gas World, 16/12/1893. Vide infra p.1732

6. W.T.K. Braunholtz, The Institution of Gas Engineers (1963), p. 113. Vide infra p.1731

7. N.B.A.G.M. 1887. Vide infra p.1729

Fig. 3.147 Mr. WILLIAM YOUNG.

Source : N.B.A.G.M. 1911 p.99

in 1857, Ayr in 1859, and at Partick, Hillhead and Maryhill in 1871. John Young[1] (1815-1886) was an apprentice shoemaker at Galashiels, but constructed a private gasworks after reading books on the London gasworks. On that basis he was appointed Manager of the new Selkirk gasworks in 1840, and became manager at Dalkeith in 1852, a year after winning a medal for a model gasworks at the 1851 International Exhibition. At Dalkeith he gave public lectures on electricity, chemistry and optics, and moved in 1868 to the Wigan Coal and Iron Company to build coke ovens for the recovery of by-products. His son, William Young[2] (1841-1907) was the most versatile technocrat in the Scottish gas industry, and after studying science under Lyon Playfair at Edinburgh in the mid 1850s, he advanced from apprentice gasfitter at Dalkeith, to gasworks manager at Lasswade in 1863, oil work manager at Straiton about 1866 and at Clippens in 1874, to become a wealthy consultant engineer. His work encompassed vertical retorts and by-product recovery for the oil industry, the Peebles oil-gas process, Aitken and Young Analyzer and vertical retorts for the coal gas industry, and by-product recovery from blast-furnace gases.

Several gas managers began their careers in the gas industry before moving into the rapidly expanding oil-shale industry of the 1860s, and then returned with greater experience.[3] A. Bell,[4] a Dalkeith gasfitter, helped W. Young to construct Pentland oilworks before becoming manager there, and then gas manager at Dalkeith in

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1. Gas World, 30/1/1886, p. 139. Vide infra p.1733

2. N.B.A.G.M. 1910, "William Young". N.B.A.G.M. 1911, "William Young - An Appreciation". Vide infra p.1733

3. Eighty nine new shale-oil companies were formed in Scotland in 1860-6. J. Butt, "The Scottish Oil Shale Mania of 1864-6", Scottish Journal of Political Economy 1965, Vol. 12.

4. Gas World, 31/7/1897.

1889. Robert Mitchell[1] of Lasswade learned gas engineering with the Phoenix company in London before working under Young at Straiton, and he subsequently became gas manager at Coatbridge, and in 1888 manager for the Edinburgh and Leith Gas Commissioners.

British companies constructing gasworks abroad provided an important training ground for skilled gas engineers[2] willing to experiment with the latest methods, after most Scottish gasworks were in large part completed. In 1865, for example, "a number of mechanics" sailed from Kirkcaldy,[3] Fifeshire, to the Island of St. Thomas, on a vessel loaded with 500 tons of gasworks equipment, from the gasometer to bricks and pipes necessary for construction of a gasworks there.

Among expatriates, S. Stewart (1833-1906) built and managed gasworks at Pernambuco (1857-62) and Bahia (c.1863-4),[4] before becoming gas engineer at Greenock.[5] W. Ewing,[6] after his apprenticeship at Hamilton gasworks, worked at Gibraltar and Para gasworks, and at two Irish works, becoming manager at Hamilton in 1892. J. McLaren[7] began as a plumber at Melrose in 1885, and was later manager at two Irish gasworks before becoming manager at Tranent in 1893. W. Smith,[8] a

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1. Gas World, 29/5/1897, 15/6/1895; J.G.L., 12/10/1880, p. 578.

2. E.g. Lanark gas manager, A.K. Darg, became manager at Panama in 1884. Levi Monk, his predecessor at Lanark, became manager at Colombo, Ceylon, before accepting management of Partick gasworks in 1891, when he was also offered the job of managing William Young's Clippens Oil Works. J.G.L., 22/1/1884, 1/9/1891.

3. The Artizan, 1/1/1865, p. 23.

4. The Bahia, Brazil, manager in 1871-6 was Hugh Baillie, formerly manager of Falkirk Gas Company. J.G.L., 19/12/1871, p. 938.

5. Gas World, 2/8/1890. Vide infra p.1731

6. Gas World, 28/7/1900. Vide infra p.1728

7. Gas World, 10/9/1898. Vide infra p.1730

8. Gas World, 14/9/1895.

meter inspector at Darlington progressed rapidly to become assistant manager in Ireland, and a year later manager at Melrose. This pathway was also trodden by the sons of gas managers. James Hislop, already mentioned, worked first as superintendent of mains pipes for the Edinburgh and Leith Company, then as consulting engineer in Ireland on behalf of a famous English engineer, George Bower of St. Neots. This was followed in 1857 by gas engineering for the Turkish government, before he returned to Scotland.

Other gas engineers progressed by training in ancilliary[1] or similar industries. W.R. Herring served his articles with a Birmingham firm of mechanical engineers, H. Pooley in his father's drawing office in Liverpool,[2] and R.B. Thomson was apprenticed as mechanical engineer with the Highland Railway Company in Inverness. James McGilchrist,[3] a friend of William Young, trained as a mechanic in his home town of Falkirk, and after studying chemistry and working at Partick gasworks under the tuition of James Hislop, he became manager at Dumbarton in 1874 and developed a national reputation as a consulting engineer. J. Terrance[4] in the 1880s trained as a civil and mechanical engineer with the firm of Ashmore, Benson, Pease & Co. For men like Thomson and Terrance, whose fathers were in the gas industry, that industry provided an inadequate depth of training to develop their capabilities and they felt obliged to look elsewhere.

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1. E.g. W. Ewing, already mentioned, worked for Messrs. Laidlaws, gas engineers of Glasgow, before going to Gibraltar; J. Terrance in 1897 was a water-gas engineer for Messrs. Humphreys and Glasgow in Australia.

2. Pooley was Dunfermline manager in 1893. Gas World, 29/7/1899. Vide infra p.1730

3. William Key, his predecessor at Dumbarton, had left to join an English gasworks. Gas World, 28/7/1894; J.G.L., 14/7/1874, p. 57. Vide infra p. 649

4. Vide infra pp.1731, 636

This was true of William Foulis,[1] whose father William Foulis senior[2] was manager at St. Andrews and later Paisley. Foulis jn. learned mechanical engineering as an apprentice at Hyde Park Engine Works in Glasgow,[3] before spending seven years as an engineer in Italian and Greek cities, and constructing gasworks at Malta, and at Palermo, Sicily. During the 1860s, in partnership with W.R. Copland, a civil engineer in Glasgow, he designed and constructed gas, water and sewage works. He was employed as adviser to Glasgow Corporation when they purchased the city gasworks in 1869, and subsequently as their chief engineer. His talents were expressed in the introduction of regenerative retorts, with Sir William Siemens, in mechanical coal charging machinery with Sir William Arrol, and in the construction of miniature steam locomotives for hauling material inside Glasgow gasworks.[4] John Reid,[5] son of the Perth gas manager, worked first as an apprentice engineer and machine-maker in Dundee, and later in England and Holland, before becoming manager at Montrose, and then with the Edinburgh and Leith company in 1860.

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1. Gas World, 16/5/1896, 6/8/1898, p. 201. W.S. Murphy, Captains of Industry (1901, Glasgow). (Murphy incorrectly claimed the Hydepark works were those of Napier and Inglis in London).

2. S.R.O., Renfrewshire Sheriff Court - Inventories, 10/5/1865, Vol. 32 (174). The Sheriff Court Inventory records, which record gas managers' occupations in the index, are an important but neglected source of information on individual engineers.

3. The Engine Works were run by Walter Montgomery Neilson, who was foreman of Glasgow Gasworks for five years, when his father J.B. Neilson was manager there. J. Butt, Industrial Archaeology of Scotland (1967), op. cit., p. 123. Vide supra p.599

4. Vide infra pp. 387, 1728

5. Reid became a Fellow of the Geographical Society and the Royal Society of Arts. In 1856 he built a water-supply system for Montrose Council, and invented a water-supply meter, and various gas apparatus including a governor and a revolving washer. Gas World, 3/10/1885, 2/11/1889. Vide infra p.1730

A good scientific education produced rapid promotion for the minority of potential managers who could achieve it. Adam Macpherson[1] studied science at St. Andrews University before training at St. Andrews gasworks under J. Hall, and subsequently became manager at Kirkcaldy. H. Pooley[2] studied chemistry and civil engineering at Victoria University, Manchester, before serving his articles under the Birkenhead manager, and becoming manager at Dunfermline in 1893. W.B. McLusky[3] of Port Glasgow took a more arduous but probably more usual route. He trained at the gasworks in his home town, but in his spare time studied the operations at a nearby large works, that of Greenock run by S. Stewart. His education was provided by the Glasgow and West of Scotland Technical College, and after progressing to the post of assistant manager at Port Glasgow, he became manager at Kirkcudbright in 1891, Kelso in 1894, and Selkirk in 1897. A. Yuill[4] studied under "the South Kensington scheme" while working at Motherwell gasworks, and subsequently became manager at Alloa in 1887.

The "South Kensington scheme" comprised a comprehensive training programme for "artizans, apprentices, foremen, managers of works, manufacturers, and technical teachers"[5] established by London Livery Companies as the City and Guilds of the London Institute. It followed a temporary surge of interest in technical education, aroused by the 1851 Great Exhibition which led in 1853 to a Science and Art Department

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1. Gas World, 30/7/1892.
2. Vide infra p.1730
3. At Port Glasgow, McLusky was instructed by J. McCubbin, the manager.
4. Yuill was secretary/treasurer of Motherwell gas company until 1887. Gas World, 25/7/1896, 6/4/1895.
5. B.P.P., Royal Commission on Technical Instruction (Second Report), Vol. I, 1844; (c.3981), Vol. XXIX. [Irish University Press 1970, Education - Scientific and Technical, Vol. 5], p. 473.

as part of the Board of Trade,[1] to encourage science teaching. Little money was granted, and in 1857 the duties were transferred to a Privy Council Committee on Education. Petitions from Mechanics Institutes in 1857 and agitation by Playfair, Spencer and Huxley led to the opening of the 1857 South Kensington Museum, with exhibits purchased from the 1851 Exhibition. Meanwhile, examinations instituted by the Society of Arts were taken over by the City and Guilds which gave assistance to institutes providing evening classes in technology in "nearly all the large manufacturing towns" in Britain.[2] From the affiliated institutes work was "inspected and examined by the Institute" which granted certificates and prizes after annual examinations. By the 1880s these were widely recognized as "diplomas of efficiency", and the work of the Institute reached considerable importance. From 202 candidates and 23 examination centres in 1879, the number had risen to 2397 candidates at 154 centres by 1883. The central organization,[3] copying Polytechnic schools in France and Germany, was originally based at Finsbury Technical School (1883) and the South London Technical Art School, though in 1881 construction commenced of a Central Institution in Exhibition Road, housing large workshops, laboratories, and a museum of apparatus, opposite the South Kensington Museum.

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1. L.F. Haber, The Chemical Industry during the Nineteenth Century (1958, Oxford), p. 73.

2. Especially large financial grants were provided to Universities and technical schools in Sheffield, Nottingham, Leicester, and Manchester.

3. Local examination centres were organized in, for example, public schools in Greenock, Glasgow, Hawick, Lochee, Wishaw and Blairgowrie in 1882, and at Beith, Falkirk and Leith the previous year, besides Gordon's College in Aberdeen, Anderson's College in Glasgow, the Edinburgh Museum, and the Young Men's Christian Association in Dundee. A detailed early history of the scheme is given in the City and Guilds of London Institute Reports 1879-84 (Birmingham University Library, s. per q. T. 107 C 5).

In 1884 the City and Guilds[1] held examinations in 34 subjects, all in technical and skilled crafts from gas manufacture to alkali manufacture, glass, textiles, electrical engineering and mechanical engineering. The Glasgow and West of Scotland Technical College[2] probably assisted with the "South Kensington scheme", and certainly gave practical lectures in the gas industry. Professor Dittmar's chemistry laboratories taught "quantitative methods of analysis", especially of gas, and amongst the daytime pupils taught by E.J. Mills, 'Young' Professor of Technical Chemistry, was J.M. Reid (1877-8), later an engineer at Dawsholm gasworks.[3] The City and Guilds, and this West of Scotland College, were among the most important sources of technical education for late nineteenth century gas managers.

Opportunities for advancement from unskilled jobs to respected managerial positions were always present in the Scottish industry. G. Keillor,[4] the new manager at Nairn in 1880, was previously foreman stoker at Arbroath. R. Robertson, ironmonger, joined Bathgate[5] company

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1. B.P.P., Royal Commission on Technical Instruction (Second Report), Vol. V, 1884; (c.3981 IV), Vol. XXXI (1). [Irish University Press 1970, Education - Scientific and Technical Vol. 8], pp. 689 (135) to 695 (141) prospectus and financial accounts.

2. Anderson's University, renamed Anderson's College in 1877, merged with Glasgow Mechanics Institution in 1884 to form the Glasgow and West of Scotland Technical College. (Termed the 'College of Science and Arts' from 1879-84). L.F. Haber, The Chemical Industry during the Nineteenth Century (1958, Oxford), pp. 75-6.

3. The 'Young' chair, endowed by James 'Paraffin' Young in 1870, was first offered to W.H.Perkin, the coal-tar chemist, but a dispute over status by the encumbent Prof. of Chemistry, Penny, prevented his arrival. Among 38 prominent technical chemistry pupils later noted by Mills, was C.Siebert who joined Glasgow tar works. 19 of the chemists employed at St.Rollox chemical works in 1870-81 included 10 trained at the Anderson Coll
B.P.P. Royal Commission on Technical Instruction (1884), op.cit., Vol. V pp. 787 (233), to 793 (239).
R.Brightman "W.H.Perkin and the Young Chair of Technical Chemistry at the Royal College of Science and Technology in Glasgow" Nature 1958 (182)p.6

4. J.G.L. 12/10/1880

5. Bathgate Directors termed one of themselves 'Manager', until giving that title to Robertson in 1880 after observing the management hierarchy use at Linlithgow and Boness Gasworks. S.R.O. Bathgate Minute Book, op.cit., 23/6/1873,4/6/1874, 3/6/1879, 2/11/1880, 15/6/1880.

as meter 'Surveyor' in 1873, but helped to repair the works in 1873. He took an interest in their construction, and by 1879 was termed "general Manager", though for engineering work he consulted G. Hislop, the Paisley gas manager. G. Caithness,[1] the new manager at Carnoustie in 1889, had been chief stoker there for twenty years. W. Duncan, 'fireman' at Cupar,[2] became manager of Tayport in 1854, but Cupar gas manager did not take a proper apprentice until 1878, when W. Robertson was accepted on three months probation followed by indenture for four years at a salary rising annually from ten pounds to twenty five pounds. William McCulloch[3] (1877-1911) worked as a stoker before taking management of Beith gasworks in 1906-11.

Flintoff[4] accused gas companies in 1860 of still employing local shopkeepers as managers despite their lack of skills, and this certainly applied to some Scottish companies. T.A. Dalzell, a tinsmith and general merchant became manager of the small Anstruther and Cellardyke Company,[5] where his predecessor John Adams as manager from 1846-76 had developed reasonable skills. Peterhead[6] appointed a local grocer, Mr. Hay, as manager in 1885. Robert L. Deans[7] (1855-1912) was gas-meter inspector in his native town of Johnstone in the 1880s, before becoming manager there.

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1. J.G.L., 12/2/1889.

2. S.R.O., Cupar Minute Book, op. cit., 14/12/1854, 10/1/1878, 3/5/1878, 8/11/1877.

3. Gas World, 25/3/1911, p. 397.

4. Vide infra p.1157

5. J.G.L., 22/8/1876.

6. J.G.L., 28/2/1885.

7. The Institute of Gas Engineers Transactions 1913, p. 431.

Table 3.148 Previous Training of Managers Employed by Various Companies

Company	Date	New Manager	Experience
Ayr	1847	T. Clark	-
"	1860	James Hislop	Manager of Falkirk gasworks
"	c.1866	Laurence Hislop	Relative of former manager
"	1876	James Robb	Manager at Haddington; formerly assistant manager at a London works and at Brighton
"	1884	Wm. Smith	Manager at Newton on Ayr (1874-84)
"	1908	J. Purves	Gas engineer at Leeds
Banff	1889	P. Macdougal	Assistant manager at Peterhead
"	1892	W. Marshall	Assistant manager at Falkirk
Boness	1844	J. Dunlop	Assisted in construction of gasworks. Some previous experience (possibly at private works)
"	1846	J.M. Gardner	- (Possibly a Director assuming this title)
"	1855	M. Naismith	Formerly chief stoker at the works
"	1862	W. Drummond	Experienced man from Glasgow (chosen in preference to Naismith's son and apprentice
"	1869	Black	Manager at Langbank
"	1874	J.A. Ambrose	Manager at Tillicoultry
Cupar	1842	Mr. Honeyman	-
"	1845	G. Buist	Brassfounder in Perth
"	1847	R. Douglas	Blacksmith's son
"	1853	W. Mackenzie	Experienced man from Greenock
"	1866	J. Gemlow	Manager at Carnoustie
Dalkeith	1828	D. Hunter	-
"	1840	G. Aitken	Manager at Musselburgh
"	1852	John Young	Manager at Selkirk
"	1867	J. Cusitor	Local School teacher
"	1874	D. Young	Elder son of John Young, trained at Musselburgh gasworks

Table 3.148 Training of Managers (contd.)

Company	Date	New Manager	Experience
Dalkeith	1890	A. Bell	Construction supervisor at Edinburgh works
"	1909	R.W. Cowie	Manager at Lockerbie
Lesmahagow	1845	W. Miller	Wright; assisted in construction of this gasworks
"	1847	R. Gordon	Smith
"	1849	J. Miller	Nailer
"	1860?	James Young	-
"	1872	R. Scott	Roadsman; resigned after one month
"	1872	James Young	(as above)
"	1881	W. Marr	Gas engineer of Whitburn
"	1884	J. Weir	Gas manager of Auchinleck
"	1888	A. Bell	Experienced man from Cambuslang
"	1889	A. Brown	Journeyman plumber of Hamilton
"	1890	J. McKerracher	Experienced man from Helensburgh
Selkirk	1835	W. Murray	Cooper
"	1840	John Young	Gas engineer of Galashiels
"	1853	W. Robson	Blacksmith at Messrs. J. & H. Brown & Co. factory
"	1893	J.D. Smith	Manager of Hawick
Stornoway	1848	R. Wilson	Manager at Crieff
"	1851	J. Anderson	Manager at Nairn
"	1853	A.C. Fraser	Gas industry experience in Inverness
"	1856	McFraser	-
"	1859	R. Wilson	Plumber of Stornoway
"	1871	J. McPhail	Chief stoker at Stornoway
"	1885	A. Ross	Mechanical Engineer from Maryhill gasworks
"	1886	D.B. McCallum	Gasfitter and engineer at Barrhead
Stranraer	1840	John Young	Private gasworks amateur; shoemaker
"	1845	R. Morland	Inexperienced
"	1866	A. McPherson	Experienced but origin unknown

Table 3.148 Training of Managers (contd.)

Company	Date	New Manager	Experience
Stranraer	1869	P. Stewart	Inexperienced local resident
"	1899	P.B. Watson	Manager at Castle Douglas
"	1903	M.B. Watson	Manager at Auchterarder
Vale of Leven	1839	E. Christie	Employee at Campsie alum works
"	1846	J. Peacock	Gasworks employee at Leven
"	1850	J. Blair	Manager at Renfrew
"	1854	T. Blair	Manager at Johnstone (brother of J. Blair)

Sources:- S.R.O. Minute Books - Ayr 29/3/1847, 3/7/1861, 4/7/1864, 5/7/1876, 2/7/1884, 28/9/1908; Boness 14/7/1844, 8/1/1846, 11/6/1855, 30/1/1862, 30/11/1869,13/8/1874; Banff 26/9/1889, 22/3/1892; Cupar 4/7/1842, 10/6/1845, 2/7/1847, 3/11/1853, 21/4/1866; Dalkeith 20/9/1828, 3/8/1840, 1/3/1867, 26/5/1874, 6/3/1909; Lesmahagow 19/10/1845, 26/2/1847, 26/6/1860, 29/5/1872, 7/6/1872, 16/5/1881, 3/1/1884, 18/4/1887, 9/12/1889, 13/1/1890; Selkirk 8/7/1835, 19/10/1840, 20/7/1853, 11/10/1893; Stornoway 16/5/1848, 3/9/1851, 3/3/1853, 10/9/1885, 5/6/1886, 28/10/1856, 2/6/1859, 22/12/1871; Stranraer 28/11/1840, 8/3/1845, 4/2/1866, 23/3/1866, 2/4/1869, 30/3/1899, 1/12/1903; Vale of Leven 11/11/1839, 15/4/1846, 22/4/1850, May 1855.

The first professional association of British gas managers was the Waverley Association[1] which met at Kelso in August 1861, with seven gas managers from the counties of Selkirk and Roxburgh. Their secretary, J.L. Adamson of Galashiels, informed his friend W. McKenzie of Cupar about the proceedings, and with J. Lowden of Leven, G. Mayers of Broughty

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1. The managers were intially concerned to douse the unrest amongst consumers caused by Flintoff's campaign. *Vide infra* p.1172

Gas World, 25/3/1893; N.B.A.G.M., 1911. W.T.K. Braunholts, The Institution of Gas Engineers - The First Hundred Years 1863-1963 (1963), pp. 255, 272. c.f. Other professional societies in Scotland also emerged from the late 1850s on a national basis, as successors to the Philosophical Societies based in particular towns. In 1857 the Institution of Engineers in Scotland was promoted by Walter M. Neilson, various railway engineers, and men like Connor from St. Rollox chemical works. J. Thomas, The Springburn Story (1964), op. cit., p. 85.

Ferry, and W. Proctor of Forfar, McKenzie organized the "Association of Gas Managers for the Four Counties of Fife, Kinross, Perth and Forfar" in July 1862.

This idea was extremely popular and Adamson advertized in The Scotsman a proposed national organization which met at Edinburgh in September 1862 as the "Scottish Association of Gas Managers"[1] with twenty two members. In 1866 it merged with the Four Counties association to become the "North British Association of Gas Managers"[2] with fifty four members. The "West of Scotland Association"[3] first met at Dumbarton in 1872, under William Key, and aimed to help small gasworks producing under thirty million cubic feet per year. It too merged with the North British Association in 1883, and this Association became affiliated to The Institute of Gas Engineers[4] in 1908.

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1. J.G.L., 3/6/1862, p. 375; 20/6/1914, p. 907.

2. First officials - Mr. Proctor of Perth as President, Mr. Young of Dalkeith as Vice President, McKenzie of Dunfermline as Secretary and Treasurer, Mr. Fraser banker of Inverkeithing as Auditor. Committee - Messrs. Reid (Leith), Clazy (Kelso), Whimster (Perth), and Hislop (Paisley). J.G.L., 2/10/1866, p. 760.

3. The W.S.A.G.M. envizaged about 30 members, but by 1874 had 120. J.G.L., 21/7/1874, p. 92.

4. This was an amalgam of English associations:-
 1864-82 The British Association of Gas Managers (J.G.L., 15/5/1864, p. 373)
 1882-90 The Gas Institute
 1890-1902 The Incorporated Gas Institute
 1891-1902 The Incorporated Institute of Gas Engineers
 1902-29 The Incorporated Institution of Gas Engineers.
Journal of Gas Lighting Centenary (1948), p. 127.
c.f. Other regional associations of gas managers were formed on the Scottish model - e.g. 1870 Manchester; 1875 Southern District; 1877 North of England; 1877 North of Ireland; 1888 Eastern Counties.
Not until 1877 did gas managers form a Masonic Lodge, the 'Evening Star'. J.G.L., 4/8/1877, p. 372.

Fig. 3.149

The Originators of the North British Association of Gas Managers, 1862.

Mr. J. LOWDEN, Leven.

Mr. WILLIAM MACKENZIE, Cupar.

Mr. G. MYERS, Broughty Ferry.

Mr. PROCTOR, Forfar.

Source : N.B.A.G.M. 1911 p.26

The immediate result was a marked increase in co-operation[1] between Scottish engineers in the 1860s, and informed criticism of their colleagues' mistaken methods. Some managers in the 1850s made gas engineering "not an art only, but a mystery",[2] and operated a strictly "secret works".[3] Levi Monk, who as manager at Lanark became president of the West of Scotland Association[4] in 1876, had refused to subscribe to the early Association of 1861 because he had visited several new gasworks under construction and became conversant with the correct arrangement of apparatus, but decided there were so few technical improvements that he would "strike out south for information, and to many foreign works too". By the 1870s such travel was unnecessary because the "Reports of Associations", Journal of Gas Lighting, and publications like Clegg's 1868 Treatise gave precise, accurate information. In place of "the reserve that existed prior to 1861", inquiries to other managers produced "courteous replies".

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1. Vide infra pp.350, 362
Advantages were so considerable that W. Proctor (Forfar) in 1864 suggested that Gas Companies should pay all the expenses of the British Association of Gas Managers; and by the 1870s Companies were contributing. Cupar, which from 1859 regularly purchased the Journal of Gas Lighting, received a circular from the North British Association and paid a guinea in 1867 and 1868 for their manager to attend meetings in Edinburgh. Boness company in 1873, Stranraer in 1879, and Bathgate in 1884, began paying 10/6d annually for their managers to belong to the North British Association; and Dalry began paying 12/6d annually in 1897. Cupar joined the 'Gas and Water Company Association' in 1871, whilst Dalkeith in 1912 paid three guineas to enable the manager to attend a meeting of gas managers in Aberdeen. Stornoway Company in 1878 paid 10/- a year to belong to the West of Scotland Assn. Muirkirk in 1874 gave £1 gratuity to the West of Scotland A.G.M. for giving a good report on the works. J.G.L., 12/1/1864, p. 9. S.R.O., Minute Books - Dalry 13/7/1897; Muirkirk 23/6/1874; Cupar 11/8/1859, 13/6/1867, 13/8/1868, 9/11/1871; Boness 9/1/1873; Stranraer 30/12/1879; Bathgate 7/6/1884; Dalkeith 10/10/1912; Stornoway 13/3/1878.

2. J.O.N. Rutter, Gas Lighting - Its Progress and Its Prospects (1849), pp. 2-3.

3. T. Whimster, Presidential Address, N.B.A.G.M. 1883.

4. L. Monk - Presidential Address, W.S.A.G.M. 1876 (at the Andersonian University); J.G.L., 24/10/1876, p. 602.

The mystique[1] of gas engineering until the 1860s was possibly of paramount importance in Britain's loss of technological leadership over other European countries, which became apparent in the 1870s. Monk's observations[2] in 1875 detail conditions which would have seemed more applicable to the decades before 1850:

> Rule-of-thumb work, apathy, and indifference have all to give way before ... scientific research; and new ideas have no chance of success [-ful adoption], unless backed up by proof of what is contended for them ... thousands of pounds are saved, and a vast amount of labour ... compared with knowledge of 20 or 25 years ago.
>
> Yet "there is too much dabbling in engineering ... One man dips his gas into a ... cold washer or scrubber as soon as it leaves the hydraulic main; another has neither washer nor scrubber; another puts his washer after his purifiers";[3] another made alterations "in such an imperfect manner" they had to be reconstructed; another "instead of looking ten years ahead, goes fifty" and built on a vast and useless scale. Monk observed "too much playing at gas management. Directors of companies and corporation committees should see that they get a gas manager when they want one, and not [some] one who has to serve his apprenticeship at the expense of consumers and shareholders". "The pay of one half of our gas managers is not sufficient to induce them to undergo thorough training" which was necessary to understand the technology of their gasworks. Consequently "a vast amount of money is being wasted upon the erection of works, the manufacture, distribution, and consumption of coal gas, as well as the utilization of residual products, that might otherwise to a great extent be saved".

Monk advised inexperienced Directors not to interfere directly in day

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1. A compromise between the need for information and the desire for secrecy, produced what Checkland has described as "community experience", but delayed the formation of professional organizations. S.G. Checkland, The Rise of Industrial Society in England 1815-1885 (1969), p.104.

2. An example of the muddle experienced even in a moderately large works is available at Ayr, where the manager J. Hislop in 1864 drew the first up-to-date plans of the location of underground pipes inside the gasworks, as well as street mains, after the "great expense and inconvenience" which the lack of such information had caused when the gasworks were remodelled in 1860-1. S.R.O., Ayr Minute Book, op. cit., 4/7/1864.

3. From the hydraulic main, the correct arrangement was a condenser, washer, and then purifiers.

to day management, and maintained that over-work[1] prevented Managers from reading up on their business and acquiring greater skills.

The gas industry failed to provide the comprehensive technical education[2] for managers which Wilson proposed in 1848, and in view of the increasing importation of European gas technology[3] in the late nineteenth and early twentieth century, the decline of British technical innovation through inadequate education lends some support to Aldcroft's analysis[4] of the 'Great Depression'. Commenting upon the gas industry in 1873, J. Wallace noted "many distinguished engineers who are all ignorant of chemistry, and many famous scientists who are without mechanical education, even of the simplest practical kind". He believed that rigid division of knowledge had prevented individual scientific advances from being integrated into the gas industry and produced "the present chaotic state of the system".[5]

Examinations by the Technical Institute of the City and Guilds of London provided the highest qualification gas engineers[6] could acquire.

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1. Similarly, Pollard views the failure of companies to develop improved methods of accountancy in the early nineteenth century, as partly caused by the heavy burden of routine work imposed upon clerks. S. Pollard, Genesis of Modern Management (1968), p. 268.

2. 'Isca' in 1878 lamented upon the very slow progress made over the previous 20 years in improving gas manufacture, which he blamed on rule-of-thumb methods and impractical theories. 'Isca', "The Education of the Gas Manager", J.G.L., 17/9/1878, p. 415.

3. Vide infra pp. 357, 363, 371, 373

4. The 'Depression' as an expression of Britain's failure to maintain the rate of technical progress, partly as a result of inadequate technical education. D.H. Aldcroft, "The Entrepreneur and the British Economy, 1870-1914", Economic History Review, 1964, Vol. XVII, p. 113.

5. J. Wallace, "The Combustion of Gas to produce Heat", North of England Institute of Mining Engineers 1873-4, Vol. XXIII, pp. 47-64. The Scottish coal-mining industry also suffered from the absence of an adequate integration of technical and practical education, which inhibited mechanization. P.L.Payne Ed. Studies in Scottish Business History (1967) p.255

6. Vide infra p. 642

Even in 1887 when William Foulis of Glasgow urged the Gas Institute[1] to finance lecturers on gas technology, he was opposed to examinations being set by the Institute. No advanced academic research was possible in the industry until the founding in 1910 of the Livesey Professorship in Coal Gas and Fuel Industries at Leeds University, followed in 1913 by a Department of Fuel and Refractory Material at the Imperial College of Science and Technology in London. The North British Association from 1879 collected "research fund" subscriptions from members, but this small sum was only used to finance accurate observations and evaluations of technology already available, like the regenerative retorts at Glasgow.[2]

Recruitment of new gas managers was normally through newspaper advertisements, and also local handbills in the early nineteenth century, but the choice of applicants was left to Directors. In 1844 Dalry company[3] refused to renew the annual contract of the manager, R. Young, and advertised locally for a replacement. From eleven applicants, the short list included Young, A. Stirrat mason, and W. Marshall a servant at Dalry manse. Marshall was appointed by the votes of four directors, whilst two supported Young and three abstained. In 1846 the Vale of Leven[4] received thirty eight applications, of whom sixteen had previous experience and twenty two were "blacksmiths, millwrights and other artizans". Although the latter group[5] had previously

1. W.T.K. Braunholtz, The Institute of Gas Engineers - The First Hundred Years 1863-1963 (1963), pp. 82, 84, 202, 207.

2. 1879 motion promoted by G.R. Hislop of Paisley, N.B.A.G.M. 1911, p. 97. Vide supra p.636

3. S.R.O., Dalry Minute Book, op. cit., 1/4/1844, 5/4/1844.

4. Even in 1839 the consulting engineer employed by Vale of Leven Company refused to recommend a suitable manager. S.R.O., Vale of Leven Minute Book, op. cit., 11/11/1839, 19/11/1839, 23/3/1846.

5. E.g. millwrights, vide S.G. Checkland, Rise of Industrial Society in England (1969), op. cit., p. 77.

supplied many able managers, Leven directors decided none who applied were "so pre-eminent" as to outweigh their inexperience, and appointed a gasworks employee from Catrine.[1] When he resigned in 1850, the company was able to choose from a wide range of skilled applicants for his replacement by J. Blair.

Table 3.150 Applicants for Management of Vale of Leven Gasworks (1850)

Gas Managers -	J. Blair of Renfrew	D. Coll of Port Glasgow
	W. Burns of Hamilton	A. Smith of Wishaw
	W. Young of Maryhill	J. Ferguson of Kilsyth
Gasworks Employees -	D. McKenzie, fireman at Greenock	
	M. Liddell, workman at Partick	
	F. Hay, foreman at Aberdeen	
	W. Colquhoun, clerk at Paisley	
Others -	P. McEwan and M. Gemmell, mechanics	
	M. Frew, mechanics foreman	

Source:- S.R.O., Vale of Leven Minute Book, op. cit., 22/4/1850.

When Stornoway[2] advertised for a new manager in the North British Advertizer during 1851, the Directors' short list included men from Portobello, Oban and Perth, though they chose the manager of Nairn gasworks. Lesmahagow[3] advertised by hand-bills for a 'Gas Keeper' in 1847 and received eleven local applicants who had to state the salary they expected.[4] The amount varied from twenty pounds to twenty five pounds per year, and Robert Gordon was chosen from those at twenty pounds because he was qualified to undertake blacksmith work.

Table/

1. S.R.O., Vale of Leven Minute Book, op. cit., 15/4/1846.
2. S.R.O., Stornoway Minute Book, op. cit., 12/8/1851, 1/9/1851, 3/9/1851.
3. S.R.O., Lesmahagow Minute Book, op. cit., 27/2/1847.
4. c.f. S. Pollard, Genesis of Modern Management (1968), p. 165.

Table 3.151 Applicants' Proposals for Annual Salary to Manage Lesmahagow Gasworks (1847)

From Kirkfieldbank - Wm. McNab £22 and house; James Kilpatrick £20

From Abbeygreen - John Walker £20; Wm. Walker £21; James Young £23; James Pelling (9/- per week); R. Gordon £20

Others - Alex. Gibson £25; T. Burnside £24; J. Sutherland £20; J. McInnon £21

Source:- S.R.O., Lesmahagow Minute Book, op. cit., 26/2/1847.

Cupar[1] obtained fifty three applicants in 1853, from towns as distant as Inverness and Perth, after advertising in newspapers and the Journal of Gas Lighting.

Boness[2] advertised for a new manager in the Journal of Gas Lighting, Falkirk Herald, and North British Advertizer in 1862, and received sixteen applications. This included three from Glasgow, two from Edinburgh, and others from Falkirk, New Pitsligo, Dundee, Ratho, Selkirk, Ferryport, Cumberland, Innerleithen, London and Warrington. The mobility of gas managers produced a national market for salary rates. When the Boness manager resigned in 1869 to become manager at Coatbridge, the Directors actually "approved of his using every fair means of bettering his position".[3] They advertised again, in the Glasgow Herald and Falkirk Herald, and received thirty five Scottish applicants. Directors travelled to Langbank, Edinburgh, and Callander to make personal inquiries about those on the short-list before making their final appointment.[4] Again in 1874 when the Boness manager left for a similar post at Falkirk, they had the choice of thirty six applicants after

1. S.R.O., Cupar Minute Book, op. cit., 3/11/1853; see also 2/7/1847.
2. S.R.O., Boness Minute Book, op. cit., 30/1/1862.
3. Ibid., 11/11/1869.
4. Ibid., 18/11/1869, 30/11/1869.

advertising in the Falkirk Herald, Glasgow Herald and West Lothian Courier.[1]

Most works could expect at least thirty to forty applicants for management by the late nineteenth century. In 1866 Stranraer[2] obtained thirty seven applicants after advertising in the Free Press, Glasgow Herald, Morning Journal and North British Advertizer; and fifty three applicants in 1899 by advertising in the Glasgow Herald and Scotsman. The small Stornoway[3] company received twenty eight in 1885, and appointed A. Ross, a "trained Mechanical engineer" from Maryhill gasworks. In 1886 they received thirty nine applicants including men from Glasgow, Dunblane, Eyemouth and Inverness, before appointing a gas-fitter and engineer from Barrhead. When Banff[4] directors advertised in 1889 in the Glasgow Herald, Scotsman, Aberdeen Free Press, Aberdeen Journal and Banffshire Journal, they were still prepared to accept relatively inexperienced men for management. The short list drawn up included a Macduff blacksmith, an Aberdeen plumber, an Edinburgh meter-tester, and the assistant gas manager at Peterhead who was chosen. Ayr[5] directors were able to choose from eighty eight applicants when the post of manager became vacant there in 1908.

Managerial functions were often assumed by Directors or stokers to

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1. S.R.O., Boness Minute Book, op. cit., 27/7/1874.

2. S.R.O., Stranraer Minute Book, op. cit., 10/4/1866, 30/3/1899.

3. Andrew Ross was the son of R. Ross, manager of the Irish Dungannon gas company. S.R.O., Stornoway Minute Book, op. cit., 10/9/1885, 5/5/1886. Gas World, 26/9/1885.

4. S.R.O., Banff Minute Book, op. cit., 26/9/1889.

5. W. Smith, the retiring Ayr manager (1884-1908) received an annual pension of £50. S.R.O., Ayr Minute Book, op. cit., 28/9/1908, 21/12/1908. c.f. Dalkeith company in 1909 received 86 applicants for management, including men from Nairn, Falkirk and Newmilns. S.R.O., Dalkeith Minute Book, op. cit., 6/3/1909.

facilitate changes in the works management. The Cupar[1] manager employed the gas manager of Ceres company for a short period in 1853 to allow him to accept a better job elsewhere. At Banff[2] in 1887 W. Watson, a local merchant, acted as interim manager when the old manager considered resigning, and in 1892 J.A. Bradenoch, an accountant, acted as manager when the former manager's illness led to the need for a new man. The chief fireman at Stornoway,[3] J. McPhail, was given temporary control in 1871 when the manager absconded. With his son as stoker, McPhail remained manager until 1885 when the Directors forced him to retire because of old age. They awarded him an annual pension of twenty five pounds for odd-jobs at the works, but when the new manager resigned in 1886 he was again appointed temporary manager for a few months.

Bonus schemes or remunerations related to Company prosperity[4] were sometimes used as an incentive for managers. The Dalkeith[5] manager in 1833 requested a salary at five per cent of the annual profits, but later accepted a salary equal to the dividend paid on fifteen shares. He was guaranteed sixty pounds if the dividend fell below four per cent, but after 1837 this system was replaced by a fixed annual salary. At Stranraer[6] a new manager was appointed in 1845 at thirty five pounds

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1. S.R.O., Cupar Minute Book, op. cit., 5/11/1853.

2. S.R.O., Banff Minute Book, op. cit., 23/6/1884, 3/3/1892.

3. S.R.O., Stornoway Minute Book, op. cit., 22/12/1871, 21/6/1872, 30/7/1885, 10/9/1885, 5/5/1886; newspaper obituary (1/5/1903) of J. McPhail in preface of Volume II Minute Book.

4. Boness Company was informed in 1856 by J. Fussell, the English gas manager previously mentioned, that a reasonable wage for Management was fifty pounds plus 7½ per cent of gas revenue, compared to the fixed fifty five pound salary they were paying. S.R.O., Boness Minute Book, op. cit., 29/3/1856; vide supra p. 604
c.f. S. Pollard, Genesis of Modern Management (1968) pp. 178 (staff given % profits), 224 (bonus schemes).

5. S.R.O., Dalkeith Minute Book, op. cit., 18/10/1833.

6. The manager also received free house, gas and coal. S.R.O., Stranraer Minute Book, op. cit., 8/3/1845, 10/4/1846, 13/3/1847, 29/6/1847.

per year, but in 1846 this was altered to twenty five pounds in addition to eight per cent of net profits after deducting company expenditure and seven and a half per cent interest on debts. The salary was guaranteed at forty five pounds if gas price was reduced, and from 1847 it reverted to a fixed salary divorced from the revenue incentive.

The Vale of Leven company in 1854 sold two million cubic feet, and offered the manager a rise of thirty pounds per year for every additional million cubic feet sold.[1] In 1859 the manager[2] there was allowed five per cent of revenue on coke sold, up to two pounds per year. Stranraer manager[3] in 1899 was promised five pounds for each additional million cubic feet above the ten million already sold annually. Boness[4] in 1863 allowed the manager five per cent of all outstanding debts which could be recovered, and five per cent in 1872 on all reduction of leakage.

Mr. Clark,[5] the first Muirkirk manager, in 1859 received twelve shillings per week, without a bonus scheme. His successor, Alex. Brown,[6] in 1861 was paid ten shillings a week for managing the works and laying service-pipes; plus four per cent of the gas and meter rents recovered, and a further three per cent for acting as rent

1. S.R.O., Vale of Leven Minute Book, op. cit., May 1854; c.f. James Scott of Weensland, the new manager at Hawick in 1857, was awarded a salary of £65 per year; plus £10 bonus up to a maximum £110, for every 1000 cu.ft. consumed above 7000 cu.ft. on average per day. Transactions of Hawick Archaeological Society 1969, op. cit., p. 26.

2. S.R.O., Vale of Leven Minute Book, op. cit., 11/7/1859.

3. S.R.O., Stranraer Minute Book, op. cit., 30/3/1899.

4. S.R.O., Boness Minute Book, op. cit., 8/6/1863, 24/6/1872.

5. Native of Dalmellington. Chosen by advertising in the Ayr Observer. All Muirkirk managers received free house, gas and coal in addition to salaries. S.R.O., Muirkirk Minute Book, op. cit., 1/12/1859, 29/12/1859.

6. Ibid., 30/7/1861.

Collector and meter inspector. John Morton,[1] manager at Muirkirk from 1862, was first paid six shillings a week and seven per cent of the revenue, but in 1864 this was altered to twelve per cent of the gas and meter revenue collected, without a supplementary guaranteed payment; he was not made responsible, however, for the bad debts of consumers.

In 1870 Morton received a bonus of two pounds for reducing gas leakage to 9.4 per cent, and his wages were raised to sixteen per cent of the revenue provided that leakage was under one per cent; he was guaranteed a minimum sixty pounds income per year. Morton's wages rose to twenty per cent of the takings in 1872, and in 1888 he still managed the works unaided. That year his guaranteed salary was reduced by nine pounds, and that of the Secretary five pounds, because of "the smaller make of Gas and dull times". Morton resigned from ill health later in 1888, and his successor Thomas Sloan[2] was paid ten shillings a week plus eight per cent of the revenue; this was about fifty six pounds per year, and in the event of falling revenue, the company guaranteed Sloan fifty pounds per year. The work load was heavy, but in 1889 Sloan accepted fourteen shillings a week when the Directors refused to allow him an assistant for the three mid-winter months. In 1891 he received fifteen shillings a week, or thirty nine pounds for the year, in addition to thirty pounds from his percentage of revenue. Not until 1896 did the Directors award an allowance for an assistant, at ten pounds, and this was paid to Sloan who was responsible for hiring and dismissing the man, giving him an incentive to

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1. S.R.O., Muirkirk Minute Book, op. cit., 23/6/1864, 21/6/1870, 17/6/1872, 23/3/1888.

2. A feuar of Muirkirk, who gave title deeds to his house as security instead of the normal £50 caution. Chosen after advertisements in Glasgow Herald, Scotsman, and Cumnock Advertiser. S.R.O., Muirkirk Minute Book, op. cit., 7/4/1888, 30/10/1889, 24/4/1891, 15/1/1896.

use assistance as little as possible, and retain the surplus allowance.

Most companies throughout the century paid a cash bonus, at the option of the Directors, for exceptional engineering work or extensions undertaken by the manager. It was most unusual for such a bonus to be paid in the form of capital stock, although in 1835, Andrew Muir,[1] the manager at Dalry, received one share in the company as recompense for his labour during the original construction of the gasworks.

There are few extant examples of Managers who took annual holidays. Cupar[2] was an exception, since the manager received four days vacation in 1854, ten days in 1856 and 1858, and seven days each year from 1873. At Stornoway[3] the chief stoker, J. McPhail, became temporary manager for three weeks in 1854 when the manager travelled south for three weeks rest cure. Bathgate[4] manager in 1891 was allowed to appoint his son as assistant manager, at no salary, to run the works whenever he was away from home. Similar temporary arrangements were probably used whenever the manager was dispatched to other gasworks to make first-hand observations on new techniques of gas manufacture.

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1. S.R.O., Dalry Minute Book, op. cit., 8/8/1835.

2. S.R.O., Cupar Minute Book, op. cit., 17/7/1854, 11/7/1856, 12/7/1858, 8/7/1873. (One weeks holiday was included in the salary from 1873).

3. S.R.O., Stornoway Minute Book, op. cit., 21/11/1854.

4. S.R.O., Bathgate Minute Book, op. cit., 9/4/1891.

(ii) Directors

Company Directors[1] controlled all important expenditure, and the appointment of managers and clerical officials. The degree to which they intervened in day to day management, instead of relying upon the Manager's judgement, varied considerably between companies. Until the 1860s Directors, at least in most medium and small companies, could easily comprehend the technical operations and took a more substantial role than later. Frequently, sub-committees were formed to examine particular aspects of company operations fairly often during each financial year.

Dunfermline[2] used sub-committees from the start. In December 1828 three Directors were empowered to revise the draft Contract of Co-partnery, and in March 1829 three were responsible for obtaining estimates for equipment. One Director, D. Inglis, acted as interim Treasurer until April 1829 when the company's temporary engineer, Mr. Oliphant, assumed that position; but Oliphant was forbidden to communicate with equipment suppliers except through the Committee of Directors.[3] That September, four Directors as a committee conferred with Oliphant, to examine the book-keeping methods he had introduced and learn them sufficiently to check the books. In December, three Directors were appointed as a committee to audit the manager's accounts monthly.[4] In May 1830 the Directors formed a special "Finance Committee" of three to audit revenue accounts every Quarter, and also a separate "Working Committee". At Selkirk in 1841 the Directors

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1. The business experience and occupations of Directors are examined elsewhere. <u>Vide infra</u> pp. 153, 785, 931

2. Dunfermline Ref. Lib., Dunfermline Minute Book, <u>op. cit.</u>, 4/13/1828, 2/3/1829, 7/8/1829, 24/12/1829, 20/4/1830, 26/5/1830, 14/6/1830.

3. <u>Ibid.</u>, 19/3/1830, 20/4/1829, 14/5/1829.

4. c.f. 7 of the 12 Glasgow co. directors acted as annual auditors in 1825. Glasgow Mitchell Lib.(G.665.7*) 'Report of the Committee' 1/6/1825

appointed two of their number to "visit and inspect the works weekly".[1] At Ayr[2] in 1847 four Directors comprised the 'Committee on Works', and another four the 'Committee on Finance'. During 1849, two members of the Works Committee had to inspect the gasworks personally once a fortnight, though later that year the frequency was reduced to once a month, and by 1886-97 that Committee was only meeting once every two months after August.[3] By 1850, the Finance Committee only met quarterly after August, to examine the Manager's quarterly accounts.[4] Hawick company in 1847 formed a special committee of two Directors[5] to inquire about the 'water-gas' process used in London.

Improved organization of the Dalry board of Directors followed a motion passed by the annual general meeting in June 1834, which stressed the importance of "a personal inspection of some of the neighbouring Gas Works". Three Directors were thereby appointed to visit Stewarton, Barrhead and other works. By December a sub-committee of three Directors was appointed to examine the efficiency of gas apparatus, and by the following March, as a result of communication with "surrounding Gas Light Companies ... and various skilled individuals", they had made the wise choice of "two Brick retorts in preference to cast metal ones".[6] Two Directors travelled to Paisley to arrange the construction of these.

In 1837 two Dalry[7] Directors were appointed as a sub-committee to

1. S.R.O., Selkirk Minute Book, op. cit., 8/11/1841.
2. S.R.O., Ayr Minute Book, op. cit., 28/6/1847.
3. Ibid., 26/3/1849, 2/7/1849, 7/7/1886, 7/7/1897.
4. Ibid., 1/7/1850.
5. Viz. J. Laing manufacturer and J. Goodfellow merchant. Transactions of Hawick Archaeological Society 1969, op. cit., p. 26.
6. Brick retorts to Grafton's design. S.R.O., Dalry Minute Book, op. cit., 26/6/1834, 3/12/1834, 30/3/1835.
7. Ibid., 9/6/1837, 20/7/1841.

examine the books of the Treasurer and Collector, and report to the full Board before the annual general meeting. A sub-committee of three was formed in 1841 to "attend occasionally at the works" and inspect the management. In 1842 the Board met Quarterly, and a sub-committee of two or three was to inspect the gasworks weekly. At Dalry,[1] this close supervision persisted throughout the century. In 1882 a deputation of Directors travelled to Irvine and Ardrossan gasworks to obtain information on repairing the retort bench; a sub-committee in 1886 "visited several Gas Works in the neighbourhood" before purchasing a station-meter; and in 1891 three Directors travelled to Paisley to inquire Hislop's advice on a proposal for the first exhauster at Dalry. From 1892, one Director inspected the manager's records almost daily; a sub-committee of four Directors in 1893 superintended the removal of an old retort bench; and in 1896 a permanent Works Committee of four Directors was inaugurated.

Directors extended their duties[2] to influence civic affairs in favour of the company, and often sat on the Parochial Board for that purpose, as at Cupar in 1853 and Boness[3] in 1851. Efficient Directors at Stornoway[4] dismissed their manager, R. Wilson (1848-51), for

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1. S.R.O., Dalry Minute Book, op. cit., 2/2/1882, 3/3/1882, 20/1/1886, 9/4/1886, 6/7/1891. 28/12/1892, 1/6/1893, 7/7/1896.

2. Directors exercised a moral responsibility for Company actions, but rarely did this cause such a deep division that outside arbitration became necessary. However, in 1889 Lord Wellwood in the Court of Session had to arbitrate between some directors of the St. Andrews company and three other Directors led by John Paterson who had been denied access to the Books following his public complaints over company policy. Vide Gas World, 27/7/1889, p. 100.

3. Boness Treasurer attended the Parochial Board in 1851-9, as did Cupar Chairman in 1853 and Muirkirk Chairman C. Watson in 1866.
S.R.O., Boness Minute Book, op. cit., 9/6/1851, 15/6/1859.
S.R.O., Cupar Minute Book, op. cit., 22/7/1853.
S.R.O., Muirkirk Minute Book, op. cit., 16/7/1866.

4. S.R.O., Stornoway Minute Book, op. cit., 12/8/1851.

inadequate gas production from the coal, inability to collect bad debts, and poor book-keeping. Similarly the Boness[1] manager received a higher wage in 1854 because the Directors were satisfied that, according to the Station Meter, he was "getting the proper Quantity of Gas from the Coals consumed".

Sub-committees in which a few Directors specialized on various aspects of the Manager's duties, were widely used by the 1850s. At the Vale of Leven[2] in 1849 two Directors were "to assist the Manager in making purchases of materials and looking after the works", and all Directors were urged to visit the works "more frequently". By 1856, three Directors and the Treasurer were in control of raw material purchases, and reported to monthly meetings of the full Board. The Treasurer later assisted the manager planning equipment for the works. Cupar[3] Directors in 1850 organized "a Finance Committee to oversee the receipts and expenditure of the Manager", and a "Committee of Works" to report on the state of the equipment to each monthly meeting of the Directorate. This Works Committee was still active in 1881, estimating the desirability of a new steam engine, scrubber and exhauster.

Boness[4] lacked a regular committee, but in 1858 the Directors appointed one of their number, together with the Clerk, to visit Linlithgow gasworks and examine the techniques in use there. The Board itself did not change from Quarterly to monthly meetings at Boness until 1870. At Stornoway[5] also, Directors only met Quarterly in 1871,

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1. S.R.O., Boness Minute Book, op. cit., 13/4/1854.
2. S.R.O., Vale of Leven Minute Book, op. cit., 8/8/1849, 5/9/1856, 13/4/1857.
3. S.R.O., Cupar Minute Book, op. cit., 8/1/1850.
4. S.R.O., Boness Minute Book, op. cit., 14/6/1858, 8/7/1858, 22/12/1870.
5. S.R.O., Stornoway Minute Book, op. cit., 9/6/1871, 13/1/1890.

and the Manager was not expected to prepare a monthly report until 1890 when he complained of being "not sufficiently in touch with the Company's Directorate". Cupar[1] Directors, in contrast, had received monthly reports from the Manager since 1845. Stranraer[2] first organized a Works Committee in 1869, and at Banff[3] the Works Committee in 1868 was exploring the possibility of a scrubber for the works though Banff Directors did not even meet quarterly to assist the manager until 1889. Dalkeith[4] first formed a "Works Committee", both to help the manager and examine accounts, in 1873, and the full Board of Directors met quarterly.

In the small Muirkirk[5] company, the Directors left most aspects of financial management in the hands of the Chairman and Secretary/ Treasurer. In 1879 the Chairman was responsible for placing annual orders for raw materials, and personally authorized an important extension of mains pipes to the post-office. The Directors only began to meet frequantly to discuss accounts after about 1894, but in 1896 formed a Works Committee of three to authorize all outlays above five pounds. From 1905 a Finance Committee of three Directors commenced to supplement the Works Committee.

For their new Manager, Companies frequently chose a man less skilled than his predecessor, who had usually left for a better position elsewhere. The new Manager received a slightly reduced salary,

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1. S.R.O., Cupar Minute Book, op. cit., 10/6/1845.
2. S.R.O., Stranraer Minute Book, op. cit., 7/7/1869.
3. S.R.O., Banff Minute Book, op. cit., 25/6/1868, 28/6/1889.
4. S.R.O., Dalkeith Minute Book, op. cit., 15/12/1873, 5/7/1878.
5. The Secretary from 1872-92 was J. Gibson, a relative of T. Gibson, bank accountant of Muirkirk.
S.R.O., Muirkirk Minute Book, op. cit., 8/2/1879, 20/6/1892, 15/6/1896, 19/6/1905.

and the Directors therefore took a more active role in Management. When Andrew Muir, the Dalry[1] manager, died in 1840 his son Robert became interim manager/collector, but refused to accept a reduction of salary from fifty pounds to forty eight pounds. Consequently, the Directors issued handbills and, after interviewing D. Morton labourer and R. Young dyer, they appointed Young at forty pounds per year as manager. A Director and local manufacturer, J. Stirrat, assisted him as Collector at six guineas a year. In 1881 Dalry company[2] refused to renew the contract of Alex. Brown, who had received seventy pounds per year, and appointed as "General Manager" William Mitchell, an employee of Captain Blair, at sixty pounds per year. Mitchell was expected to read meters and lay pipes, but knew so little about gas manufacture that the company Chairman and some Directors travelled with him "to visit some of the more important works in the neighbourhood ... to pick up information for the better management of the works." During 1886 Messrs. Brodie, gas engineers of Paisley, were awarded a contract for new equipment on condition that they sent a man to teach the Dalry manager how to pierce the streets to test for gas leaks; a very basic technique.

In Stranraer a "Working Committee" of Directors was formed in 1869, when the Company appointed a local resident as manager at seventy/five pounds per year after the resignation of their former manager who earned ninety pounds. Members of the committee were paid[3] and held monthly briefings with the manager, whilst from 1878 one member had to sign a weekly inspection of the Manager's book showing employees' wages. In 1898

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1. S.R.O., Dalry Minute Book, <u>op. cit</u>., 18/5/1840.
2. <u>Ibid</u>., 4/2/1881, 9/2/1881, 7/7/1881, 26/6/1883, 4/5/1886.
3. Each Director received two guineas a year.
S.R.O., Stranraer Minute Book, <u>op. cit</u>., 7/7/1869, 3/7/1878.

the Stranraer Directors[1] made a special inquiry in depth on gas technology before deciding to employ low quality coals to reduce working costs.

In several companies, active Directors supplemented the knowledge and initiative of their Manager. Cupar[2] Directors in 1884 found a more economical mixture of coals from the Manager of Dunfermline works, and not only instructed their Manager to employ it, but also sent him to St. Andrews gasworks to improve his knowledge of technology, and by-product revenue. Selkirk Directors[3] first heard of W. Young's oil gas process from Provost C. Brown, and travelled to Peebles in 1893 to appraise it personally.

When the steam boiler at Cupar[4] was damaged in 1891, an investigation was held by the Works Committee, who were responsible for dismissing one employee, upbraiding the manager's conduct as "lax and unsatisfactory" and imposing penalties. The assistant Manager was given greater powers, and the Manager instructed to inspect and record the boiler reading twice every morning and afternoon, as well as keeping a detailed "daily time Book" on the activities of all employees.

Interaction between different Company officials was apparent at Cupar where a new retort bench was required in 1891. The Directors began by taking advice from outside engineers, Hall of St. Andrews gasworks and McKenzie of Dunfermline, and examined technical leaflets on

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1. S.R.O. Stranraer Minute Book, op. cit., 6/7/1898, 23/8/1898. c.f. Dalry Directors in 1893 sought detailed information from the gas companies at Largs, Kilwinning, Saltcoats and Beith on the number of workmen employed, the gas output per 24 hours, the sources of lime supplies, and the possible advantages of a 'washer'.
S.R.O., Dalry Minute Book, op. cit., 27/11/1893.

2. S.R.O., Cupar Minute Book, op. cit., 30/6/1884.

3. S.R.O., Selkirk Minute Book, op. cit., 26/7/1893.

4. S.R.O., Cupar Minute Book, op. cit., 9/4/1891, 13/4/1891.

regenerative retorts.[1] The Gas Manager, Chairman of Directors, and Works Committee Convener were then appointed[2] as a committee to visit and examine Musselburgh gasworks, and Leven gasworks, where Hislop's regenerative retorts[3] were in use, before obtaining an estimate of installation costs for Cupar. At Dalkeith they also saw a furnace system by Mr. Denis, who visited Cupar and made an estimate of costs which the Directors considered excessive. The initiative then passed to the Cupar manager,[4] who with the Convener discovered a retort system at Pittenweem which was similar to that at Cupar and had been converted cheaply to high-temperature regenerative firing by the manager himself. The Cupar Directors were again reluctant, and the manager spoke of an imminent "complete breakdown" of supply before the Directors finally in 1893 chose a semi-regenerative system designed by MacPherson of Kirkcaldy.[5]

Directors took active steps to ensure that minimal assistance was used at the works. When the Muirkirk manager[6] in 1897 requested eighteen pounds instead of ten pounds to pay his helpers, the Directors obtained statistics on wages of both managers and assistants from gas companies at Mauchline, Auchterarder, Girvan, Holytown, Stevenston and Cumnock. They agreed to provide fifteen pounds only on condition that night work was undertaken at the same heats and weight of coal charges

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1. S.R.O., Cupar Minute Book, op. cit., 11/6/1891, 18/2/1892.

2. Ibid., 10/3/1892.

3. Vide supra p. 368

4. S.R.O., Cupar Minute Book, op. cit., 14/4/1892.

5. MacPherson received £105 commission for converting all 22 retorts to the semi-regenerative system which he had previously installed at Dysart and Leslie gasworks. S.R.O., Cupar Minute Book, op. cit., 13/4/1893, 8/6/1894. Vide supra p.367

6. In 1901 the allowance for a manager's assistant was raised from £15 to £18; and in 1903 to £20. S.R.O., Muirkirk Minute Book, op. cit., 12/11/1897, 26/11/1897, 11/1/1899, 30/6/1899, 2/10/1901, 18/12/1903.

as in daytime; that separate station-meter records were kept for the day and night shifts; coals broken smaller; and a third retort left unused as much as possible to reduce wear and tear. In 1899 the Directors also appointed a Collector, on their own initiative, to allow the manager to spend more time on engineering duties.

At Dalry,[1] the gas manager employed assistants for periods of only two weeks, and in 1876 was rebuked for abuse of power in engaging an assistant for one year. Thereafter, assistants were given four-week contracts, and during the financial stringency of 1879 when the manager's salary was reduced by five pounds to correspond with a national fall in wages, the Directors forbade any workmen being hired, or material purchased, without their special permission. The Dalry manager had two "permanent assistants", on short contracts, up to 1889 when they earned twenty two shillings a week. In 1892 the Directors[2] warned the Manager that the works were over-staffed, and reduced the number to two "permanent" stokers and two winter assistants, on twelve hour shifts. In 1894, despite having reduced wages to twenty one shillings per week, the Directors dismissed temporary helpers early in March, and dismissed one of the stokers in May. Wages to the remaining assistant were raised to twenty four shillings during the summer, and the second stoker was taken back the following winter. Rising demand prevented this experiment being repeated in 1895, and in 1897 a third full time assistant was obtained, though at a differentially lower rate of twenty shillings.

Salaries for Directors were first given to those with special

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1. S.R.O., Dalry Minute Book, op. cit., 3/7/1876, 30/6/1879.
2. Ibid., 28/12/1892, 22/2/1894, 23/4/1894, 28/6/1894, 13/9/1894, 29/10/1897.

tasks, like Auditors and members of the Works Committee, although many companies, like Ayr[1] which still gave no salary in 1867, were most reluctant to make payments. Glasgow Directors in the early 1830s received no fees. Cupar[2] began payments in 1845 with two guineas to each of the two Directors acting as auditors. Stranraer[3] paid two guineas in 1869, and three from 1872, to members of the Works Committee. Elsewhere payment was used as an incentive for more attentive Directors. Stornoway[4] company complained of poor attendance by Directors and in 1852 began to pay each five shillings for meetings attended. A general company meeting at Cupar[5] in 1847 awarded twelve pounds per year to the Board of Directors, to be divided in proportion to their attendance at monthly meetings. Bathgate[6] Directors first received an annual fee, of one pound each, in 1868, while Dalkeith[7] Directors in 1878 received ten shillings and sixpence for each Quarterly meeting attended, and one guinea if they served as auditors. Galashiels[8] company in 1884-97 provided three pounds ten shillings for each meeting of Directors, to be divided amongst those present.

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1. Ayr later paid £47 per year to the Board of Directors in 1876-80, £90 from 1881, and £100 from 1908. S.R.O., Ayr Minute Book, op. cit., 3/7/1867, 5/7/1876, 6/7/1881, 1/7/1896, 1908.

2. S.R.O., Cupar Minute Book, op. cit., 12/8/1845.

3. S.R.O., Stranraer Minute Book, op. cit., 7/7/1869, 1/7/1872.

4. S.R.O., Stornoway Minute Book, op. cit., 8/6/1852.

5. Cupar paid £16 to the Board from 1894. S.R.O., Cupar Minute Book, op. cit., 6/7/1847, 11/7/1895.

6. Bathgate paid £10 per year to the Board from 1896, and £21 from 1901. S.R.O., Bathgate Minute Book, op. cit., 11/6/1868, 4/9/1896, 14/6/1901.

7. S.R.O., Dalkeith Minute Book, op. cit., 5/7/1878.

8. S.R.O., Galashiels Minute Book, op. cit., 3/6/1884, 29/6/1897.

(iii) Clerical Officers

Large gas companies employed skilled clerical officers from their commencement. Glasgow in 1817 obtained the services of Andrew Templeton,[1] banker, as company Treasurer. In the vast majority of companies, however, such officers were local tradesmen, artizans or other residents, who undertook a wide range of duties. The Treasurer was at first regarded, especially by small companies, as a rent Collector. At Innerleithen in 1846 the Treasurer[2] assisted by the Clerk had to collect all debts and accounts due to the company, and discharge all debts. At the Vale of Leven[3] company in 1848, J. Robertson was both Collector and Treasurer. As well as keeping "a Journal" of cash transactions, and balancing it before the annual general meeting, he accompanied the Manager reading meters five times a year, compiled the "notes of charge" to consumers, and collected their gas rents. All sums above five pounds had to be lodged immediately in the Bank, and cash cheques withdrawn from the Bank by the Treasurer were all countersigned by the President of Directors. The company provided books, but the Treasurer, who was a shareholder, paid his own office rents.

Training was provided for Collectors by Gas Managers, though it

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1. A. Templeton (d.1829) was trained by Mr. Duguid, a sugar manufacturer and founding member of Paisley Union Bank, which Templeton managed from 1802-1829, and was a leading partner by 1809. With R. Thomson of Adelphi Cotton Works, Templeton made considerable profit from purchasing the right to collect debts owed to the Merchant Banking Company of Glasgow after its collapse. In 1817 Henry Monteith, merchant, gave unconditional security for any intromissions by Thomson acting as Treasurer to Glasgow gas company. R.S. Rait, The History of the Union Bank of Scotland (1930, Glasgow), pp. 191, 199. Glasgow City Archives (D.G.E. 1).

2. S.R.O. (B.T. 2/3998), Innerleithen Contract of Co-partnery.

3. S.R.O., Vale of Leven Minute Book, op. cit., 19/5/1848.

was not a formal part of their duties. The Vale of Leven manager in 1849 refused to teach McKinlay,[1] a new collector, who was uncertain of the task even though he had acted as Treasurer but not collector in 1847, succeeding his father who began in 1839. McKinlay was forced to travel to Paisley gasworks to learn his duties. Gas Managers remained the repository of all skills.

The Treasurer was considered only a part-time official at the Vale-of-Leven [2] in 1860, and the number of collections had declined from six in 1849, to four in 1850, and to three per year in 1860. At slightly larger companies, like Dumbarton and Helensburgh, the Treasurer did operate full-time by 1860. In many Companies a Director fulfilled the function of Treasurer gratis in the early nineteenth century, like J. Anderson the Boness company chairman,[3] from 1846-52. His predecessors since 1843 were apparently also unpaid.

Distinctions between the tasks of Directors, Treasurers*, Clerks, Collectors, and Managers varied in each company. Galashiels[4] in 1851 appointed a local shoemaker to assist the Manager in winter clerical work only. By 1856 this clerk was employed throughout the year, and also checked meters and collected rents. Three years later, in 1859, the clerk still acted as Collector of gas rents, but it was the Manager who read meters and made out consumers' accounts. By 1860 the clerk was termed the Collector, and suffered a reduction in salary from

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1. J. McKinlay was a former Agent of the Clydesdale Bank. J.M. Reid, The History of the Clydesdale Bank (1938), p. 67. J. Neil, Records and Reminiscences of Bonhill Parish (1912, Dumbarton), p. 114. S.R.O., Vale of Leven Minute Book, op. cit., 24/5/1839, 8/6/1847, 14/6/1847, 22/8/1849, 8/8/1849.

2. Ibid., 22/8/1849, 22/4/1850, 12/11/1860. c.f. Stornoway part-time meter reader in 1872 received 20/- for each survey instead of an annual salary. S.R.O., Stornoway Minute Book, op. cit., 21/6/1872.

3. S.R.O., Boness Minute Book, op. cit., 14/6/1847, 9/3/1846, 14/6/1852, 27/11/1843, 8/12/1843.

4. S.R.O., Galashiels Minute Book, op. cit., 21/10/1851, 7/10/1856, 2/8/1859, 1/5/1860, 26/6/1860.

* Vide infra p. 985

twenty pounds to fifteen pounds per year. Since meters were only read, and money collected, three times a year, this was really a part-time job. Payment was related to the work involved, and he received a rise from fifteen pounds in 1861 to twenty pounds in 1865 because the number of meters had risen from 1209 to 1421 in Galashiels.

The Treasurer was frequently also the Clerk, sometimes termed 'Secretary'. G. Gray became Clerk and Collector at Dalkeith[1] in 1869 at forty five pounds per year, but in 1880 received an additional salary of thirty pounds as Treasurer. That year the salaries were combined, and raised to one hundred pounds. The combined jobs subsequently became too great, and in 1897 Gray received a further ten pounds to enable him to employ a personal assistant as Collector. He was succeeded by his son J.P. Gray as Secretary and Treasurer at £110 per year in 1904. Because of the flexible employment structure, able, determined and reliable clerks were able to secure well paid, responsible jobs in the industry. Many remained in office for a very considerable time, and accumulated experience which assisted new Directors. Hugh King remained secretary of the Kilwinning[2] company from 1836 until after 1888.

The qualifications of men appointed Clerk or Treasurer varied considerably, although the banking and legal professions were well represented.[3] From 1842-57 Annan[4] employed a local solicitor,

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1. S.R.O., Dalkeith Minute Book, op. cit., 22/11/1869, 2/7/1880, 14/7/1897, 5/7/1904.

2. J.G.L., 10/7/1888.

3. None but the largest Scottish companies used all 27 types of "Books Required in the Keeping of a Gas Company's Accounts" detailed in 1883 by T. Newbigging in The Gas Manager's Handbook (1883) 3rd. Edn., p. 327.

4. S.R.O., Annan Minute Book, op. cit., 28/5/1842, 29/5/1857.

A. Downie, as Treasurer and Secretary at the large annual fee of twenty pounds. Banchory[1] company in 1845 employed Messrs. P. amd A. Davidson, advocates of Aberdeen, for secretarial work, and Crieff[2] company in 1843 employed J. Gowans, writer and procurator fiscal, as secretary. The Vale of Leven[3] company in 1849 received applicants for the position of Treasurer and Collector from two grocers, a clerk, two spirit-dealers and a former excise officer, all local men. They appointed a grocer, W. McKinlay, but he was succeeded in 1853 by a solicitor from Dumbarton. Many companies employed solicitors as Treasurers and Secretaries in the late nineteenth century. At Galashiels,[4] where W. Haldane held both offices from 1857-87, he was succeeded by J.Pike, a local solicitor, and then in 1898 by J. Chapman, another solicitor. Chapman's duties included all the secretarial work, the minutes of Directors meetings, and all Company correspondence. He kept the register of share transfers, and gave free legal advice to the Directors. He received and made all Company transactions, kept books on all the financial affairs, supervised the Collector and periodically examined his books, made out the annual profit and loss accounts, and paid out dividends. Above a salary of seventy five pounds, he received a further ten pounds for making out and collecting the gasfitter's accounts for service pipe fittings.

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1. Banchory, as earlier stated, was linked to railway developments, and 1845 Directors included J. Ogg, Bank of Scotland Agent in Banchory, and Provost Blaikie of Aberdeen. S.R.O., Minute Book (Banchory), op. cit., 3/11/1845; Vide infra pp.117, 852

2. Company chaired by local estate owner Captain A. Porteous (1783-1860) son of D. Porteous, distillery owner and gentleman farmer. A. Porteous, The History of Crieff (1912, Edinburgh), p. 186.

3. S.R.O., Vale of Leven Minute Book, op. cit., 22/8/1849, 8/8/1849, 27/7/1853.

4. S.R.O., Galashiels Minute Book, op. cit., 29/12/1887, 3/5/1898.

Perth[1] in 1836 employed George Gray, writer, as Clerk and Treasurer. In comparison the very small company at Dunning[2] appointed J. Martin, a local manufacturer and Director of the company, as Treasurer, and P. Graham, a weaver, as clerk. Dundee[3] in 1856 had David Keith, writer, as clerk, with Christopher Kerr and Company as additional "Law Agents". Stirling[4] company in 1866 under the chairmanship of William Graham, ironmonger and bank agent, employed W. Patton, accountant, as Treasurer, and J. Davidson, writer, as Secretary. The advantages of having a well trained Treasurer also led Selkirk[5] company to amalgamate their separate Treasurer and Secretary in 1879, and appoint a local firm of solicitors. Some qualified men worked for several companies. J.C. MacCal,[6] a chartered accountant, was Treasurer of the Cove and Kilcreggan company and the Partick, Hillhead and Maryhill Company in 1888. At Renfrew, gas and harbour rents were collected in 1868 by W. Herron,[7] agent of the Union Bank.

Municipal employees sometimes placed their skills at the service of gas companies. In 1862 J. Craig, Town and Sheriff Officer at Inverkeithing, Keeper of the Town Hall, and Valuator for the Burgh, also acted as Gas Surveyor.[8] His colleague, John Grant, Treasurer for the Burgh, acted as Secretary and Treasurer to the Gas Company.

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1. Edinburgh Almanac or Universal Scots and Imperial Register (1836), op. cit., p. 62.
2. S.R.O., (GB1/87/1), Dunning Company Contract, Article 19.
3. The Dundee Directory for 1856-7 (1856, Dundee), p. 21.
4. Threepenny Guide and Directory for Stirling (1866), Nat. Lib. Scotland.
5. S.R.O., Selkirk Minute Book, op. cit., 26/3/1879.
6. J.G.L., 17/4/1888.
7. Watson's Directory for Paisley, Renfrew &c (1868, Paisley), p. 62.
8. Westwood's Parochial Directory for the Counties of Fife and Kinross (1862, Edinburgh), p. 115.

Stranraer[1] employed a Director, Mr. Guthrie, as Collector from 1843. In 1853 he also became Secretary and Treasurer to the company, until 1856 when the duties of Collector were given to the gas Manager. But in 1898 Stranraer had another individual, W. Balford, acting both as Treasurer and Collector. Guthrie[2] himself had remained Secretary and Treasurer of the Company until after 1877. At Boness[3] in 1857-64 the company Clerk was also the Collector, with a free supply of gas as part of his salary in 1862.

Selkirk[4] company employed a Secretary to arrange Directors' meetings and to write minutes from 1851, but all extra work was left to the manager until 1870 when the Secretary began to audit the accounts of the Manager and Treasurer, the latter being only a part-time official. A separate meter reader and collector was first appointed in 1875; the local blacksmith G. Turnbull. Two years later a new Clerk was appointed acting as Meter Reader and Collector, and Assistant Manager also. Stornoway manager was first provided with assistance in 1859 when J. Macfarlane acted as Secretary, Collector and Treasurer for both the gas and water Companies, the latter paying a third of his salary, whilst he retained an outside job as Inspector of Poor.[5] In 1878 the Secretary's salary[6] of fifty pounds, and three pounds ten

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1. S.R.O., Stranraer Minute Book, op. cit., 5/10/1843, 25/6/1844, 28/6/1853, 5/6/1856, 23/8/1898.

2. Ibid., 29/6/1868, 4/7/1877.

3. S.R.O., Boness Minute Book, op. cit., 9/6/1857, 3/7/1862, 10/6/1864. c.f. Selkirk clerk/collector in 1892 was allowed free gas and 3 tons of coal also. S.R.O., Selkirk Minute Book, op. cit., 12/7/1892.

4. S.R.O., Selkirk Minute Book, op. cit., 10/6/1851, 9/6/1870, 8/10/1875, 17/6/1875, 14/6/1877.

5. Extant list of assistant's duties. S.R.O., Stornoway Minute Book, op. cit., 2/6/1859, 14/6/1859.

6. Ibid., 12/6/1878.

shillings for fire and light in his Stornoway office, included whatever wages he paid to an assistant to survey meters. When the Company's new Manager[1] began reading meters as part of his duty, the Secretary's salary was reduced to forty pounds, and the fire and coal concession withdrawn in 1889. At Leslie in 1862, J. Swan acted as collector[2] for both the gas and water companies. The Cupar[3] meter reader and collector appointed in 1881, T. Urquhart, had been upgraded to assistant manager by 1884.

Directors delegated some of their duties to clerical officials. Thus the Vale of Leven[4] Treasurer was instructed in 1856 to research "the comparative value of the various qualities of gas coal". Professional auditors sometimes also provided practical directional assistance. C. Cowan,[5] Edinburgh accountant and auditor for Ayr company from 1869-98, received ten guineas in 1892 for obtaining technical details concerning a variety of Scottish gasworks. Another bonus of ten pounds followed in 1893 when he examined the advantages of the Peebles oil gas process.

Clerical salaries varied as much as duties, and sometimes varied according to Company revenue. J. Burnett, clerk and collector at Boness[6] in 1847-51 received five pounds plus five per cent of the money he collected. W. McKinlay banker began as Treasurer and Collector at the Vale of Leven Company[7] in 1849 with a fixed salary of ten pounds,

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1. S.R.O., Stornoway Minute Book, op. cit., 20/11/1889, 23/12/1889.
2. Westwood's Parochial Directory for the Counties of Fife and Kinross (1882, Edinburgh), p. 161.
3. S.R.O., Cupar Minute Book, op. cit., 11/11/1881, 13/11/1884.
4. S.R.O., Vale of Leven Minute Book, op. cit., 26/8/1856.
5. S.R.O., Ayr Minute Book, op. cit., 4/12/1893, 6/7/1892.
6. S.R.O., Boness Minute Book, op. cit., 14/6/1847, 9/6/1851.
7. S.R.O., Vale of Leven Minute Book, op. cit., 22/8/1849, 8/8/1849, 27/12/1850, 10/6/1851.

but the following year it was changed to "four per cent of the gas consumed actually collected". It was reduced to three per cent in 1851, provided that came to between twenty pounds and twenty five pounds.

Small companies like Stornoway regulated clerical salaries by inviting tenders from persons willing to undertake the job.

Table 3.152 Applicants and Their Terms for Remuneration to become Treasurer/Secretary at Stornoway in 1890

A. Barclay, teacher	£40	G. Mackenzie, joiner	£27
R. Morrison, merchant	£27	W. Clarke, merchant	£26 10/-
J. Fraser, merchant	£40	D. McCallum, gas manager	£22 10/-
A. Macinnes, clerk	£30	W. Gillanders, accountant	£19
D. Robertson, accountant	£25	D. Maciver, merchant	£28
C. Mackenzie, solicitor	£30		

Source:- Stornoway Minute Book, op. cit., 9/1/1890.

Elsewhere the "method of comparisons" was used as in other aspects of management. The Vale of Leven[1] company raised their Treasurer's remuneration from twenty five pounds to forty pounds in 1856 after collecting information from gas companies at Dumbarton, Port Glasgow, Johnstone, Helensburgh and Airdrie.

Incentive schemes, and bonus payments for good service, were similar to those applied to gas Managers. At Dalry[2] from 1842 J. Stirrat acted as Collector for a salary of three and a quarter per cent of the collection. H. Hunter as Collector received four per cent of the Dalry revenue in 1871 as did W. Crawford in 1879. The Dalry collector provided a monthly abstract of his returns to the Directors up to 1897, but thereafter presented a weekly abstract together with his nightly

1. S.R.O., Vale of Leven Minute Book, op. cit., 14/6/1851, 23/3/1856, 13/6/1856.

2. S.R.O., Dalry Minute Book, op. cit., 3/6/1842, 12/7/1871, 30/6/1879, 1/2/1897.

record of gas pressure from the Gas-Governor at the works. Boness[1] collector and clerk in 1857 received five pounds bonus, twenty five per cent above his annual salary, and a further two pounds ten shillings in 1877, because of the rapid rise in gas consumption. Dalkeith[2] directors awarded ten pounds bonus to the Treasurer, Manager and Clerk in 1841 when shareholders first received a bonus, and five pounds to both the Clerk and Manager in 1858 when the company was prosperous. The clerk and assistant manager received ten pounds in 1862 to enable them to visit the International Exhibition, and ten pounds went to the Treasurer in 1890 for collecting overdue rents which the Manager failed to recover. Bathgate[3] Treasurer received one pound bonus in 1861 and five pounds in 1868. Galashiels[4] Treasurer was awarded ten pounds in 1884 for his pamphlet advertising the advantages of gas cooking.

1. S.R.O., Boness Minute Book, op. cit., 16/6/1847, 9/6/1851, 9/6/1857, 25/6/1877.

2. S.R.O., Dalkeith Minute Book, op. cit., 18/6/1841, 2/7/1858, 2/7/1862, 17/10/1890.

3. S.R.O., Bathgate Minute Book, op. cit., 5/6/1861, 11/6/1868.

4. S.R.O., Galashiels Minute Book, op. cit., 3/6/1884.

(iv) Labour

Large city gasworks in Scotland in the 1820s relied heavily upon the temporary labour of migrants from Ireland,[1] and the Highlands[2] and islands. Most labourers were laid off during the summer slack season, though as semi-skilled men they could obtain employment at a gasworks the following winter, and a pattern of transhumance developed which lasted past the 1890s. Irishmen from gasworks like Glasgow, and later shale-oil works[3] also, spent the summer season working on farms in Berwickshire and Roxburghshire, before returning to their winter jobs. In the 1900s more than 15,120 gaswork employees in Britain had to find alternative summer employment. During the late nineteenth century they were an important element in many low paid industries[4] which operated largely during the summer season, like brick-making, building, carpentry, coopering, harvesting, saw-milling, clothing manufacture, dock, riverside and coal portering, fishing, market gardening, fruit and hop picking, house and ship painting, carting and quarrying. Gasworks men also acted as navvies, and as firemen on pleasure steamers, whilst many Irishmen returned to work their own farms.

Table/

1. E.g. at Dundee and Aberdeen gasworks. In Edinburgh in the 1820s most of the 45 lamplighters were Irish. J.E. Handley, The Irish in Scotland 1798-1845 (1943, Cork), pp. 117, 129, 124. J.E. Handley, The Irish in Modern Scotland (1947, Cork), p. 177

3. E.g. P. Gallagher (b. 1873), My Story by Paddy the Cope (1939), pp. 57-63.

2. Highlanders were less important because they usually worked on their smallholdings in winter, and only worked in the Lowlands in large numbers during the summer harvest season. Evidence of J.B. Neilson, B.P.P., Report from Commissioners for Inquiry into the Condition of the Poor in Ireland (Appendix G) Report on the State of the Irish Poor in Great Britain 1836 [40] XXXIV, p. 126 [601].

4. F. Popplewell "Seasonal Fluctuations in Employment in the Gas Industry", Journal of the Royal Statistical Society 1910-11, Vol. LXXIV, p. 693.

Table 3.153 Seasonal Variation in Employment Illustrated by Wages Paid to Stokers at Galashiels (1866)

Fortnightly Period	Wages		
February 10 - 24	£15	14	5
April 7 - 21	9	6	0
June 2 - 16	6	4	0
September 22 - 6 October	11	4	0
November 17 - 1 December	18	11	2

Source:- Galashiels Minute Book (S.R.O.), op. cit., 1/5/1866.

The Irish immigrants into towns like Glasgow[1] depressed the wages of labourers in the 1820s and early 1830s. At Glasgow gasworks in 1836, ninety to a hundred labourers were employed[2] "charging furnaces, wheeling coals, digging trenches for pipes, and other coarse work" at fifteen shillings a week, except for a dozen at eleven shillings. About sixty per cent were Irish, and the rest Highlanders, though J.B. Neilson considered the Irish "the best labourers". They did not harass the Highlanders, who were more difficult to manage and had tried to start a "combination" or Union.

Glasgow gas company took a paternalistic attitude towards its employees, quite unlike other Scottish companies. The Glasgow gasworkers Mechanics Institution was inspired by Neilson's idea of "self-help" and by the lectures initiated for working men by G. Birkbeck at the Andersonian Institution.[3] In 1821 the Company provided a room with free

1. B.P.P. 1836 (40) XXXIV, op. cit.

2. Neilson did see the Irish, however, as "a bad moral influence" on Glasgow, through heavy drinking, uncleanliness, and their practice of sending uneducated children early to work. BPP 1836 (40) XXXIV, op. cit., p. 116 [590].

3. The background to the Gasworkers Institution is examined in detail by M. Tylecote, The Mechanics' Institutes of Lancashire and Yorkshire Before 1851 (1957, Manchester), p. 13. Bibliography on Mechanics' Institutes &c. vide W.H. Marwick, "Adult Education in Glasgow Eighty Years Ago", Proceedings of the Royal Philosophical Society of Glasgow 1930-1, Vol. LIX, p. 86.
G.Birkbeck (1776-1841) presided over London Chemical Society(1824) organised on the same basis. W.H.Brock "The London Chemical Society" AMBIX 1967 Vol. XIV p.133

light and heat, to be used as a reference library and evening meeting room, in place of the ale house. Fourteen men agreed to pay a small weekly subscription, and by 1823 thirty members met twice a week to discuss the books. Later that year A. Anderson, a joiner who attended lectures at the Andersonian, began to give illustrated lectures to the workmen. By 1824 Glasgow gasworks employed about sixty men, of whom only twelve were skilled mechanics, yet about forty two had joined the Institution, and the men themselves organized lectures on popular topics. It was the first attempt by any Scottish industry to provide technical education for its employees.[1]

In 1824 the gas Company provided a new room,[2] which included a laboratory, workshop, air pump, and electricity machine. D. Bannatyne,[3] a director of the company urged other "Proprietors of Large Manufactories" to provide similar instruction, which would result in a great increase in "useful inventions and discoveries from minds

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1. It directly inspired a similar Society at the Glasgow University Printing Office in 1824, and the Keighley Institute of 1825. M. Tylecote, The Mechanics' Institutes (1957), op. cit., p. 225. Memoirs and Portraits of a Hundred Glasgow Men (1886, Glasgow), Vol. I, p.248. Glasgow Mechanics Magazine 1825, Vol. III, p. 155, 5/10/1824 letter, "Glasgow Gas Workmen's Institute".

2. Dugald Bannatyne, "An Address to the Proprietors of Large Manufactories". J. Cleland, Statistics of Glasgow and Lanark 1831-2 (1832), p. 297. W.H. Marwick, Economic Developments in Victorian Scotland (1936), p. 169. D. Bannatyne, Mechanics Magazine 1824, Vol. III, p. 260.

3. Dugald Bannatyne (1755-1842), a founding member of Glasgow Chamber of Commerce and Manufactures (1783) and Secretary to the Society 1809-42. Became apprentice stocking weaver to Mr. Johnstone in 1768, who was his partner from 1775; premises in Nottingham (1776). About 1798, in partnership with his brother, formed a cotton-spinning company which purchased Rothesay Mills - Messrs. Anderson, Bannatyne and Co. employed many hardloom weavers in Glasgow area. D. Bannatyne became postmaster of Glasgow. His sons Andrew (1798-1871) and Dugald John, founded the legal firm of A. & D.J. Bannatyne and were leading promoters of the Edinburgh and Glasgow, and Glasgow and Ayrshire Railways. Dugald junior also invested in the Glasgow City and Suburban gas company. A. Bannatyne, Memoir of Dugald Bannatyne (1896, Glasgow). Memoirs and Portraits of One Hundred Glasgow Men (1886, Glasgow), Vol. I, p. 25.
Vide infra p.1124

awakened ... [by] self-discipline". This has recently been seen as a turning point against those who opposed "giving education to the lower orders".[1] J.B. Neilson, in a speech to the workmen, maintained that people and not money constituted "the blood of a state", that the philosophers of Rome and Greece wrote for the ordinary citizens not for men of "bloated and pampered wealth", and that "knowledge is power". Consequently, "as the working classes are the most powerful and important of the community, a kingdom must become powerful and important as their knowledge is increased".[2] An insurance scheme was associated with the Institution. In addition to a weekly contribution of ¾d towards the Library, which took two thirds, and towards the Laboratory and Workshop, members paid a subscription of seven shillings and sixpence, collected in instalments. This was refunded as unemployment benefit to men who left the company's employment, or to the family or heirs of men who died. There is no evidence of similar early schemes to improve the self-respect of labourers in other Scottish gasworks, or of the duration of the Glasgow experiment. In gasworks the labouring work was "very severe".[3] With the original luted lids[4] on retorts, two men

1. M.D. Stephens and G.W. Roderick, "The British Artizan - Scientific and Technical Education in the Early Nineteenth Century" (a thesis based upon evidence from Glasgow Mechanics Magazine). Annals of Science - An International Review of the History of Science and Technology since the Renaissance (1972), Vol. 29. See also - R.K. Webb, "Literacy among the Working Class in Nineteenth Century Scotland", The Scottish Historical Review 1954 (Vol. 33), p. 100. A.R. Thomson, "The Use of Libraries by the Working Class in Scotland in the Early Nineteenth Century", The Scottish Historical Review 1963 (Vol. 42), p. 21.

2. Neilson's address to his workmen at the opening of the enlarged library at the Glasgow Gas Workmen's Institute. Mechanics Magazine 1825, Vol. III, p. 155.

3. S. Hughes, A Treatise on Gas Works and the Practice of Manufacturing and Distributing Coal Gas (1853), pp. 108-12. Hughes was the earliest author to describe in detail the physical labour involved, though conditions in the 1850s were little different to the 1820s apart from the larger size of works and an increase in the number of retorts per oven.

4. Vide infra p.303
Later, self-sealing lids were hinged onto the retort mouth.

Fig. 3.154 Labourers Discharging Horizontal Retorts (1972)

Manual discharging of retorts at Biggar Gasworks in 1972, shortly before the closure of the works, was typical of operations at most nineteenth century Scottish gasworks.

Raking incandescent coke from retort into iron coke-barrow.

Removal of coke-barrow to water-quench outside retort house.

unscrewed the mouthpiece support, and a third man hammered cross-bars off the 'ears' of the retort lid, and broke the lime lute. Escaping residual gas was lighted to prevent accidental explosions inside the retort. Two men then lifted off the cross-bar and screw, to place them on the retort house floor, before doing the same with the lid which they held in their hands by its 'ears'. Three stokers then pushed in twelve foot long iron rakes, or simple rods with the end flattened and bent at right-angles, to pull red-hot coke out of the retort mouth where it fell into either a coke cellar or iron barrows. A fourth labourer threw cold water over the coke as it emerged, to quench it and reduce the heat. In a large works this team was supplemented by another labourer to place fresh lutes on the retort-lids,[1] and a sixth man to wheel in coal for recharging.

Three stokers then charged the retort with coal. In Scotland this was normally done by throwing in coal by shovel, but English works often used a scoop, placed on the floor for filling and then lifted by all three men using iron hooks, into the retort where it was inverted and withdrawn. The luted lid and cross-bar were then replaced and screwed tight. In small works two stokers were required for every two ovens of five retorts, one holding the lid ready for replacing as soon as the other completed filling the charge. Large works required a far smaller workforce in proportion to the number of retorts. A team of three stokers and three labourers could discharge a bench of seven retorts in thirteen minutes, and recharge it in a further seven minutes, a total idle period of twenty minutes for each bench. One London works with thirty men on each of two daily shifts, operated 400 retorts or more

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1. A mortar of fire-clay and spent lime, applied with a trowel. The fourth labourer in smaller works wheeled off the coke while the others began recharging the retorts.

than thirteen retorts per man in 1853. High temperatures within the retort house made the labouring work arduous, and especially so in buildings made of minimal size to reduce capital expenditure. Greenock corporation was obliged to spend £130 in 1850 to raise the retort house roof in order "to give more air to the men employed therein".[1]

In 1840, Greenock[2] had an output of sixteen million cubic feet per year, and employed twenty men at thirteen shillings per week, "of whom 12 work six days in the week, and 8 seven alternately, ten hours a day". For comparison, Dundee[3] in 1885 had an output of 389 million cubic feet, and over 300 employees, including specialist blacksmiths, tinsmiths, painters, glaziers, slaters, gas-fitters, and men constructing wet gas-meters and street lamps. The firemen and stokers worked a three-shift system of eight hours a day.

Total employment statistics for the Scottish gas industry are not available before the Census returns of 1861 which show a total of 966 employees. Statistics on gasfitters, who were self-employed, are either absent in 1861, or liable to inaccuracy because such men usually designated themselves "plumbers". Nevertheless, Lanarkshire with 130 gas-fitters, Edinburgh county with forty six, Renfrewshire with thirteen, and Forfarshire with fifteen, appear with the most.

Table/

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1. J.G.L., 10/9/1852, p. 422.
2. New Statistical Account, Vol. VII, p. 442.
3. Gas World, 18/7/1885, p. 76.

Table 3.155 1861 Gasworks Services Employees (Managers, Stokers, Labourers &c.)

County	Employees	County	Employees
Shetland	0	Stirling	22
Orkney	2	Dumbarton	20
Caithness	3	Argyll	9
Sutherland	1	Bute	6
Ross and Cromarty	6	Renfrew	84
Inverness	6	Ayr	71
Nairn	1	Lanark	130
Elgin	7	Linlithgow	15
Banff	7	Edinburgh	222
Aberdeen	56	Haddington	12
Kincardine	10	Berwick	8
Forfar	115	Peebles	2
Perth	45	Selkirk	7
Fife	54	Roxburgh	8
Kinross	2	Dumfries	13
Clackmannan	7	Kirkcudbright	9
		Wigtown	6

Source:- H.M.S.O., Census Returns 1861.

Although the Census data may not be definitive,[1] a concentration of employment in the industry within the counties of Edinburgh, Lanark, Forfar, Renfrew, Aberdeen, Fife and Perth, is outstanding. Stirling and Dumbarton shires were also well represented, in a distribution which reinforces the appearance of concentration in the Midland Belt of Scotland, as previously noted.[2]

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1. Even allowing for gasworks operated by the manager alone, the number of employees is far too low in counties like Inverness and Kinross. Only two females were working in the industry in 1861, in Ross/Cromarty and Forfar. Only Saltcoats gas company is known to have had a Manageress, the widow of W. Shearer, first manager there in 1836, and she remained only 3 years. J.G.L., 7/8/1888.

2. Vide supra p. 182

Table 3.156 Number of Stokers Assisting Gas Managers

Company	Date	Number	Notes	Company	Date	Number
Dalkeith	1838	One	-	Stornoway	1854	One
Annan	1838	One	-	Cupar	1859	Three
Stranraer	1840	One	A	Cupar	1862	Five
Cupar	1844	Three	-	V. of Leven	1861	Three
Cupar	1845	Two	B	Banff	1865	Four
Boness	1846	One	C	Dalkeith	1868	Three
Ayr	1847	Two	D	Cupar	1871	Four
Stranraer	1849	One	E	Stornoway	1886	Two
Stranraer	1850	One	F	Stranraer	1888	Two
Stranraer	1852	Two	G	Cupar	1892	Seven
Cupar	1852	Five	-	Banff	1913	Three
Cupar	1853	Six	H			

Notes - A winter work only; B one employed all year; C only on Saturday and Sunday nights in winter; D also as lamp-lighters; E winter work and odd jobs; F employed all year; G one employed only two months in winter; H nine retorts in use.

Sources:- S.R.O., Gas Company Minute Books - Annan 10/8/1838; Dalkeith 19/4/1838, 30/6/1838; Cupar 31/4/1844, 10/6/1845, 3/11/1853, 3/11/1859, 9/1/1862, 9/11/1871, 18/2/1892; Boness 8/1/1846; Stranraer 28/11/1840, 25/6/1850, 24/11/1852, 29/6/1888; Stornoway 16/5/1854, 25/11/1886; Vale of Leven 7/1/1861; Ayr 30/8/1847; Banff 5/7/1865, 8/1/1913.

Table 3.157 Gasworks Employees in Scottish Towns (1861)

Town	Gasworks Services		Gasfitters	
	Total Employed	Aged under 20	Total Employed	Aged under 20
Aberdeen	41	1	220	94
Arbroath	11	2	2	0
Coatbridge	3	0	-	-
Dunfermline	5	0	-	-
Edinburgh	173	6	41	14
Glasgow	332	18	119	61
Greenock	31	3	9	7
Hamilton	6	1	2	0
Kilmarnock	15	0	4	2
Kirkcaldy	8	0	-	-
Paisley	19	1	4	0
Stirling	5	0	3	0
Airdrie	4	1	3	2
Ayr	9	0	-	-
Barony	6	0	2	0

Table 3.157 (contd.)

Town	Gasworks Services		Gasfitters	
	Total Employed	Aged under 20	Total Employed	Aged under 20
Dumfries	6	0	1	0
Dundee	6	0	7	2
Forfar	6	1	1	0
Govan	19	1	2	1
Inverness	5	1	-	-
Leith	17	2	5	4
Montrose	7	0	2	0
Perth	14	0	8	1
Total Numbers in Sample	811	39	220	94

Source:- H.M.S.O., Census Returns (1861)

Table 3.158 Gas Industry Employees in Scotland (1871)

Gas Works Service - total 1895 males

Age group (years)	5-10	10-15	15-20	20-25	25-35	35-45	45-55
Number employed	0	8	76	165	490	456	400
Age group (years)	55-65	65-75	75+				
Number employed	213	79	8				

Gasfitting - total 304 males, 2 females

Age group (years)	5-10	10-15	15-20	20-25	25-35	35-45	45-55
Number employed	0	51	63	37	66	47	24
Age group (years)	55-65	65-75	75+				
Number employed	13	3	0				

Gas Meter Manufacturing employees - total 152 males, 2 females

Age group (years)	5-10	10-15	15-20	20-25	25-35	35-45	45-55
Number employed	0	8	19	21	36	28	28
Age group (years)	55-65	65-75	75+				
Number employed	12	0	0				

Source:- H.M.S.O., Census Returns (1871)

By 1871 the Census recorded 1323 males employed in the Scottish gas industry in 'Town Districts', 559 in 'Mainland Rural Districts', and 13 in 'Insular Districts'. A comparison between the employment in Scotland and that of other regions of Britain is possible for 1886, when Scotland had more gasworks employees than the West Riding or the

Northern Counties of England, but only twenty five per cent as much as the total in the London region. Again the statistics cannot be considered definitive.

Table 3.159 Gas Industry Labour Force in Sample Regions on 1/10/1886

District	Men	Boys	Total Wages in 1885 (£)	Average Wage per Person (£)
Scotland	2486	19	154,910	61.84
London	9734	277	853,286	85.23
Northern Counties	1766	39	131,278	72.73
Midlands	3691	86	261,385	69.20
S. Lancs./ N. Cheshire	4139	83	274,261	64.96
West Riding	1919	78	133,378	66.79
Ireland	624	36	47,470	71.92
Total	27,965	705	2,080,080	72.55

Note - Statistics on 28,670 persons at 315 gasworks.

Source:- B.P.P. Wages Paid by Local Authorities and Private Companies (1892), [Industrial Relations, Vol. 20, 1970, Irish University Press], p. 889.

Youths employed as assistant stokers[1] received very low wages. One at Stornoway[2] working from October 1884 to March 1885 received only six shillings per week.

Incentive schemes and gratuities were provided for the workmen in some companies as well as for the manager. Piece-rate working was unusual, however, though stokers at Forfar[3] in 1879 received twopence halfpenny per 1000 cubic feet gas produced. Exceptional service often earned a bonus. The labourer at Dalkeith[4] received a bonus of two

1. Hobsbawm underestimated the role of youths in the industry. Vide E.J. Hobsbawm, Labouring Men - Studies in the History of Labour (1965), p. 162.
2. S.R.O., Stornoway Minute Book, op. cit., 30/7/1884.
3. J.G.L., 25/2/1879.
4. S.R.O., Dalkeith Minute Book, op. cit., 19/4/1838, 30/6/1868.

guineas in 1838 for extra work during severe winter storms, and all three workmen received a bonus of one pound in 1868. Cupar[1] provided flannel working-shirts gratis each year from 1862 to 1894. Pensions and sickness benefits were sometimes given on a similar basis to those for managers. When J. Dey retired at Banff[2] in 1884 he received ten shillings per week pension in return for odd jobs at the works. T. Ritchie had long served as fireman at Cupar[3] before his illness in 1856 and was granted full wages for the first week of absence, and half-wages for a further month.

Free gas and coal were sometimes provided. Cupar[4] in 1890 refused the stokers' request for a rise of one shilling per week, but for men with over six months' service they agreed to provide two tons of coal annually to permanent staff, and one ton to winter staff. An earlier concession of free coke was withdrawn. The system was sometimes maligned. At Ayr[5] the new gas manager in 1909 recognized that free coal and up to 10,000 cubic feet gas per year were legitimate perks for employees resident at the works. But only two employees were resident, and the Directors were "much surprised to learn" that the Company clerk, collector, charwoman, and former manager, all received free gas elsewhere in the town; that practice was abolished.

Penalties for poor work were sometimes imposed directly by the

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1. S.R.O., Cupar Minute Book, op. cit., 11/12/1861, 12/12/1872, 10/12/1874, 11/1/1894.

2. C.f. Banff collector was earning 10/- a week in 1914, when he retired at age 70 and received 5/- per week pension. S.R.O., Banff Minute Book, op. cit., 28/6/1884, 23/8/1913.

3. S.R.O., Cupar Minute Book, op. cit., 14/5/1857, 11/6/1856.

4. Coal concession withdrawn in 1894. S.R.O., Cupar Minute Book, op. cit., 11/12/1890, 11/1/1894.

5. S.R.O., Ayr Minute Book, op. cit., 20/9/1909.

Directors. Boness[1] Directors in 1860 resolved to deduct one day's wages from all employees if the gas was found to be impure. Holidays were most unusual, although both Stranraer and Galashiels allowed their men time to visit the Glasgow Exhibition[2] in 1888.

Even in fairly small works, wage rates varied according to the skill of the firemen. Details are fragmentary but at Cupar,[3] J. Pratt, a new fireman added to the team of five in 1853, received only ten shillings and sixpence per week. Another fireman, A. Allan, received a rise to twelve shillings in 1854, whilst the chief stoker, W. Duncan, received a raise from fourteen shillings to fifteen shillings in 1855 but left later that year to become gasworks Manager at Tayport. His wage cannot be compared directly with that of the other firemen because the figures are missing, but the new fireman who replaced Duncan in 1855 received only twelve shillings a week.

Hamilton gas manager W. Ewing[4] estimated in 1899 that the skill of stokers could make the difference between 6000 cubic feet and 9000 cubic feet output per retort, an amount equivalent to fifty per cent of labour costs. He advised managers to retain close supervision, and even check the station meter index hourly. Mistakes committed by stokers which reduced output, included the use of damp coal, uneven charges with a depth of three inches of coal at the rear of the retort and twelve inches by the mouthpiece which involved less work, and the charging of retorts immediately after discharging instead of closing

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1. S.R.O., Boness Minute Book, op. cit., 5/1/1860.

2. Stranraer men also given 30/- bonus. S.R.O., Stranraer Minute Book, op. cit., 29/6/1888. S.R.O., Galashiels Minute Book, op. cit., 26/6/1888.

3. S.R.O., Cupar Minute Book, op. cit., 3/11/1853, 9/2/1854, 9/3/1855, 14/12/1855.

4. Gas World, 8/4/1899.

the mouthpiece door to restore even heating to areas of conspicuously dull heat. Stokers were also liable to forget to refill the producer furnace, or remove clinker from it, and to leave the producer doors partly open despite noticing the inadequate heat on the retorts.

Consecutive statistics on the wages of Scottish gasworks labourers are only available for Glasgow where there was no change from 1817 to 1840, followed by a rise of twenty per cent, and another of eight per cent in 1854. The rate then increased rapidly with a seventy three per cent increase from 1855-73, as shown in Table 3.160. The level was considerably below that of a comparable London company, shown in Table

Table 3.160 Glasgow Gasworks Labourers' Wages (1817-87)

Date	Wage per Day s.	Wage per Day d.	Rate per Hour d.	Hours per Day
1817 to Nov.1840	1	8	2.0	10
Nov.1840 to Jan.1854	2	0	2.4	10
Jan.1854 to Sept.1855	2	2	2.6	10
Sept.1855 to Nov.1865	2	4	2.8	10
Nov.1865 to May 1866	2	6	3.0	10
May 1866 to Nov.1871	2	8	3.2	10
Nov.1871 to June 1872	2	10	3.4	10
June 1872 to Feb.1873	3	4	4.0	10
Feb.1873 to Nov.1887	3	9	5.0	9

Note - Anonymous works described as "one of the largest in Scotland"; probably Glasgow, the only alternative being Edinburgh which also commenced in 1817.

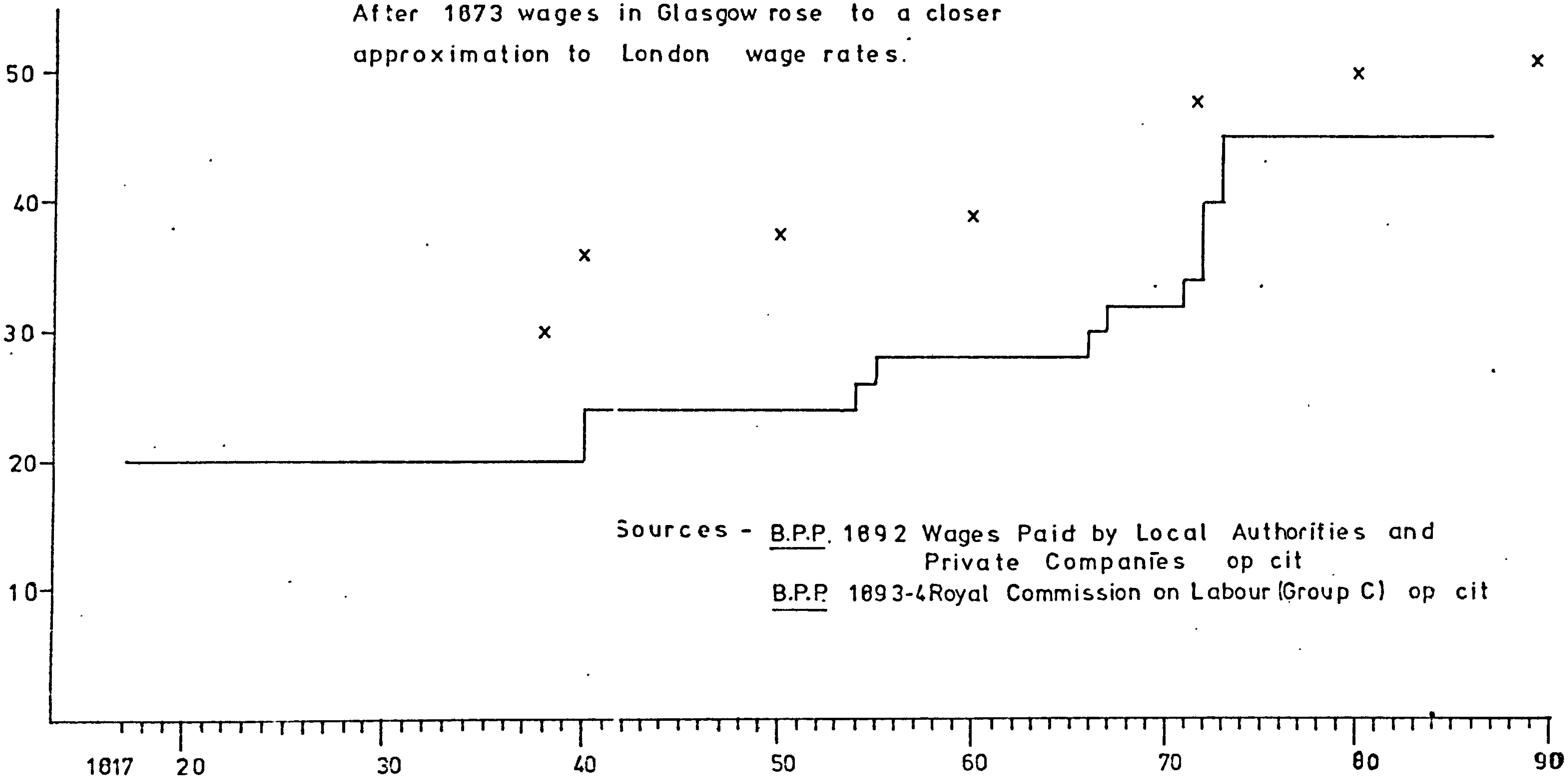
Source:- B.P.P. 1892,"Return of the Rates of Wages paid by Local Authorities and Private Companies to Police, and to Work-people employed on Roads, and at Gas and Water Works." [1970, Irish University Press, Dublin, Industrial Relations, Vol. 20], p. 890 [30].

Table/

Fig.3.161 Daily Wages of Gasworks Yard Labourers at Glasgow

Note - ——— Glasgow gasworks
x S. Metropolitan gasworks London

After 1873 wages in Glasgow rose to a closer approximation to London wage rates.



Sources - B.P.P. 1892 Wages Paid by Local Authorities and Private Companies op cit
B.P.P. 1893-4 Royal Commission on Labour (Group C) op cit

Table 3.162 Yard Labourers' Wages at S. Metropolitan Gasworks, London

Date	Wages per Day s.	d.	Date	Wages per Day s.	d.
1838	2	6	1872	4	0
1840	3	0	1880	4	2
1850	3	1.5	1889	4	3
1860	3	3	1890	4	7.5

Note - 10 hour day to 1889 ; 9.5 hours in 1890.

Source:- B.P.P. 1893-4 [c. 6894 - IX] Vol. XXXIV. Minutes of Evidence before Group C of the Royal Commission on Labour [1970, Irish University Press, Industrial Relations, Vol. 33]. Vide infra p.1862

The 'differential' between Stokers' wages and those of labourers, increased considerably at Glasgow between 1863 when the difference was eightpence per day, and 1867 when it was two shillings and twopence (Table 3.163). At Kilmarnock gasworks the 'differential' rose from seven shillings in 1861-8 to ten shillings and sixpence per week in 1874.

Table 3.163 Day Wages of Stokers and Labourers at Glasgow Gasworks 1857-68

Date	Stokers s.	d.	Labourers s.	d.	Differential s.	d.
1857-63	3	0	2	4	0	8
1863-4	3	4	2	4	1	0
1864-5	3	9	2	4	1	5
1865-6	4	0	2	6	1	6
1866-7	4	6	2	10	1	8
1867-8	5	0	2	10	2	2

Note - Probably Glasgow Old Company, though from 1866 labourers' rates are slightly different to those shown in Table 3.160

Source:- Glasgow City Archives, Miscellaneous Papers, Vol. 15, p. 465.

Table/

Table 3.164 Weekly Wage Rates at Kilmarnock Gasworks 1861-74

Date	Firemen s.	Firemen d.	Labourers s.	Labourers d.	Differential s.	Differential d.
1861-9	21	0	14	0	7	0
1870	22	6	14	0	8	6
1871	23	6	15	0	8	6
1872	25	6	17	0	8	6
1873	28	0	18	0	10	0

Source:- J.G.L., 20/10/1874.

At Leith gasworks also, wages rose rapidly during the economic boom of 1872-4, and maintained that level (Table3.165) until 1878 before falling gradually up to 1889. Edinburgh gasworks reduced wages in 1878, and did not raise them again until the labour agitation of 1890.

Table 3.165 Wage Rates at Edinburgh and Leith Gasworks 1870-99

Date	EDINBURGH Per Week (Shillings/Pence) Retort men	Barrow men	Yard men	LEITH Per Hour (Old Pence) Retort men	Barrow men	Yard men
1870	23/6 & 22/-	18/-	16/-	4.14	3.14	3
1871	23/6 & 22/-	18/-	16/-	4.25	3.25	3.2
1872	23/6 & 22/-	18/-	16/-	5 & 6	4 & 5.3	3.6
	Per Hour (Old Pence)					
1873	7.5 & 6	6	5.5	6	5.3	3.6
1874	7.5 & 7	6	5.5	7	6	4.4 & 4
1875	7.5 & 7	6	5.5	7	6	4.4 & 4
1876	7.5 & 7	6	5.5	7	6	4.4 & 4
1877	7.5 & 7	6	5.5	7	6	4.4 & 4
1878	7 & 6.5	5.5	5	7	6	4.4 & 4
1879	7 & 6.5	5.5	5	7 & 6.5 & 6	6.5 & 5.5 & 5	4.4 & 4
1880	7 & 6.5	5.5	5	7 & 6.5 & 6	6.5 & 5.5 & 5	4.4 & 4
1881	7 & 6.5	5.5	5	7 & 6.5 & 6	6.5 & 5.5 & 5	4.4 & 4
1882	6.5	5.5	5	6.5	6.5 & 5	4
1883	6.5	5.5	5	6.5	6.5 & 5	4
1884	6.5	5.5	5	6.5	6.5 & 5	4
1885	6.5	5.5	5	6.5	6.5 & 5	4
1886	6.5	5.5	5	6.5	6.5 & 5	4
1887	6.5	5.5	5	6	5.5 & 5	4
1888	6.5	5.5	5	6	5.5 & 5	4
1889	6.5	5.5	5	6.5	6 & 5.5	5
1890	6.5 & 7.5	6	5	7.5	7 & 6	5
1891	7 & 7.5	6	5	7.5	7 & 6	5

Table 3.165 (contd.)

Date	Per Hour (Old Pence)			Per Hour (Old Pence)		
	Retort men	Barrow men	Yard men	Retort men	Barrow men	Yard men
1892	7 & 7.5	6	5	7.5	7 & 6	5
1893	7 & 7.5	6	5	7.5	7 & 6	5
1894	7 & 7.5	6	5	7.5	7 & 6	5
1895	7 & 7.5	6	5	7.5	7 & 6	5
1896	7 & 7.5	6	5	7.5	7 & 6	5
1897	7 & 7.5	6	5	7.5	7 & 6	5
1898	7 & 7.5	6	5.18	7.5	7 & 6	5.18
1899	7 & 7.5	6	5.18	7.5	7 & 6	5.18

Source:- S.R.O. (G.B.1/29/25) Edinburgh and Leith Gas Commissioners Minutes, 1891, 1899.

Elsewhere, data is quite fragmentary. At Galashiels[1] 'firemen' received an important wage rise in 1847, and by 1864 the principal stoker received eighteen shillings a week, four other stokers seventeen shillings and the remainder sixteen shillings a week. The first two groups obtained a rise of one shilling per week in 1864, and the annual wage bill at Galashiels rose from £226 that year, to £253 in 1865 and £294 in 1866 when an hourly rate of fourpence was instituted. Recorded wage charges appear in Table 3.166, and existing wage rates in Table 3.167.

Table 3.166 Recorded Wage Increments

Date	Company	Increase in Weekly Wage s.	d.	Date	Company	Increase in Weekly Wage s.	d.
1855	Cupar	1	0	1872	Banff	1	0
1856	Banff	1	0	1873	Cupar	1	0
1857	Stornoway	1	0	1899	Banff	1	0
1859	Cupar	1	0	1911	Banff	1	6
1864	Cupar	1	0	1913	Banff	1	6

Note - These are specific increases, and not a confusion between rates to various staff.

Sources:- S.R.O., Cupar Minute Book, op. cit., 9/3/1855, 3/11/1859.
S.R.O., Stornoway Minute Book, op. cit., 10/11/1857.
S.R.O., Banff Minute Book, op. cit., 1/7/1872, 7/7/1899, 5/7/1911, 8/1/1913.

1. S.R.O., Galashiels Minute Book, op. cit., 6/7/1847 (no details), 6/12/1864, 1/5/1866.

Table 3.167 Recorded Wage Rates of Stokers/Labourers in Various Companies

Date	Company	Weekly Wage s.	d.	Notes
1838	Annan	12	0	-
1840	Stranraer	10	0	Winter work only
1845	Boness	15	0	Possibly Acting Manager
1845	Cupar	14	0	-
1846	Boness	18	0	Later termed Manager instead of Fireman
1847	Ayr	12	0	Yard Labourers/Lamplighters combined
1849	Cupar	14	0	-
1849	Stranraer	(£18 year)		Winter Labourer/Part-time pipe-layer
1849	Stranraer	(£25 year)		Full time assistant
1853	Cupar	10	6	Unskilled fireman
1854	Cupar	12	0	-
1854	Stornoway	(£15 year)		-
1855	Cupar	15	0	Chief Stoker
1856	Stornoway	14	0	(9/4d by Gas Co., 4/8d by Water Co.)
1857	Stornoway	15	0	(10/- by Gas Co., 5/- by Water Co.)
1860	Vale of Leven	13	0	-
1861	Vale of Leven	14	0	-
1863	Cupar	15	0	-
1871	Cupar	18/- & 16/-		-
1873	Cupar	19	0	-
1874	Dalry	21	0	Two year-round assistants
1875	Dalry	22	0	Do.
1879	Dalry	20	0	Do.
1880	Dalry	20/- & 22/-		Do.
1886	Stornoway	(17 (12	6 0	Night Shift Day Shift - Trainee to Manager
1889	Dalry	22	0	Two year-round assistants
1894	Dalry	(21 (24	0 0	Winter rate Summer rate to one year-round assistant.

Sources:- S.R.O., Gas Company Minute Books - Annan 10/8/1838; Stranraer 28/11/1840; Boness 5/9/1845, 8/6/1846; Cupar 12/8/1845, 28/6/1849, 3/11/1853, 9/2/1854, 9/3/1855, 8/9/1864, 9/11/1871, 21/7/1873; Stornoway 16/5/1854, 28/10/1856, 10/11/1857, 25/11/1886; Vale of Leven 7/1/1861; Ayr 30/8/1847.

Table 3.167 Recorded Wage Rates (contd.)

Date	Company	Weekly Wage s.	d.	Notes
1896	Dalry	21	0	Winter rate
1897	Dalry	24	0	Winter rate for Chief Fireman
		20	0	Rate for Assistant
1898	Dalry	26	0	Winter rate for two Firemen
		24	0	Summer rate for Chief Fireman
1911	Banff	23	6	
1913	Banff	25	0	

Sources:- S.R.O., Dalry Minute Book, op. cit., 18/6/1875, 7/10/1879, 3/3/1880, 25/11/1889, 28/12/1892, 28/6/1894, 24/12/1896, 25/5/1898.
S.R.O., Banff Minute Book, op. cit., 5/7/1911, 8/1/1913.

Wage rates conformed to national, or certainly broad regional levels, as a direct result of vigilant Directors applying the "method of comparisons". In June 1875 the Dalry Directors[1] refused a petition forwarded by manager A. Brown on behalf of his two assistants who requested an increase of three shillings a week in winter and one shilling in summer. The Directors claimed that those men did very little work for four summer months, worked only one Sunday every three weeks, and "Mechanics' wages are on the decrease at the present time". When the men persisted, in September, the Directors enquired "what wages are paid to similar workmen engaged in neighbouring Gas Works". On the basis of information from Johnstone, Beith, Irvine, Kilwinning, Ardrossan, Saltcoats and Old Cumnock, the men were awarded a rise of one shilling per week. In March 1879, however, the two assistants had their wages reduced from twenty two shillings to twenty shillings a week because of "the greatly reduced rate of wages for all classes of labour".

1. The assistants at Dalry had their contracts renewed every two weeks until at least 1879. S.R.O., Dalry Minute Book, op. cit., 18/6/1875, 24/9/1875, 3/7/1876, 25/3/1879, 7/10/1879, 30/3/1880.

The men complained in October, but in March 1880 only one received an increase to twenty two shillings per week.

In confirmation of this national wage market, Boness[1] for example, agreed to raise stokers' wages in 1872 because of the general "demand for labour" in the country. In 1878, however, because of dull trade and a regional surplus of labour, Edinburgh gaslight company[2] reduced employees wages by a halfpenny an hour. The overall pattern demonstrated particularly rapid wage increases in the mid 1850s, mid 1860s, 1871-3, 1889-90, and the early 1910s. Rapid increases may have occurred in the other booms[3] of 1837-9 and 1846-8, but the evidence is uncertain. At Greenock, total wages[4] did rise rapidly in those years, but wages fell in comparison to total gas output;[5] the wage bill may simply have reflected an increase in the total number of employees as output rose. Glasgow gas labourers, as previously stated, received no increase until 1840, and then only twopence per day and an extra fourpence in the mid 1850s. Stokers' wages may not have followed the same pattern, as these men were more skilled and probably had greater potential for seeking a similar grade of employment in other sectors of the economy.

The cost of living[6] in west central Scotland rose about twenty one per cent in 1819-70, with the largest increases after 1850, though differential price movements prevent firm estimates. Slaven claims

1. S.R.O., Boness Minute Book, op. cit., 4/1/1872.
2. J.G.L., 24/9/1878.
3. Vide infra p.739
4. Vide supra p.480; also p.1593
5. Vide infra p. 1726
6. A. Slaven, The Development of the West of Scotland : 1750-1960 (1975), pp. 175-6.

that income and real wages[1] did not rise appreciably until after the 1847 railway construction programme, were deflated by commercial crisis in 1856-7, and only gained long term advance in the 1860s or even 1870. Certainly, wages in the gas industry rose more rapidly during the 1860s than formerly, with a final sprint in the early 1870s, but the rise of one shilling per week granted by several companies in the mid 1850s appears sufficiently substantial to have offset inflation and provided a higher real-wage in that period. Unlike, for example, blast-furnace keepers' wages[2] the higher rates once gained were apparently normally maintained for some time after rates fell in other trades; the first record of widespread reductions were those after 1878.

The boom of 1871-3 presaged a long recession in which the differential wages of skilled employees was eroded. At Leith gasworks the retort-men earned one penny per hour more than barrow-men in 1870-8, and barrow-men by 1874 obtained 1.8d more than yard men. By 1887, retort men's wages there had fallen one penny per hour compared to 1878,

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1. Similarly, Habakkuk stated that a "demonstrable rise in the real wage of industrial workers did not occur until the 1850s and 60s"; previously, since 1815, labour from rural areas where wages were very low had exceeded the demands of industry and depressed wage rates. In this context, the growing complexity of gas technology which raised the skill and hence wage differential of stokers, was an important though incalculable factor in raising their real wages compared to unskilled labour. H.J. Habakkuk, American and British Technology in the Nineteenth Century - The Search for Labour Saving Inventions (1962, Cambridge) pp. 139-40. Habakkuk's view re-stated by E.J. Hobsbawm in Labouring Men - Studies in the History of Labour (1965) p. 121.

2. Corrins has shown that in west central Scotland the earnings of Furnace Keepers fell from the mid 1840s to mid 1860s, then rose to the boom of the early 1870s, fell again to the level of a decade earlier and remained low until the mid 1880s before rising gradually until 1910. Colliery hewers at Gartsherrie rose rapidly in the early 1870s, but fell rapidly thereafter, did not regain the 1860s level until 1880, and then declined (apart from 1890, 1893) until the late 1890s.
R.D. Corrins, "Wm. Baird and Company "(1974, Unpublished Ph.D. Thesis, University of Strathclyde) pp. 358, 360.

and were only 0.5d more than barrow-men, whilst the second scale of barrow men were only one penny above yard labourers. On a fifty six hours week, a reduction[1] of four shillings and eightpence which brought stokers down to their 1873 mid-boom level of twenty eight shillings per week, rather less than contemporary wages of skilled carpenters and masons with whom they had reached parity (Table 3.168) between 1874 and 1882; only in 1890 did stokers restore their differential above those artizans. Despite the low commodity prices[2] of the 1870s which raised general living standards, the 16.7 per cent wage reduction between 1874 and 1887 produced an overall reduction in real-wages growth after calculating the difference from G.D.H. Cole's Index. A marked fall in growth of living standards was probably the main stimulus for labour agitation in the period up to 1889-90.

Table 3.168 Living Standard of Leith Stokers 1873-1890

(1) Comparison with Carpenters' and Masons' Weekly Wages

Date	Leith Stokers		Edinburgh Carpenters		Glasgow Masons		and Carpenters	
	s.	d.	s.	d.	s.	d.	s.	d.
1873	28	0	29	9	31	10	32	0
1874	32	5½	31	10	34	0	34	0
1882	30	2¾	27	8	29	9	29	9
1887	28	0	29	9	29	9	32	0
1889	30	2¾	29	9	30	10	34	0
1890	35	0	31	10	31	10	34	0

Note - Leith Stokers' wages calculated for 56 hour week.

Source:- A.L. Bowley, Wages in the United Kingdom in the Nineteenth Century (1900, Cambridge); vide infra p. 734

1. According to Bowley, coal miners in S. Scotland had a continual reduction of weekly wages from 9/11d in 1872 to 3/2d by 1878. A.L. Bowley, Wages in the United Kingdom in the Nineteenth Century (1900, Cambridge)

2. It has been claimed that cheap grain imports, and other goods, provided higher living standards in the 'Great Depression' of 1873-96, but a declining rate of increasing exports reduced profits and dividends in many industries. P. Mathias, The First Industrial Nation (1969) pp. 343, 398, 405, 453. S.G. Checkland, The Rise of Industrial Society in England 1815-1885 (1969), p. 60.

Table 3.168 (contd.)

(2) Comparison with Cole's National Index

Date	COLE'S INDEX using 1850 statistics as 100%		LEITH STOKERS WAGES		
	Money Wage (x)	Real Wage (y)	Money (Old Pence per week)	Real Wage Index	Increase of Real Wage Index from 1870
1870	133	118	232	205.8	0
1873	155	128	336	277.5	71.7
1874	156	133	392	334.2	128.4
1882	147	135	364	334.3	128.5
1887	149	155	336	349.5	143.7
1888	151	157	336	349.4	143.6
1889	156	159	364	371.0	165.2
1890	163	166	420	427.7	221.9

Notes : * Real Wage Index for Leith Stokers calculated thus -

$$\frac{\text{Wages(old pence)}}{(x)} \times (y)$$

Rapid rise of Leith stokers' real wages in 1870-4, stagnation until 1882, slow growth until 1888, and rapid improvement in 1889-90.

Sources : Vide supra p. 697
G.D.H. Cole *A Short History of the British Working Class Movement 1789-1947* (1947) p.272

As Scottish gasworks grew larger, they employed an increasing number of specialists and direct comparison of wage rates is therefore not possible. The diversity is presented in Tables 3.169 - 173.

Table 3.169 Wage Rates of Various Employees in Scottish Gasworks (1866)

	EDINBURGH region		GLASGOW region	
	Wages per week	Hours per week	Wages per week	Hours per day
Gas Maker (Foreman)	32s 6d	84	24s	12
Stokers	26s to 27s3d	84	24s	12
Retort Men	26s to 27s3d	84	24s	12
Coke Men	20s	84	-	-
Engineers	40s	57	36s	10
Joiners	23s to 29s	57	26s	10
Bricklayers	29s	57	30s	10
Smiths	26s to 28s	57	24s	10
Pipe Layers	21s to 23s	57	17s	10
Gas Fitters	21s to 28s	57	24s	10
Labourers	15s to 17s	-	15s	10

Sources : B.P.P. 1887 [c.5172] LXXXIX Wage Rates 1830-86 (*Industrial Relations* Vol.20, 1970 Irish University Press p. 349 [361])

Table 3.170 Gas Industry Wage Rates in Edinburgh Region (1880 and 1883)

	1880 (per week)		1883 (per week)		Hours per Week
Gas Maker and Leading Stokers	37s	6d	32s	8d	56
Ordinary Stokers	31	0	30	4	56
Retort Labourers (Helpers)	25	8	25	8	56
Coal Porters	20	0	23	4	56
Coke Fillers	20	0	23	4	56
Engine Drivers	28	6	34	6	56
Carpenters & Joiners	29	0	29	9	51
Bricklayers/Retort Setters	32	6	34	0	51
Smiths	29	0	38	0	51
Gasfitter (in Works)	28	0	-		-
Outside Fitters and Service Pipe Layers	25	0	25	6	51
Mains Pipe Layers	-		29	0	51
Meter Makers	25	6	27	6	51
Plumbers	28	6	-		-
Labourers	20	0	21	3	-

Source:- B.P.P. 1887 [Industrial Relations 1970 Irish University Press Vol. 20], op. cit., p. 349 [361].

Table 3.171 Gas Industry Wage Rates in Glasgow Region (1880 and 1883)

	1880				1883			
	Day Wages		Day Hours	% Total Workforce	Day Wages		Day Hours	% Total Workforce
Gas Maker and Leading Stokers	5s	2d	12	1.9	5s	6d	12	1
Ordinary Stoker	5	0	12	19.5	5	0	12	24
Retort Labourers (Helpers)	3	6	12)		3	4	12	44
Coal Porters	3	6	12)	20.8	3	6	12	3
Coke Fillers	3	6	12)		3	6	12	1
Engine Drivers	4	2	12	1.5	5	0*	12	1
Carpenters/Joiners	4/6 to 5/3		9	1.2	5	10*	10	1
Bricklayers/Retort Setters	5	8	9	1.3	7	6*	10	2
Smiths	5	0	9	1.4	5	10*	10	1
Gasfitter (in Works)	4	6	9	1.3	5	10*	10	0.5
Outside Fitters and Service Pipe Layers	4	6	10	5.8	4	0	10	5
Mains Pipe Layers	5	0	10	0.4	5	0	10	0.5
Meter Makers	4	8	9	7.6	+		-	6
Plumbers	4	8	9	0.3	-		-	-
Labourers	3	2	9	37.0	3	4	10	10

Note - * Paid hourly wages, instead of daily as formerly.
+ Meter makers paid 7d per hour for 51 hour week.

Source:- B.P.P. 1887 [Industrial Relations 1970 Irish University Press Vol. 20], op. cit., p. 349 [361].

Table 3.172 Gasworks Employment Structure in Large Scottish Towns (Population 40,000 or above) in 1886

Total employed in October 1886 - 2,266 persons.
Total wages paid in 1885 - £141,161.

Category	Number Employed	% Total Number	Average Weekly Wage	Number within 10% of Weekly Wage	Average Weekly Wage Maximum s.	d.	Average Weekly Wage Minimum s.	d.
Gangers	57	2.5	41s 10d	56	-		-	
Stokers and Firemen above 35/-	198	8.7	35 0	198	-		-	
" 30/- to 35/-	122	5.4	30 7	122	-		-	
" 25/- to 30/-	88	3.9	27 7	88	-		-	
Retort Labourers (Helpers)	189	8.3	24 5	189	26	10	23	4
Coke Wheelers and Fillers	72	3.2	21 6	62	24	0	18	0
Engine Drivers/Boiler Men	34	1.5	29 4	31	31	6	22	8
Meter Makers and Repairers	134	5.9	27 1	130	30	10	24	0
Bricklayers/Retort Setters	55	2.4	34 2	50	35	0	27	7
Carpenters/Joiners	25	1.1	30 2	23	32	3	24	0
Smiths	28	1.2	29 10	26	30	7	26	7
Hammermen	22	1.0	20 7	18	23	4	19	0
Engine Fitters	32	1.4	31 2	30	31	8	26	7
Outside Fitters and Service Pipe Men	113	5.0	28 5	97	30	0	23	10
Other Mechanics	17	0.8	28 4	4	31	6	22	11
Mains Pipe Layers	77	3.4	23 10	75	25	0	21	0
Lamplighters over 15/- week	38	1.7	21 7	13	24	2	19	0
" under 15/- "	67	3.0	11 11	67	-		-	
General Labourers	818	36.1	20 1	774	23	9	16	6
Others above 25/- week	42	1.9	28 10	36	29	10	25	0
" under 25/- "	26	1.1	21 8	16	24	0	20	0
Boys above 10/- week	10	0.4	13 5	3	16	0	10	0
" under 10/- "	2	0.1	6 3	-	-		-	

Note - Most Gangers worked 70 hours a week; a few 56 hours. Stokers and Firemen - 42% worked 56 hours; 58% worked 70 to 84 hours. Retort Labourers - 50% worked 56 hours; 50% worked 70 hours. Engine Drivers - 50% worked 56 or 80 hours; 50% worked 70 hours. Boys - 51 to 56 hours work per week. The table gives rates for 7 days a week for Gangers, Stokers, Retort Labourers and Engine Drivers; and 6 days per week for Coke Fillers (though some worked 7 days). Lamplighters hours varied. Those paid under 15/- only lit and extinguished lamps.

Source:- B.P.P. 1892, Rates of Wages Paid by Local Authorities and Private Companies, [Industrial Relations 1970 Irish University Press Vol. 20], p. 91 [1001]

Table 3.173 Gasworks Employment Structure in Small Scottish Towns (Population under 40,000) in 1886

Total Employed in October 1886 - 239 persons.
Total wages paid in 1885 - £13,749.

Category	Number Employed	% Total Number	Average Weekly Wage		Number within 10% of Average	AVERAGE WEEKLY WAGE Maximum s.	d.	Minimum s.	d.
Gangers	5	2.1	31s	4d	4	-		-	
Stokers and Firemen above 30/-	12	5.0	31	3	12	32	6	30	0
" 25/- to 30/-	62	25.9	27	6	62	-		-	
" 20/- to 25/-	34	14.2	23	8	31	-		-	
Retort Labourers (Helpers)	7	2.9	18	5	6	22	0	17	2
Coal Wheelers and Coke Fillers	10	4.2	18	10	10	-		-	
Smiths	5	2.1	25	2	3	28	0	22	6
Outside Fitters and Service Pipe Men	12	5.0	23	10	8	27	0	21	0
Other Mechanics	10	4.2	27	9	7	32	2	23	6
Mains Pipes Layers	6	2.5	24	4	5	-		-	
Lamplighters and Cleaners	11	4.6	14	8	4	22	0	9	6
General Labourers	49	20.5	19	3	47	-		-	
Others	9	3.8	23	9	4	25	6	19	8
Boys	7	2.9	12	2	6	13	0	10	0

Note - Gangers worked about 70 hours a week. Stokers and Firemen - 22% worked 56 hours; 78% worked 70 to 84 hours; sometimes allowed an occasional Sunday off without loss of pay. Lamplighters and Cleaners - 7 day week, variable hours; those paid 9/6 only lit and extinguished lamps. Others working 6 day week - worked 56 to 60 hours; some worked 51 hours. Gangers, Gas Stokers and Firemen worked 7 day week. Retort Labourers, Coal Wheelers, &c. worked 6 day week.
Difficulties in collecting information probably produce greater error by default in the table of Small Towns than Large Towns.
In Britain as a whole, in October 1886, gasworks in large towns employed 24,163 men, and in small towns 4,507, who received £2,080,000 in wages during 1885.

Source:- B.P.P. 1892, Rates of Wages Paid by Local Authorities and Private Companies, [Industrial Relations 1970 Irish University Press Vol. 20], p. 91 [1001]

Most Scottish managers preferred to sub-contract[1] as much work as possible, rather than employing gas-fitters and masons on the staff. This reduced working costs, but resulted in much poor workmanship by fitters,[2] described as "a most ignorant set of men" in 1846.[3] Poor fittings only harmed the consumers;[4] mason work was executed to high standards, and on large contracts gas companies employed an independent craftsman to observe the construction. Dunfermline company[5] in 1829 awarded a masonry contract of £682 to R. Bowman, who offered the lowest of four tenders; but the company also paid ten shillings and sixpence per week to T. Balfour, a local mason, to make observations upon the work three times a day, and to attend constantly when the foundations were laid and clay puddle placed in the gasholder tank. The Vale of Leven[6] directors in 1839 felt unable to make personal assessments of new masonry work, and employed George Barr, a local mason, to oversee the construction.

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1. Initial engineering work, as previously stated, was sub-contracted to outside engineering firms. In 1834 the list of such companies supplied to Dalry gas company by their consultant engineer, Mr. Cook, included Messrs. Fulton and Neilson of Lancefield Forge, Robert Donald of Johnstone, Messrs. Reid and Hanna of Paisley, Messrs. Barr and McNab of Abercorn Foundry in Paisley, Andrew Liddel of Glasgow, and Mr. Paton of Kilmarnock. S.R.O., Dalry Minute Book, <u>op. cit.</u>, 10/7/1834.

2. Gasfitters organized an Exhibition at the London Polytechnic in 1851, a year after the 'Gas Fitters' Mutual Association' commenced. Lectures were arranged in London, but the Association collapsed about 1856 and did not noticeably improve standards of workmanship. Most Scottish gas-fitters were originally trained as plumbers, and undertook both trades. <u>J.G.L.</u>, 11/11/1850, 10/3/1851, 10/2/1851, 10/4/1851, 10/2/1854, 10/10/1854, 10/8/1855, 10/7/1855, 13/5/1856, 10/6/1856.

3. <u>The Builder</u> 1846, Vol. IV, p. 113.

4. <u>Vide infra</u> p.1254

5. Dunfermline Ref. Lib., Dunfermline Minute Book, <u>op. cit.</u>, 30/3/1829, 10/3/1830, 11/3/1829, 12/3/1829.

6. S.R.O., Vale of Leven Minute Book, <u>op. cit.</u>, 27/8/1839.

Most ironwork requirements were contracted out, by taking tenders, and small items were frequently provided by local foundries.[1] Pipe-laying too was frequently contracted out, apart from gradual extensions made by the gas manager and his staff. When Messrs. Campbell and Christie laid mains for the Vale of Leven company[2] in 1839, D. Machlachlan, a Dumbarton plumber, was employed independently by the gas company to supervise their work. Dalry[3] gas company in 1835 employed J. Boyle to install service-pipes, under contract at one shilling and sixpence each. When Lesmahagow[4] company relaid gas mains to the 'new town' in 1871, these were joined and laid under contract by a local blacksmith, A. Walker, and the eighteen inches deep trenches opened and filled by men from J. Sommerville, road surveyor.

In 1880 Dalry employed extra labourers from a contractor, Mr. Wotherspoon, to lay pipes to Kyle and Aitken's new mill; and in 1888 contracted A. Faulds, a drainer of Kilwinning, to cut and refill the pipe track for a new four inches diameter main pipe to Drakemyre at fourpence per yard.

Gas-fitting improved late in the century, but in 1860 Lesmahagow company entrusted the repair even of defective meters to a local tinsmith. Cupar[5] company had only one full-time gas fitter in 1890,

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1. E.g. Boness company in 1853 ordered two new purifiers from Steel's Foundry Company in Boness; and in 1868 purchased two new purifier-covers at £11 from J. Wardlaw, after receiving 4 tenders for the work. S.R.O., Boness Minute Book, op. cit., 22/7/1863, 25/2/1868.

2. The Vale of Leven Directors in 1849 obtained a plan of gas-mains laid by their manager and by "the man who has been employed in all the pipe layings of the Co.", presumably Machlachlan working as a contractor. S.R.O., Vale of Leven Minute Book, op. cit., 27/8/1839, 19/2/1849.

3. S.R.O., Dalry Minute Book, op. cit., 25/10/1835, 1/10/1880, 4/2/1888, 15/2/1888.

4. S.R.O., Lesmahagow Minute Book, op. cit., 25/5/1871, 14/12/1860.

5. S.R.O., Cupar Minute Book, op. cit., 25/10/1890, 14/12/1893, 12/3/1903.

paid twenty four shillings a week in 1890-3, twenty five shillings in 1902 and twenty eight shillings in 1903. Galashiels[1] company first employed one in 1901, at thirty two shillings per week raised to thirty four shillings in 1903, the same wages as other 'plumbers' in the town despite extra skills: R. Hislop, who held that position in 1903, had previously been manager of Lauder gasworks. Dalkeith[2] company also had a gas-fitter on the staff by 1912, paid thirty shillings a week that year, and thirty two shillings in 1913.

Until the 1880s Ayr[3] gas company contracted out all building work to specialist masons, usually Messrs. McLachlan and Son, but in 1888 the Directors considered placing masons on their own payroll. The gas manager successfully opposed this, since one skilled labourer repairing retorts would require an assistant but would still be much slower than two contractors, and there was insufficient work for two full-time masons. The manager further claimed that it would be far more difficult to get a good job done unless he could threaten to bring in alternative workmen.

Smaller companies[4] periodically employed masons without special knowledge of the gas industry, because their charges were lower. Dalry[5] in 1882 accepted a local brickbuilder, J. Stewart, to construct

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1. S.R.O., Galashiels Minute Book, op. cit., 25/6/1901, 3/6/1902, 5/5/1903.

2. S.R.O., Dalkeith Minute Book, op. cit., 4/7/1913.

3. S.R.O., Ayr Minute Book, op. cit., 12/1/1889, 17/12/1888.

4. E.g. Boness in 1850 employed W. Donaldson, mason, to install retorts. In 1867 Boness employed W. Donaldson again, to replace two ovens for £7 10/-, but also received tenders from R. Drysdale at £7 15/- and B. Scott of Linlithgow at £8. These were general masons, as were Brock and Syme of Linlithgow, employed in 1870 to rebuild Boness retort bench on improved principles for £35, in competition with R. Drysdale who tendered at £37 10/-. S.R.O., Boness Minute Book, op. cit., 27/6/1850, 10/6/1867, 15/7/1870.

5. S.R.O., Dalry Minute Book, op. cit., 27/4/1882.

the retort-bench for fourteen pounds ten shillings because C.M. Hamilton of Hamilton, a contracting gasworks' mason, quoted twenty pounds. The gas manager had to supervise construction details, and even companies of large size with "an old experienced bricklayer" in the late nineteenth century retained traditional methods of retort-bench construction until the stimulus of labour problems produced greater concern for efficiency.[1]

Independent contractors also provided a means whereby company Directors could test the quality of output, and ensure[2] that the Manager maintained a high-candlepower[3] and pure gas. Cupar[4] directors in 1877 employed Mr. Reid of Madras Academy to test gas quality; for two guineas a year. Galashiels gasworks installed a photometer by J. Milne and Son in 1861, but this was operated only by the gas manager until 1876 when W. Arnot, Galashiels Burgh Analyst and member of the 'Chemical Laboratory and Engineering Services' of Edinburgh, received two guineas a year to test the gas. In 1882 Dr. Falconer King of Edinburgh made the tests, and by 1888 undertook three annual analyses for five guineas.

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1. Evidence of A. Wilson, Glasgow gas manager. The Institute of Gas Engineers Transactions 1911, p. 60.

2. Sometimes, other permanent employees made this check. Dalry employed W. Crawford, Collector, "to attend some of the neighbouring works" in 1875 to learn photometry and maintain a check on the gas manager. S.R.O., Dalry Minute Book, op. cit., 28/11/1875, 6/7/1877. Vide supra p.673 (duties)

3. 'Standard candles' of wax were legislated by Parliament in 1850; superseded by spermaceti-oil candles of 6 to 1 lb burning 120 grains per hour in 1860; and later by the Harcourt one-candle pentane lamp following recommendations by a Photometric Committee in 1891-4. V.B. Lewes, "The Use of Gas for Domestic Lighting", Gas World, 28/11/1896. Vide infra pp. 994, 1118

4. S.R.O., Cupar Minute Book, op. cit., 13/12/1877.

By 1894, however, the Galashiels gas manager resumed this responsibility, and in the following year the company refused King's offer to make three annual tests for six guineas plus travelling expenses.[1]

Dr. F. King was probably the leading Scottish gas analyst, and was employed by Hawick[2] company in 1884. In 1888, whilst Edinburgh City Analyst, King was employed by Dalkeith company to silence complaints voiced there by the Burgh commissioners. He reported the gas to be 21.9 candlepower, and claimed it should have been 25 to 28. He persuaded the company to purchase a new twenty one pound photometer, from Messrs. Milne, and when the candlepower was raised to 27 the gas company[3] began to publicise the tests in Dalkeith Advertiser to avert public dissatisfaction. This was the main task of external analysts, many of whom were gas managers. Thus, after council complaints over gas quality, Stranraer[4] company in 1886 employed the Coatbridge gas manager to verify its purity, and similar complaints led Carnoustie company that year to employ the Arbroath[5] gas manager who showed the gas to be pure and of 28 candlepower.

Like small Birmingham workshops[6] where masters and men maintained cordial relations, labour relations in most Scottish gasworks were strict but unembittered. Gas managers, though the aristocracy of

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1. Tests were, however, still conducted regularly; a new £36 Milne photometer was purchased in 1897, and Galashiels did not reduce candlepower from 28 to 25 until 1904 when this was part of a national trend. S.R.O., Galashiels Minute Book, op. cit., 3/9/1861, 4/6/1878, 2/7/1878, 28/6/1882, 1/10/1895, 1/6/1897, 7/6/1904.

2. J.G.L., 9/12/1884.

3. A fall of candlepower to 16 in January 1890 was ascribed to "the men not working very regularly after the New Year", for which the Manager was rebuked. S.R.O., Dalkeith Minute Book, op. cit., 2/10/1888, 10/11/1888, 21/1/1889, 4/1/1890.

4. J.G.L., 6/12/1886.

5. J.G.L., 12/1/1886.

6. P. Mathias, The First Industrial Nation (1969), op. cit., p. 270.

labour, usually had an arduous baptism and were well aware of their subordinates' problems. "There can be few situations more onerous and poorly paid than the manager of a small gasworks" complained one in 1875, because for sixteen hours of every day he was "stoker, collector, manager and secretary",[1] at the beck and call of every consumer yet treated with hostility as if he were the tax collector. The majority of Scottish gasworks employed only a handful of staff[2] which inhibited the formation of unions. Even in the principal cities, no effective gasworkers unions were formed until the late 1880s.

A twelve-hour day and two-shift working, seven days a week, was normal in the medium and large gasworks of the 1860s. These long hours became the principal cause of labour agitation in 1859-90. Sunday working had earlier produced public indignation in several Scottish towns, but not firm action. When Stranraer[3] directors proposed a reduction in Sunday labour in 1848 the manager objected that it was a necessity. Boness[4] manager in 1858 was instructed to reduce such labour "as much as possible". By the 1860s, however, the labour force in the Scottish gas industry had expanded to a size which encompassed sufficient malcontents for the issue of working hours to become significant for Companies. The sub-division of labour, and

1. I.G.L., 5/1/1875, p. 14.

2. Small-scale industrial works apparently fulfilled the search for identity, or self-actualization and job-enrichment which dissident industrial psychologists, like J. Maslow, have recently placed at the top of the hierarchy of human needs, in contradiction to Marxist emphasis upon the supremacy of job security. Gas industry employees, through the flexibility of the system, could rise to become managers of large works, or remain in positions which satisfied their psychological needs. R. Ardrey, The Social Contract - A Personal Inquiry Into the Evolutionary Sources of Order and Disorder (1970), pp. 156-63, 171-2.

3. S.R.O., Stranraer Minute Book, op. cit., 16/3/1848.

4. S.R.O., Boness Minute Book, op. cit., 21/1/1858.

specialization of tasks into more rigid routines may have contributed to the discontent.

F. Popplewell distinguished three groups of workers[1] in 1906. 34.3 per cent of employees were retort-house men, 34.3 per cent were yard-men, and 20.7 per cent distribution men, with the remainder having mixed jobs. The retort-house men suffered the greatest fluctuation in numbers, with 186.6 per cent more employed in December than in June. Yard-men, especially craftsmen, found most of the summer jobs overhauling the works, and distribution employees[2] had the most regular employment.

Table/

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1. Retort-House men:- coal and coke porters and wheelers, firemen, stokers, retort-cleaners, pipe-cleaners, retort-labourers, and coal trimmers.
Yard-Men:- purifier and bye-products men, engine drivers and boiler attendants, stove repairers, coke fillers, general labourers; tradesmen like platers, riveters, smiths, bricklayers, retort-setters, carpenters, and joiners.
Distribution sector:- gas fitters, service-pipe and mains pipe layers, their labourers, meter inspectors and repairers, carters, lamplighters, and general labourers.
F. Popplewell, Journal of the Royal Statistical Society 1910-11, op. cit.

2. The labour involved in Lamp-Lighting varied. In 1884 an Edinburgh 'Leary' served 200 lamps per night (J.G.L. 17/6/1884) whilst in Arbroath 50 to 60 of the 304 lamps were lit by each lamplighter within an hour after sunset (J.G.L. 16/9/1884); Perth with 408 lamps employed three lamplighters at 21/4d each per week. For many it was a part-time job. Dalry company in 1883 employed a lamplighter at 7/- per week, but by 1892 two of the Town 'Scavangers' received 2/6d each for the lighting of lamps. S.R.O., Dalry Minute Book, op. cit., 12/9/1883, 15/2/1892. Vide infra pp. 1785 et seq

Table 3.174 Employment Structure within Gasworks - Greenock (1885)

Employees	Number of Men	Wage per Week	Duties
Foreman	1	45/-	General superintendence
Time and Store Keeper	1	27/-	Weighing; Keeping Wage and Waggon Books
Retort House Clerks	1	27/-	Office work; Keeping Coal and Carbonizing Books
	1	9/-	
Blacksmith	1	30/-	Firemen's tools repair; jobbing
Yard Labourers	8	20/-	Cleaning purifiers, stowing coal, coke trimming, &c.
	1	21/-	
	1	22/-	
	2	16/-	
	1	12/-	
Still Men	4	(4/6d day)	By -Products works
Night watchman	1	23/4d	Checking pressure guages &c.
Coal Checker at Railway	1	18/-	Recording coal waggons
Mason	1	27/-	Work on Retort bench and buildings
Foreman Fireman	2	(5/2d day)	Superintending Retort House
Engineman	2	(4/6d day)	Operating exhausters, pressure machinery &c.
Firemen	12	(4/6d day)	Stokers (Number varied seasonally)
Senior Office Clerk	1	50/-	
Junior Office Clerks	1	32/6	
	1	25/-	
	3	10/-	
	1	8/-	
Meter Inspectors	6	35/-	
	1	34/-	
	1	30/-	
Distribution Foreman	1	40/-	
Pipelayer	1	28/-	
Pipefitters	1	27/-	
	3	24/-	
Pipefitters' Labourers	2	20/-	
	1	15/-	

Notes - Four categories earned day-wages; the remainder were paid by the week.

All worked twelve hours a day, six days a week. Firemen worked two shifts; the remainder were day shifts except the Night Watchman. He, together with the General Foreman and Firemen, was paid for a seven day week.

Source:- Greenock Ref. Lib., Greenock Police Board Minutes 1885, p. 127.

Effective trade union organization among employees began in the large Manchester and London gasworks,[1] with the Loyal Stokers Protection Society of 1859. The <u>Journal of Gas Lighting</u> urged companies to provide better social facilities rather than treating the men as "so many machines". Retort house labourers were "notorious" for "intemperance and a neglect of self-respect" or cleanliness. A "general eating and sitting room" with personal lockers, and improved moral standards were seen as the only way to show "the working men that the interests of masters and men are felt to be identical". Otherwise they would "look upon the question of wages as being simply one in which either party is entitled to take whatsoever advantage he can of the other to the bargain", with the "bitterness of class disputes".

Public support by a gas manager in favour of the abolition of Sunday labour was first made by Mr. Morton[2] at a meeting of the British Association of Gas Managers in 1870. He received a hostile reception from other managers, though some were trying to minimize Sunday working. Mr. Hislop at Ayr[3] did so from 1865, but recorded in 1876 that despite the strict Sabbatarian views in Scotland,[4] Sunday labour was widespread

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1. Strikes were called in both towns during 1859. The London gas workers were paid 4d an hour, equal to a Bricklayer's labourer, for 12 hours a day, 7 days a week. They struck for equal hours with other workers, 10 hours per day for 5 days, 8 hours on Saturday, and Sunday off. One Sunday off every month was granted at 3 London gasworks. Westminster suffered blackout in a strike of 1834 which served as a precedent. <u>J.G.L.</u>, 1/2/1859, 15/2/1859, 19/7/1859; <u>Vide infra</u> p. 1743

2. R. Morton (1834-1911), trained as an engineer by H. Balfour & Co., Leven; became prominent London gas engineer and devised self-sealing retort lids. <u>The Institute of Gas Engineers Transactions</u> 1911, p. 456.

3. Mr. Alexander (Costorphine), "Sunday Labour in Gasworks", <u>N.B.A.G.M.</u> 1876. <u>J.G.L.</u>, 22/8/1876.

4. From the 1830s, Sir Andrew Agnew (1793-1849) of Lochnaw (M.P. for Wigtownshire from 1830), led other Evangelicals like Thomas of Banchory, in the Lord's Day Society which lobbied Parliament, and presented Bills in 1832-7, to forbid all Sunday labour e.g. on railways. J. Baird forbade Sunday labour in his ironworks from 1837, but most ironworks had a 7 day week till 1914. <u>Dictionary of National Biography</u> (1908) Vol. I, p. 178. N. Munroe, <u>The History of the Royal Bank of Scotland 1727-1927</u> (1928, Edinburgh), p. 215. W.H. Marwick, <u>Economic Developments in Victorian Scotland</u> (1936), p. 155.

in gasworks. Blast-furnace owners[1] had strongly opposed Sunday stoppages, and claimed they would cause a loss of production for half the week, but in the early 1870s they began to provide Sunday holidays without reducing output.[2] The Corstorphine[3] gas manager showed that a gas company with twenty to fifty employees could maintain retort-furnace heats and prevent damage, by employing two to five men on Sunday, each man doing this duty five times a year. Sufficient gas for Sunday was produced by a ten per cent increase in output during the preceding week.

London strikes over working-hours in 1872 resulted in many companies[4] there awarding double-pay on Sundays, and because the stokers preferred this to a holiday, gas managers widely complained that stokers had made a mercenary argument over religion. In 1876 one manager, C. Woodall[5] again pressed for Sunday holidays for stokers, and most London

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1. Evidence of Mr. Fraser of Inverkeithing, J.G.L., 22/8/1876.

2. Shorter hours were becoming popular in many industries. Marwick quotes demonstrations by drapers for shorter shop hours in 1853-4, and dates a "new phase of the labour question" from the success of Nine Hours Committees in the building trades after an Edinburgh strike in 1861. Shipwrights' hours fell from 60 in 1866 to 51 per week in the 1870s, and the railway strike of 1890-1 was in favour of a 10 hour day, and time-and-a-half pay on Sundays. W.H. Marwick, Economic Developments in Victorian Scotland (1936), pp. 155-8.

3. J.G.L., 22/8/1876. c.f. Galashiels gasworks ceased Sunday labour in 1864; Gas World, 8/4/1899.

4. Concessions were granted despite severe repression of the strikers. London stokers who struck in 1864 and 1872 were dismissed and replaced by black-legs, who only required about 2 months practice to become sufficiently skilled. 24 men received 6 weeks hard labour in 1872 under the Master and Servant Act, and 6 leaders received 12 months under the 1871 Criminal Law Amendment Act. Evidence of H.E. Jones, B.P.P. 1893-4 [C.6894 - IX] Vol. XXXIV. Minutes of Evidence before Group C of the Royal Commission on Labour [Industrial Relations 1970 Irish University Press Vol. 33], p. 203, Q.26,368. G.D. Cole, A Short History of the British Working-Class Movement 1789-1947 (1947), p. 207. G.D. Cole and A.W. Wilson, British Working Class Movements - Select Documents 1789-1875 (1951), p. 574.

5. C. Woodall (London), "Sunday Labour in Gasworks", lecture to British Association of Gas Managers, J.G.L., 18/7/1886.

companies began to suspend gas-making from 6 a.m. to 6 p.m. on that day while periodic changes of shift allowed the men a full twenty four hours off. This required a seven per cent increase in capital plant size, which combined with Sunday working costs raised the prime manufacturing cost by 0.53d per 1000 cubic feet. However, the extra equipment was useful to meet winter peak demand, and productivity was raised among the more alert staff.

Scottish gasworks slowly adopted similar systems, and several years before 1884 W. Foulis at Glasgow "stopped all Sunday labour at his works".[1] At Edinburgh a shift system was still used and Sunday stokers worked from 6 a.m. to 10 p.m. Some undertakings like Aberdeen[2] preferred to offer an eight hour day, three shift system, which continued unchanged on Sundays. Labour agitation in the large Scottish gasworks increased throughout the 1880s. In 1884 seventy Aberdeen stokers[3] who received twenty five shillings for a seven day week, formed a "Benefit and Protective Society" to complain that their wages were so much lower than in Glasgow which paid five shillings per shift. Little action was taken, but in 1888 Aberdeen town council agreed to cease Sunday labour at the works during eight months of the year. Two men instead of forty would stay on Sunday, though trials indicated that an annual loss of £200 would be caused by letting the furnace fires down. Ayr stokers[4] pressed for Sunday holidays in 1888, but no change was made to

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1. J.G.L., 5/8/1884.

2. J.G.L., 22/8/1876. c.f. Arbroath council in 1879 turned down their manager's proposal to reduce Sunday working, and decrease hours from 84 to 56 per week, after collecting statistics from 20 other Scottish works of which three quarters were operated the same way as Arbroath. J.G.L., 20/5/1879.

3. J.G.L., 2/12/1884, 4/11/1884, 9/12/1884, 29/5/1888.

4. S.R.O., Ayr Minute Book, op. cit., 11/9/1888, 27/10/1888.

the system which allowed them one Sunday every fortnight when shifts were changed. Alternatively, the foreman would replace them by a "yardsman" if they wished to take Sunday off with a loss of wages.

The most rapid change in labouring conditions in Scottish gasworks occurred in 1889-92. In March 1889 the "National Union of Gas Workers and General Labourers of Great Britain and Ireland" commenced,[1] and was led from July by William Thorne.[2] The Union pressed effectively[3] for an eight hour day and improved sanitary facilities. Stokers often wore only "old rags, chiefly flannel",[4] whilst on duty, but often had only a bucket of water in which to wash before changing their clothes to return home. The new mood of agitation had already begun in Scotland. Leith stokers working for Edinburgh and Leith Gas Commissioners struck in 1889 to enforce their demand for wage parity with Edinburgh stokers. The Commissioners employed black-legs at fivepence an hour for a fifty one hour week, and refused to re-employ the strikers though they did grant the wage demand. Edinburgh men[5] had previously

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1. In the vanguard of the 'New Unionism' described by Pelling as assisting especially the unskilled and low-paid workers. H. Pelling, A History of British Trade Unionism (1972), pp. 93, 94, 98.

2. W.J. Thorne (1857-1946) had been a stoker for 14 years, 7 at Birmingham and then at the S. Metropolitan and Chartered companies in London. By 1893 the Union had reputedly 50,000 members, 60% of whom worked in the gas industry; only Bolton and Birmingham gasworkers had independent effective unions. Evidence of W. Thorne, B.P.P. 1893-4, Group C of Royal Commission on Labour, op. cit., p. 121 (433). W. Thorne, "The 8 Hour day in Gasworks", Gas World, 8/9/1897, p. 427; 5/11/1898. J.M. Bellamy and J. Saville, Dictionary of Labour Biography (1972), Vol. I, pp. 314-9 (Bibliography).

3. G.D.H. Cole, A Short History of the British Working-Class Movement 1789-1947 (1947), p. 243. B.P.P. 1893-4, Group C. of Royal Commission on Labour, op. cit., Appendix XLV, p. 587 (899), "List, with dates of commencement and termination, locality, cost, cause, and result, of all strikes connected with the Gas Workers' Union since its formation".

4. Evidence of W.H. Ward, assistant secretary to G.W. & G.L.U., B.P.P. 1893-4, Group C of Royal Commission on Labour, op. cit., p. 99 (411).

5. T.R. Cameron, "A History of Gas Manufacture in Edinburgh", (1951 typescript), op. cit.,

threatened to walk out in September 1888 because of bad working conditions and excessive heat. They requested a reduction in the work load from four ovens of eight retorts each to three ovens, and did achieve improved conditions. Edinburgh Trades Council supported the Leith men, and a hundred formed the "Gas Workers Protective Association"[1] in October 1889. The retort and barrow men of the carbonizing department demanded an increase from four shillings and elevenpence to five shillings a day, and the yard men copied Bristol agitators in requesting a raise of one halfpenny per hour and time-and-a-half for overtime including Sunday.

Greenock stokers also demanded five shillings a day instead of four shillings and sixpence for a twelve hour shift. Perth faced criticism in March 1889 because a mason, acting as Assistant Manager, received only thirty two shillings a week. Perth council agreed to raise the weekly rates of retort men by one shilling and sixpence and labourers one shilling, though new men were to commence at twenty four shillings and twenty shillings respectively. Gas fitters also received an increase of two shillings a week, giving thirty one shillings to foremen and twenty two shillings to workmen. Glasgow stokers[2] campaigned vigorously for an eight hour day instead of twelve hours, at the same rate of five shillings a shift. The Council replied that in 1887 they had already reduced the work load by twenty five per cent, and a further thirty three per cent would cost £20,000 a year. They claimed the work was really "unskilled labour" and involved only twenty five minutes activity every hour. Nevertheless the gas manager, W. Foulis, was sent to Birmingham and Manchester to obtain confidential

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1. c.f. Perth rates had increased from 3½d per hour in 1879 to 6d by 1890. <u>J.G.L.</u>, 15/10/1889, 22/10/1889, 13/11/1889, 18/2/1890.

2. <u>J.G.L.</u>, 29/10/1889.

information on wage rates. Kilsyth Police commissioners[1] in November 1889 allowed gas employees rises of one shilling to two shillings a week.

R. Mitchell at Edinburgh resisted the further wage demands made in 1890 but allowed a reduction in hours from twelve to eight per shift without a reduction in wages. He was then able to employ "a superior class of men".[2] P. Curran,[3] local organizer of the National Union of Gas Workers, arranged union branches at Carlisle, Glasgow and Edinburgh in 1891, but not in Aberdeen where only eight men volunteered instead of the twenty he required. By 1892, when Ayr[4] took the advice of Paisley manager Mr. Hislop and refused to reduce the hours to eight, labour agitation in the Scottish gas industry had subsided.[5] The results, however, remained of great significance to technological change.

Labouring conditions in the gasworks of Scotland improved very considerably from 1889-1892, with rising wages and reduced hours. The old twelve hours shifts of retort-house men which included "considerable intervals for meals and rest"[6] were replaced at many works by three shifts of eight hours, excluding meal breaks, and jobs were rearranged to raise productivity per hour.[7] Wages were the same, or even higher,

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1. J.G.L., 12/11/1889.
2. J.G.L., 1/7/1890.
3. J.G.L., 28/4/1891.
4. S.R.O., Ayr Minute Book, op. cit., 26/12/1892. Hislop pointed out that during the summer months, Ayr employees had very little work to do despite the length of shifts.
5. A 'Shorter Hours Movement' affected many Scottish industries in the 1890s. W.H. Marwick, Economic Developments in Victorian Scotland (1936), p. 155.
6. B.P.P., Rates of Wages Paid by Local Authorities and Private Companies (1892), op. cit., [Industrial Relations 1970 Irish University Press, Vol. 20], p. 887.
7. Ibid., p. 888.

per shift on the shorter shifts. In Scotland[1] from 1886-96 stokers received an increase of five to fifteen per cent in wages, and other gas workers of five to ten per cent.

Several gasworks still operated twelve hour shifts in 1910, however, when Popplewell[2] observed the precise conditions. One oven of retorts was charged every two hours, but the actual labour took one hour, and the last charge was rushed through in three quarters of an hour before the men left. The next shift arrived one and a quarter hours later to discharge the retorts, which reduced the real length of shifts to ten and three quarter hours. With eight hour shifts the retorts were charged hourly, and took half an hour of labour, making the entire shift in reality seven and a half hours.

To explain the rapid growth of union activity in the gas industry, E.J. Hobsbawm has postulated the absence of "any major mechanization" before 1889, but an increase in the work-load[3] placed upon stokers and firemen, which became chronic during a boom in consumption about 1888-90. The stokers and others whose jobs were easily learned, had family commitments which previously prevented them taking union action in the winter season, to avoid being laid off in the slack summer season; they only reacted to the excessive new burdens placed upon them. Hobsbawm believed they were wholly successful in raising their wages, "in safeguarding their status against the machines" which were

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1. B.P.P., Rates of Wages Paid by Local Authorities and Private Companies (1892), op. cit., [Industrial Relations 1970 Irish University Press, Vol. 20], p. 889.

2. Popplewell estimated that 75.7% staff at British gasworks had 8 hour shifts, and 24.3% 12 hour shifts; Journal of the Royal Statistical Society 1910-11, op. cit.

3. Hobsbawm based this upon a comparison of total coal carbonized, and total wages paid, in London gasworks in the 1880s. E.J. Hobsbawm, Labouring Men - Studies in the History of Labour (1965), pp. 162-3.

not a financial success until the early twentieth century,[1] and in retaining their jobs because output rose so rapidly that labour requirements increased despite mechanization.

The Scottish situation did not conform to this pattern. A shorter hours movement gained momentum throughout the 1880s, and resulted in increased mechanization which further antagonized the stokers by effectively reducing the number employed. Stoking machinery at Aberdeen has already been mentioned,[2] and was certainly effective in the late 1890s. Regenerative furnaces may have increased the work load of stokers, and were the most important change, producing higher productivity from the 1880s whilst reducing labour requirements, as shown in Table 3.175.

Table 3.175 Labour and Working Costs Reduced at Falkirk by Hislop's Regenerative Furnaces and Peebles Oil Gas Process (1895)

Per Week	(1) Old System August 1895	(2) New System September 1895
Retorts in Use	44	24
Fires to be stoked	8	3
Gas output (cu.ft.)	695,800	1,512,000
Output per Ton Coal (cu.ft.)	8,400	9,000
Wages	£15 12/-	£12 16/6
Stokers' Wages per 1000 cu.ft.	5.37d	2.03d
Number of Stokers	11	9

Note - Total saving 11.06d per 1000 cu.ft., including 0.5d on coke.

Source:- Gas World, 26/10/1895, p. 521.

Union activity in English cities, especially London, catalyzed existing discontent in Scotland over long hours and wage rates, and employers

1. E.J. Hobsbawm, Labouring Men - Studies in the History of Labour (1965), pp. 171, 176. Hobsbawm thereby denied the comments of J. Burns in 1890, quoted by Pelling and central to his view of 'New Unionism', that "labour saving machinery is reducing the previously skilled to the level of unskilled labour", and hence Unions had to aim for the support of less skilled workers besides those with skills. H. Pelling, A History of British Trade Unionism (1972), p. 101.

2. Vide supra p.374

were intimidated into granting considerable concessions. This stimulated heavy investment by many Scottish gas undertakings in mechanical stoking equipment, water-gas plant and other labour-saving devices which replaced many of the highly paid stokers by fewer, lower paid, machine operators. Mechanization, which was feasible but expensive in the early 1880s, became most attractive to embattled managements, who paid the high capital costs not only to reduce prime manufacturing costs, but in a search for greater security against the threat from organized labour unions.

The few available statistics (Table 3.176) suggest that Scottish stokers in large town gasworks, on twelve hour shifts, were better paid than their English contemporaries of 1886 in the Midlands, and received almost as much as those in Lancashire. In 1892 however, they were paid significantly less than stokers in Yorkshire, northern England and the London area. Those at small gasworks, which were so widespread in Scotland, also received much less than their English counterparts.

Table/

Table 3.176 Comparison of Wage Rates in Scotland and England (1886 and 1892)

(1) Stokers Wages and Shift Hours Before Alterations (October 1886)

Sample	Number of Works	EIGHT HOUR SHIFTS Number Stokers	EIGHT HOUR SHIFTS Average rate per 7 shifts	TWELVE HOUR SHIFTS Number Stokers	TWELVE HOUR SHIFTS Average Rate per 7 shifts
Scotland - large towns	3	172	29s 0d	236	34s 4d
S. Lancashire - large towns	4	169	35 7	739	34 6
" - small towns	5	84	34 1	154	32 6
Mid England - large towns	3	258	31 7	335	32 6
Other Places	8	421	31 9	1367	31 8
Total Sample and Averages	23	1104	32 1	2831	32 9

(2) Regional Gasworks Wage Rates (1892) - Weekly Averages

	Stokers & Firemen	Engine Drivers (Boilers)	Outside Fitters	Brick-layers	Smiths	Hammer-men	Cleaners & Lamp-Lighters	Lamp-Lighters	General Labourers
Large Towns in -									
Scotland	32s 1d	29s 5d	28s 5d	34s 2d	29s 10d	20s 7d	21s 7d	11s 11d	20s 1d
London region	36 2	32 3	29 11	38 11	35 9	25 5	21 8	-	23 11
North England	33 11	29 7	26 1	32 5	29 2	19 10	19 3	-	21 10
Mid England	32 1	28 5	-	35 10	29 9	20 10	20 1	11 7	20 5
West Riding	34 10	28 9	-	33 4	28 1	20 1	20 1	10 0	20 9
Small Towns in -									
Scotland	26 8	-	23 10	-	25 2	-	14 8	-	19 3
North England	31 5	-	26 0	29 1	-	-	20 1	10 10	20 5
Mid England	29 1	27 3	26 11	31 6	25 11	19 0	19 6	11 10	19 4
West Riding	30 5	21 11	23 3	-	26 2	20 3	18 9	12 4	20 3

Source:- B.P.P. (1892), Wages Paid by Local Authorities and Private Companies, op. cit., p. 889.

The gas industry as a whole in the early 1890s paid wages (Table3.177) as high as heavy industries like pig-iron manufacturers, and railway waggon manufacturers, despite its vastly larger labour force.

Table 3.177 Average Earnings by Gasworkers compared to Other Industries (1894-6)

Trades with Average Annual Earnings of £70 and Above

Industry	Number of returns	Number employed on 1/10/1886	Wages paid in 1885	Average per head
Steel manufacture	17	9,343	£691,905	£74
Gasworks	306	28,670	£2,080,080	£73
Pig Iron Blast Furnaces	54	7,173	£524,908	£73
Railway carriage/waggon	22	3,145	£230,834	£73

Trades with Average Annual Earnings of £60 up to £70

Industry	Number of returns	Number employed on 1/10/1886	Wages paid in 1885	Average per head
Chemical Manure	58	1,689	£117,171	£69
Shale mines and Paraffin Oil Works	5	3,091	£212,618	£69
Waterworks	167	5,275	£353,369	£67
Chemicals	100	14,976	£983,421	£66
Government Works				
Royal Gas Factory	1	54	£4,007	£74

Source:- Report of H.M. Board of Trade. Abstract of Labour Statistics 1 - 3, 1893-4 to 1895-6, pp. 74-5 (Wage Rates in Private Works).

The average weekly rate of 27,965 gasworks employees recorded by the Board of Trade in 1894 was 27/2d made up thus:

Table 3.178 Gasworks Wage Rates (1894)

Shillings Per Week	Under 10	10-15	15-20	20-25	25-30
Number of Employees	60	374	2,362	10,176	4,854
Shillings Per Week	**30-35**	**35-40**	**Over 40**		
Number of Employees	4,580	4,609	947		

Source:- Report of H.M. Board of Trade, op. cit., p. 80.

At Hamilton,[1] the average wage of stokers in 1899 was thirty shillings

1. Gas World, 8/4/1899.

a week. First, second and third class stokers received thirty eight and sixpence, thirty six and ninepence, and thirty five shillings respectively.

Changing labour conditions helped to inspire Directors from 1889 to inquire increasingly into mechanization and improved technology,[1] since wage rates assumed growing importance at a time when, despite expensive coal, gas prices throughout Britain were beginning to fall rapidly in order to compete with electricity. Where skilled men were still required, shorter hours and automation did not reduce their wages, but many were displaced by lower paid machine operators. The differentially higher price charged by small Scottish works, with a larger and more skilled labour force in relation to output compared to large gasworks, reinforced the advantages of long-distance pipelines which were becoming technically feasible, and the development of regional gas-grids resulted in the closure of many small works after the First World War.

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1. c.f. In 1868 Naismith stated that strikes were more important than profits in causing increased mechanization. S.G. Checkland, The Rise of Industrial Society in England 1815-1885 (1969), pp. 87, 134.

CHAPTER IV

Company Finance

Gross capital formation[1] and annual profits in the Scottish gas industry were considerably influenced by national and regional economic fluctuations in both manufacturing industries and trade. With ubiquitous and yet geographically localised markets, each gas undertaking was affected by national variations in coal and labour prices, and interest rates upon loans, which produced a particularly broad interface with external economics. The standard of living of consumers in a particular market could be as important as the prosperity of local manufacturers in affecting the total consumption of gas, and ultimately the profits received. Very little precise information is available on an annual basis concerning industrial prosperity in Scotland during the most important period of gas company development, 1817-50. A summary is given here in graphs.[2]

New gas companies at Glasgow[3] and Edinburgh in 1817 were an expression of growing prosperity in Scotland following the end of the Napoleonic wars. The tobacco trade which had dominated Scotland's external economy[4], collapsed in 1776, to be superseded by textiles, especially cotton by the 1790s. From the 1810s cotton spinning and weaving, and ship-building developed rapidly in the West of Scotland[5]. Wage-rates in the construction industry[6] rose during the 1820s, to a peak in 1825-6, but fell to a low level in the period

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1. 'Gross Capital' here includes both 'fixed capital', represented by equipment purchased, and the initial 'working capital' necessary for commencing operations. Little data is available for fixed capital formation in Britain as a whole in 1750-1850 despite the crucial importance of this period.
   J.P. Higgins and S. Pollard Ed. Aspects of Capital Investment in Great Britain (1750-1850) (1971) p.3
   Municipal Gasworks finance is considered separately Vide infra 'Municipal' p.1004 et seq
2. Vide infra pp. 729, 738
3. Vide infra pp. 155, 1008
4. A. Slaven The Development of the West of Scotland 1750-1960 (1975) p. 23
5. ibid pp. 99, 108, 128
6. Vide infra pp.734, 735; Figs 4.6, 4.7


Fig. 4.1 Economic Factors Affecting The Gas Industry
[1] Business Cycles - N.J. Silberling
Review of Economic Statistics 1923
[Harvard]
[L] Cost of Living
[D] Cost of Domestic-production articles
[F] Cost of high-freight articles
[1] End of Napoleonic Wars
[2] Economic Boom 1825
[3] Boom and Scottish coal famine 1836
[4] Cheap Gas Movement
[5] Boom - railway promotions 1846-7
Source - vide infra p.733.a
200
190
180
170
160
150
140
130
120
110
100
90
80
70
1810
15
20
25
30
35
40
45
50
D
L
F
1
2
3
4
5

Fig. 4.2

[2] Index of Industrial Activity by W. Beveridge

Oxford Economic Papers 1940 vide infra p. 733.a

Fig. 4.3

[3] The Hoffmann Index, and Gross Total Capital Formation in Britain

Hoffmann Index of Industrial Production, excluding Building (1900 A.D data = 100) in Mitchell and Deane British Historical Statistics

Gross Total Capital Formation (£ millions) estimated by B.R. Mitchell Journal of Economic History 1964 Vol. xxiv

Vide infra p. 733.a

R – Recession/slump

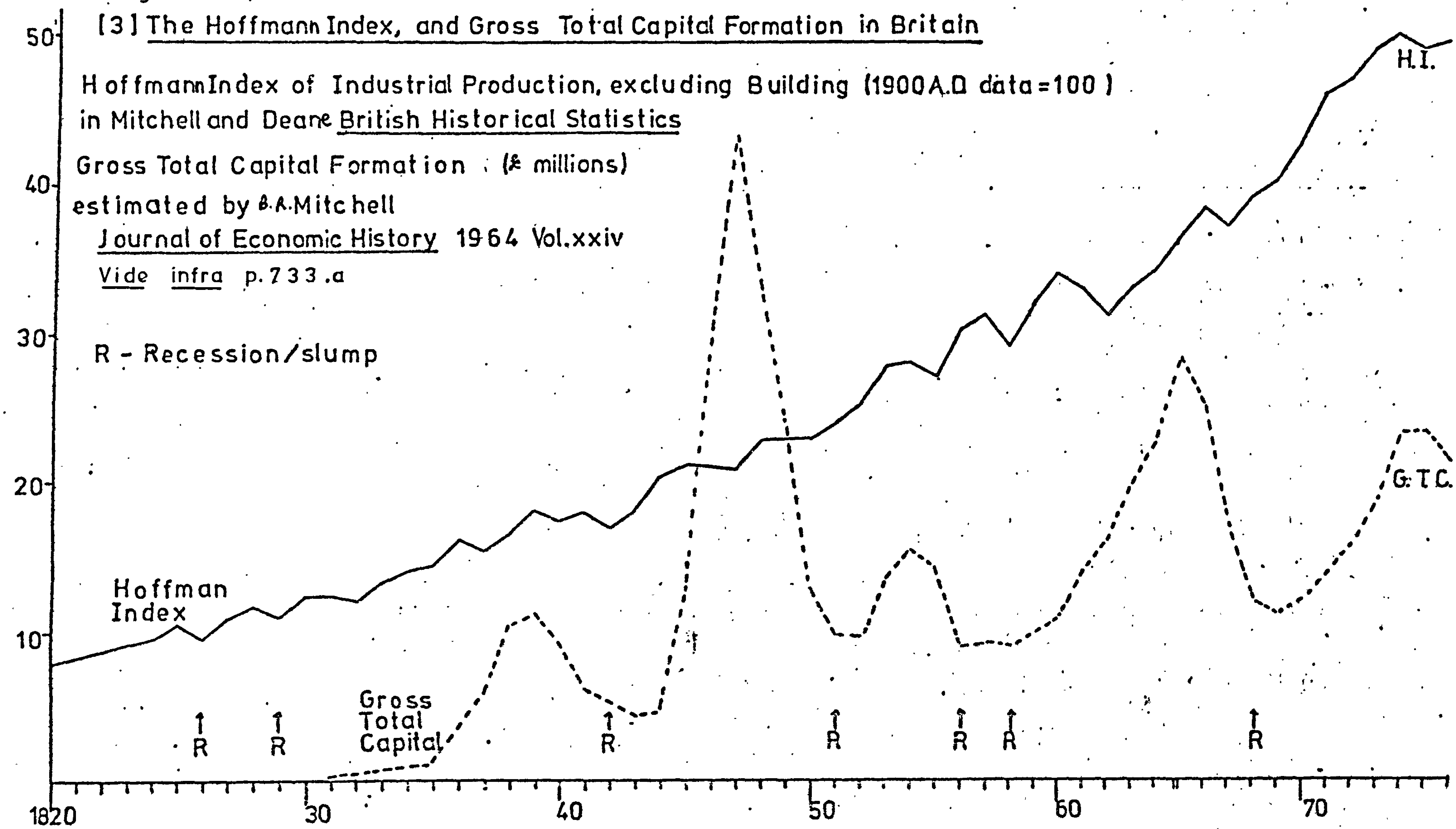


Fig. 4.4.

Bank and Discount Rates on Loan Capital

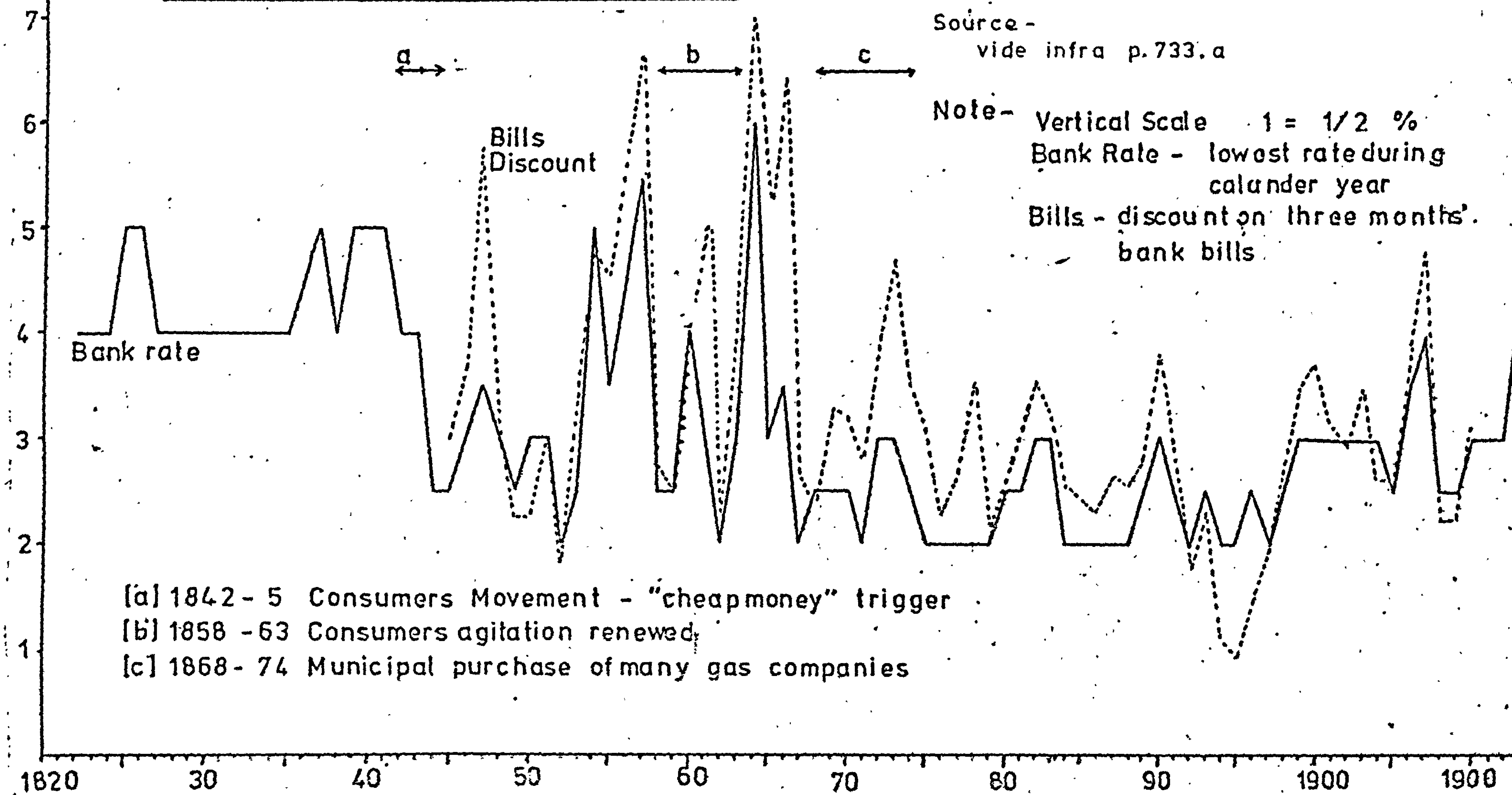
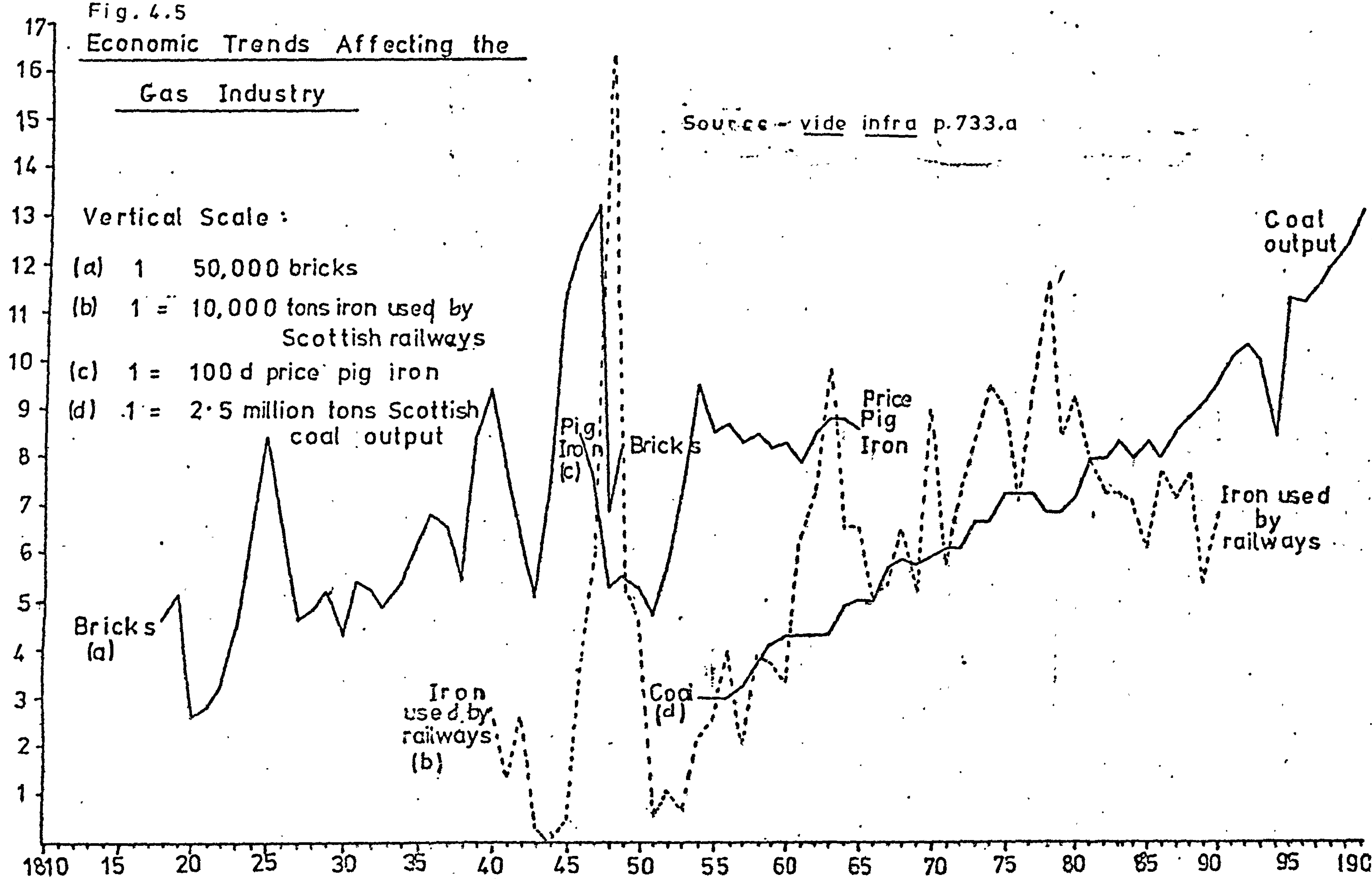


Fig. 4.5

Economic Trends Affecting the Gas Industry



Trade Cycle Diagrams - Sources

Fig. 4.1 N.J.Silberling "British Prices and Business Cycles 1779-1850" Review of Economic Statistics 1923 (Harvard) Vol.5 pp.232,235

Fig. 4.2 W.Beveridge "The Trade Cycle in Britain before 1850: A Postscript." Oxford Economic Papers (1940) No.4 p.67

Fig. 4.3 B.R.Mitchell and P.Deane Abstract of British Historical Statistics (1962, Cambridge)
B.R.Mitchell "The Coming of the Railways and United Kingdom Economic Growth" Journal of Economic History 1964 Vol.XXIV

Fig. 4.4 Lowest bank rate per calendar year : Mitchell and Dean Historical Statistics (1962) op cit p.456

Market rate of Discount on Three Months' Bank Bills : ibid p.460

Fig. 4.5 Pig iron prices : ibid ;

R.H.Campbell "Statistics of the Scottish Pig Iron Trade 1830 to 1865" Journal of the West of Scotland Iron and Steel Institute 1956-7 Vol. 64 ;

J.Butt "The Scottish Iron and Steel Industry before the Hot Blast" Journal of the West of Scotland Iron and Steel Institute 1965-6 Vol. 73

H.Bumby "Iron and Steel in the West of Scotland", statistics for 1875-1900 Journal of the Iron and Steel Institute 1901 p.18

Annual statistics of pig iron prices 1845-60 Glasgow Daily Herald 1/1/1861

Average prices of pig and bar iron 1854-1884 (statistics from J.Watson and Co.,Glasgow, and W.Fallows and Co.,Liverpool) B.P.P First Report of Royal Commission on Depression of Trade and Industry pp. 168 (184), 139 (155)

Average Scottish pig-iron 1867-1878 Commercial History and Review (Supplement to The Economist) 1878 Vol. XXXVII 8/3/1879 p.23

Wholesale British iron prices 1845 - 1869 Commercial History and Review 1868 Vol. XXVII 13/3/1869 pp. 42, 44

Bricks charged excise duty in Scotland (calendar years) : A.K. Cairncross and B.Weber "Fluctuations in Building in Great Britain, 1785-1939" Economic History Review 1956-7 Vol. IX p.296

Coal output : Mitchell and Dean Historical Statistics (1962) op.cit.;
see also graph of output 1873-1939 in Scottish Coal Fields - The Report of the Scottish Coalfields Committee (1944, H.M.S.O. Edinburgh) p.56

Railways iron consumption : W.Vamplew "Railways and the Iron Industry : A Study of their Relationship in Scotland" in M.C.Reed Ed. Railways in the Victorian Economy (1969, Newton Abbot)

Fig. 4.6

Trade Cycle Impact Evident in Scottish Wage Rates

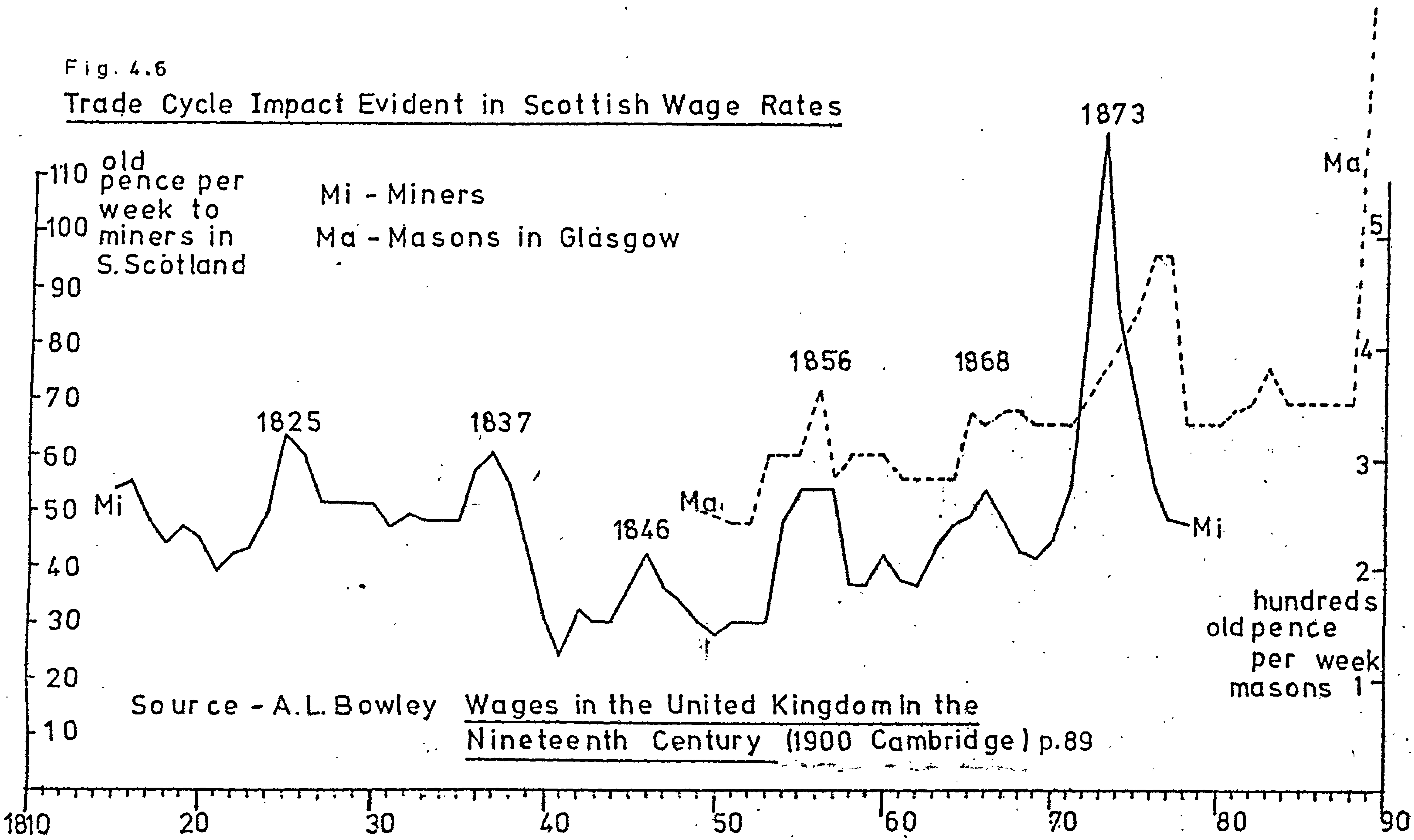


Fig. 4.7

Lower Wages in the Building Industry after 1826 - A stimulus to gasworks construction in the late 1820s.

Edinburgh weekly wage rates 1820-33

Source - L.A. Wallace, builder

B.P.P. 1836 [40] xxxiv p.99 [571]

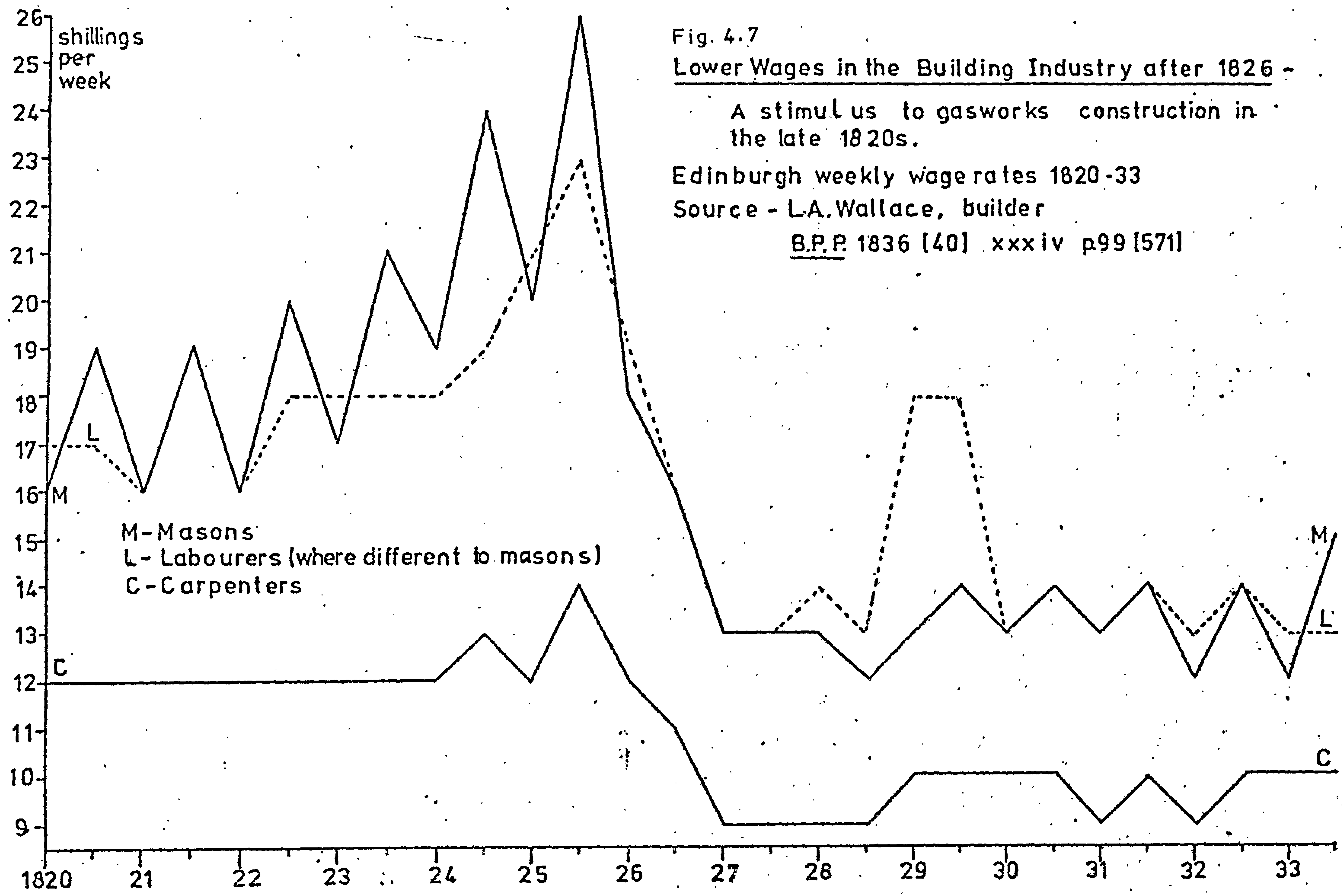
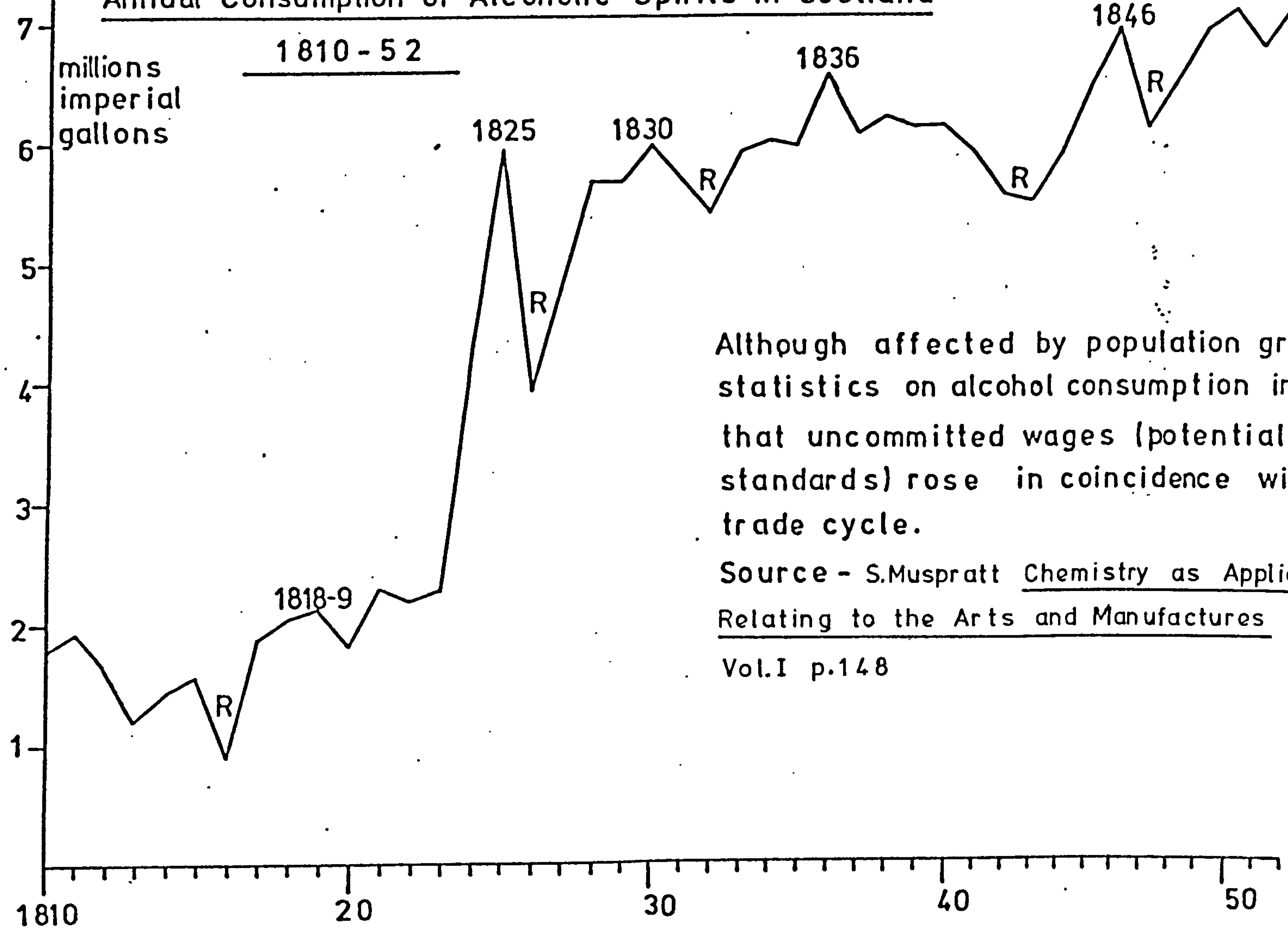


Fig. 4.8

Scottish Trade Cycle Reflected in Annual Consumption of Alcoholic Spirits in Scotland 1810-52



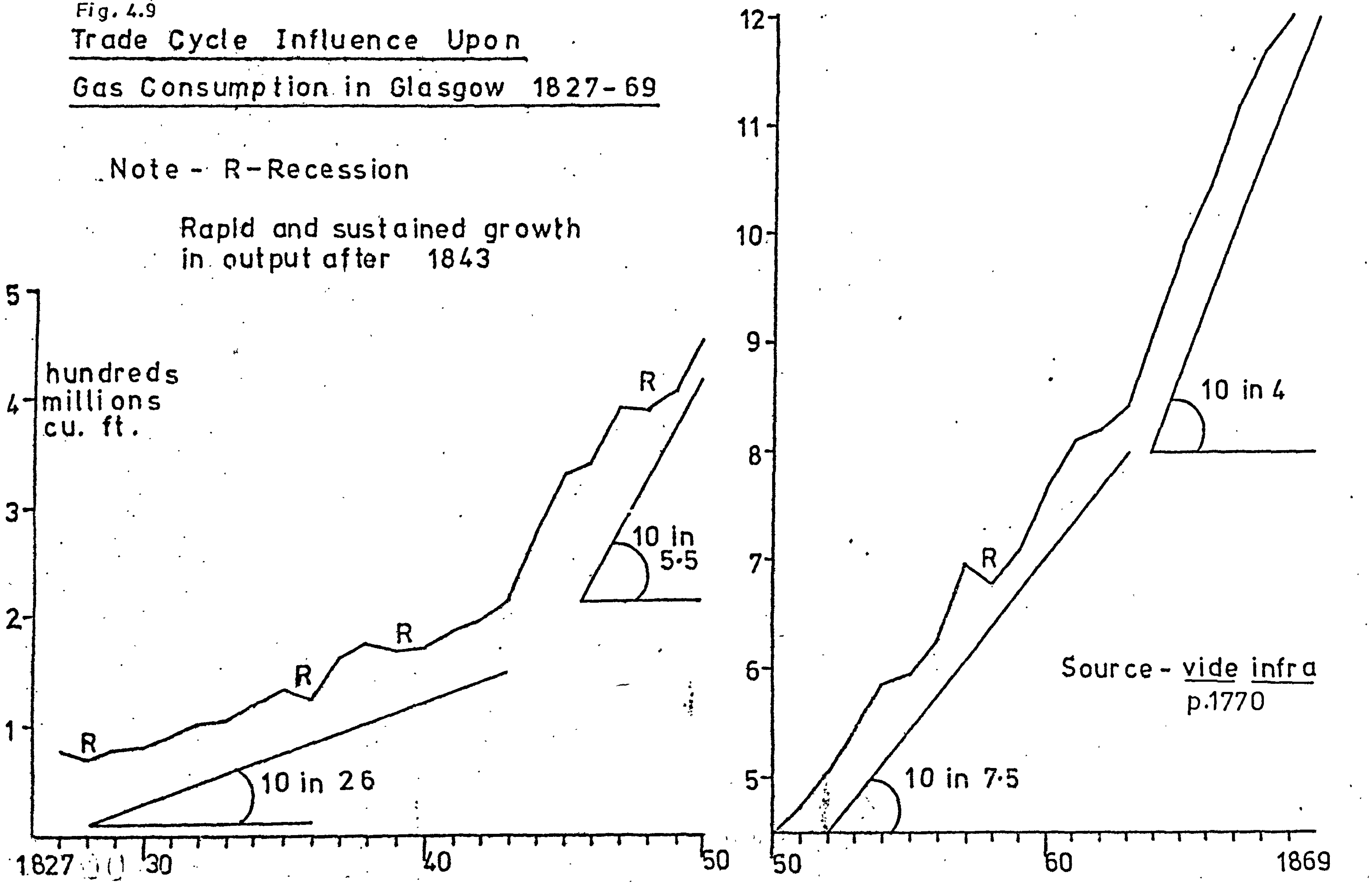
Although affected by population growth, statistics on alcohol consumption indicate that uncommitted wages (potential living standards) rose in coincidence with the trade cycle.

Source - S.Muspratt Chemistry as Applied and Relating to the Arts and Manufactures (1853) Vol.I p.148

Fig. 4.9
Trade Cycle Influence Upon Gas Consumption in Glasgow 1827-69

Note - R-Recession

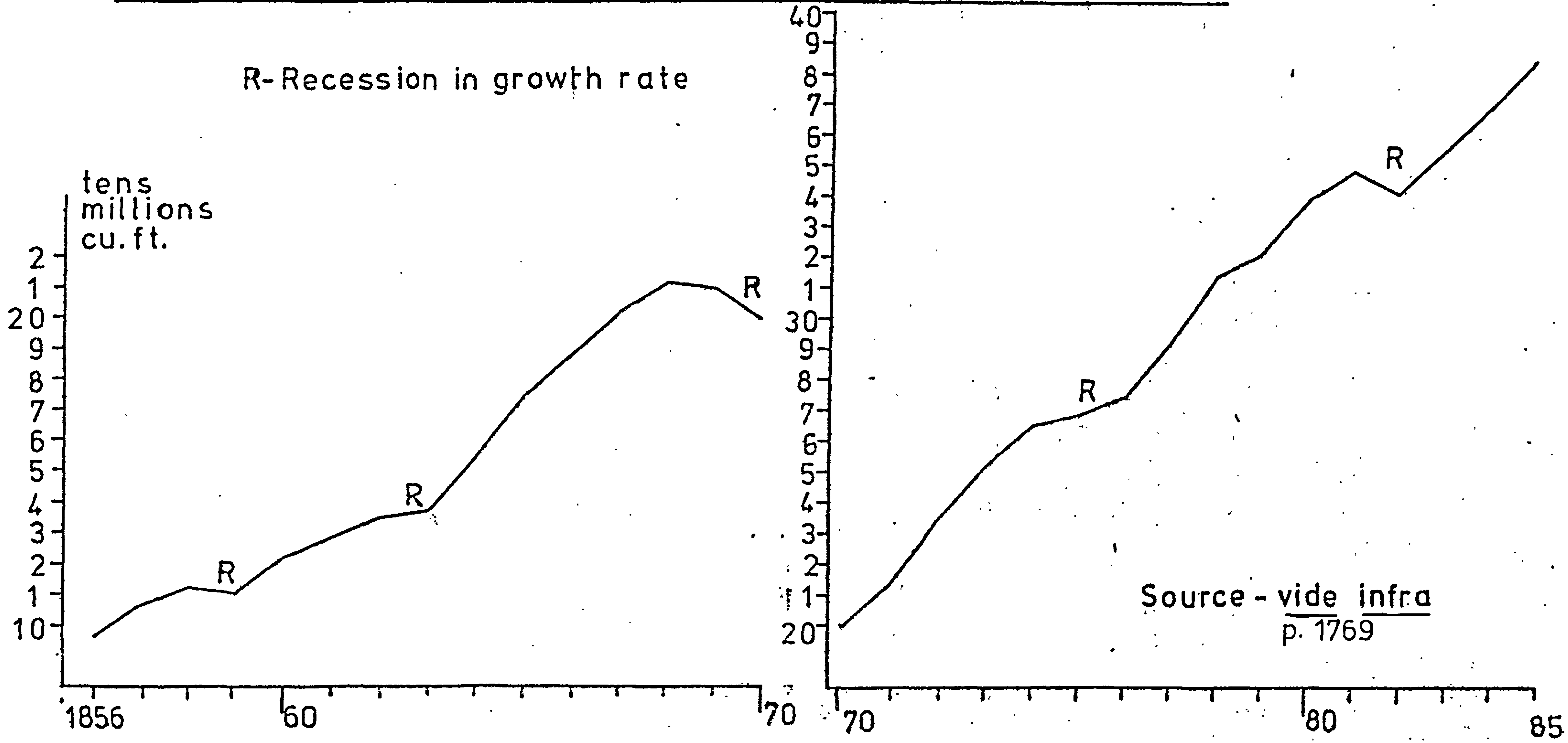
Rapid and sustained growth in output after 1843



Source - vide infra p.1770

Fig. 4.10

Trade Cycle Impact Upon Total Gas Sales at Dundee 1856-85



1827-33 when many Scottish towns built gasworks for the first time. Low prices were probably an important stimulus. The boom in British construction industries from 1835-6 also saw heavy investment in the gas industry[1]; both wages and construction statistics show a boom in 1843-5, but in 1846 when total construction[2] expanded into the railway boom, gasworks investment slumped. Brick production[3] showed only a minor increase in 1835-8, but a boom from 1843-8. Bricks production had slumped in 1826, following a boom which was not repeated until that of 1839, and excess capacity probably assisted in reducing construction costs for gasworks until at least the mid 1830s.

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1. Vide infra pp. 745, 746

2. Vide infra p. 730 Note: In Scotland the rapid expansion of textiles 1790-1830, was followed by depression of hand-loom weavers' incomes from 1830-50; but heavy industries especially iron founding grew rapidly in 1825-40, and shipbuilding along the Clyde followed suit into the 1870s. Despite regional differences, Scotland was affected by fluctuations in the English economy which entered a boom in 1825; recession 1826-32; boom 1832-6; partial recession 1837-42; boom 1842-6; financial crisis 1847-8; trade revival 1849-56; financial crisis 1857; expansion (especially of limited liability companies) 1858-65; financial crisis 1866-7; boom 1868-73; financial crisis 1873-4; contraction of rate of growth of foreign markets and reduced competitiveness 1873-84; shipbuilding slump 1883-6 and excess manufacturing capacity; financial crisis 1890. A chronological examination of external economic factors affecting the gas industry is given later.

   H. Hamilton The Industrial Revolution in Scotland (1932, Oxford)
   J. Mackinnon The Social and Industrial History of Scotland from the Union to the Present Time (1921)
   W.H. Marwick Scotland in Modern Times (1964) op cit
   S.G. Checkland The Rise of Industrial Society in England (1815-85) 1969
   W.H. Marwick Economic Developments in Victorian Scotland (1936) op cit
   A. Slaven The Development of the West of Scotland 1750-1960 (1975) pp. 103, 118

3. Vide infra p. 733 Fig. 4.5

The coal shortage[1] of 1836-8 was an important reflection of industrial expansion in Scotland, and within the gas industry such fluctuations in coal price became one of the most important stimulants for improved financial management and technology. Low bank and discount rates[2] assumed particular importance during the period 1844-6 when they contributed to agitation in favour of new, rival companies run by consumers for their own benefit[3]. Cheap iron from 1845 was another important factor. The low bank rates in 1858-9 contributed to renewed action by consumers, and rates rose after 1862 at a time when consumer agitation diminished. Low rates in 1867-71 assisted municipal ownership of gasworks which was then embarked upon, using loans which became available for that extensive programme.

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1. Vide infra 'Coal' p.505

2. Low interest on bank loans and low charges to exchange Bills for cash

3. The decline of consumer action after 1846 coincided with a period of general financial uncertainty; Flintoff's campaign of the early 1860s was one of many projects encouraged by the availability of Limited Liability.

   S.G. Checkland The Rise of Industrial Society in England 1815-1885 (1969) pp. 36, 43

   The prosperity which was expected to follow railway developments undoubtedly stimulated some consumers' companies in the early 1840s, as at Edinburgh in 1845. Vide infra p. 1139

Gas companies in Scotland were with few exceptions, local entrepreneurial ventures. Parochial initiative relied largely upon potential consumers becoming investors[1], but during the 1830s gas-lighting was still considered a hazardous investment[2]. Consequently, the initial capital stock was projected at the very minimum feasible, to reassure and encourage investors. Nominal share values were far lower than in many other commercial enterprises in order to encourage a wide spectrum of support, to spread the possible risks and to reduce the hazard[3] to individuals. At a later period, smaller towns were involved with fewer potential local investors, and this procedure was maintained to entice them. As urban growth progressed through the nineteenth century, the small original gas companies expanded[4] rapidly and eventually were considered one of the safest financial investments[5] available.

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1. Vide supra Chapter II p.164; also pp. 787, 911, 915, 1004

2. Vide infra pp. 161, 1212

3. In fear of possible mishaps, the small Boness company shortly after commencing in 1844, decided to place £15 per year from profits for the first five years into a Contingency Fund, to be maintained at £75. This was 1.8 per cent on the total stock and a heavy annual burden. S.R.O. Boness Minute Book op cit 16/7/1844.

4. e.g., Motherwell gas company commenced in 1845, and grew with the town. In 1852 there were about 1274 inhabitants, who purchased gas at 8s.6d, but the company still paid no dividends. In 1869 gas at 5s.0d. was consumed by 428 consumers and 69 public lamps in a town of about 9000. By 1891 the population was 18,700 of whom 2,500 consumers and 260 public lamps used 30 million cu ft of gas per year at 3s.9d.
Economies of scale vide supra pp. 175,323,325,329,482; also p.1150

5. The security of gas company shares was, however, less than that of municipal gas annuities.
Vide infra p.808
The degree of security influenced the type of shareholders. Glasgow City and Suburban company in 1869 claimed its shares were considered a safe investment by persons who had lost money in railway, bank and other companies. Consequently, large numbers were held by ladies and by trustees. The old (pre-1857) stock was held thus - 4330 shares by ladies, 3478 by trustees, 7192 by gentlemen; new stock - 890 shares by ladies, 1396 by trustees, and 2714 by gentlemen
J.G.L. 13/4/1869 p. 274

Initially, however, they were frequently undercapitalized and failed to pay any dividend[1] for several years. They suffered from a number of characteristic weaknesses: an acute shortage of working capital; inexperience at gauging the price to charge for gas[2] and which coals to purchase; inexperienced technical management; and frequently the burden of loan capital.[3] Unlike other joint-stock enterprises which tempted investors by forcasting that only a fraction[4] of the nominal value of shares would be called up, the entire amount was normally demanded quite soon after a gas Company was formed.[5] The Edinburgh company Prospectus, for example, stated "that the whole stock will be required in 18 months from 1st of March, 1817".

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1. Some investors regarded the use of gas-light as adequate reward for their money.
   Stornoway gas company paid no dividend from its formation in 1848, up to 1860 in which year 4s.0d was paid, but the nominal value of shares was raised from £2.10.0d. to £4 at the same time to acknowledge the reinvestment of surplus profits during the interim. By April 1849 the original works had cost £2020, but only 584 shares were subscribed, giving £1460.
   S.R.O. Stornoway Minute Book op cit 30/11/1860, 30/3/1861.

2. Gas prices quoted herafter refer to units of 1000 cu ft, unless otherwise stated.

3. e.g., Kilmarnock company commenced in 1822 with £4000 capital stock, and aimed to raise £1000 in loans. Dividend was prohibited until such mortguages were repaid. Stock was raised to £5000 in 1823, and dividend at 6 per cent first paid in 1827 J.G.L. 25/3/1884.

4. The uncalled portion was "reserve liability", a fiscal measure popularized by the 1844 and 1858 Bank Acts, under which banks could only call 50 per cent on their £100 shares. Insurance companies had a similar system, calling £5 to £10 on £100 shares J.B. Jeffreys "The Denomination and Character of Shares, 1855-1885" Economic History Review 1946 Vol. 16

5. e.g., Edinburgh calls - June 1817 20 per cent; September 1817 15 per cent and 15 per cent;March 1818 20 per cent.
   Dalkeith calls (£10 shares) - January 1827 £2 ; May 1827 £2 ; October 1827 £4 and £4 Fully called-up by 1829.
   Ayr calls (£5 shares) - Deposit 5s.0d August 1845 £1; February 1846 £1; May 1846 £1 ; Fully called-up by June 1847.
   Even where a full call was not originally contemplated, the very rapid extension of markets made it desirable, as at Paisley in 1824 Glasgow Courier 11/3/1824 p.3

Full calls gave greater confidence to investors, especially when Limited Liability became widely available after 1856. Gas companies of moderate size survived recurrent crisis of liquidity without 'leviations'[1], and obtained adequate loan capital without offering "reserve liability" as security for repayment. With small denomination shares they obtained the support of the middle classes and a wide variety of investors who were being deliberately excluded from other commercial enterprises[2]. By preceding railway developments in Scotland, gas companies introduced large sections of the population to the principles of joint-stock investment.

Table 4.11 Nominal Share Values in Scottish 'Limited' Gas Companies

Nominal Value	1858-9	60-4	65-9	70-4	75-9	80-4	85-9	90-4	95-9	00-4	05-9	10-14
£1 and less	6	11	15	19	19	20	21	22	31	32	35	42
£1.1.0d to £4	3	5	6	9	8	9	9	7	7	7	10	9
£5	1	1	3	5	5	8	8	9	9	10	8	7
Above £5			2	2	3	4	7	6	7	7	6	5

Source - S.R.O. Board of Trade records. Vide infra p.1817

The most frequently used denominations for shares[3] were £1, £2 and £5.

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1. i.e., Calls made in excess of the initial nominal value of share. 'Leviations' were frequently used by eighteenth century companies to raise capital without issuing new shares or acquiring new partners. L.C.B. Gower The Principles of Modern Company Law (1954) p. 24

2. Until the commercial crisis of 1866 when business confidence was shaken by calls of £50 per share in many industries, financial stability was believed to reside only in wealthy, well-informed merchants and capitalists who remained the principal investors in Britain until that time. Shares were priced up to £1000, to discourage other potential investors. Even railway and canal shares were rarely under £25, and "safe" investors who wished to minimize risk, were confined to these, and to consols and public utilities like gas companies. Only after 1866, when "reserve liability" was seen to make personal liability virtually unlimited even in Limited Companies, did businessmen favour large numbers of low value shares held by a large body of investors to spread the risk. By the 1880s most new shares were of £1 to £5, and were almost wholly called-up. J.B. Jeffreys Economic History Review 1946 op cit

3. c.f. Of all Limited Companies in 1863-5 about a third used shares over £20, a third of about £10, and only about a third used £5 or less.

   H.A. Shannon "The First Five Thousand Limited Companies and their Duration" Economic History (Supplement to Economic Journal) 1930-33 Vol. II pp. 407-8

Table 4.12 Nominal Share Values in all Scottish gas companies noted by the Journal of Gas Lighting

Nominal Share Value	1853	1861	1871
£1 and less	18	30	40
£1.1.0d. to £4	17	24	26
£5	30	39	44
£6 - 9	3	2	5
£10	8	9	9
£11 - 19	3	4	4
£20 - 25	9	10	8
Total Companies in sample	88	118	136

Source - Journal of Gas Lighting

In all but nine of the companies recorded by the Journal of Gas Lighting[1] in 1853, 1861 and 1871, a full 100 per cent call had been made upon the nominal value of shares. Under 10 per cent of Scottish gas companies with Limited Liability[2] failed to make a full call on shares within a few years of issuing them. The exceptions were over-ambitious rather than pursuing a "reserve liability" policy. Shares of £5 nominal value were most typical[3], and a swing towards these and lower denomination shares occurred from the 1860s and possibly earlier[4].

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1. Vide infra pp. 1399 - 1410
2. Vide infra p.1824
3. Because £5 = 100s., dividends could be calculated very easily e.g., 5s.0d. = 5 per cent. This simplified financial management.
4. e.g., Glasgow Gaslight Co. from 1818 used £25 shares, but by 1861 issued new stock in £6.5s.0d shares.

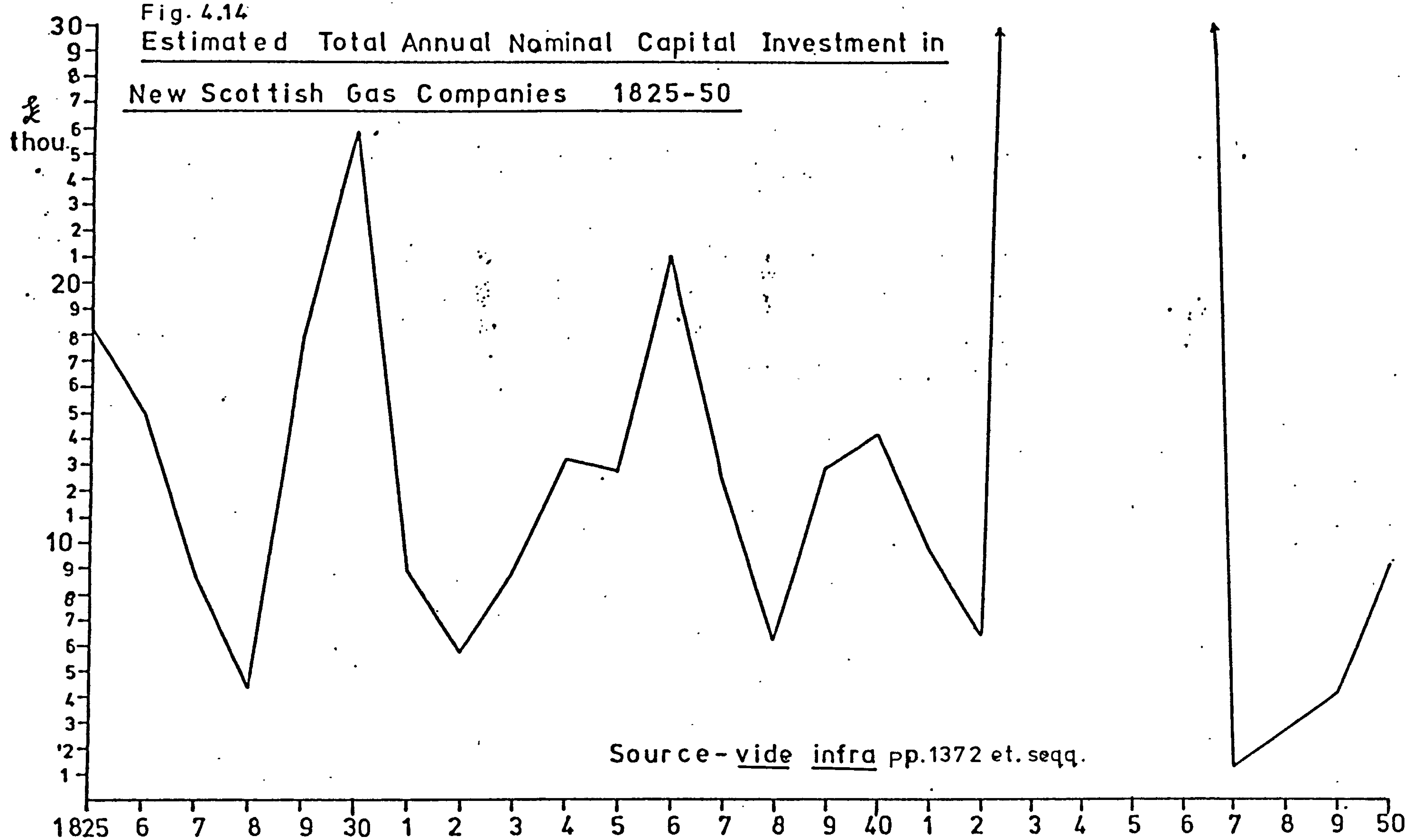
	Company	Old Stock	New Shares
1853-61 Share denominations	Moffat	£5	£2.10.0d.
	Peebles	£5	£2.10.0d.
	Newburgh	£5	£1
	Irvine	£10	£2.10.0d.
1861-71 Share denominations	Inverness	£10	£5
	Perth (Old)	£25	£5

Several Limited Companies also reduced nominal share values. Barrhead (in 1899) from £2.10.0d. to £1, Turiff (1906) from £3.15.0d to £1, Largs (1902) from £20 to £5, Slamannon (1912) from £2 to £1, Lockerbie (1872) from £5 to £1.

Vide infra p.1127

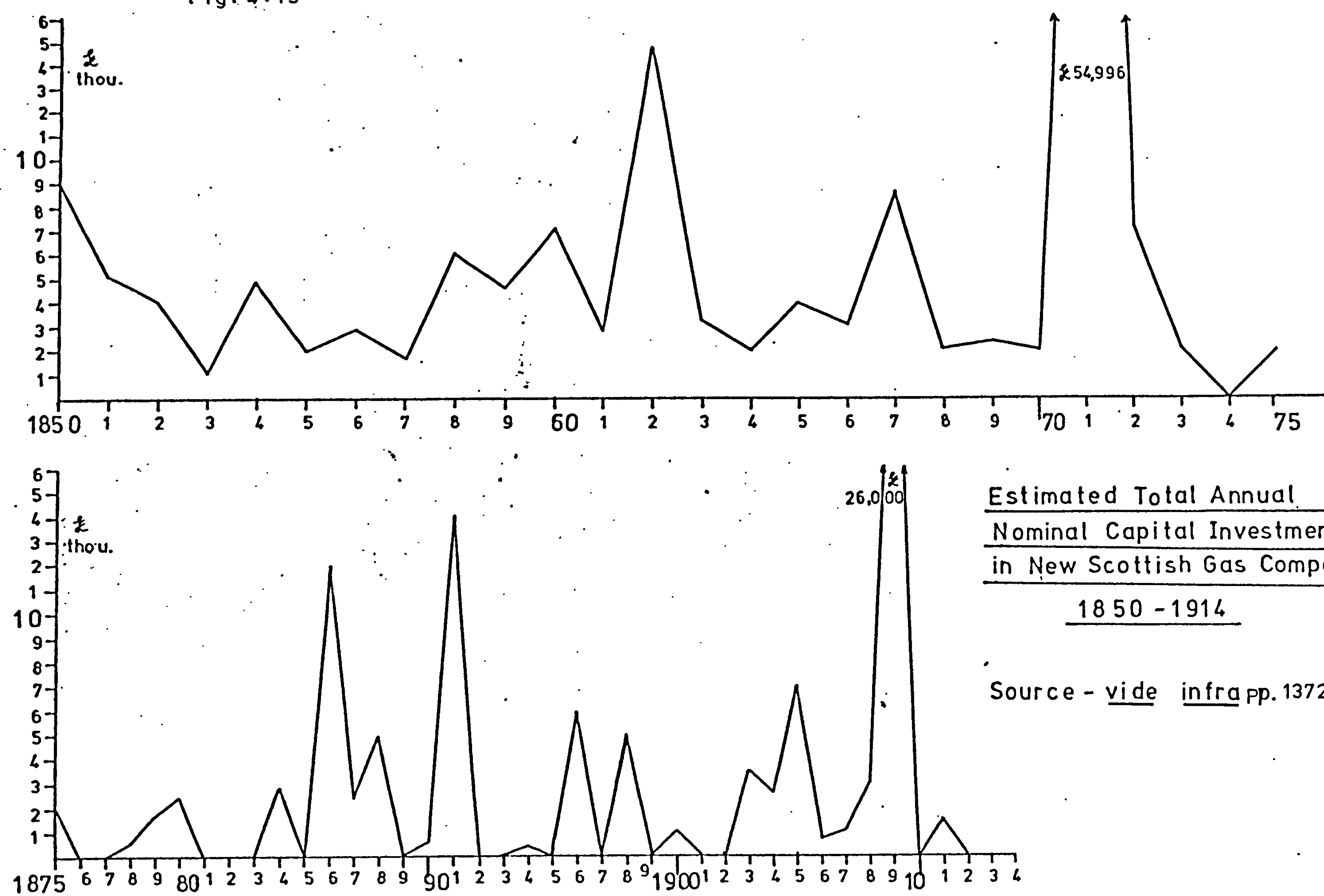
Estimated Total Annual Nominal Capital Stock of New Scottish Gas Companies 1816 -50

Fig. 4.14
Estimated Total Annual Nominal Capital Investment in New Scottish Gas Companies 1825-50



Source - *vide* *infra* pp.1372 et. seqq.

Fig. 4.15



Estimated Total Annual Nominal Capital Investment in New Scottish Gas Companies

1850 - 1914

Source - vide infra pp. 1372 et. seqq.

Fig. 4.16

Extant Records of Initial Nominal Stock in New Gas Companies Compared with Date of Company Formation 1815 -80

Companies with above £7,000 stock

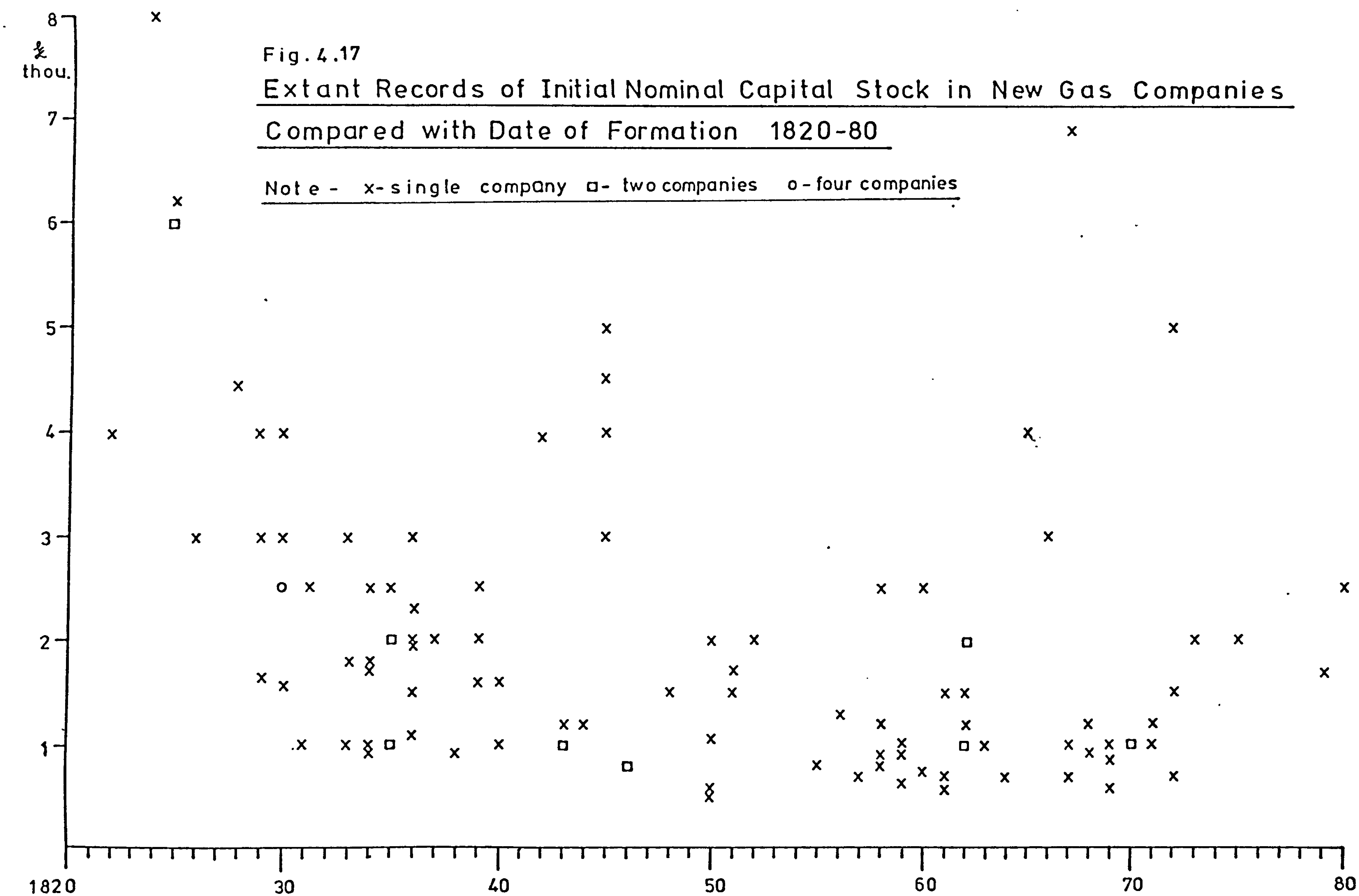


Fig. 4.17

Extant Records of Initial Nominal Capital Stock in New Gas Companies Compared with Date of Formation 1820-80

Note - x- single company □- two companies o - four companies

Total investment in the early Scottish gas industry is difficult to estimate[1]. Although detailed statistics are available[2] on eighty companies in 1853, and 22 companies before 1840, several problems hinder extrapolation for the further 98 companies known to have been operating in Scotland in 1853. At that date, nominal capital was usually synonymous with paid-up capital, but not with the market "value" of fixed capital stock. Before 1840, variable quantities of nominal stock remained unissued. Conversion of the nominal capital stock to a percentage of the total town or village population[3], in both periods shows great variation, and although this may be due in part to 'reploughing' or unissued reserve stock, several other factors appear to be involved. Inverness in 1853 had a capital stock £240 per cent higher than the population, and two possible explanations are inaccurate population statistics, and the use of gas by industrial premises.

In several cases, capital investment was apparently more closely related to industrial activity than to town population, for example at Kinross and Milnathort in 1835 (129 per cent), and Innerleithen in 1846 (101 per cent)

Table 4.18 Anomolous Investments (1853) (Nominal Stock £ as % Town Population)

Bervie	114%	Blairgowrie	126%	Coupar Angus	149%
Dundee	113%	Dunfermline	100%	Inverary	107%
Stirling	114%	St. Andrews	113%	Leslie	139%
Aberdeen	12%	Arbroath	13%	Cullen	1.9%
Nairn	18%	Linlithgow	24%	Rutherglen	29%
Bathgate	29%				

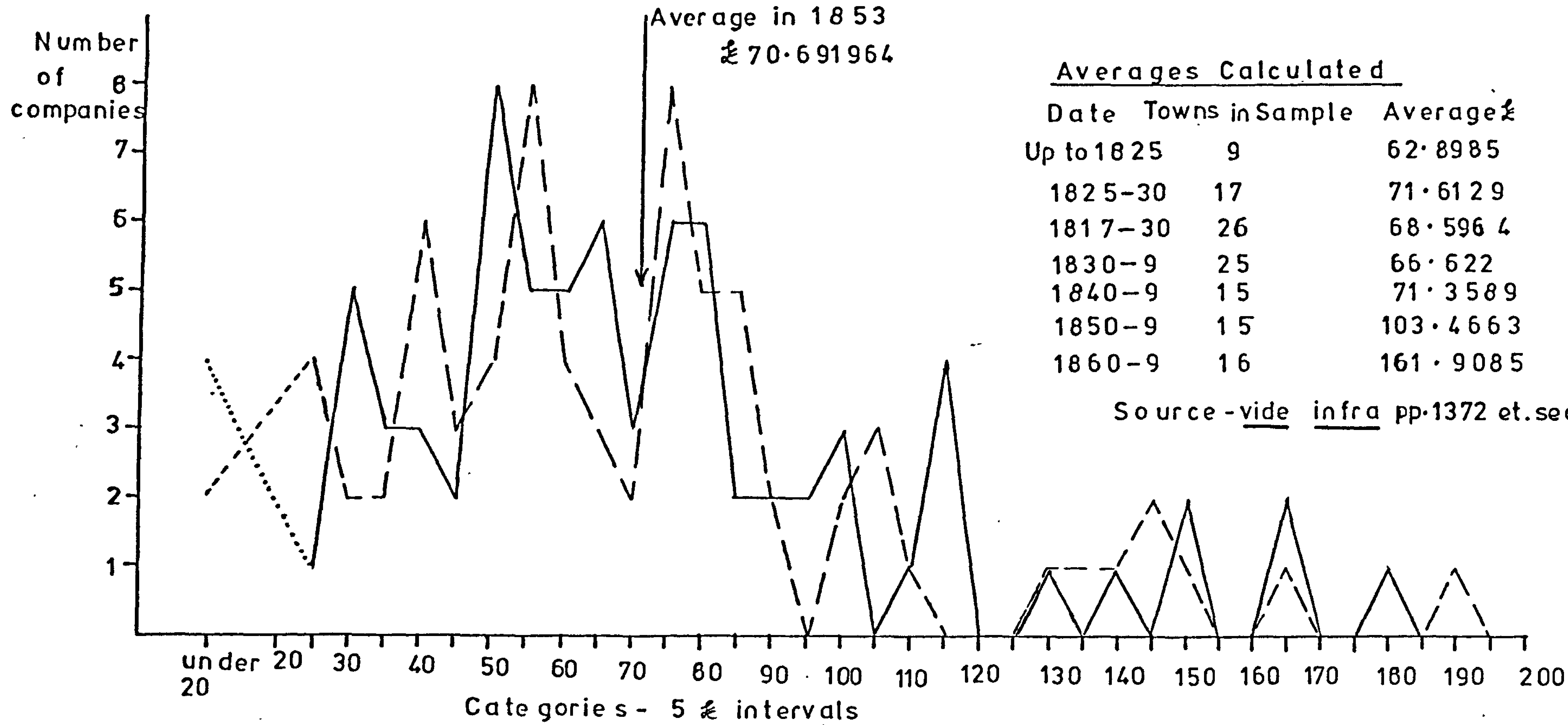
Sources - Vide infra p. 1383

Abnormally low 'apparent' investment could be the result of reploughing or a hostile market caused either by high prices or the desire by manufacturers to produce their own gas supply.

1. As one aspect of gross fixed capital formation, even in the 1830s-40s, this is relevant to the problem of W.W. Rostow's theory on the increase of capital formation from 5 or 6% to 10 or 12% per year. Recent evidence has suggested that the rate did not increase above about 7% until the 1830s or later.
J.P.P. Higgins and S. Pollard, Aspects of Capital Investment in Great Britain 1750-1850 (1971) p.1

Fig. 4.19 GRAPH OF NOMINAL CAPITAL INVESTMENT IN GAS COMPANIES PER 100 RESIDENTS IN MARKET TOWN

Sample - pre 1850 74 towns; 1853 78 towns



Averages Calculated

Date	Towns in Sample	Average £
Up to 1825	9	62·8985
1825–30	17	71·6129
1817–30	26	68·5964
1830–9	25	66·622
1840–9	15	71·3589
1850–9	15	103·4663
1860–9	16	161·9085

Source - *vide* *infra* pp·1372 et.seqq

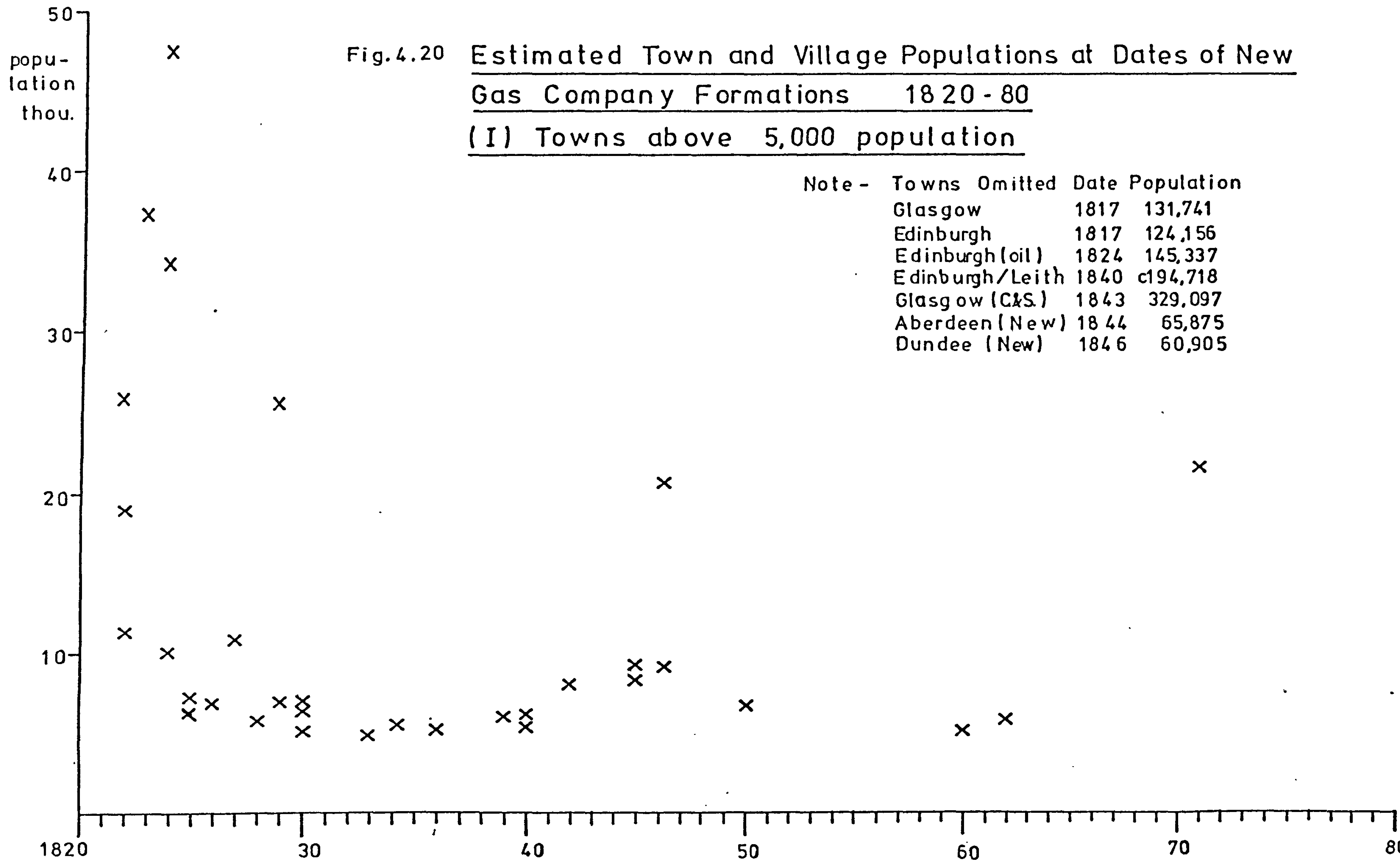


Fig.4.20 Estimated Town and Village Populations at Dates of New Gas Company Formations 1820 - 80

(I) Towns above 5,000 population

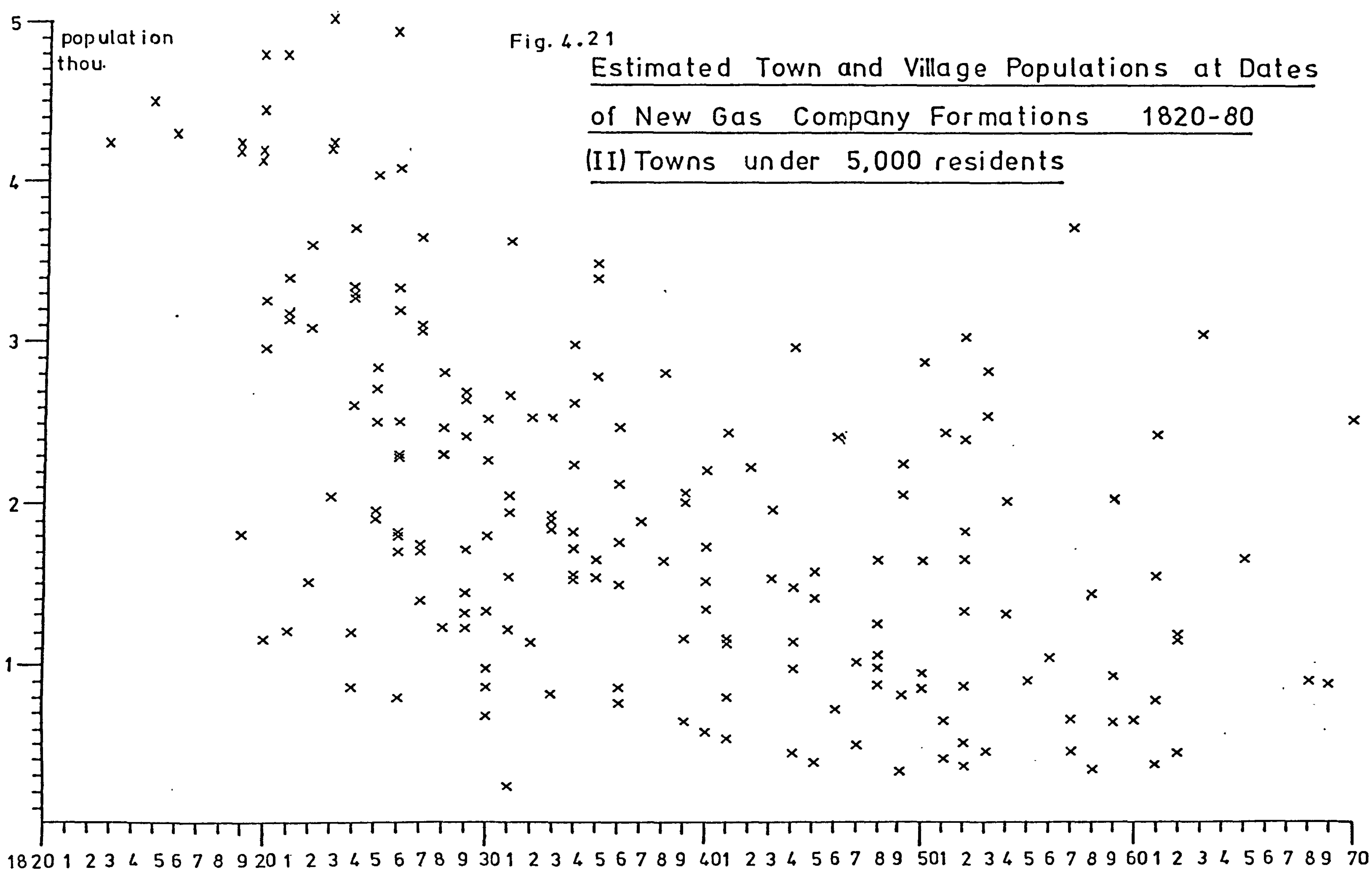
Note -

Towns Omitted	Date	Population
Glasgow	1817	131,741
Edinburgh	1817	124,156
Edinburgh (oil)	1824	145,337
Edinburgh/Leith	1840	c194,718
Glasgow (C&S.)	1843	329,097
Aberdeen (New)	1844	65,875
Dundee (New)	1846	60,905

Fig. 4.21

Estimated Town and Village Populations at Dates of New Gas Company Formations 1820-80

(II) Towns under 5,000 residents



There is no definite pattern relating to population size and the date[1] of company formation, and inadequate datum to show a periodicity in company size and date of formation[2]. The call-up of capital, moreover, may have been delayed one or more years after the company formulated its contract[3]. Therefore, although it remains possible that engineers advised "blocks" of capital stock in a definite series on the basis of very rough population/consumption estimates, it is impossible to calculate the possible capital-stock of companies in individual towns where data are not available. The approach has therefore been made through the average percentage of nominal capital to population in the sample of 1853.

This provides a 'Percentage Multiplier' which has been applied to the total population of towns with companies in 1853 where the nominal capital is not known. It has also been used with the estimated populations of all towns where the gas companies commenced in the same year, which gives a rough approximation of total nominal capital formation in each year up to 1850.

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2. Vide infra Appendix III

3. Census data before 1851 is fragmentary, and many of the population statistics used here are only estimates
Vide infra Appendix III

1. Dates also may be inaccurate. A new company built a new gasworks at Muirkirk in 1860, for example, but a company was operating there in 1853.
Date sources are given in Appendix XVIII

2. Falkus postulated such periodicity, but when companies formed so rapidly in the 1830s-40s it was not operative.
M.E. Falkus "The British Gas Industry Before 1850" Economic History Review 1967 II Series Vol XX op cit

3. e.g., Banchory vide ~~supra~~ infra p.852

These calculations show a nominal capital stock investment in the Scottish gas industry of about £1,178,939 by 1853, but it is probable that a further £500,000 to £750,000 of loan capital[1] was also in use. By comparison, G.R. Porter in 1851 estimated a total of £10 million invested in all British gas companies[2], a figure which now appears to be an understatement. Another national estimate was made in 1860 by G. Flintoff[3] who claimed that 991 United Kingdom towns were supplied with gas. The Gas companies had an annual expenditure of about £25,041,309 and the 95 municipal[4] and private gasworks an expenditure of £2,114,309 making in total £27,155,814. Scotland was believed to have 149 unincorporated companies and 8 parliamentary companies, Ireland 52 and 4, and England 533 and 150 respectively. Later statistics are given in Appendix VI.6.

Gas companies were afflicted by two important types of debtors: shareholders who refused to pay calls upon their shares, and consumers who failed to pay their gas 'rent'. Both were summarily dealt with, involving minimal difficulty; the former by forefeiture[5] and the latter by cessation of supply[6]. Very few companies allowed underpaid shares to remain on the books[7]. Ivergorden[8] company, was formed in 1872 and issued

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1. *Vide infra* p.779
2. G.R. Porter *Progress of the Nation* (1851) p. 624
3. *Engineering and Mechanics Magazine* 1/3/1860
4. Manchester municipal gasworks were the most important. R.H.I. Palgrave *The Local Taxation of Great Britain and Ireland* (1871) p. 60
5. A provision in contracts of co-partnery *Vide infra* pp.908, 904
6. *Vide infra* p.858
7. c.f. Grantown company in 1844 commenced with the issue of 600 shares, on which a full call of £1 was made the same year. £49 was not paid, and £40 remained unpaid until the company dissolved in 1898 (i.e., 6 per cent of the total £700 capital stock issued by 1866) S.R.O. (BT2/168)
8. S.R.O. (BT2/404)

783 shares, of which 11 were forfeited the same year, and £24 remained unpaid on the others. Strichen company also began in 1872, and issued 645 shares of £1, out of which 30 with £13 paid-up were declared forfeit in 1874.

Early nineteenth century investment practice did not invariably conform to this pattern. Annan company[1], in which £3000 stock was subscribed by 70 local residents in 1837, made four calls of £1 on £5 shares during 1838, but the final call of £1 was delayed until 1856 and used to finance extensions of capital equipment. Boness company[2] practised 'leviation' in 1844 when rising construction expenditure led a general meeting to add £1 to the price of all £5 shares already issued and paid up.

The precise order of fiscal decisions may be seen at Dunfermline[3] where a public meeting[4] in October 1828 decided from broad generalizations without engineering estimates, that a gas company required a capital of "not less than £4000" in £10 shares. By November when the company was actually formed, subscriptions had been received for £4450 stock. A month later, when Directors had been appointed, they called up 25 per cent on all shares and received £1057.10.0d. One Director was empowered to operate a company account at the local Bank of Scotland branch. Two months later, recalcitrant subscribers were given one week to pay their installment, or forfeit the shares, and only four failed to comply. Only at that stage was a consultant engineer chosen, who estimated the total cost at £3000. In March 1829 land was purchased, and then contracts placed for masonry and the gasholder-tank. One month later, another call of 25 per cent was made

1. S.R.O. Annan Minute Book op cit 16/12/1836, 13/2/1837, 2/4/1838, 10/8/1838, 7/4/1856, 6/5/1856

2. Calls made; £1 on 27/11/1843, £1 on 8/12/1843, £2 on 2/2/1844
By 1/9/1843, 168 shares of £5 subscribed (£840). By leviation, nominal stock rose from £1000 to £1200, but each existing shareholder paid the full £6 in calls (£1008) because equipment expenditure was £1184 by 28/12/1844 of which only £54 was unpaid
S.R.O. Boness Minute Book <u>op cit</u>
<u>Vide infra</u> Appendix V

3. Dunfermline Ref. Lib. Dunfermline Minute Book op cit

and paid up within four weeks. Only then, in April, were contracts placed for the gas-apparatus, gas-holder and pipes. An Engineer was appointed as 'Superintendent' of the works, and only upon his advice were orders placed for consumers' gas meters, service pipes, and miscellaneous equipment like a 'Syringe' for pressure-testing pipes, a 'guage gasometer' and weighing machine.

Six months therefore elapsed between the first decisions on stock and the final orders for equipment. In a rising market this could critically influence total expenditure, and companies formed in the later 1830s tended to place equipment orders far more rapidly. At Dunfermline a third call of 25 per cent was made in June 1829, and in October recalcitrants were given 30 days to pay-up or suffer forfeiture. By December 1829, £3641 had been spent on equipment when a new factor emerged. Consumption had risen beyond all forcasts, and a further £1375 was required for extensions. The Directors believed that construction costs could be reduced by making the extension virtually a continuation of the original building work. The final call of 25 per cent was therefore made in March 1830, and two months later 100 new shares were created and offered for sale to the original shareholders, to meet the expenditure.

Very small gas companies which formed in the 1850s and later, and which registered immediately for Limited Liability, had the greatest problems in raising adequate capital, and many shareholders defaulted. Dalbeattie[1] company, formed in 1858 with £5 shares, undertook to call-up only £1.5.0d a year on the shares, though no transfers were allowed until

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4. Dunfermline Ref. Lib. Dunfermline Minute Book op cit 21/10/1828, 19/11/1828, 4/12/1828, 19/12/1828, 6/2/1829, 11/2/1829
Land for the site cost £350 (19/3/1829) In May 1829, £1058 received from call (1/5/1829, 14/5/1829); in June 1829 greater difficulty in obtaining payment, with only £1028 received by August (7/8/1829), 18/8/1829)

1. S.R.O. (B.T.2/45)

they were all fully paid-up. Meanwhile the Directors were empowered to borrow up to 75 per cent of the nominal value of total stock to finance construction work. Nevertheless many shareholders lapsed into arrears, and in 1862 the Company had to borrow a further £100 when it was unable to sell 20 reserve shares.

Table 4.22 Finance Problems at Dalbeattie (1859-67)

Date	1859	1860	1861	1862	1863	1864	1865-7
Nominal Capital	£900	£1000	£1000	£1000	£1000	£1000	£1000
Shares Taken	180	180	180	180	180	200	200
Called-Up	£1.5.0	£2.10.0	£3.15.0	£5	£5	£5	£5
Received	£219.7.6	£445	£590.12.6	£8247.6	£968.15s	£968.15s	£1000
Unpaid	£5.12.6	£355	£209.7.6	£175.12.6	£31.5s	£31.5s	-

Source - S.R.O. (B.T.2/45)

The mistake may have been made in the choice of £5 denomination shares, as many companies of a similar size using £1 shares were able to make a full call upon their shares in the first year, and only suffered short term arrears during that year[1]. One exception, however, was the Aberlour[2] Company in Banffshire, with a nominal capital of £650 in £1 shares.

Table 4.23 Finance Problems at Aberlour (1860-68)

Date	Number of Shares Subscribed	Called-up	Received	Unpaid	Number of Shares forfeit
1860	518	£1	£466.10.0d	£66.10.0d	5
1861	523	£1	£471	£25	27
1862	523	£1	£481	£12	17
1863	523	£1	£491	£10	22
1864	523	£1	£491	£10	22
1865	497	£1	£484	£15	27
1866	497	£1	£483	-	27
1867	497	£1	£477	-	33
1868	497	£1	£482	-	

Source - S.R.O. (B.T.2/48)

1. *Vide infra* p.1824

2. Amounts "received" as stated to the Registrar of Companies S.R.O. (B.T.2/48)

Gas Company promoters by the 1820s produced in advance rough estimates[1] of potential costs and profits, but despite attempts to obtain accurate information for such projections, the extant figures demonstrate only annual calculations and not detailed analyses of working costs. In 1821 William Spittal[2] made "a most minute enquiry" into gas-lighting at Glasgow and Edinburgh before suggesting the formation of a gas company in Alloa. The project was not fulfulled, but Spittal prepared the earliest financial calculations for a small Scottish gasworks.

Table 4.24 Plan for Lighting Alloa with Gas (1821)

	£
Annual Expenditure	
Interest on £1600 capital stock	80
80 tons Coal (7000 cu ft gas per ton) and Furnace Coal	40
Fireman and 'Lighter's' wages (10.0d per week)	26
Superintendent of Gasworks	25
Contingencies	50
Total expenditure	221
Estimated Revenue	
Gas for Street Lights (equal to average oil lamps over past 5 years)	70
Gas for shops, warehouses, breweries, dwelling houses	200
	270

Profit £49 for 5% dividend

Source: S.R.O. (C.B. 10/13)

"Dividend" was quite separate from "interest", meaning dividend equal to the current rate of interest on loans. Spittal proposed that when the Contingency Fund reached £200, "dividend" would be raised from 5 per cent to 12 per cent. The price of gas was to be reduced for shareholders in proportion to their investment, 5 per cent on one share, 10 per cent on 6, 15 per cent on 10 shares, a scheme which later companies did not adopt.

1. c.f. S. Pollard Genesis of Modern Management (1968) p. 257
2. This estimate was made during a critical phase in the change from private gasworks to joint-stock company organization S.R.O. Coal Board Records (C.B.10/13)

The importance of public lighting, and the accounting practise of declaring coal expenditure less revenue from by-products[1], were both emphasised in the prospectus for Perth Gas Company in 1822.

Table 4.25 Financial Estimates for Perth Gas Company (1822)

	£	s.	d.
Annual Expenditure			
Coal	823	10	0
Coke and by-product revenue	672	0	0
"Supposed loss on coal annually"	151	10	0
Other expenditure	620	0	0
Total	771	10	0
Annual Revenue			
186 street lamps at 33s.0d each (based on average cost of oil lamps for past 5 years)	306	18	0
1500 private lamps at 25s.0d each (time contracts)	1875	0	0
Total	2181	18	0

Source. Perthshire Courier 13/12/1822

The expected profit[2] of £1410 was enormous (182 per cent) in comparison to anticipated total annual expenditure, and was expected to give 10 per cent dividend on £10,000 capital as well as "an undivided surplus of 410 L for additions to the works, incidents etc." The public lamps could be relied upon, and promoters claimed that if the private lamps 'for a year or two' did not exceed 1000, they could still pay 5 per cent dividend and place £300 into a reserve fund.

One factor which was inadequately recognized in early estimates of capital expenditure was the effect of fluctuating demand during each year. While gas was used only for illumination, the high peak of winter consumption produced heavy overheads for fixed capital which was lying idle throughout the summer. At Aberdeen[3] in 1839 the daily output in winter was 140,000 cu ft when about half of the 64 retorts were normally in use, whilst in summer only about 18,000 cu ft per day was consumed, using 4 to 10 retorts. Glasgow[4] in the 1830s used about 105 retorts in winter but only 30 in summer, and a similar pattern persisted throughout the century. In 1868

1. A practise still followed by Flintoff in 1860 Vide infra p. 1158; also p.797
2. Pershire Courier 13/12/1822 p. 3
3. New Statistical Account Vol. XII p. 75
4. New Statistical Account Lanarkshire pp. 162-5

the Glasgow City and Suburban Company[1] had to meet a demand of 3,060 thousand cu ft on 21st December compared to only 534 thousand cu ft on 19th June. During 1845-6 the Dundee Company[2] required a gasholder capacity of 250,000 cu ft to supply a maximum winter demand of 300,000 cu ft per day, though in summer the consumption was as low as 40,000 cu ft per day.

Payment for construction work was usually made in installments, of which the last could be witheld if the work was unsatisfactory. When David Laidlaw designed Callander gasworks in 1860, a local mason, T. Turnbull, contracted to erect the dwelling house and other masonry work for £326. He was paid £100 in mid-September and again in mid-October, but the company refused to make a final payment on the basis of incorrect workmanship and a leaking clay-puddle gasometer tank. Turnbull was forced to sue the company[3], but was successful only when he proved that the errors were caused directly by the negligence of Laidlaw and the Directors.

Originally, insufficient capital in many gas companies resulted primarily from the attempt to demonstrate as cheaply as possible the practical value of this illumination to a sceptical and largely conservative market. Bathgate gas company, for example, began in 1833 with a nominal capital of £1000, and had no debts until 1838, but had to operate with under £124 working capital.

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1. Glasgow City archives Miscellaneous Papers Vol. 15 (465) Report by S. Stewart (Greenock)

2. Evidence of J. Russell H. Commons 1846 Vol. 98 25/3/1846 p. 38

3. S.R.O. Unextracted Process (Currie Dat.T. 8/29) Callander Gas Light Co. 1860 Includes detailed engineering specifications by Laidlaw
Laidlaw *vide supra* p.140

Table 4.26 Bathgate Gasworks Expenditure 1833-5

		£
Capital Equipment	- Erection of Works and Main Pipes	830
	Consumers' Gasmeters and 'Jets'	44
Working Costs	- Coal and Manager's Wages	68
	Miscellaneous	22
Reserve Funds	- Cash in Bank	32
	Cash held by Treasurer	2
		996

Source S.R.O. Bathgate Minute Book op cit

Local financial support was frequently inadequate, and although gas company promoters always claimed that the sale of shares would provide all fixed and working capital, a large proportion of companies did require loan capital during the first decade of their operations. Cupar[1] company in Fife commenced in 1830 with a nominal £2500, but even in 1841 £630 remained unsubscribed. Heavy loans were taken almost immediately, so that no dividend could be afforded during the first five years, and the market value of shares fell from £10 to £6, discouraging other potential investors. Stranraer[2] company began in 1836 with a nominal £2000, £1400 was very gradually subscribed, whilst difficulties in arranging for a supply of coal[3] also delayed completion of the works until 1840. In the absence of sufficient shareholders, a Bill of £550 had to be taken to cover the debts incurred during construction.

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1. Heavy reinvestment of profits in the early years to complete the necessary equipment was required at Cupar.
S.R.O. Cupar Minute Book op cit 6/3/1851

2. David Guthrie, a leading promoter of Stranraer Company in 1836, recalled that"it was not thought a good investment then, and great difficulty was experienced in getting up the Capital, and also in regard to a site" Hence a bank loan became necessary. Total £698 debt by 1840
S.R.O. Stranraer Minute Book op cit 18/9/1882, 31/8/1840, 26/10/1840, 12/12/1840

3. In 1839 it was stated that expensive fuel "prevents the establishment of any extensive manufacturers in the parish", and a few weavers were the only industry in this market town.
New Statistical Account Vol. IV p. 97

Dalkeith[1] gas company began in 1826 with a nominal £3000, but a decade later only £1520 had been subscribed. In July 1827 the company also fell into dispute with its consultant engineer, W. Tait C.E., and employed a second engineer. Tait threatened legal action and obtained £200 compensation out of court; a large sum compared to the cost of the entire retort-house apparatus at £118. The dispute further discouraged investors and a loan of £600 had to be taken. Once construction of a gasworks had commenced, there was a powerful incentive to complete the works and obtain some recompense for the investors.

When equipment contracts had been signed, the cost of installation was fixed. In a period when many new gas companies were purchasing equipment, however, competition for limited supplies may have raised prices in the interval between the original deliberations on the capital stock required and the placing of contracts. This was probably the case at Lesmahagow, but elsewhere it is difficult to distinguish this from the possibility of deliberately inadequate stock.

Selkirk[2], for example, began in 1835 with a nominal £1100, but immediately placed contracts for equipment totalling £1133, and in 1840 was still in debt for £400. Similarly Muirkirk[3] began, as a limited company, in 1861 with a stock of £1000 all paid-up, but spent £1736 that year on capital equipment and borrowed £548 from the Clydesdale Bank. The nominal capital in those cases was perhaps set at the maximum which the potential but reactionary investors were willing to contemplate.

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1. S.R.O. Dalkeith Minute Book op cit 30/1/1827, 26/5/1827, 6/8/1827, 2/10/1827, 1/7/1827, 16/7/1827, 19/1/1828, 10/6/1836

2. Selkirk purchased £398 masonry, £260 pipes, £375 gas apparatus S.R.O. Selkirk Minute Book op cit 2/3/1835

3. Calls on £1 shares: 2s.6d. on 27/7/59; 5s.0d on 20/8/1859 and 17/9/1859 and 7/11/1859; and finally 2s.6d. on 1/12/1859 S.R.O. Muirkirk Minute Book op cit 6/12/1859

Elsewhere inaccurate engineering estimates were to blame. In 1839 the Vale of Leven[1] company at Alexandria decided on a capital stock of £2500 upon the advice of their consultant engineer, Mr. Cook of Paisley. Within two months it was seen to be inadequate and a further £500 stock was created, but this was not subscribed until 1840 because construction problems dismayed the shareholders. Besides higher costs, leakage from a masonry gasholder-tank led the contractors to use extra puddle clay costing £82. The Directors refused to pay extra, and legal action was rumoured. By June 1840 total expenditure had reached £3035, but the subscribed capital was only £2470, and £500 had to be borrowed on a Bill.

At Lesmahagow[2] the new company of 1844 had a nominal stock of £500, and their consultant engineer, J. Ritchie of Ardrossan, estimated construction costs at £474 including pipes. The work was delayed by complaints which led to a change of site, and by 1848 the cost had risen to £683. Although 590 shares of £1 had by then been subscribed and paid up, a loan of £100 was immediately required. The Bridge of Weir[3] company which commenced in October 1846, had a capital stock of £850 which was entirely subscribed by 1848 when the works were valued at £1280, of which £30 was the premium received for shares, and £400 loaned on Bill from the City of Glasgow Bank.

A very rapid initial extension of markets, combined with conservatism before the event, contributed significantly to the use of loan capital. Dalry company[4] commenced in 1834 with a nominal capital stock of £800 in £5 shares, but a blank space was left in the contract of copartnery. In 1835 a general meeting agreed instead to a stock of £950, though the Directors were still unable to judge the ultimate cost because

1. S.R.O. Vale of Leven Minute Book op cit 6/4/1839
2. S.R.O. Lesmahagow Minute Book op cit 6/9/1844, 19/5/1848
3. S.R.O. (B.T.2/3265)
4. S.R.O. Dalry Minute Book op cit 4/2/1834

of "additional outlays for the improvement or rather completion of the works"[1]. £1 was called up on shares in July 1834, a further £2 in September, and by March 1835 a full call had been received on the 159 shares subscribed[2]. In 1836 thirteen shares were sold at an upset[3] price of £5.5.0d, and a further 16 sold to existing shareholders[4] at £5.10.0d.

Nevertheless, loans soon played an important role in the company. In 1834 a three-months Bill of £60 was used as part of the payment to Messrs Barr and McNab[5] for equipment prior to calls on shares. In June 1835 no dividend was paid, and surplus profits were used as working capital, but the company Treasurer J. McCosh had still "advanced money from time to time out of his own funds"[6] and in August the company agreed to borrow £150 on Bill to repay him and all other debts. By 1836 this loan was provided by Miss L. Crawford[7], who with six shares was the second-largest shareholder in the company. A further loan of £72 from J. McCash was in use, but repaid later that year.

At Dunse, all Directors of the new company in June 1836 signed a letter of guarantee to Messrs. Cunningham and Hillston, agents for the

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1. <u>ibid</u> 18/6/1835
2. <u>ibid</u> 8/7/1834, 17/9/1834, 30/3/1835
3. <u>ibid</u> 14/5/1836, 30/7/1836
4. Dalry company was prosperous from the start. In 1835-6, on a share and loan capital of £1092, a profit of £48 (4.4 per cent) was made above an expenditure of £191. Revenue included £72 kitchen lights, £28 weavers lights, £84 metered gas, and £3 street lamps. S.R.O. Dalry Minute Book op cit 4/6/1836
5. Gas engineers of Abercorn Works, Paisley, which were later run by Hanna, Donald and Wilson. S.R.O. Dalry Minute Book op cit 25/10/1834
6. ibid 13/6/1835, 8/8/1835 Entire list of items of expenditure 1834-6, including £10 to A. Cook for plans and £8 for his assistance <u>Vide</u> <u>ibid</u> 4/6/1836
7. <u>ibid</u> 4/6/1836

British Linen Bank[1]:-

> "We hereby guarantee you and the Bank for whatever Sums may be overdrawn by the Treasurer and Chairman or two Directors of the Dunse Gas Company upon their Deposit account kept with you in the name of the Company, the over draughts [sic] not exceeding three hundred pounds"

Records are not available of the loans used during construction of that works, but in 1838 a general meeting authorized the Directors to borrow £250 to reply outstanding debts. In 1844 A. Darling recalled that the original capital stock of £1400 had been inadequate to complete the works, and since all those shares had not been subscribed "it appeared to the Directors of that time impolitic to attempt raising funds by creating and selling additional shares, as such shares could only have been disposed of at a great depreciation". Consequently, when the remaining shares[2] had been taken by "a few public spirited shareholders" the remaining capital was raised "from the Bank on the credit of the Directors", and at their personal risk if the Company had collapsed.

In order to repay the debt, dividend was restricted to 3% in 1837, and in 1838 when profits were adequate for 5%. 4% was paid in 1839 and 5% in 1840, 1841, 1842 and 1843. In 1843 a proposed bonus of 5% was rejected by the general meeting, and this parsimony which was designed to repay the bank debts was the origin of a process of reinvesting surplus profits[3], or 'reploughing', which characterised most gas companies. By 1844 Dunse Company had repaid all debts, and upheld Darling's motion "that in order to bring the capital [stock] of the Company nearer to the real outlay on the works, the sum of three hundred and fifty pounds be added and appropriated to the shareholders, in the proportion of one fourth of a share for each share held by them"[4]. Each old share of £5 was given a new nominal value of £6.5.0d.

1. S.R.O. Dunse Minute Book op.cit. 7/6/1836, 3/10/1838
2. Reserve shares sold at par to existing shareholders in 1837 ibid 4/7/1837
3. <u>Vide</u> <u>infra</u> p.819
4. S.R.O. Dunse Minute Book op cit 2/7/1844

From a review of railway investment, Gourvish and Reed[1] have recently suggested that during the 1830s and 1840s the Scottish economy demonstrated a greater willingness to provide loan capital than share capital. Thus while English[2] share-capital was of great importance to Scottish railways from the 1830s, large sums of loan capital were provided in Scotland. The new joint-stock banks[3] of the 1830s had a far more liberal lending policy than established Edinburgh banks, even to speculative railway schemes[4]. For the more modest requirements of early gas companies, "cash credit" or overdraft facilities were available for sums under £1000, granted against a Bond entered into by the borrower. These facilities, and personal loans, were of considerable importance to the gas industry on two separate occasions: during initial construction with a consequent liquidity shortage; and during major extensions like a gasholder or retort-bench required during booms in consumption.

The decision to use loan capital was normally a perogative of a general meeting of shareholders in gas companies. Company contracts, as explained elsewhere, specifically prohibited Directors from independently taking large loans, with their consequent risks, on behalf of the company except with the approval of most partners[5].

1. T.B. Gourvish and M.C. Reed "The Financing of Scottish Railways Before 1860: A Comment". Scottish Journal of Political Economy 1971 Vol. 18

2. e.g., 1845 Caledonian Railway obtained 21 per cent capital from Scotland, 55 per cent from London and Home Counties, 16 per cent from N.W. England.
   J. Butt and J.T. Ward "The Promotion of the Caledonian Railway Company" Transport History Vol. III 1970

3. e.g., 1832 Western Bank (crashed 1857 through excessive loans); 1839-78 City of Glasgow Bank; 1838 Edinburgh and Leith Bank. Thomas Blaikie, Provost of Aberdeen, a Director of Greenock Union Bank (1840) was also a gas company promoter with 250 shares in Banchory company in 1845. Maxwell claims that Scotland became "over-banked" because so many branch offices were opened in small towns and villages to channel deposits into the main industrial and commercial centres.
   W.H. Marwick. Economic Developments in Victorian Scotland (1939) op cit pp. 75-80
   M. Gaskin The Scottish Banks - A Modern Survey (1965) p.34
   J. Reid The History of the Clydesdale Bank 1838-1938 (1938) op cit p.73

Unlike a shareholder, a person lending money to a gas company could demand regular interest and became a preferential creditor if the company collapsed. These were considerable advantages in an apparently high-risk industry. Company Directors usually took personal obligations for all loans, although the Company made provision to indemnify them, by clauses in the company contract of co-partnery or by the resolution of a special general meeting. In 1860, for example, £100 was advanced by Mr. Gibb, banker, to Lesmahagow company[1] after a minute had been entered into the company books "signed by the Directors authorizing Messrs. Brown and Henderson to sign a joint Bill for the same; Bill to be renewed every four months till paid".

Unsubscribed shares were not accepted as "reserve liability" although some companies tried to use them in this way to obtain loans. The Vale of Leven company[2], with 106 "reserve" shares in 1840 was unable to obtain cash credit from a bank "to the extent of the value of their unsubscribed stock". Such credit would have been in the Company's name, and in 1842 the Clydesdale Bank refused such credit to the Vale of Leven Company[3] even when the Directors, who wished to obviate "stamps and discounts", offered a supplementary personal guarantee. Instead the Bank would only renew a Bill of £500, granted to the Directors, with a fixed time-limit of 18-months for repayment.

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4. e.g., June to Dec. 1839 Glasgow, Paisley and Greenock Railway raised 53 per cent in loans. 1826 Royal Bank loaned £10,000 to Monkland and Kirkintilloch Ry., 1838-42 Glasgow Union Bank £50,000 overdraft to Glasgow, Paisley, Kilmarnock, Ayr Ry. Gourvish and Reed Scottish Journal of Political Economy 1971 op cit

5. Vide infra p.926

1. S.R.O. Lesmahagow Minute Book op cit 14/12/1860
2. S.R.O. Vale of Leven Minute Book op cit 13/4/1840, 20/12/1842
3. ibid 20/12/1842, 29/5/1843, 13/10/1847

Bills or Promissory Bills were promises of payment plus interest at a specified future date, given to a lender in return for a loan. Originally they were used in trade by, for example, a manufacturer who received raw materials as the loan, and repaid it in cash a few months later by the sale of the manufactured goods. Gas companies provided such Bills to a Bank[1], or a private lender, in return for a cash loan. The interest and stamp duty paid was far greater than for bank overdrafts or mortguages, and although the stipulated time limit for repayment provided greater security to the lender, it was a cause for great anxiety to the gas company. Bills were frequently renewed, but like terminable Debentures[2] used later in the century, a lender could always demand cash payment at the termination date.

Because Bills had to be used to purchase fixed capital equipment, and not just saleable raw materials, any such termination forced a gas company to obtain other Bills elsewhere at the market price, to repay the debt; or to sell extra shares at a time when the uncertainty afflicting the lender may have also affected potential buyers; or to enter liquidation. In most cases, new Bills were used, but the insecurity of such loans led companies to seek, where possible, mortguages and personal loans[3] with greater stability of interest rates and of longer duration.

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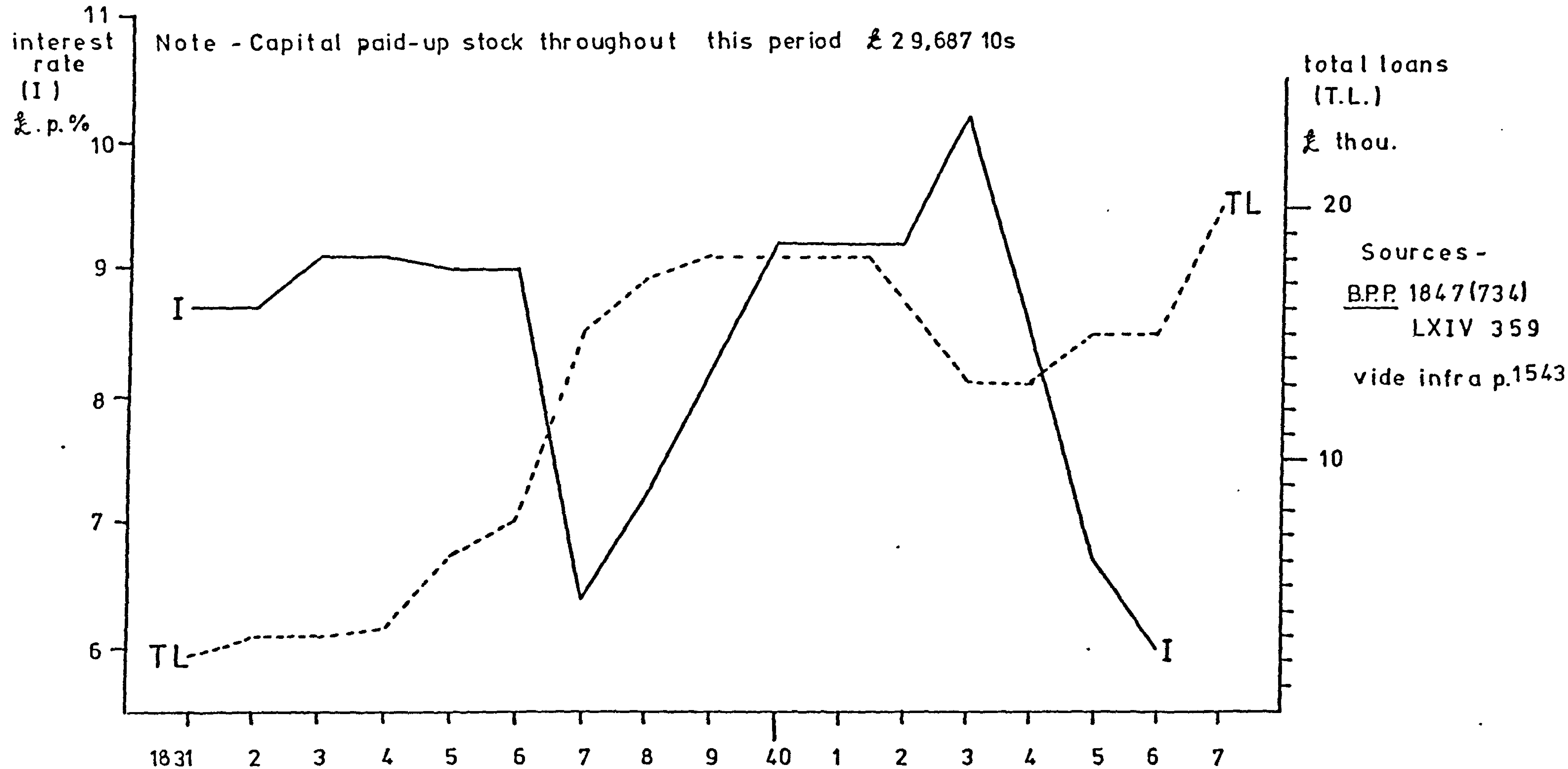
1. Banks charge an interest, or 'discount', against Bills which varied according to their assessment of the risk of non-payment; formerly Banks provided cash against Bills which had already been accepted as payment, e.g., by a trader from a manufacturer, and the 'discount' was the amount less the face value which they paid in return for the risk of collection.
   P. Deane <u>The First Industrial Nation</u> (1965) <u>op cit</u> p. 172

2. Non-terminable Debenture Stock, without voting rights, was a solution adopted by a few prosperous gas companies in the late nineteenth century.

3. These were more freely available after 1854 when the 5 per cent maximum limit on interest rates under the Usury Laws was abolished for loans secured against real property. In 1833 that limit had been first repealed on 3-month Bills discounted at the Bank of England.
   S.G. Checkland <u>The Rise of Industrial Society in England 1815-1885</u> (1969) pp. 196, 359

Fig. 4.27
Relationship between Total Loans and Interest Rates Paid on Loans at Dundee Chartered Gas Company 1831 - 46



Greater faith was apparently placed by lenders in Chartered companies, which probably used a lower percentage of loans than other gas companies. Glasgow City and Suburban company in 1857 had a capital stock of £150,000 of which £115,000 was issued and bank loans of £29,000, or 25.2 per cent extra, but never used the mortgage powers[1] allowed by Act of Parliament. "Parties were willing to advance money without the expense of mortgage security; and the company preferred borrowing from the bankers instead of exercising their loan power"[2]. Glasgow old company, which had a maximum mortgage borrowing power of £10,000 under an 1826 Act, by 1857 had a capital stock of £150,000 and loans of £35,000 from "bankers and others"[3]. £12,000 of loan capital had been spent on capital equipment, and the remainder was used as trading capital.

Paisley[4] chartered gas company, with a paid-up capital stock of about £16,000 took a series of loans from private individuals in the late 1820s, to a total of £4050 equivalent to 25.3 per cent of the stock, in 1829. The company increased its capital stock to £25,200 in 1832-3, and thereafter ceased to use loans. Dundee old company[5], however, by 1846 had £20,000 on loans, equivalent to 69 per cent of the £29,000 capital stock. The Dundee company[6] continued to prefer loan capital, and in 1867 had an unchanged stock, but a mortgage debt of £50,000 at 5 per cent interest, which was 68 per cent larger than the entire capital stock.

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1. Chartered company powers to borrow on mortgage (bond) vide J.S. Will Michael and Will on the Law Relating to Gas, Water and Electric Lighting (1894) 4th Edn.p. 629

2. Evidence of S. Wrangham, a Glasgow Councillor J.G.L. 26/5/1857 p. 252

3. Glasgow old company by 1857 also had a "suspense account" of £29,000 surplus profits accummulated in 1836-57, and had spent £59,376 more on 'restoring' depreciated equipment during 1817-56. Including the reserve fund used as a "loan to [fixed] capital account", the total capital expenditure by 1857 had been £300,000
Evidence of J. White, a director of Glasgow Gaslight Company J.G.L. 26/5/1857 p. 257, 1/9/1857 p. 422

4. Paisley borrowed £1000 from Miss Alicia Dickson from 1826-32; £1000 from 1827-32; £2000 from Dr. Freer in 1827; £2050 from Mrs. Cowper 1828-30; and £2000 from James Scott in 1831-2
H. Lords 31/7/1844 op cit pp. 212-45 Vide infra p.1602 et. seqq.

5. The loans, at 3 per cent to 4 per cent interest, cost £800 per year. Dundee company paid no dividend in 1825 and 1826; 30s. (6.3%) in 1827, 32s.(6.7%) in 1828 and 1829, and an average 48s.(10.1%) from 1829-46. Per centages calculated on the paid up amount (£23.15s) of shares (nominal £25)
H. Lords 1846 Vol. 10 20/5/1846

By the mid-nineteenth century, Directors of unincorporated companies were increasingly unwilling to take the personal obligations for loans, which banks required. They were only able to use the Company name with private loans, and hence a preference developed for taking loan capital from private individuals, who were willing to accept the Company's security[1]. At Boness[2], the company's first, and continuing Chairman and Treasurer, Mr. Anderson, provided a "letter of security" to the Royal Bank for loans taken by the Company. In 1866, a local resident McNair, agreed to lend £500 to the Company, but insisted at first "that the Directors would officially and individually grant him a bond in security of repayment". The Directors refused, and instead of a "bond on the property of the Company", that is a mortguage, McNair agreed to take a "letter of security" like the Bank.

When Anderson died in 1870, none of the Directors was willing to provide a "letter of security", but they did accept responsibility for mortguages. That year they requested a large loan of £1500 from the Royal Bank on "bonds over the works and plant". The Bank refused, but by advertising in The Scotsman and Falkirk Herald, the Directors obtained four loans of £500 each from persons willing to accept "bonds".

However unsuitable Bills were, they remained the principal form of loans until at least the 1850s, and probably even the 1870s.

Table 4.28 Bills for Loan Capital used by Cupar Gas Company

1839	£750	from	James Russel
1844	£150	from	British Linen Company
1847	£300	from	R. Balfour

Source: S.R.O. Cupar Minute Book op cit

In 1849, Cupar company[3] borrowed £400 "on the Directors' Bill, payable

6. During 1868, in the months preceeding municipal takeover, the mortgage was repaid by issuing £50,000 extra capital stock in £10 shares which raised a premium of £2.10.0d.
J.G.L. 9/6/1868 p. 491

1. Mortgages in the Company name were one of the advantages of Limited Liability

2. S.R.O. Boness Minute Book op cit 19/12/1866, 24/12/1866, 9/1/1867 22/12/1870, 5/1/1871, 14/4/1871

3. S.R.O. Cupar Minute Book op cit 3/7/1839, 20/8/1844, 17/3/1847, 9/1/1849

12 months after date". Lesmahagow company in 1865 granted a Bill to obtain £150 on loan from a local farmer[1]. Galashiels[2] company obtained loans in 1847 by overdrawing the Bank account, and in 1859 on a mortgage, but in 1860 had to grant Promissory Bills to obtain further loans worth £1550. In 1868 when £4500 was borrowed against the security of the works, all the Directors were obliged to make "direct personal obligations for repayment". The bankers' axiom of telling a Bill from a Mortgage was widely accepted by private individuals and although the loans were used to purchase fixed capital, lenders were unwilling to consider them a long-term investment. Hawick[3] gas company, with a capital stock of £15,750 in 1888, had £2524 on loan on Promissory Bills.

Extensions to gasworks were financed by reinvestment of surplus profits, loans, or additional stock capital, in that order of probability. The initial lack of adequate stock produced an immediate and almost compulsory demand for reinvestment of profit, especially when demand frequently rose far more rapidly than the investors initially expected. Such reinvestment remained characteristic[4] throughout the century.

When additional stock capital was desired, new shares were usually offered preferentially to existing shareholders. This procedure was developed in the late eighteenth century by canal companies[5], and followed throughout the nineteenth century by gas companies. The Edinburgh gas

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1. S.R.O. Lesmahagow Minute Book op cit 20/12/1865
2. S.R.O. Galashiels Minute Book op cit 6/7/1847, 26/9/1856, 7/7/1860 13/3/1868, 30/6/1868
3. Annual output 30 million cu ft. Works valued at £26,040 and total liabilities £30,273, achieved by reinvesting surplus profits J.G.L. 1888
4. e.g., in 1881 the new Cove and Kilcreggan company paid no dividend, but reinvested 2.75 per cent profits on extending equipment J.G.L. 30/8/1881
5. G.H. Evans British Corporation Finance 1775-1850; A Study of Preference Shares (1936, Baltimore)

company prospectus[1] of 1817 stated that any increase of the capital stock, of £20,000 in £25 shares, would be in shares of the same value, and existing subscribers would have "the preference of taking the new stock in proportion to the shares they hold in the old". The idea was to give maximum benefit to those who took "the whole hazard of an experiment", while allowing them to refuse further contributions if the venture was unsuccessful.

Later in 1817 Edinburgh company obtained an Act conferring limited liability, but Parliament raised the stock to £100,000, to be paid up within 5 years in order tocoverany claims made for damages. In 1818, to achieve the minimum threshold set by the Act, Directors subscribed for £50,000 stock "in trust for the other members of the Company", and took that burden of risk without paying cash. Nevertheless, later in 1818 £15,000 was sold to outsiders, to finance extensions of the works. The following year, £35,000 was offered preferentially to the original shareholders, but both they and the Additional Stock partners subscribed for only £10,475 because of the early technical problems and lack of renumeration afflicting the company.

The perogative system retarded expansion of the Edinburgh company. In January 1820, forty shares were offered to the partners to finance retort-house extensions, but only 21 were taken. By the spring of that year confidence in the Company had returned, and the Directors sold 373 shares to the Original Subscribers and holders of Additional Stock, at the par value of £25, and 347 shares to outsiders at £32. These outsiders were not warned about the perogative clause in the Prospectus, and in 1822 when the market value of shares had risen to £45, they objected to the Directors' proposal to offer the remaining £30,000 stock to the

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1. Edinburgh Prospectus rule I
   S.R.O. Unextracted Process (McNeil R.16/2) S. Reid v. Gas Light Co. (1822)

Original Partners at £25. The Court of Session[1] prohibited the sale of that reserve stock except by public auction to the highest bidder, and this became the practise of all Scottish Chartered gas companies, but unincorporated companies continued to make preferential issues of their new stock.

Thus Boness[2] in 1846 issued 50 new shares of £6 to finance extensions to Kinneil Foundry, and allowed one share to be purchased at par by each person holding four old shares, and the remaining 15 shares to "be ballotted for". Another 50 new shares issued in 1850 were distributed at par in the ratio of 1 to 6 old shares. Limited companies followed the same practise. Blantyre[3] in 1875 offered 1500 new shares preferentially to existing shareholders, as did Innerleithen[4] with 600 shares issued in 1877 to finance extensions. When Baillieston[5] company issued new shares of £1.10.0d in 1913, existing shareholders were paid a bonus of 10s.0d to encourage them to make purchases.

Nevertheless, new share capital was often a less reliable source of additional funds than were loans. In 1845 Galashiels[6] gas company ordered a new gasholder for £576, which with other extensions was met by overdrawing the company account at the National Bank. The Coal crisis of 1846-9 produced discomforture with the debt, and early in 1848 351 new 'Half Shares' of £2.10.0d were issued preferentially to the shareholders to facilitate repayment. Few shareholders accepted, because gas consumption was declining. The shares were not taken up until later in 1848

1. In the case taken by S. Reid, W.S., against preferential issues of stock, he maintained that the Act entirely superceeded the Prospectus; that the reserve stock was "part of the property of the Company", as much as buildings, and every partner had an equal proportionate interest in it; and in the event of an accident, if no new investors had appeared, each shareholder would "have had his proportion of reserved stock assessed upon him" i.e., unissued stock was "reserve liability". No other resolution of this legal point has been located. ibid 'Case of Sylvester Reid' 8/8/1818
2. S.R.O. Boness Minute Book op cit 15/10/1846, 4/6/1849, 23/10/1850
3. S.R.O. (B.T. 2/120)
4. S.R.O. (B.T. 2/3998)
5. S.R.O. (B.T. 2/6249)
6. S.R.O. Galashiels Minute Book op cit 1/7/1845, 29/2/1848, 4/7/1848, 3/7/1849

when a new railway projected to Borrsbank was likely to reduce coal costs and even then the purchasers included 56 entirely new investors. During 1849 Stranraer[1] company issued 100 new £5 shares in order to reduce the loan capital. They were divided into Half Shares for equable distribution to existing shareholders, but even when 14 shareholders purchased additional fractions, 51 of the Half Shares could not be disposed of.

Preference shares were unpopular in the Scottish gas industry despite the similarity of investment problems with those of railway and canal companies where they were frequently used. G.H. Evans[2] suggests four reasons for preference shares in the transport industries. A long period of hazardous development preceded any profits[3], while unlike trading enterprises the profits were earned gradually and failed to produce unexpected bonuses to encourage investment. When capital was embarked in specialized equipment, the drive to complete work despite engineering problems which exhausted the original capital, led to the use of preference shares to ensnare extra investors during the railway and canal "manias". Remoteness from large capital centres forced many promoters to raise the original funds from numerous small subscriptions, including merchants who wanted better transport[4], and others with "a feeling of community obligation". Preference shares tempted these persons to invest again if a project seemed short of finance.

All of these problems were faced by Scottish gas companies, but,

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1. S.R.O. Stranraer Minute Book op cit 26/6/1849

2. G.H. Evans British Corporation Finance 1775-1850; A Study in Preference Shares (1936, Baltimore)

3. e.g., 2 years for the first 10 mile canal, Worsley to Manchester
   4½ years for the 27 mile Stockton to Darlington Railway (1825)

4. Businessmen like Edward Pease and Josiah Wedgewood, or the Cheshire salt producers and Staffordshire earthenware manufacturers who supported the Grand Trunk Canal.

lacking financial controls imposed by Parliament[1], they turned in emergencies to loan capital and this was normally both available and adequate. The Cupar company, which relied heavily upon loan capital from 1830, did not consider using Preference Stock until 1869 when the Directors thought it a good idea, because the dividend could be fixed at a lower percentage than that paid on Ordinary Shares. The Preference shareholders obtained preferential credit of a Company's assets and therefore theoretically took less commercial risk. A special general meeting, however, opposed the idea at Cupar and instead authorized extra loans for extending the works. Cupar first used Preference shares[2] in 1893, to raise £1550 in 4 per cent Prefenence Shares of £7, for financing extensive renovation of the works. By October, 153 of these shares had been purchased, but the holders were allowed "no vote or voice in the deliberations of the Company", and the system was regarded as merely a cheap alternative to obtaining loan capital. Lochgilphead company, formed in 1844 with a capital of £1200 in £5 shares, is the earliest Scottish gas company known to have used preference shares[3]. For extensions to plant, a general meeting in 1848 authorized 240 Preference Shares of 2½ per cent to be issued at £1.5.0d as "Quarter Shares".

Out of only eight Limited gas companies known to have adopted Preference shares, the practice did not develop[4] until the 1880s-90s, and especially in early 1900s when it may have been related to rapid expansion which was required to produce cheap gas to compete with electricity.

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1. Early Statutes, and Parliamentary Standing Orders from 1836, prohibited Railways obtaining more than 33% loans compared to share capital. Preference shares were used by the Aberdeenshire (1801) and Edinburgh/Glasgow (1824) Canals, and Edinburgh Water Co. (1819)
2. S.R.O. Cupar Minute Book op cit 24/3/1893
3. The coincidence of this action with the banking crisis of 1847-8 was probably significant.
S.R.O. (B.T.2/24)
4. _Vide infra_ p.1822

Frequently, loan capital was used as an extended form of reinvestment, or "reploughing in advance". Money used to repay the loan, and interest, was obtained from profits which could only be achieved by the extension of capital equipment, and more efficient manufacture, made possible by the loan itself.[1] In return, the Company took the risk that revenue would increase, the equipment was not faulty, and the loan would not be recalled inconveniently. Many manufacturers provided insurance against equipment malfunction[2], and no gas company appears to have suffered embarassment through the recall of loans.

Loans were therefore widely used for major additions to capital equipment which could not be financed by reinvesting current surplus revenue or reserve funds. This normally meant new gasholders[3], or reconstruction of the retort bench, at a time of rapidly rising consumption. Because industrial publications, like the Journal of Gas Lighting, recorded individual construction programmes of this nature, they provide a rough guide to the periods when loan capital was in great demand.

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1. Previously, "lump" capital loans have been regarded as an accidental feature, somewhat foist upon a Company when investment requirements were required more rapidly than surplus profits accumulated. If the loans had been a burden, however, greater effort would have been made to raise profits and to repay them in a shorter time.
   P. Mathias The First Industrial Nation (1969) p. 149

2. e.g., When Boness gas company built a new gasholder in 1851, Drysdale and Henderson received the tank contract in return for "warrenting the Tank watertight for the first year". The Vale of Leven company in 1860 agreed to experiment with a telescopic gasholder after inspecting others built by Reid and Hanna in Paisley and Glasgow, and obtaining a guarantee for that firm to repair any storm damage for one year after completion of the £220 holder.
   S.R.O. Boness Minute Book op cit 23/10/1851
   S.R.O. Vale of Leven Minute Book op cit 16/7/1860
   Fire and explosion risks Vide infra. p.273

3. e.g., Galston Gas company in Ayrshire purchased a new gasholder in 1885 using a loan at 4 per cent interest J.G.L. 30/6/1885
   As previously explained, new gasholders were usually much larger than their predecessors e.g., Dumbarton with total storage capacity of 90,000 cu ft in 1881 purchased one new gasholder with 140,000 cu ft. contents J.G.L. 29/11/1881
   Vide supra 'Technology' p.327; also p.829

A comparison of the ratio of loan capital to share capital in ten companies shows several with a very high level of loan capital in the 1830s, up to 144 per cent greater than the capital stock. Many loans were repaid during the early 1840s. Several periods followed in which demand for loan capital was particularly great:- 1847-8, 1853-6, 1861-8, 1873-5, 1884-5, 1900-2. These were periods of active growth, or crises caused by raw materials prices. Repayment predominated in 1849-52, 1869-72, 1875-83, 1887-1895, 1903-9 and as shown in Figures 4.29 and 4.30

Fig. 4.29

Loan Capital as a Percentage of Paid-up Share Capital

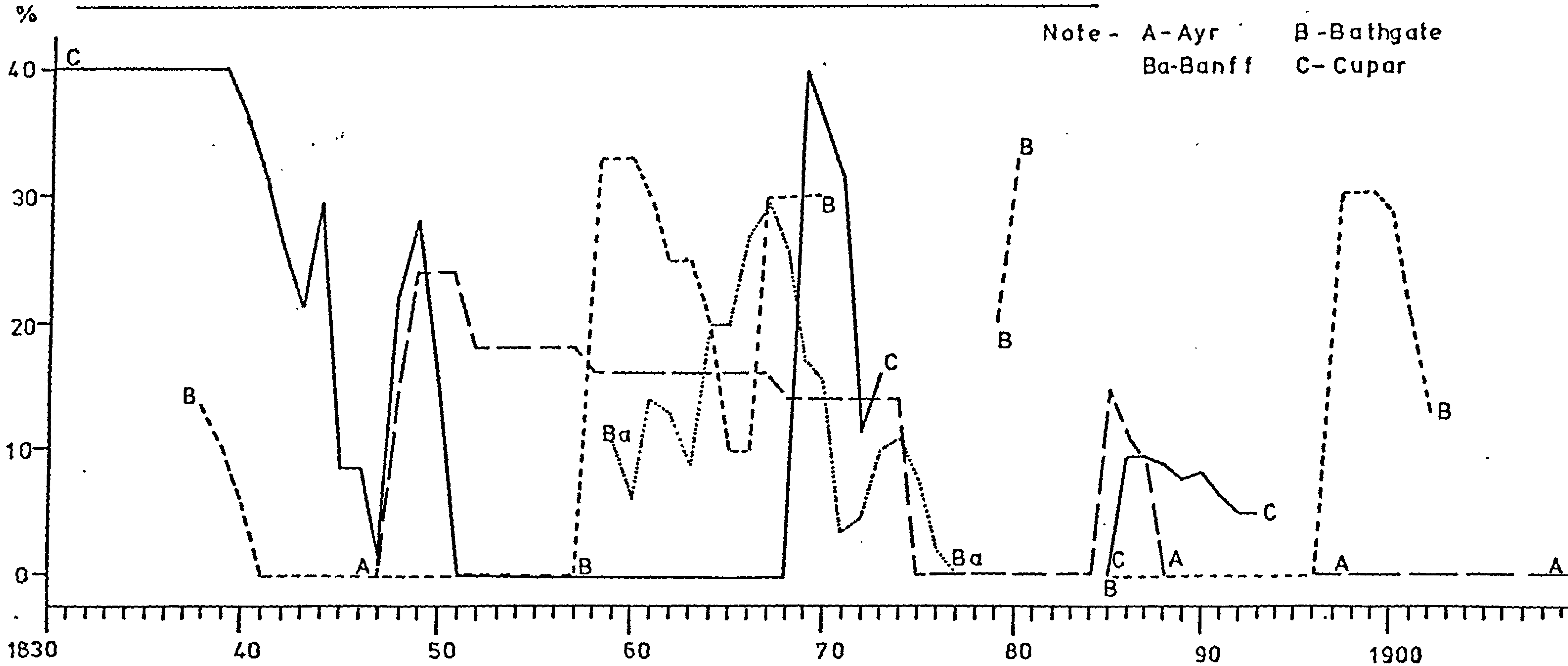
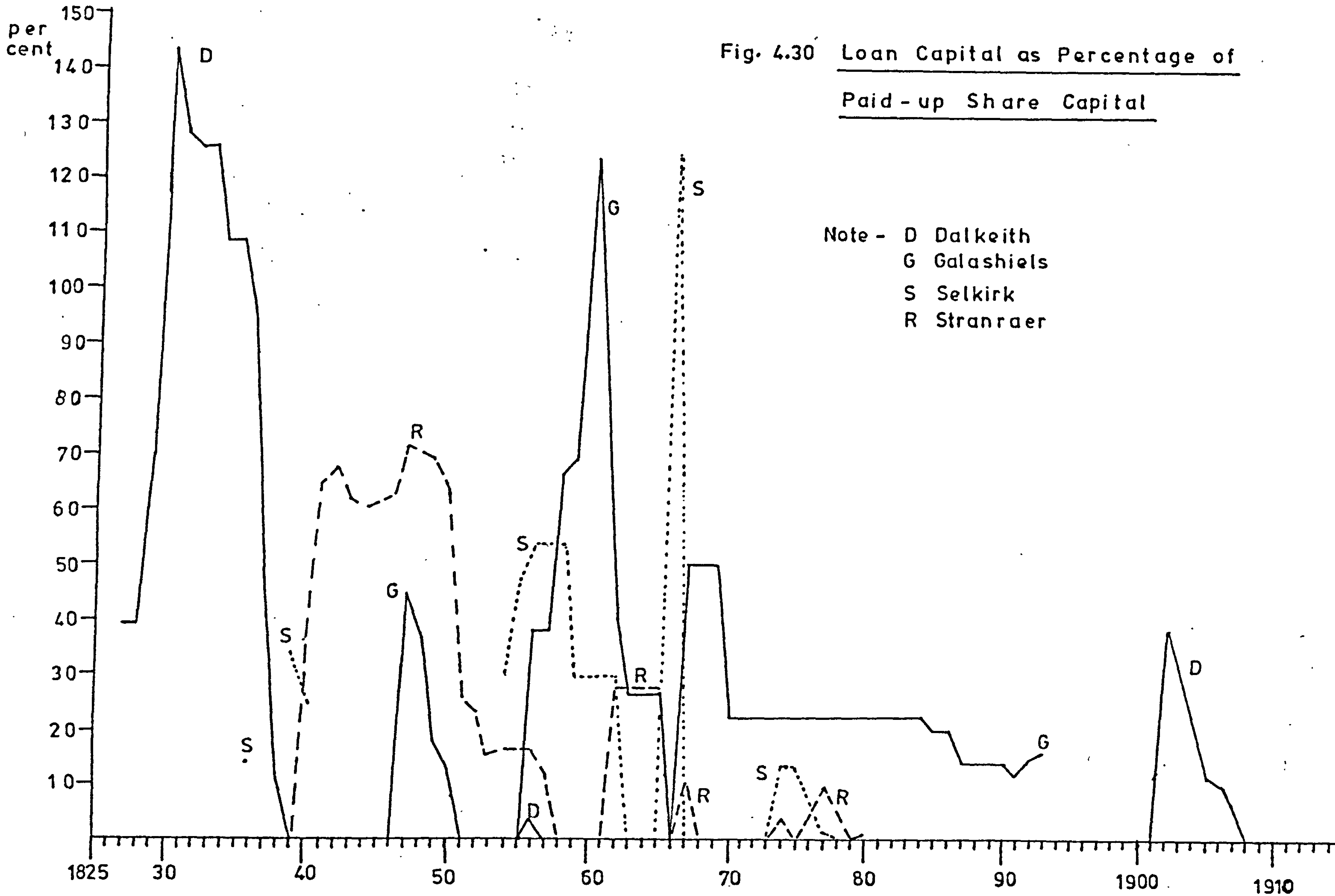


Fig. 4.30 Loan Capital as Percentage of Paid-up Share Capital



Even where share-capital was subsequently raised, loans were often taken during the immediate construction phase to prevent delays. When interest rates could be obtained which were lower than dividends[1], the shareholders gained more by borrowing money than by selling shares to outsiders, or paying cash for extra shares themselves. Instead, the loan was gradually repaid from profits, without depressing the dividend rates. Eventually, when it was paid off at the expense of the consumers, the nominal value of shares was increased correspondingly just as if the shareholders had financed the extensions from their own pockets.

Loan capital was also required on two other occasions, as working capital: during the coal crises, and during the liquidity crises which sometimes followed capital plant extensions financed by extra share capital. Cupar[2] experienced all four stages. A loan of about £750 was used in the 1830s because of inadequate initial investment. Further loans helped finance new gasholders in 1847, 1869 and 1886, and purchased coal during the 1873 crisis. Short-term loans were used in 1894 and 1901 to pay dividends and purchase raw materials, after the constructions of a regenerative retort bench and gasholder, both financed wholly by new share capital.

Table 4.31 Use of Loan Capital at Cupar (1830-99)

Date	Equipment Cost	Equipment	New Loans £	
1830-9		Gasworks Construction	750	Inadequate initial capital
1844		Manager's New House	150	No extra shares issued
1847	520	Gasholder (15,000 cu ft)	100	£210 new share capital
1869	990	Gasholder (30,000cu ft)	1000	No extra shares issued
1873			272	Coal Crisis
1886	933	Gasholder (31,000 cu ft)	600	No extra shares issued
1894	700	Regenerative Retort Bench	300	£1071 new Pref. stock issued
1899	2700	Gasholder (100,000 cu ft)	1000	£3679 new Pref. stock issued

Source - S.R.O. Cupar Minute Book *op cit*

1. Consumer complaints against Selkirk gas company in 1861 led the Directors to explain that debts at 4½ per cent interest were far cheaper than extra capital stock at 7½ per cent dividend. S.R.O. Selkirk Minute Book *op cit* 1/10/1861

2. *Vide infra* Appendix V

The relative capital expenditure necessary on various items of equipment is indicated by the Paisley capital account for 1845-70 (Table 4.32) and the Glasgow City and Suburban total expenditure account for 1844-59 (Table 4.33).

Table 4.32 Total Capital Equipment Expenditure at Paisley (1845-70)

	£	% Total
3 New gasholders (£6914) less sale of old (£2277)	4633	21.6
New retort bench (£2093) less sale of old material (£973)	1120	5.2
Mains and Service Pipes (inc. £7628 extensions)	11452	53.5
New coal stores (in 1852 and 1861)	1364	6.4
Branch railway	1364	6.4
Station meter	225	1.0
Steelyard and Weights	97	0.4
Ammonia purifiers (in 1863)	231	1.0
Exhauster and engine (in 1855)	275	1.3
Lime purifiers (in 1855)	213	1.0
Condenser (in 1863)	217	1.0
Chimney repairs and extension	161	0.8
Miscellaneous	56	0.3
Total	21,408	99.9

Note - Works run by Trust (vide infra p. 1020)

£1795 paid from Deterioration Fund existing in 1845

£15,398 paid from surplus profits in 1845-70

Source - W.B. Watson Abstract Statement (1870) op cit
Vide infra p 1020

Table 4.33 Total Expenditure by Glasgow City and Suburban Gas Company (1844-59)

	£	% of £218,674
Parliamentary costs	9,338	4.3
Construction of Works	52,573	24.0
Pipe Account	61,606	28.2
Gas Meters Purchased	28,643	13.1
Dalmarnock property	3,990	1.9
Iron roofs on Buildings	6,803	3.1
Gas Holders and Framing	9,952	4.6
Station Meter	333	0.4
Counting House Furniture	225	0
Equipment Total	173,963	
Gasfitting Account	15,780	7.2
Works Wages Account	2,614	1.2
Total Wages Account	26,317	12.0
Total Expenditure	218,674	100

Note - Simple sum total of expenditure.

Source - J. McClelland C.A. "Report to Sheriff of Lanarkshire" (1859) Glasgow City Archives <u>Miscellaneous Papers</u> Vol. 18 ; Reprinted in 1861 by Glasgow Council <u>Glasgow Herald</u> 4/1/1861 p.7

Although decisions upon issuing new shares or acquiring loans were of paramount importance to long term growth, many other aspects of financial management affected the annual performance and viability of a gas company. Decisions had to be taken on the price to charge for gas, the expenditure required to enlarge the market without over-extending capital resources, and the profits or dividends to which the shareholders were entitled. All of these factors, moreover, had to be continually reviewed in the light of fluctuating market conditions. The acquisition of knowledge about developments in the gas industry as a whole was the most important single factor.

Successful financial management was thus largely based on the "method of comparisons" by which Directors and Managers acquired information on the operation of other gas companies in comparable circumstances with regard to markets and raw material supplies. The Leven[1] company during a local trade slump in 1848-9, sought a solution by obtaining information for the first time on "the prices of Gas, wages, consumpt., revenue and expenditure" from other gas companies at Barrhead, Neilston, Kilsyth and Kirkintilloch. These were analysed against a standard unit of 1000 cu ft gas output for "each year of this Company's existence" at Leven, and revealed that wages were too high, gas too expensive, and discounts to large consumers too generous. This was a firm basis for action. The manager's wages, the price of gas, and discounts were all reduced that year, and the decline in consumption halted.

A trade depression at Stranraer in 1841-5 led the gas company directors there to consider renting out the unprofitable gasworks in 1845. A survey then undertaken of other Scottish gasworks however, persuaded them instead to re-organise the entire basis of operations, from finance to the enlargement of markets. Using the experience gained by other gasworks, including Pollokshaws, Inverary and Brechin, the Directors[2]

1. Gas reduced initially from 9s.0d to 8s.9d; discounts reduced from 5, 10 and 15 per cent to 3, 6 and 10 per cent respectively. Leven made another survey of "neighbouring gas companies" in 1858
S.R.O. Vale of Leven Minute Book op cit 1/6/1846, 14/6/1847, 1/5/1858
2. S.R.O. Stranraer Minute Book op cit 30/1/1845, 6/3/1845

recommended many improvements which were rapidly implemented. The manager's salary was reduced, but he was granted an assistant stoker in winter to facilitate "a great saving of coals". Strenuous efforts were made to reduce the interest paid on loan capital from about 7½ per cent to the 3½ per cent achieved by some other companies. Clay retorts were adopted, leaving only one iron retort for the summer season, and a stock of coals was laid in at lower prices in the summer season. New purifiers were seen to be necessary, and the advantage of changing them to Stock instead of Working expenditure was recognized. For the first time, advertisements were made to sell ammoniacal liquor, and surplus tar which was not burned in the furnaces. The company undertook "a very liberal reduction" in the cost of street lamps, to "encourage the public and individuals to light such lamps" and thus extend the market. Gas to private individuals was reduced from 12s.0d to 10s.6d. to "increase the consumption so as ultimately to afford a larger profit". Although the "method of comparisons" did not always inspire changes as comprehensive as those at Stranraer, it was a most important feature of financial and technological improvement throughout the industry.

Several small gasworks were managed so poorly that it was found more profitable to lease them out to contractors who took all the financial risks and paid a fixed rent. The Castle Douglas company leased[1] its works to J. Jardine from 1857 to 1884, and Whitehorn company leased their works to Mr. Romans of Edinburgh until 1875. A two year lease of Bathgate gasworks was granted in 1851 to James Ferguson,[2] the previous manager there, at £103.10.0d per year. Ferguson was obliged to provide security for his intromissions, but retained the lease until 1854 when he was £34.10.0d in arrears. During the interim period the Company dismissed its Treasurer, but continued to hold annual general meetings for the election of Directors[3], and paid 5 per

1. J.G.L. 6/7/1875, 10/6/1884, 3/2/1884
(Romans may have been the Newbattle Colliery agent of that name)

2. Bathgate Company made a profit of only £12 in 1850
S.R.O. Bathgate Minute Book op cit 20/5/1851, 22/8/1851, 30/5/1854
Vide infra p.1439

3. ibid 5/5/1852, 24/3/1853, 30/5/1854

cent dividends in 1852, 1853 and 1854. Lesmahagow[1] gas company paid no dividends from 1865-8, and developed a trading deficit in 1867-8. This was blamed on faulty meters and the works were advertised "To be Let". The highest offer received was £63 a year, but the Directors had second thoughts and instead retained control. After getting the meters repaired professionally, they achieved a profit of £31 in 1870, and dividends were again issued.

Comrie[2] gasworks, which in 1880-1 sold only 230,000 cu ft gas from 60 tons of coal, had paid little dividend for many years and faced a choice between leasing the works out to a local plumber, or raising the price of gas from 10s.0d to 11s.8d. Other small and remote companies had similar problems. Thurso gasworks, built in 1842, were leased from 1871 to T.W. Stears[3] of Hull for 50 years on condition that he supplied gas at 7s.6d. or less. He could also purchase the works at any time for £1200, but after giving very poor gas he abandoned the works which were not re-opened until 1879 by the Thurso New Gas Company[4].

Consumer-investors used great exertions to retain many geographically handicapped gasworks. The Stromness[5] gas company had to be liquidated in 1888 because of debts amounting to £700 and the refusal of further bank loans. The works fetched only £800 by public auction, and were taken by a new Stromness Gas Company Limited[6] using £2000 loans, but that company collapsed in 1889 after repaying only 11s.2d on each £5 share. Aberuthven[7] gasworks in Perthshire, opened in 1857 and closed in 1877 after paying

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1. C.T. Miller, A Lesmahagow joiner, offered £63 per year as rent, and John Kay of Motherwell offered £36 per year.
   S.R.O. Lesmahagow Minute Book op cit 4/9/1867, 15/9/1868, 29/9/1868
2. J.G.L. 9/8/1881
3. Gas previously sold at 12s.0d.
   J.G.L. 7/11/1871 p. 838, 21/10/1879
4. Nominal Capital £15,000 in £10 shares. The New Company was not successful, and in 1888 the works were sold at public auction for £4,800
   J.G.L. 25/11/1879; 1879 p. 825; 22/5/1888
5. J.G.L. 22/5/1888, 31/7/1888
6. J.G.L. 29/1/1889
7. J.G.L. 14/9/1877

dividends only twice despite high charges for gas. The proprietor of New Cumnock[1] gasworks became bankrupt in 1883 and had difficulty in selling the unremunerative plant. When the fifty-years old Portsoy gasworks were sold in 1888 as a result of disagreement between the executors of Colonel Moir[2], the main shareholder, local residents hastily organized a new company to retain the unprofitable works. Armadale[3] gasworks in Linlithgowshire paid no dividends from 1866-88 as a result of poor management and loss of consumers, but shareholders in 1888 voted against a proposed dissolution. Similarly the New Pitsligo[4] shareholders in 1887 outvoted their directors' recommendation to close that gasworks.

Larger companies with larger markets had greater security, and could apply more subtle views on the role of profits, which could be reinvested as capital equipment, held in reserve for contingencies, or simply distributed to the shareholders as dividends. Firstly, however, they had to be in a position to comprehend those profits.

Book-keeping like other aspects of management was derived from both local methods of accounting, and the "method of comparisons". The standards achieved varied considerably[5]. Because of the variety of occupational groups among shareholders, from shopkeepers and merchants to landed proprietors, accounts contained various admixtures from the Merchants' System and the Master and Servant System. The former made no allowance for depreciation,

1. J.G.L. 11/12/1883
2. Portsoy gas consumption 451,000 cu ft in1880; 626,000 cu ft in 1888 Works purchased by new company for £350
   J.G.L. 30/10/1888, 1/1/1889
3. J.G.L. 18/9/1888
4. Total capital £400, of which £243 held by Lord Clinton.
   J.G.L. 27/9/1887
5. Companies were even confused over whether to show 'Capital Stock' on the Balance Sheet as a 'Liability', or as equipment 'Assets'. Small gas companies often ignored the capital account, and showed only annual revenue and expenditure ('profit' and 'loss' accounts) to the annual meetings, with loans as outstanding liabilities in a separate category. Loans were often stated as "debts due the Treasurer", or "owed by Company to Manager", and other similarly vague pseudonyms. Vide S.R.O. Stranraer Minute Book op cit 27/6/1843, 29/6/1847
   S. Pollard Genesis of Modern Management (1968) op cit pp. 246-52, 275

and treated all working and fixed capital as trading capital. The latter, widely used in mining ventures, placed all revenue as "Charge" and all expenditure as "Discharge". "Discharge" therefore concealed heavy reinvestment from surplus revenue upon fixed capital, which in turn prevented any depreciation allowance being disentangled from new equipment, and also created massive variations in apparent profit each year. This was likely to dismay shareholders unfamiliar with business practise, and although variations of the Master and Servant System were used throughout the Scottish gas industry, "Gross Profits" before reploughing, were often carefully distinguished from "Real Profits" or deficits, after reploughing[1].

S. Pollard has stated[2] that accurate accountancy was far less important in the early nineteenth century than later, because the selling price for goods was always high relative to expenditure on raw materials, partners took only a small fraction of surplus profit as dividends, total revenue and surplus was high compared to labour costs (especially before 1830) and companies operated as semi-monopolies because capital and entrepreneurship were in short supply. The Scottish gas industry differed considerably from this pattern. Like other joint stock ventures[3] it had the advantage of regular annual accounts in order to pay dividends, instead of the irregular journal of accounts used in other industries. But the selling price of gas was not always high relative to coal purchases, dividends sometimes exceeded annual profits[4], and consumers always had the option of

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1. An important aim was to provide "an element of certainty and assurance" to shareholders.
   S. Pollard <u>ibid</u> p. 250
   c.f. Stranraer Directors deluded shareholders with separate Gross Profits from the 1840s. During the coal crisis of 1901, the 'Income' of £3848 included £550 from reserve funds. Expenditure was £3806, of which £357 was on capital equipment, yet the Gross Profit was stated at £3919 and the Real Profits £42. In reality there was a trading deficit.
   S.R.O. Stranraer Minute Book <u>op cit</u> 3/7/1901
2. S. Pollard <u>Genesis of Modern Management</u> (1968) <u>op cit</u> p. 285
3. S. Pollard <u>ibid</u> p. 252
   By the 1840s some small gas companies, like Bathgate, provided a printed Abstract of Accounts to shareholders each year. S.R.O. Bathgate Minute Book <u>op cit</u> 20/5/1845 .
   The general meeting of Dunse company in 1840 voted for sophisticated annual reports "exhibiting the different receipts and disbursements ____

building a private gasworks of their own[1], or starting a rival Consumers Company[2]. External forces, especially the availability of coal, were a great stimulous to planning in advance, and because many gas companies were small enough for the gas-manager to handle routine book-keeping personally, the Company Secretary and Treasurer was in a less strenuous position than in other industries and had the opportunity to take a broad view of the Company's progress and to advise on improved fiscal management[3].

Costing as an aid to management was important in the gas industry from its inception, when rough estimates of potential consumption were made before construction commenced[4]. It remained a very imprecise tool, however, until[5] the 1840s. Book-keeping itself was so varied that extant accounts are difficult to decipher and probably confused shareholders, if not the accountants themselves. A distinction must, however, be made between clarity and advanced accounting. If, for example, the annual "income" total included cash brought forward, and shareholders were aware of this, the account was clearly presented. On the other hand if, as at Dalkeith, loans were entered as "Income", then shareholders were misled.

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of the Company during the year, arranged under separate heads; so as to distinguish the floating from the fixed capital"
S.R.O. Dunse Minute Book op cit 17/7/1840

4. 'Profits' in the sense of surplus annual revenue after total expenditure.

1. Vide infra pp. 91, 1234

2. Vide infra p. 1111

3. Pollard blamed poor methods of accountancy upon over-worked clerks fully occupied on tedious routine work. Innovations were not a distinction between "entrepreneurs" and routine "managers", but between long-term "strategic" and short term "tactical" decisions by management and employees.
S. Pollard Genesis of Modern Management (1968) op cit pp. 268, 291

4. e.g., Dunse Company in 1835 before building the works obtained information from Kelso, Galashiels and Jedburgh on "the Expense of erecting Gas Works at these places, - the Annual Expenditure - the Annual Returns - The mode of management of the Gas companies, & c."
Vide supra. Chapter II p. 160; also p.1510

5. Vide infra p 793

Table 4.34 Confusion Between Capital and Revenue Accounts at Dalkeith (1833-40)

Date	Gas Revenue £	Coke/Tar £	Public Lamps Revenue £	Total Income £
1833	520	2	-	604
1834	505	12	-	630
1835	601	19	110	3460
1836	665	9	127	946
1837	656	20	113	1221
1838	723	22	108	1727
1839	825	43	120	1771
1840	802	35	118	1673

Source S.R.O. Dalkeith Minute Book op cit

In 1835 "Income" included a loan of £1200, and in both 1838 and 1839 contained £605 from two 50% calls on a new issue of capital stock. Actual Revenue in 1840 and later was under 50% of the amount shown annually as "Income". This was the fault of book-keeping methods which followed eighteenth century practises[1].

Where the annual abstract of accounts showed 'profit' as the surplus after paying dividend, instead of before paying it, as at Bathgate in the 1840s, the account was clearly presented and easily understood. Decisions made upon reserve or contingency funds, or other special arrangements (with the exception of reinvesting revenue on capital equipment which occurred continuously in a concealed form) depended both upon a knowledge that such practises were feasible and the agreement of a General Meeting that they were useful.

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1. In the absence of a fixed capital account, "capital-cum-profits" was calculated by subtracting all liabilities (except original stock capital) from total assets (including debtors) Debts thus appeared with assets.

   S. Pollard Genesis of Modern Management (1968) op cit p. 275

Very detailed statistics of revenue and expenditure were collected by companies from their commencement. Four categories of books were kept by a large company like the Glasgow Gaslight Company[1] in 1861. Ledgers for various districts contained a record of gas used by each consumer with a meter. Separate books showed all persons with time contracts. The collectors' books showed the daily collections of gas rates made in different districts, and a book of abstracts showed total daily collection in all districts. Finally a general cash book, day book, journal, and ledger for the capital revenue and other general business accounts, were maintained.

Market trends were visible both from the abstracts of revenue, and from consumption registered on the Station Meter[2]. Small companies which lacked such a meter based their judgement of market demands upon statistics laboriously compiled from consumers' meter readings. Consequently, financial calculations were made on the basis of short sample-periods, a method still used at Annan in 1844.

Table 4.35 Assessment of Market Trends at Annan 1838-44

Gas Consumption in Six weeks up to	1838	1839	1840	1841	1842	1843	1844
15th October	56,331	38,845	45,403	38,780		41,988	50,219
15th January		90,947	84,324	89,891	79,381	93,127	
15th April		39,181	43,968	39,066	28,324	39,066	43,968
15th July		9,761	15,902	9,684	10,085		
Total		178,597	189,597	177,424			

Source : Annan Minute Book 10/2/1842, 10/2/1843, 13/5/1843, 21/10/1844

1. Evidence of J. McClelland, C.A.
J.G.L. 12/2/1861 p. 95
Vide infra 'Labour; 'Organisation' pp. 674, 987

2. Vide supra 'Technology' p.323

Correct evaluation of manufacturing costs was developed as a skill by the early 1840s under the stimulous of threatened competition. Besides annual abstracts showing total revenue and expenditure, great precision was achieved for the purpose of comparing companies, by relating individual items to a standard unit of output, 1000 cu ft. This also served to highlight the efficiency of individual items of equipment, although only a few gas managers and directors appear to have used the system until perhaps the late 1850s. An early example of such evaluation was prepared for Aberdeen by Mr. Ritchie[1] in 1844, as shown in Table 4.36.

Table 4.36 Evaluation of Annual Working Costs at Aberdeen (1844)

Revenue -				
32 million cu ft gas at 8s.0d		£12,800	0	0
Less 5% discounts	£640			
Less 7% leakage	£760			
Less 1% bad debts	£128			
		£1,536	0	0
Net Revenue from Gas		£11,264	0	0
Meter rent on 5000 meters at 2s.0d	£500			
Tar, Coke, Lime, Ammonia Water	£200			
		£800	0	0
Total Revenue		£12,064	0	0

Expenditure -

	Cost per 1000 cu ft		Total Cost		
	s.	d.	£	s	d
4% interest on £65,000	1	7.5	2600	0	0
Parrot coal (2000 tons at 23s.0, 1500 tons at 15s.0)	2	0	3200	0	0
Wages of Stockers and Labourers		6.75	900	0	0
Salaries of Manager, Secretary and Collector		5.5	700	0	0
Feu Duties and Taxes		1.25	166	13	4
Interest on One Year's Stock of Coal		1.25	166	13	4
Interest on Cash Account		0.75	100	0	0
Incidentals		1.5	200	0	0
Stationary and printing		0.5	66	13	4
Lime for Purifiers		0.75	100	0	0
Repair to house		0.5	66	13	4
Repairs to Mains and Services		0.5	66	13	4
Repairs to Retorts and Apparatus		4.0	533	6	8
Repairs to Meters		1.5	200	0	0
Repairs to Utensils		0.5	66	13	4
Cost of Manufacture (Including interest on loans)	5	8.5	9,133	6	8

Source - Aberdeen Journal 14/2/1844

A.Ritchie was manager of the profitable Greenock municipal gasworks from 1839, and was a leading advocate of improved book-keeping. Table 4.37 shows his analysis of working costs at Greenock, as drawn up in 1851.

Table 4.37 Evaluation of Greenock Working Costs per Thousand cu ft Output (1831-50)

Average Expenditure per 1000 cu ft. (Old Pence)

Date	1829-31	1832-5	1836-9	1839-40	1841-4	1845-8	1849-50
Expenditure -							
Interest on Loans	16.5	10.5	10.75	11.0	12.75	13.0	13.25
Coals	20.1	18.0	22.3	19.2	20.3	24.3	18.6
Wages	7.0	9.9	9.6	7.4	6.5	5.7	4.3
Salaries	9.5	5.1	3.5	3.7	5.0	3.4	3.1
Lamps	3.3	5.3	4.2	3.2	4.5	2.8	1.9
Retort-Bench repair	4.8	4.0	3.0	1.4	3.7	2.6	2.4
Lime for Purifiers	3.0	1.8	1.1	1.3	0.9	0.7	0.7
Feu Duty/Tax/Insurance	1.3	1.1	1.2	2.0	2.6	1.7	2.4
Repairs/Stationary etc	2.1	2.6	1.6	3.6	2.1	3.8	2.6
Total	67.75	58.25	57.25	52.75	59.25	58.00	50.25

Note - Decimals of Pennies were used in original table; the only alternation made here is to give whole shillings as pennies.

Source - A. Ritchie J.G.L. 10/5/1851

Glasgow Gaslight Company in the late 1850s analysed costs in relation to each 1000 cu ft gas sold, as did Kilmarnock in the 1860s, but no similar analysis is extant for Ayr gas company until 1896.

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1. Though based on the Aberdeen Company accounts, Ritchie presented this in a hypothetical form to show profitability if the Police Commissioners purchased the works, and had to pay interest on loan capital of £65,000 and on working capital for coal.

   Aberdeen Journal 14/2/1844 Vide Infra 'Consumer Relations' p.1135

Table 4.38 Analysis of Glasgow Gaslight Company Accounts 1857 -8

	Total (£)	Per 1000 cu ft sales
Expenditure -		
General Expenditure	19,074	1s. 1.349d.
Coal (45,854 tons at 19s.4.75d)	44,468	2s. 7.121d.
Repairs to Works and Plant	3,580	0s. 2.505d.
	67,121	3s. 10.975d.
Interest on loans and bank overdraft	2,857	0s. 2.000d.
Depreciation written off	1,500	0s. 1.050d.
Total	71,478	4s. 2.025d.
Revenue -		
Gas income (and estimated arrears)	75,903	4s. 5.122d.
Gas debts recovered from previous year	2,077	0s. 1.453d.
By-products & c	6,738	0s. 4.716d.
Total	84,718	4s. 11.291d.
Surplus Profit -	£13,240	0s. 9.266d.

Note - annual sale 342.924 million cu ft

Source - J. McClelland J.G.L. 12/2/1861 p. 97

Table 4.39 Analytical Examination of Working Costs used at Kilmarnock Gasworks (1861-74)

(I) Average Carbonization Costs per ton of Coal

Date	Wages		Salaries		Lime		Charges		Repairs		Total	
	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
1861	4	11	4	4	0	11¼	2	2¼	7	0	19	4½
1862	4	5¾	4	5½	0	9¾	2	2	6	0¼	17	0¼
1863	4	8¼	4	8½	0	10½	2	2	4	9¾	17	3
1864	4	8½	4	6¼	0	9¾	1	10½	4	1¼	16	0¼
1865	4	8	4	5½	0	11¼	1	9½	4	4¾	16	3
1866	4	9¼	3	11¼	1	3½	2	2¼	3	1	15	3¼
1867	5	0	3	3¼	1	2	2	0½	1	8¼	13	2
1868	5	0	3	3¾	1	1¾	1	11¾	2	5	13	10¼
1869	4	7¼	3	3	1	6	1	9¼	3	5	14	6½
1870	4	3¾	3	2¼	1	1	1	11¼	1	5¾	12	0
1871	4	1	2	9¾	1	3	1	8¼	2	4¾	12	2¼
1872	4	7½	2	7¾	1	4	1	9¾	1	11	12	4
1873	4	7¼	2	2	1	3½	1	6½	2	0¼	11	7½
1874	5	2¼	2	2½	1	3¼	1	4½	1	8	11	8½

(II) Average Prime Manufacturing Costs per 1000 cu ft gas

Date	Coal		Wages	Salaries	Lime	Charges	Repairs	Total Excluding coal	
	s.	d.	d.	d.	d.	d.	d.	s.	d.
1861	1	8	6½	5¾	1¼	2¾	9½	2	1¾
1862	1	6½	6	6	1	2¾	8	1	11¾
1863	1	6¾	6	6	1	2¾	6¼	1	10
1864	1	6¼	5¾	5¾	1	2¼	5¼	1	8
1865	1	7	5¾	5½	1	2¼	5½	1	8
1866	1	7¼	6¼	5¼	1½	2¾	4	1	7¾
1867	1	8¾	7	4½	1½	2¾	2¼	1	6
1868	1	11¼	7¼	4¾	1½	2¾	3½	1	7¾
1869	1	10½	6¾	4¾	2¼	2½	5	1	9¼
1870	1	9	6¾	5	1¾	3	2¼	1	6¾
1871	1	8¾	6½	4½	2	3	3¾	1	7¾
1872	1	8½	7¼	4¼	2¼	3	3	1	7¾
1873	2	5¾	7	3¼	2	2¼	3	1	5½
1874	3	9	8¼	3½	2	2¼	2½	1	6¼

Note - Wages per 1000 cu ft increased almost 50 per cent in 1861-74

Source - J.G.L. 20/10/1874

Table 4.40 Expenditure Evaluation prepared by Ayr Gas Company (1896)

	£	s.	d.	Cost per 1000 cu ft Gas s.	d.
Coal (£4759) less By-Products (£1231)	3527	19	5	1	3.2
Lime for purifiers	261	13	4	0	1.1
Repairs and Renewals	1100	0	0	0	4.8
Workmen's Wages	1205	14	4	0	5.2
Salaries - Manager, cashier, collector	415	0	0	0	1.8
Management	400	0	0	0	1.8
Burdens	420	0	0	0	1.8
Bad Debts	80	0	0	0	3.0
Profits on Manufacture	3000	5	5	1	1.0
Total				3	9.0
Meter Rents	327	7	10	0	1.3
Gross Profits	3327	13	3	1	2.3

Source - S.R.O. Ayr Minute Book op cit 27/4/1896

The economies of large-scale production[1] were widely understood by the 1830s, and were used to encourage increased consumption. "To impress upon all subscribers the importance of individual exertion in inducing parties who may not have done so, to become consumers", the directors of the Vale of Leven Company[2] in 1840 made an estimate of the lower prices which would become possible as consumption rose.

Table 4.41 Estimated Potential Effects of Scale upon Prices and Profits at the Vale of Leven (1840)

Annual Gas Sales (cu ft)	Price Gas	% Dividends (Profit)
500,000	6s.0d.	4½%
750,000	4s.8d.	8¾%
1,000,000	4s.1d.	12⅓%

Source S.R.O. Vale of Leven Minute Book op cit 13/4/1840

Information from other gas companies assisted directors in assessing the advantage of selling cheaper gas, but caution prevented rapid progress. Selkirk[3] in 1842-3 obtained a profit of £266 from gas sold at 15s.0d, but the general meeting agreed to reduce gas to 12s.6d, or £93 at a static rate of consumption, after being assured of sufficient profit to maintain dividends at the normal 6% level plus a surplus for the Reserve Fund. This was successful, and without lowering the dividends, gas was reduced to 10s.10d in 1844 and many subsequent reductions became possible as consumption increased.

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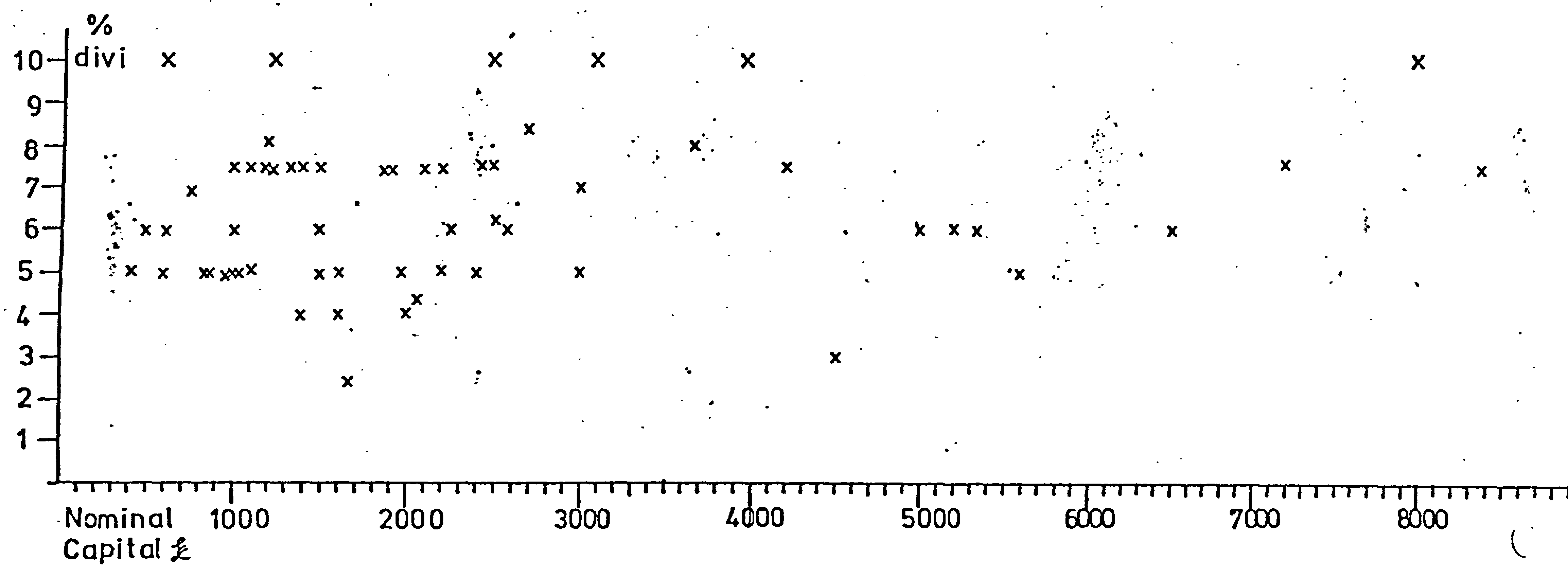
1. Vide supra 'Technology' pp. 175, 325, 872, 1126, 1150
2. S.R.O. Vale of Leven Minute Book op cit 13/4/1840
3. 6 per cent dividend was £101.8s.0d on a capital stock of £1690. S.R.O. Selkirk Minute Book op cit 2/5/1843

Fig. 4.42

Shareholders' Dividends Compared With Company (Nominal Capital) Size in 1853



Note - dividends varied independently to company size

Source - <u>vide</u> <u>infra</u> p.1399

Although most shareholders were local residents, a national awareness of dividends, and hence well defined categories of dividends, had developed by 1853. 5 per cent and 7½ per cent were most usual, followed by 6 per cent and 10 per cent, and these tended to be stable levels of dividend returns.

Table 4.43 National Categories of Dividend Payments (1853-71)

	1853		1861		1871	
Divident (%)	Number of Companies	% of Total Companies	Number of Companies	% Total Companies	Number of Companies	% Total Companies
Below 5	7	8.8	8	7.1	4	3.4
5	22	27.8	25	22.1	30	25.4
5.1 to 5.9	0	0	0	0	0	0
6	11	13.9	17	15	19	16.1
6.1 to 7.4	2	2.5	12	10.6	9	7.6
7.5	21	26.6	25	22.1	23	19.5
7.6 - 9.9	7	8.9	8	7.1	12	10.2
10	9	11.4	18	15.9	20	16.9
Above 10	0	0	0	0	1	0.8
Total Companies in sample	79		113		118	

Source - Journal of Gas Lighting Vide infra pp. 1398 et seqq

Dividend policy varied from company to company[1] but normally aimed to maintain a stable rate of dividend over fairly long periods of time. The average rate of dividend over past years directly affected the market price of shares[2]. During the slump of 1848, when Galashiels was trying to sell

1. Dividends in Chartered Companies were restricted by Parliament. Vide infra p979 Unincorporated companies, like Aberdeen, usually paid income tax on top of the declared dividend, thus making it "free of tax" e.g., Aberdeen. J.G.L. 23/5/1871 p. 400

2. No evidence has been found of original stock capital being used to pay artificial "dividends" to encourage investment in new gas companies. Fluctuations in the market value of gas shares in Scotland were related to changes in the level of dividends, the quantity of surplus profits which had been reinvested, and the threat of competition, far more than changes related to the national trade cycle, with peaks in 1824, 1830, 1845 and slumps 1833-7 and 1848, as noted by A.D. Gayer, W.W. Rostow and A.J. Schwartz The Growth and Fluctuation of the British Economy 1790-1850 (1953, Oxford) p. 432

extra stock, reserve funds were used to raise the dividend to its normal level of 10% because shares would "sell at a much higher price than if the dividends were made lower"[1]. In more prosperous circumstances, a fixed dividend produced rapid growth of reserve funds which would also boost the market price of shares in anticipation of a revaluation of the nominal value of shares, and because the Company was a 'safer' investment. Revaluation usually increased share values to approximately the market value, but often forced a reduction in the percentage dividend which the company could afford[2].

Policy was guided by the Directors, but the dividend could always be altered by voters at annual general meetings. Only a few examples of long-term decisions are recorded. Stranraer[3] company in 1840 decided upon a regular 7½ per cent dividend, and if profits were inadequate in any year compensation was to be made in subsequent years. When the Dalkeith[4] company encountered financial problems during extensions to capital equipment in 1906, the Directors reduced dividend from 10 to 8 per cent and declared it was "desirable that the annual dividend should be maintained at as uniform rate as possible with a view to steadying the value of shares".

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1. S.R.O. Galashiels Minute Book op cit 30/6/1848 . See also infra p.1160

2. c.f. When Coatbridge raised the capital stock in 1877 from £7590 to £20,000, the price of gas was raised from 3s.9d. to 4s.2d. to maintain dividends at the same level.
J.G.L. 18/9/1877

3. S.R.O. Stranraer Minute Book op cit 6/10/1840

4. S.R.O. Dalkeith Minute Book op cit 20/3/1906, 30/3/1906

Fig. 4.44

Company Dividends

(Bonus included, except for Dalkeith)

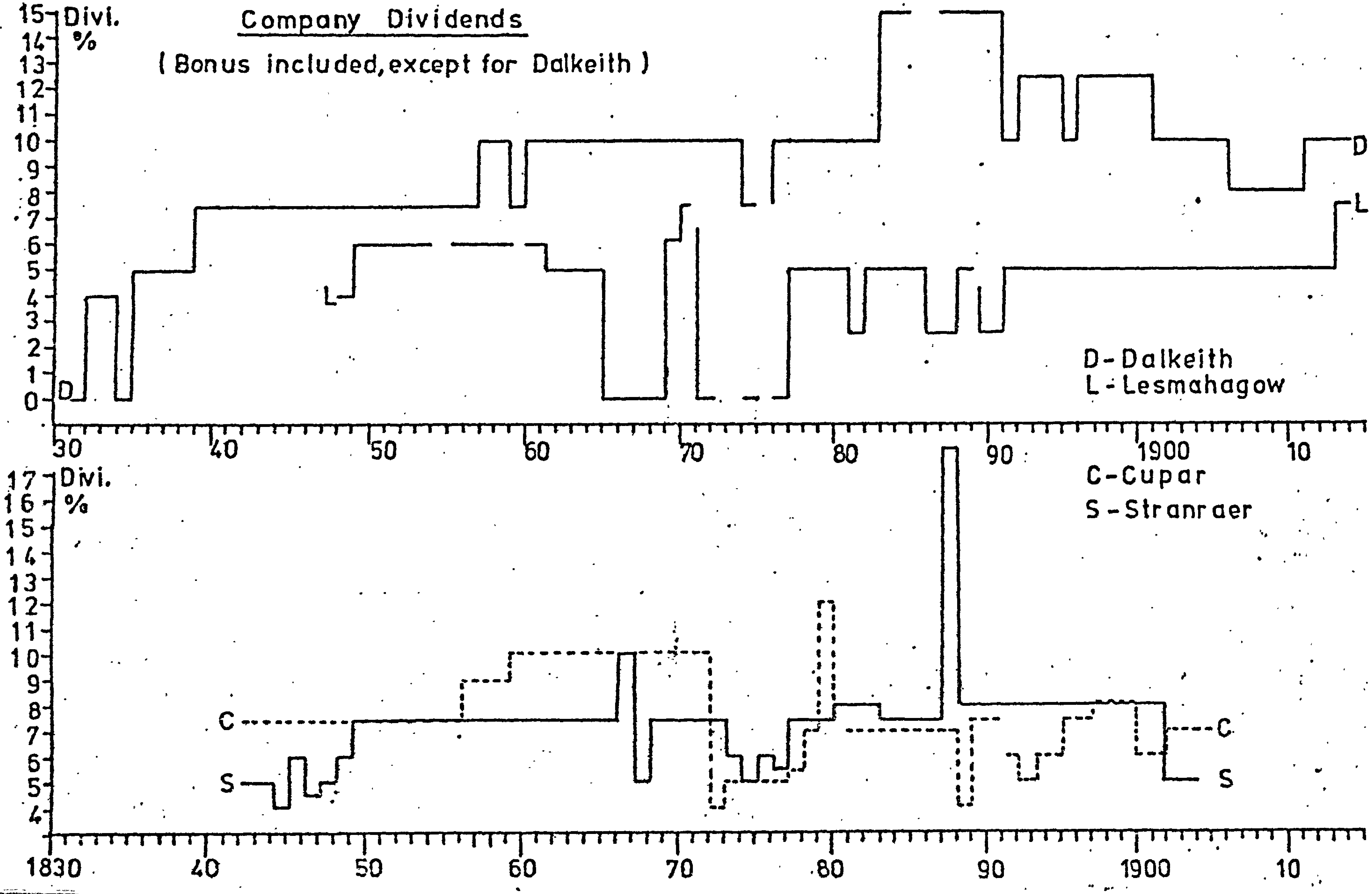


Fig. 4.45
Company Dividends

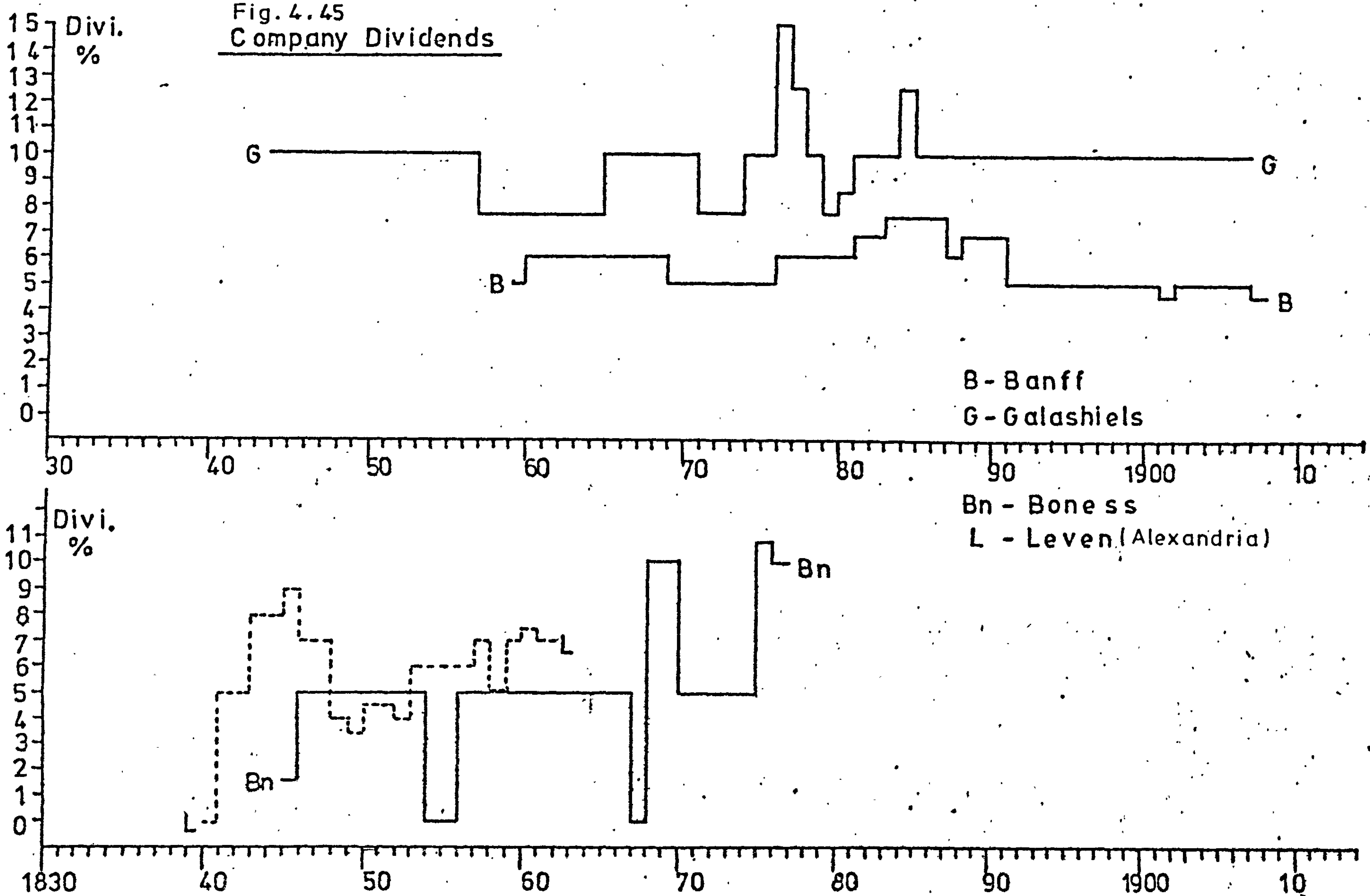
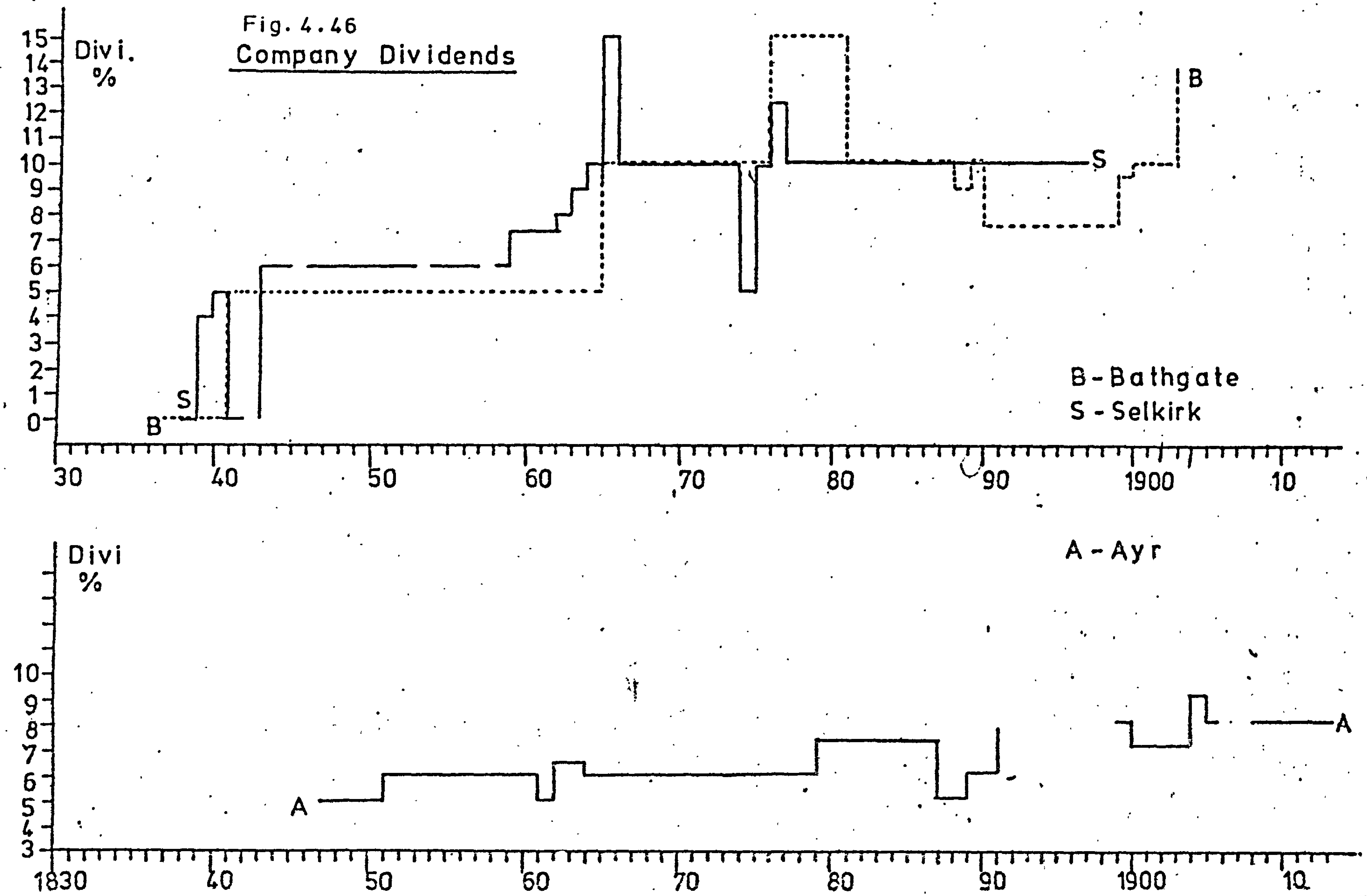


Fig. 4.46
Company Dividends



Shareholders received a 'bonus' in exceptionally prosperous years, but the 'dividend' was maintained at a steady level. Thus Dalkeith company in 1842 paid to shareholders a bonus of £240 and a gratuity of £40 from surplus profits. The demand for respectable dividends in many new companies of the 1830s - 40s produced a series of fluctuating dividends, and nil dividends, until a sustained level of profits enabled dividends to be maintained at a fairly constant rate.

The 'bonus' was sometimes a transitional phase towards regular, higher dividends. Cupar, for example, paid 7½ per cent dividend regularly from 1842-55, followed by three years of 7½ per cent and 2½ per cent bonus, and then 10 per cent dividends from 1859-72. It was also used as restitution for an earlier period of unavoidably lower dividends. Many regarded 5 per cent dividend as a legitimate return on capital, as if it were interest and only amounts above that represented true profit. In 1843 the annual meeting of Dunse[1], narrowly defeated a motion for 5 per cent bonus above the 5 per cent dividend, to make up the 'loss of interest' when lower dividends were paid during the early years of the company. Dalkeith[2] gave a bonus of 7½ per cent in 1841 as compensation for previous years.

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1. S.R.O. Dunse Minute Book op cit 4/7/1843

2. S.R.O. Dalkeith Minute Book op cit 18/6/1841

Table 4.47 Examples of Bonus Dividend Payments

Date	% DIVIDEND	% BONUS	DATE	% DIVIDEND	% BONUS	DATE	% DIVIDEND	% BONUS
AYR								
1862	6	0.5	1863	6	0.5	1891	6	2
1899	6	2	1904	7	2			
BANFF								
1881-2	6	0.7	1883-6	6	1.5	1889-90	6	0.7
BATHGATE								
1876-80	10	5	1899	7.5	2.5	1903	10	2.5
CUPAR								
1856-8	7.5	2.5	1877	5	1	1878-87	5	2
1888-90	5	2.5	1894	5	1			
DALKEITH								
1841	7.5	10	1842	7.5	10.9	1843	7.5	40
1844	7.5	10	1845	7.5	9.6	1847	7.5	0.7
1847	7.5	0.7	1852-3	7.5	7.5	1854	7.5	5
1870	10	5	1876	10	2.5	1878	10	2
1880-2	10	5						
SELKIRK								
1865	10	5	1876	10	2.5			
STRANRAER								
1887	8							

Source - S.R.O. Minute Books op cit

Bonus payments reflected the prosperity of individual companies. In 1857 Cupar stated that the bonus was to cover "Insurance", without further explanation. No pattern of national prosperity in particular years is evident from the bonus payment statistics.

Table 4.48 Relationship of Bonus Dividends to Normal Dividends at Galashiels

Date	Normal Dividend %		Date	Extra Bonus Dividends %
1865-70	10			
1871-3	7½	(coal crisis)	1876	5
			1877	2½
1874-8	10			
1879	7½			
1880	8½		1884	2½
1881-1907	10			

Source - S.R.O. Galashiels Minute Book op cit

Boness company[1] paid 6s.0d. (5 per cent) dividends each year from 1846-74 with the exceptions of 1854, 1855 and 1867 when there was no dividend. However, in 1868 a bonus of 6s.0d. was paid in lieu of the 1867 dividend, and a further bonus of 6s.0d. in 1869 was made, the company stated, as restitution for 1855.

At a given price of coal, the price of gas was closely linked with dividend policy. Shareholders felt justified in expecting a minimum dividend of 5 per cent, the maximum permitted under the eighteenth century Usury Laws. Thereafter the price was broadly controlled by the social conscience of shareholders, a desire to enlarge the market, and the possible threat of a rival gas company, private gasworks, and the Consumers Movement. Cupar[2] gas company, for example, reduced the price of gas in 1838 despite high coal prices and poor quality, and the following year promised the consumers that further reductions would be made provided they were compatible with 5 per cent dividends.

Very high "apparent" dividends resulted from reinvesting a proportion of profits without altering the 'book' value of nominal stock. They were to some extent illusory, because new shareholders had to pay for more than the nominal price of shares to obtain the dividend[3], whilst

1. Vide infra Appendix V
2. S.R.O. Cupar Minute Book op cit 6/3/1851
3. e.g., Dunfermline capital stock in £10 shares rose from £4450 in 1828 to £5450 in 1830 and £7000 in 1832. By 1843 P. Chalmers recorded the market price of shares as £21, and the value of the works £11,278

old shareholders could obtain the same benefits by distributing extra, fully "paid-up" shares, amongst themselves, and declaring a more rational dividend. After the Consumers Movement of the mid 1840s, this proved a wise precaution against irate consumers, and was therefore often adopted to conceal the profits. Thus in 1866 Dalkeith[1] company witheld a 5 per cent bonus, and used the surplus to raise the nominal capital stock by distributing 150 "paid-up" shares gratis to shareholders. W. Anderson[2], chartered accountant of Glasgow, stated in 1871 that "the stocks of gas companies paying a 10 per cent dividend usually sell at a price to leave 5 per cent" on the monetary outlay.

Insofar as the premium paid for shares was used by companies like Glasgow Gaslight Company as part of their capital stock, some companies made illegal use of such 'capital' for the payment of dividends. The Glasgow City and Suburban Company[3] held 700 shares in reserve until 1855 when they were issued at upset prices, and those premiums used for several subsequent years to boost the inadequate trading profits so that 10% dividends could be issued. The company later claimed this was justified because Parliament had not forbidden it from issuing the shares at par to existing shareholders, who, if inclined to purchase, would have obtained the same benefits by paying a lower purchase price.

In paying themselves dividends, shareholders had to accept that loan capital was a long term burden, and also to acknowledge fluctuations in external economic circumstances. Whilst many companies paid no dividends for several years after their formation to allow reploughing[4] and debt

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of which £9200 was from the sale of 860 shares, and £2078 from the "old sinking fund" and share premiums. Heavy reinvestment of profits allowed high apparent dividends, 10 per cent up to 1838, and 12½ per cent in 1839-43
P. Chalmers Historical and Statistical Account of Dunfermline (1844, Edinburgh) p. 393
Dunfermline Press 9/11/1929 p. 5 "Dunfermline Gasworks Centenary Celebrations" (Dunfermline Ref. Lib)

1. S.R.O. Dalkeith Minute Book op cit 6/7/1866
2. J.G.L. 23/5/1871 p. 398
3. Evidence of Wm. Fleming, C.A., Secretary of Glasgow C & S 1843-71 J.G.L. 26/5/71 p. 255
Vide infra pp.1129 et. seq.; c.f. pp.1123, 980.
Attempted evasion of Parliamentary dividend controls at Hamilton, vide infra p.966

repayment, both of those features had to be subordinated as soon as possible to the profits for shareholders, to retain their support. At Stranraer[1], the first dividend payment at 5 per cent was made in 1840 only after a general meeting had defeated proposals to use the entire £79 annual profits towards reducing the debt of £698.

Exceptional expenditure caused either by expensive coal and labour, or by heavy reinvestment could precipitate a reduction of dividends. The former could be overcome by the development of Reserve Funds to pay dividends unwarrented by the profits of a particular year, and stimulated the adoption of such funds. The latter caused a reduction of liquidity and absorbed the Reserve Fund, so that excessive reinvestment was the most usual cause of reduced dividends in large well organised companies.

Boness[2] gas company increased its total debts to £1245 in 1859-60 in order to finance considerable improvements designed by a consulting engineer, Mr. Young of Dalkeith. Despite the loan of £800 from the Clydesdale Bank and £445 "due the Treasurer", Young advised the Directors against their proposal to pay no dividend, and was in favour of maintaining dividend at 5 per cent. The alternative "would hardly be justice to the present shareholders as it would be causing them to bear all the expense of the recent repairs. Such expense should be spread over a series of years", as the new retort bench would last a considerable time. By making immediate repayment, reduced dividends would have reduced the market value of shares for partners wishing to sell them in the near future, giving new partners the unjustified privilege of a low price and the future benefits of the new equipment.

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4. e.g., At Kilmarnock total revenue rose from £559 in 1823 and £660 in 1824, to £1091 in 1826, but in order to reinvest and keep pace with demand, the first dividend was not paid until 1828 (6 per cent). J.G.L. 25/3/1884

1. S.R.O. Stranraer Minute Book op cit 1/12/1841

2. S.R.O. Boness Minute Book op cit 11/6/1860, 20/7/1859, 9/6/1859

At Dalkeith[1] in 1873 when expensive coal depressed profits, the normal 10 per cent dividend was paid by additions from the reserve funds, but in 1874 dividend fell to 7½ per cent of which £600 was paid out of reserve funds. In 1887, when profits slumped due to reduced consumption and a fall in by-product revenue, 3½ per cent of the 15 per cent dividend was paid out of reserves. In 1891 very high coal and labour prices forced dividend down to 10 per cent which used £82 from reserves. The coal crisis of 1901 caused dividend to be reduced from 12½ to 10 per cent, and it remained at that level because of very heavy expenditure on capital equipment in 1903. The Montrose[2] gas company in 1891 paid its usual £3 dividend by using reserve funds since profits had been eroded by the coal crisis.

In 1860 Lesmahagow[3] company reduced dividends from 6 per cent to 5 per cent to preserve liquidity while building a new gasholder. Low profits prevented any dividends being paid in this mismanaged company from 1865-8. At Stranraer[4], heavy expenditure on capital extensions coupled with expensive coal and low profits led to a reduction in dividend from 7½ per cent to 5 per cent in 1867, while very high coal prices caused a reduction from 7½ to 6 per cent in 1873. In 1875 even a 5 per cent dividend involved 3 per cent borrowed from the reserve funds. In 1902 Stranraer reduced dividends to 5 per cent specifically to increase liquidity during extensions of the works. The small Cullen[5] gas company reduced dividends from 5 per cent to 2½ per cent in 1878 in order to repay some debts, and Kirkwall[6] in 1887 reduced dividend from 7½ to 5 per cent to preserve liquidity during a period of heavy expenditure on extending the works.

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1. S.R.O. Dalkeith Minute Book op cit 1/7/1873, 1/7/1874, 13/9/1887, 19/7/1892, 18/7/1890
2. J.G.L. 21/7/1891
3. In 1886-7 Lesmahagow also used a reduction of dividend, from 5 to 2½ per cent, in order to repay a Bill of £40
   S.R.O. Lesmahagow Minute Book op cit 3/9/1860, 14/12/1860
4. S.R.O. Stranraer Minute Book op cit 3/7/1867, 29/6/1874, 30/5/1903
5. Cullen nevertheless reduced the price of gas, from 8s.9d. to 8s.4d., at the same time. J.G.L. 6/8/1878
6. J.G.L. 30/8/1887

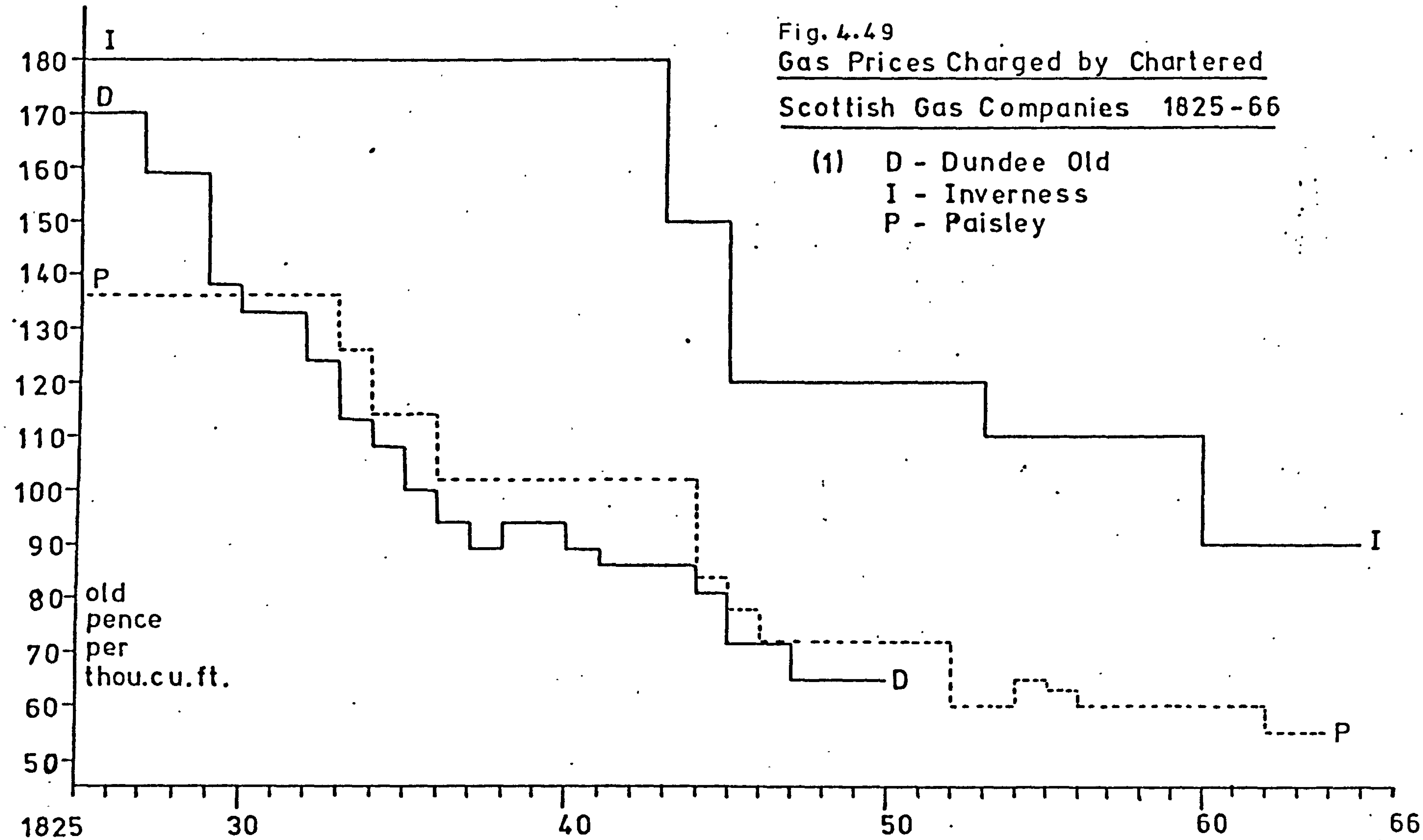


Fig. 4.49
Gas Prices Charged by Chartered Scottish Gas Companies 1825-66

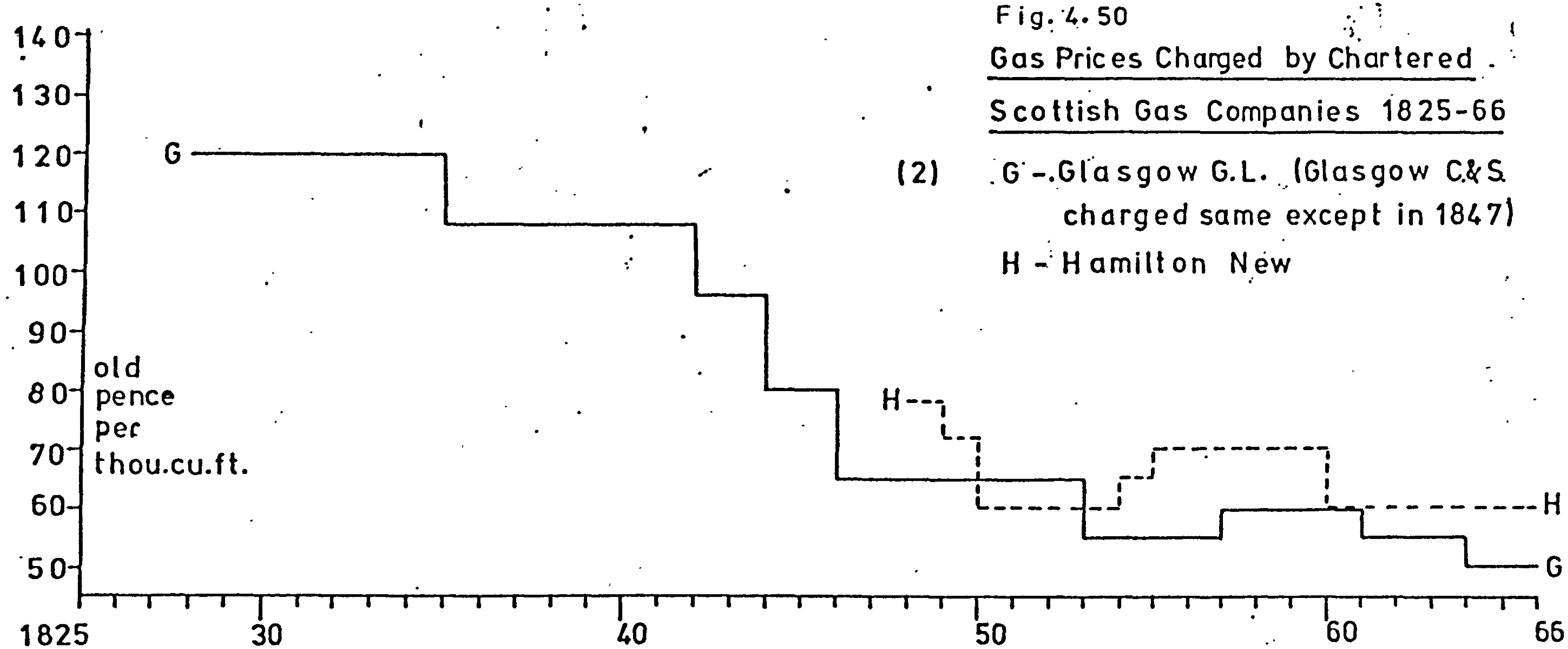


Fig. 4.50
Gas Prices Charged by Chartered Scottish Gas Companies 1825-66

(2) G - Glasgow G.L. (Glasgow C&S charged same except in 1847)

H - Hamilton New

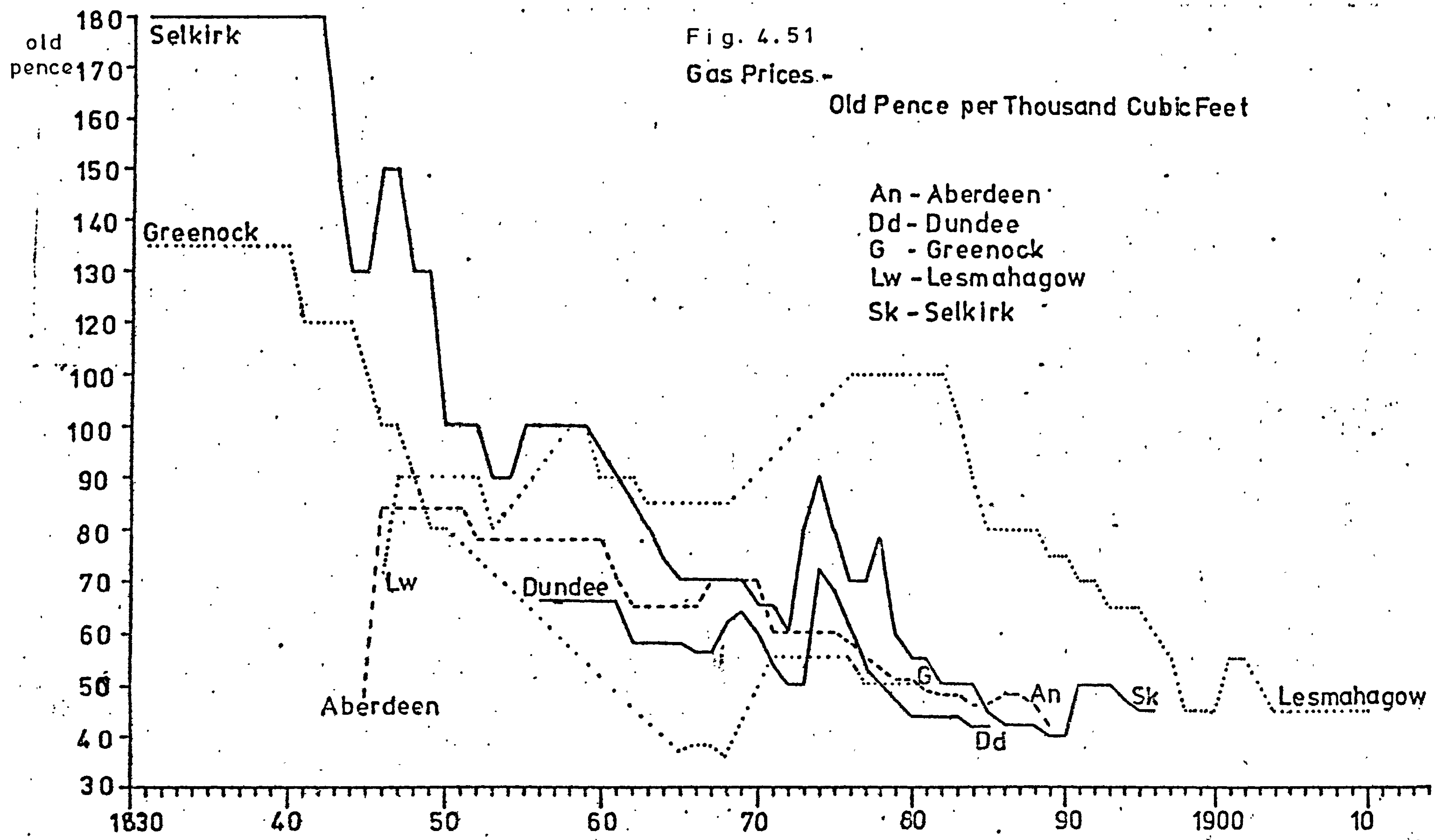
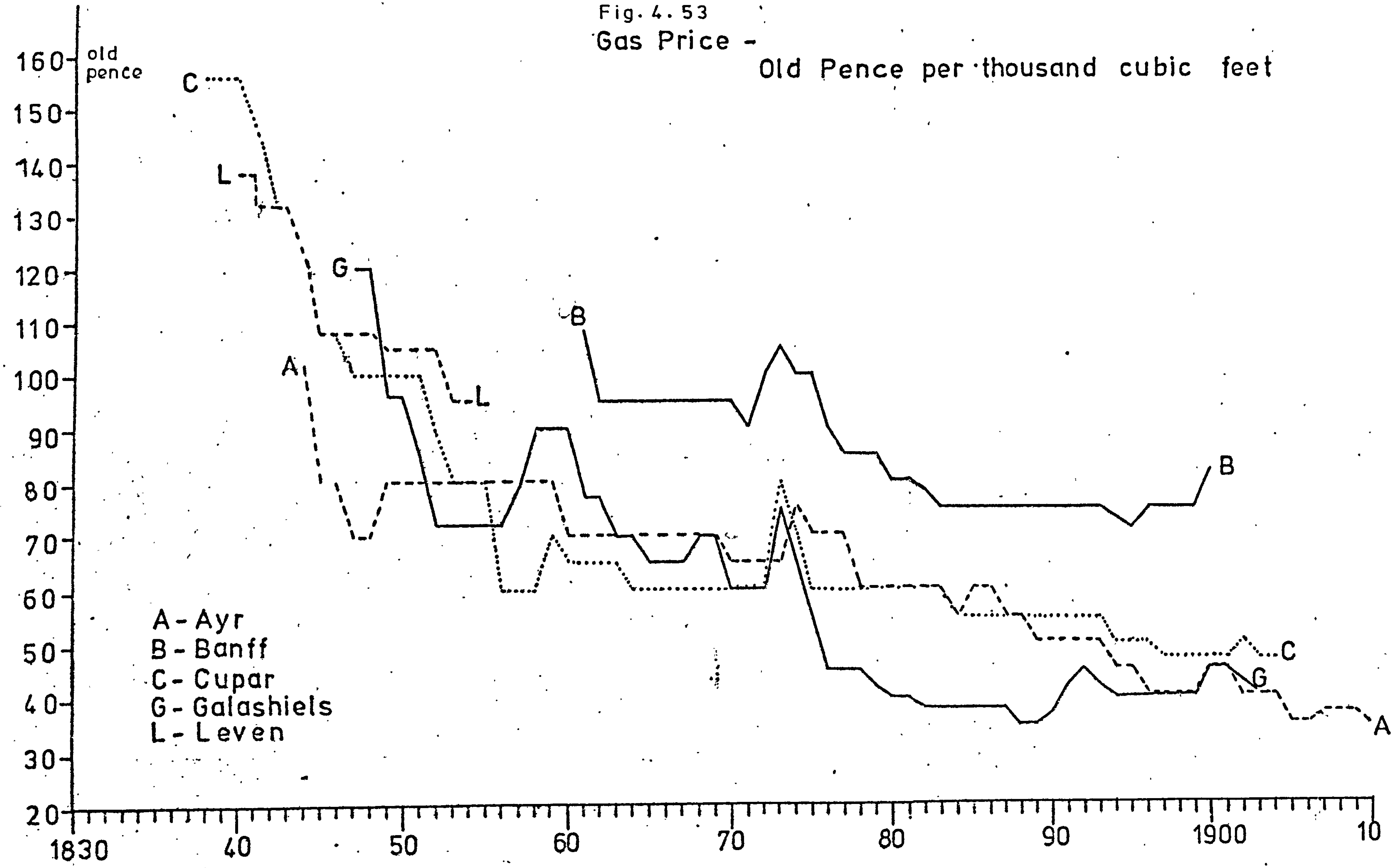


Fig. 4.51
Gas Prices -
Old Pence per Thousand Cubic Feet

Fig. 4.52
Gas Prices - Old Pence per Thousand Cubic Feet

Fig. 4.53
Gas Price - Old Pence per thousand cubic feet



The relationship between dividends, gas prices and market size may be seen in a sample area comprising the southern counties of Roxburgh, Berwick and Selkirk in 1866. Whilst dividend policy appears as a significant factor in the high gas prices of moderate sized towns like Jedburgh which paid 10 per cent, transport and technical problems were more significant in small towns like Melrose and Chirnside which charged highly but paid little dividend.

Table 4.54 Dividends, Gas Prices, and Population in Southern Towns (1866)

	Dividend	Population (in 1861)	Gas Price		Capital Stock	Capital Stock per Person in Market
	%		s.	d.	£	£
Chirnside	0	901	13	4	400	0.44
Melrose	4½	1456	10	0	746	0.51
Lauder	5	1137	10	0	885	0.78
Ayton	5	-	7	6	600	-
Eyemouth	5	1721	7	6	800	0.46
Galashiels	7½	6433	5	10	4000	0.62
Coldstream	8	1834	6	8	1000	0.55
Dunse	8	2556	6	8	1400	0.54
Selkirk	10	1899	6	3	1690	0.89
Hawick	10	8191	6	3	4400	0.54
Jedburgh	10	3428	7	0	1500	0.44
Kelso	10	4309	6	8	3000	0.70
					Average	0.58

Source - The Southern Counties Register and Directory (1866, London)

Capital stock varied between £0.89 and £0.44 per head of population, and averaged £0.58.

The social conscience of consumer-investors[1] had an important

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1. Vide infra 'Consumer Relations' p.1121; also pp.1004,1006
   c.f. In 1898 the Stranraer Company Secretary/Treasurer resigned over a decision to employ inferior coals, and accused the Company of watering the shares since 1875 when all £5 shares were raised to £7. He claimed this was "a common practise with companies when they desire to conceal the true rate of dividend. The shares have been yielding 8 per cent on £7 which is equal to 11.1/5 per cent on the original £5 paid", and "the public are fairly entitled to have a good gas". S.R.O. Stranraer Minute Book op cit 3/2/1875, 23/8/1898

effect upon gas prices. Annan[1] shareholders in 1843 considered a 5 per cent dividend adequate reward, and promised consumers that in the succeeding year, if it could be maintained, gas would be reduced from 12s.6d. to 11s.0d. The Dunoon[2] company contract of co-partnery in 1852 required gas prices to be reduced whenever dividend exceeded 10 per cent, and this may have been agreed by several companies. By contrast, a special meeting of Muirkirk shareholders in 1877 defeated a motion to place a maximum limit of 7½ per cent on future profits[3], and automatic reduction in gas prices whenever profits exceeded that rate. However, the first Kelty[4] gas company, in 1905, stated dividend controls in its deed of constitution. The maximum was 7½ per cent, or 5 per cent if gas prices exceeded 4s.2d, and every ½ per cent increase in dividend had to be matched by a 2d. reduction in gas price.

Comprehensive information is not available, but a table of anonymous Scottish companies in 1911 indicates that considerable variations in the burden of dividends upon gas sales still occurred at that date, independently of the absolute size of capital stock. The burden of both dividends, and total capital stock, did not decline as capital stock increased, although this could have been expected if stock[5] was correctly adjusted to market demand for gas. One company with a nominal capital of £1000 charged 3.6 old pence per 1000 cu ft for 7 per cent dividends, and the stock was equivalent to 4.3 shillings per 1000 cu ft annual sales, whilst another with £6000 capital stock charged 15.8 old pence per 1000cu ft for 5 per cent dividends, and had a stock of 26.7 shillings per 1000 cu ft annual sales. These figures ignore the cost of interest for any loan capital used, but in view of the lower annual cost of loans than dividends they do reflect great differences in the treatment of consumers by local gas companies.

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1. S.R.O. Annan Minute Book op cit 4/10/1843
2. S.R.O. (B.T.2/2585) Dunoon Contract, article 16
3. Provided £200 remained in the Reserve Fund
   S.R.O. Muirkirk Minute Book op cit 16/9/1872, 17/6/1872
4. Kelty gasworks designed by R.S. Carlow, Perth gas manager.
   S.R.O. (B.T.2/5842)
5. Reinvestment of surplus profits, and depreciation accounting, obviously modified to a very large degree the total investment represented by Stock.

Table 4.55 Variations in Dividend Burden Placed Upon Gas Prices (1911)

Nominal Capital (£)	Dividend %	Dividend Cost per 1000 cu. ft. (d)	Gas Sold (hundred thousand cu. ft)	Capital Stock per 1000 cu ft sales (shillings)
1000	7	3.6	46	4.3
1530	10	8.5	43	7.1
1750	6⅔	5.1	54	6.5
2000	7.5	5.0	71	5.6
2000	10	11.1	43	9.3
2000	10	6.8	70	5.7
2600	6.5	10.9	37	14.1
2780	10	10.6	63	8.8
2800	7.5	5.8	87	6.4
3000	10	8.2	88	6.8
3000	5	1.4	63	9.5
3000	6	10.7	44	13.6
3050	6	7.4	59	10.3
3200	10	7.6	100	6.4
3500	10	8.8	95	7.4
3500	5	4.0	102	6.9
3500	7.5	11.4	55	12.7
4000	8	5.6	137	5.8
4000	5	3.8	125	6.4
4000	5	8.3	57	14.0
4000	7 } 3 bonus }	9.8	98	8.2
4100	6	4.9	120	6.8
4573	7.5	7.2	114	8.0
4800	6	7.7	89	10.8
5000	5	9.5	63	15.9
5000	5	13.9	43	23.3
5000	6	11.5	62	16.1
5100	5	9.3	65	15.7
5100	4.5	5.8	94	10.9
6000	5	15.8	45	26.7
6000	6.5	12.0	77	15.6
6500	5	6.2	126	10.3
7578	10	15.2	118	12.8
8000	5	7.4	129	12.4
8447	7	14.0	101	16.7
8595	5	10.1	102	16.9
9500	6	10.5	130	14.6

Note - All Scottish companies (names witheld)

Source - Gas World 28/10/1911

Table 4.56 The Extent of Profit Reinvestment in Various Companies

Company	Date	Paid-Up Nominal Capital Stock (£) Old	New	Nominal Value of Old Shares (£)	Each Old Share replaced by:
Kirkcaldy	1866	6750	13500	5	One share £10
"	1883	20500	30750	10	Three shares £5
Ayr	1858	13300	14630	5	$1\frac{1}{10}$ shares of £5
Banff	1869	3750	4500	10	One share £15
"	1906	4500	5100	15	One share £17
Bathgate	1874	1000	2000	5	One share £10
"	1902	3000	6000	15	Six shares £5
Cupar	1872	2500	6250	10	One share £25
Galashiels	1870	9000	13500	5	One share £7.10.0d
"	1878	13500	18000	7.10.0	One share £10
Dunfermline	1870	8600	15050	10	One share £17.10.0d
"	1891	22575	32250	17.10.0	One share £25

Sources - S.R.O. Ayr, Bathgate and Cupar Minute Books op cit

S.R.O. (B.T.2/1200) Kirkcaldy, (B.T.2/2245) Dunfermline.

Capital equipment extensions paid out of profits over a long period were equivalent to 150 per cent of contemporary share capital at Kirkcaldy, 70 per cent at Banff, 200 per cent at Bathgate, 150 per cent at Cupar, and 100 per cent at Galashiels. Thus, as in several other British industries[1], ploughed-back profits were sometimes the greatest single source of capital.

1. P. Mathias The First Industrial Nation (1969) p. 149 Vide infra p.1179 c.f. Duckham has suggested that most late eighteenth century capital for Scottish coal mines was derived from ironworks, glasshouses, landowners and banks, especially through the interlocking partnerships in iron and mining industries, rather than being directly reinvested from profits. Bank loans were a last resort for coal companies. B.F.Duckham Scottish Coal Industry (1970) pp.189-199

Progressive extensions of capital equipment, like mains pipes, were paid annually out of profits, usually under the heading of "maintenance costs". Little attempt was made to distinguish between reploughing of profits and share premiums on renewals and on extensions, so that few companies realized the value of fixed capital in use. Periodically gas-works were evaluated by skilled engineers, and the nominal value of shares raised to correspond with the increased fixed capital. Alternatively, additional shares were created at the old value, and distributed gratis as fully "paid-up", proportionally to the existing shareholders[1].

This was an important bonus, which on rare occasions was used to boost confidence in the company. The Vale of Leven[2] company at Alexandria which commenced in 1839, was faced with several technical problems including a leaking gasholder-tank, which caused heavy loans to be taken at a time of severe local trade depression. Consequently the nominal value of shares was progressively raised, to impress shareholders by adding 'book' money as well as paying dividends.

Table 4.57 Revaluation of Shares at the Vale of Leven (1839-44)

Date	Nominal Value Shares	Dividend	Total Debts £	Profit £
1839	£5	-		
1840	£5	0	500	47 (1.9%)
1841	£5.5.0d.	5%	500	
1842	£5.10.0d.	5s. (4.5%)	500	258 (10.4%)
1843	£5.10.0d.	8s. (7.2%)	500	290 (11.7%)
1844	£6	8s. (6.6%)	300	470 (19%)

Source S.R.O. Vale of Leven Minute Book op cit

Revaluation on almost an annual basis was impractical, and in 1847 Leven restored all £6 shares to their original nominal value of £5. By that date, £996 had "been already transferred from Revenue to Capital Account", and it was still desirable to credit the original shareholders with stock to an equivalent value. 250 new shares were therefore created, and one

1. Vide infra pp.819 Table 4.56; 827 Table 4.60
2. S.R.O. Leven Gas Company Minute Book op cit. Vide Infra Appendix V

offered to each person holding two old shares. However, only £4 was credited as "paid up" on them, and by 1849 a hundred and fifty had not been claimed by partners unwilling to pay the final £1. This type of confusion was prevented elsewhere by the more usual practise of automatically allocating such shares fully "paid up".

In 1831-46 Hamilton old company[1] with a nominal capital of £3000 reinvested at least £200 surplus profits, or about 6.7% extra. The dissolution of the 1841 Dunblane[2] gas company in 1887 was blamed upon its failure to reinvest on a sufficient scale to meet the growing demands of the town. These two companies were exceptional; in most cases reinvestment of both surplus revenue and share premiums occurred upon a very large scale, as did repayment of loan capital out of revenue. The overall effect was evident in the revaluation and reallocation of shares made at a later date.

Reinvestment of surplus profits on a very large scale occurred at Aberdeen, one of the most important unincorporated companies, where G.A. Jamieson[3] reconstructed the accounts on behalf of Aberdeen Corporation in 1871. Between 1847 and 1871 the company[4] made total profits of £203,087, paid dividends of £133,349, and retained £63,547. During 1847 a 'surplus'

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1. Evidence of W. Henderson. H. Commons 1846 Vol. 102 11/5/1846 p.63
2. Works offered at auction in Stirling for £2300 in 1887 but proved unsellable. A new and larger company was formed to absorb the old company and supply the town.
   J.G.L. 15/3/1887, 3/5/1887
3. An Edinburgh accountant, employed also by Dundee council in 1867 to analyse the Dundee gas company books. Jamieson had access to the Aberdeen balance sheets, and profit and loss accounts, but not the Company books. His figures were verified by J. Meston, accountant in Aberdeen. J.G.L. 3/5/1871 p. 397
4. New and old Aberdeen gas companies amalgamated 1846 giving a united £80,000 capital; the works were evaluated at £92,000; but following an agreement in 1852 the capital stock was voluntarily reduced in 1856 to £65,000. In 1846 the old gas company's works was sold for £14,818 to the new railway company in Aberdeen, and £13,000 of that revenue spent extending gas mains to the town suburbs. Bonus of 10s.0d. per share to partners in 1853 at a cost of £15,000. New gasworks built in 1866 and old works sold.
   Evidence of J. Webster J.G.L. 23/5/1871 p. 400
   Vide infra Consumers Companies pp. 1124, 1133; also p.1058

of £744 was placed into .. "what they called a contingent account" which accumulated to £2694 by 1851 despite considerable additional extensions made to the works out of revenue. The "Capital account" rose from £81,578 in 1847 to £90,783 by 1851 by the reinvestment of £9205 profits. During 1853-7 surplus profits totalled £17,000 of which £6500 was spent on extensions, and £11,000 written off the "capital account" which was reduced from £76,000 to £65,000 in 1857 and remained at that level on the books up to 1871.

During the period 1857-71 a total £30,000 of unappropriated profits was used in other ways, partly through various "funds" of types examined separately later[1]. Aberdeen company opened a 'Reserve Account' with £848 in 1858, and allowed it to rise to £11,000 by 1864, before falling to £10,600 from 1867. Other surplus profits entered a Fire Insurance Fund which commenced with £802 in 1864, reached £1112 by 1866, and then rose by £150 per year to £1724 by 1871. Another £12,324 remained as liquidity and stores on hand in 1871, and at least £5,014 was spent on capital extensions during 1857-71. More of the undivided surplus revenue was used for large scale depreciation. The ground at Sandilands was valued at £1054 in 1862, but entirely written off the following year. The "capital balance", of assets other than the gasworks, was reduced from £9576 in 1867 to £5084 in 1870 by writing off £4493 covered out of revenue.

In 1862 Aberdeen gas company voluntarily agreed, as a result of Flintoff's campaign, to make a maximum limit of 10 per cent on dividends to shareholders[2]. Nevertheless, large surplus profits[3] continued to be exacted without a corresponding reduction of gas price. Total surplus profits were £18,539 in 1862-71, of which £7774 was used to raise total

1. <u>Vide infra</u> pp. 835, 839
2. In 1871 J. Webster claimed that the Directors decided informally upon a 10 per cent maximum in 1856, but did not inform the public of that restriction until 1862
   <u>J.G.L.</u> 23/5/1871 p. 400
3. Average £11,513 total annual profits 1861-71 e.g., £11,000 in 1867, £10,000 in 1861, £12,000 in 1869, £15,000 in 1870. Stock on hand rose from £5000 in 1868 to £12000 in £1870. During 1870 gross revenue £31,671; manufacturing costs £14,488 management costs £2125, repairs/renewals £3321, £1012 reinvested on capital equipment, £6500 paid in dividend.

company assets from £74,590 to £82,364. Jamieson was unable to state where the remaining £10,766 had been used, or many of the earlier surpluses. Through the policy of reinvestment, Aberdeen company had no external debts in 1871 and more than adequate reserve funds. John Webster[1], the company Chairman, stated that they had "no depreciation account because the works have been so thoroughly and substantially maintained that it has been unnecessary", but since 1847 £57,000 had been spent on extensions "wholly exclusive of the amount which is necessarily spent every year for maintaining the works in perfect order". Repairs therefore were differentiated from extensions, but both were treated simply as working costs.

Jamieson maintained that the entire unappropriated profits of the company had been used for the benefit of consumers. They had not been used to make immediate reductions in the price of gas, but neither had they benefited shareholders, and in the long term the consumers obtained the full value of a well constructed and well managed gasworks. Some companies, like Glasgow[2] in the 1830s, publically acknowledged the reinvestment of profits on a large scale as a form of "social compact" with consumers who paid less for gas under that arrangement than if the money had been obtained from loans or from additional shares.

Although chartered gas companies were, in theory, closely controlled by Parliament, a devious manipulation of depreciation accounting and reserve funds enabled tham to reinvest surplus profits on a large scale. The printed annual statements distributed to shareholders failed to provide a precise definition of depreciation, and Glasgow company was particularly criticised for this, by consumers[3] in 1836.

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1. J. Webster, advocate; Lord Provost of Aberdeen 1856-9; Director of Aberdeen Gas Company 1846-71

2. Vide infra p. 1121

3. Vide infra 'Consumer Relations' p. 1125

Table 4.58 Falsification of Glasgow Accounts 1825-34

(1) Accounts Stated by Glasgow Gaslight Company (£)

Date	1826	1827	1828	1829	1830	1831	1832	1833	1834
Expenditure	14,771	14,597	15,651	13,279	15,691	15,925	16,464	17,171	17,752
Profit	-	-	-	2,896	1,501	6,511	4,508	4,412	3,605

(2) Accounts Restated by R. McGavin and G. Card

Expenditure	12,018	12,315	14,451	11,840	13,490	12,610	15,427	18,299	16,551
Profit	-	-	2,463	8,973	7,326	7,561	7,843	15,801	5,635

Note - Expenditure: Coal, Wages, Wear and Tear
Profit: Total Surplus Profit plus Interest
McGavin and Card were auditors appointed by Glasgow City Council

Source - Glasgow City Archives (D.G.E - 126)

Gavin and Card claimed the company had exacted £32,834 surplus profits in excess of those openly declared. Besides failing to state the sum charged annually as "wear and tear" against revenue, large sums entered a capital account openly for new property, and flowed into a "Suspense Account" for replacing gas meters. By 1839 the cost of gas meters hired out, including fitting was recorded as £2100, yet the "Depreciation" and renewals were £2014, so that the capital value of those meters was represented as only £86. Although by 1839, the deterioration allowance was stated separately, it remained excessive, and the accounts seen by shareholders did not give the total wiped off as "deterioration" in past years.

When Glasgow Gaslight Company[1] spent £9000 extending mains pipes through the suburbs in 1860-1, that expenditure raised the total fixed capital to £290,452 compared to share capital of £150,000. During consumer agitation, the company defended its heavy loan capital on the grounds that it cost less in interest than did capital stock.

1. J.G.L. 13/8/1861 p. 595
Vide infra 'Consumer Relations' p.1159

Table 4.59 Glasgow Gaslight Company - Finances (May, 1861)

	(£)	
Expenditure of Capital - Works, pipes, meters	290,452	(after depreciation)
Compulsory Reserve Fund (under Act)	5,000	
Annual net revenue	16,225	
Sources of Capital (Fixed and Working Capital):-		
6000 shares of £25	150,000	
Premium on Shares (on which no Dividend allowed)	49,725	
Reserve Funds account	26,492	
Mortgages	49,500	
Debts due to Tradesmen, etc	31,514	
Unclaimed dividends	352	
	307,583	

Source - J.G.L. 13/8/1861 p. 595

The Glasgow company[1] in 1857 had £29,104 surplus profits and premiums in hand, but through interest this sum rose to £40,000 by the time it was used to purchase capital equipment in the following twelve years. During that interval a further £30,000 of surplus profits was reinvested, making a total of £70,000 capital expenditure above the share capital by 1869. During 1869 £7500 stock was issued for £11,397, which was then written off the earlier capital expenditure, a form of arbitrary "depreciation"[2] which concealed the effect of profit reinvestment in many chartered companies.

Chartered companies were unable to raise the nominal value of shares, and dividends at a fixed maximum level declined in real value as the market price of shares rose. Unicorporated companies could and did raise the nominal value of shares. Theoretically the new nominal value corresponded fairly

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1. Evidence of James White of Overtoun, company Chairman. Average capital expenditure £10,000 per year from 1857-69 J.G.L. 13/4/1869 pp. 271-5

2. Vide infra p. 844 Chapter
Any assumptions based upon published U.K. figures for capital expenditure by chartered companies must make allowance for the large scale of concealed reinvestment on fixed capital equipment. e.g., statistics for 1882-1913 quoted by W. Page Commerce and Industry (1919) op cit. Vide infra p. 1537

closely with their market value. In 1866 Galashiels issued new £5 shares at an upset price of £7.10s.0d., and in 1870 revalued all shares at £7.10s.0d. Cupar[1] shares of £10 nominal value had been worth £14 in 1845, but the nominal value was only raised in 1872. The market price had been above £20 for several years, and the new nominal value was £25. At Banff, however, the shares were revalued from £10 to £15 in 1869, but when 50 new shares were sold preferentially to shareholders the following year they only realised £12.10s.0 to £14. Nominal capital stock, even when revalued, was only an approximation of "true" value in terms of the market evaluation of potential risks and profits.

Many established gas companies revalued their nominal share stock during the process of obtaining Limited Liability, which often involved a new contract of co-partnery. The works were therefore evaluated, usually by a consultant gas engineer[2], and the shares altered accordingly[3]. The new value of shares prevented municipal authorities[4] from acquiring gasworks at low prices which ignored the effect of reploughing, and this was important at Dunfermline, for example in 1896. Limited companies did not always make full acknowledgement of plant value during registration. At Irvine in 1908 the limited company offered, for each old share of £10, 23 new shares of £1 paid-up or £36 cash, a considerable difference. St. Andrews limited company in 1910 offered, for each old share of unrecorded value, four new £10 shares paid-up, or £70 in cash; in 1914 a further revaluation was made there.

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1. 65 reserve shares sold at £14 in 1844
   S.R.O. Cupar Minute Book <u>op cit</u> 3/12/1844

2. e.g., Forres was valued at £6841 by G.R. Hislop of Paisley, and so registered in 1889 with a nominal capital of £6840. At Largs, gas output in 1890-1900 rose from 6.2 to 10.3 million cu ft without the use of additional share capital, and the works were not evaluated until 1901 when R.F. Hislop of Paisley stated they were worth £9721, and a new Limited Company was formed to purchase that of 1888.

3. In many cases where the nominal capital of the old company is not known, the Limited Company did not take over by a simple exchange of shares in the ratio 1 new: 1 old. Some, like Kirkintilloch (1868) did, but Larkhall (1897) gave 5 new for each old share, and Crieff (1903) gave 3 new for 2 old shares. Both revaluation of stock, and a move towards smaller denomination shares, were involved at the same time.

4. <u>vide infra</u> 'Municipal Organization' pp. 1048, 1051

Table 4.60 The Extent of Profit Reinvestment in Various Limited Companies

Company	Date Registered	Date of Alteration	Nominal Capital Stock Old	Nominal Capital Stock New	Nominal Old Shares £	One Old Share replaced by:
Turiff	1906	1862	912.5	1218.25	2.5	One share £3.75
Bridge of Earn	1859	1866	1000	1200	1	$\frac{1}{5}$th share of £6
Blantyre	1862	1873	1800	2000	1	$1\frac{1}{9}$ shares £1
Innerleithen	1898	1874	800	1311	2	One share £3
Barrhead	1880	1880	5550	12500	1.5	1.7 shares of £2
Largs	1901	1901	5600	7000	20	Five shares £5
Irvine	1908	1908	20170	46391	10	Twenty three shares £1
St. Andrews	1910	1914	16960	21000	10	$1\frac{1}{4}$ shares of £10

Sources - S.R.O. (B.T.2/6284) Turiff; (B.T.2/46) Bridge of Earn; (B.T.2/20) Blantyre; (B.T.2/3998) Innerleithen; (B.T.2/3998) Barrhead; (B.T.2/1809; B.T.2/4843) Largs; (B.T.2/6880) Irvine; (B.T.2/2245) St. Andrews (B.T.2/7690)

Innerleithen[1] had a nominal capital stock of £800 from 1846-74, but during 1874 £222 loan capital was in use and John Young of Bonnyrigg evaluated the works at £2488, or 300 per cent on the capital stock. In 1866 the Bridge of Earn Company[2] had £246 fixed capital in excess of stock, and after allowing £46 depreciation, shares were regrouped so that five £1 shares became one £6 share.

1. S.R.O. (B.T.2/3998)
   c.f. Turiff company (B.T.2/6284) had a stock of £912.10.0d unaltered from 1838 to 1862
2. To allow for depreciation each £6 share was reduced to £5 nominal value in 1884.
   S.R.O. (B.T.2/46)

The effects of reinvestment upon the market value of shares and upon the capital value of a gasworks were acknowledged whenever works were purchased by municipal authorities.* Where the price was agreed at a lump sum, it was based upon their actual value regardless of the share-stock, plus an amount which represented the loss of profits over a period of usually about 20 years. The normal price of feu duties in Glasgow[1] in 1871 was 22½ years purchase price and provided a comparison for such evaluations. Dundee gas company[2] shares with £23.10s.0d paid up, had a market value of £51 at the time agreement was reached with the Council in 1867, which upon the advice of a consulting engineer agreed to pay £63, equivalent to 21 years purchase[3] at the level of the last dividend of £3.

Where the price was paid on annuities, these were related to the previous level of dividends. The security of gas company shares was considered by financiers to be less than the security of municipal gas annuities, and municipalities used this important difference to pay lower annuities than the previous dividends. They argued that the rise in market value of shares which became annuities compensated the shareholders for the reduction in annual revenue. Payment of annuity was guaranteed even if the works were demolished by a conflagaration, or superceded by other forms of illumination. Glasgow in 1889 paid 9 per cent annuities in place of 10 per cent dividends. J. Meston[4], accountant, stated in 1871 that gas annuities were as safe as Consols so that £100 stock with a 9 per cent annuity had a market value of £225, considerably above the market value of £100 company shares with 10 per cent dividend.

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1. Evidence W. Anderson, C.A. Glasgow
   J.G.L. 23/5/1871 p. 398
2. In 1867 the two Dundee companies promoted a Bill for amalgamation. Evidence of C. Kerr, Dundee Town Clerk 1822-68
   J.G.L. 9/6/1868 p. 423 Vide infra 'Municipal' p.1035
3. The price was fixed by arbitrators; the Town Council had no access to company books, or statistics even showing gross annual revenue, before the purchase. The companies originally requested a price of £21,000 per year (£525,000 in total), later reduced to £14,000 £362,000) but the Council enforced the use of arbitration which reduced the cost to £8662 per year compensation (£216,000). Therefore, although the arbitration itself cost £40,000 the council saved a total of £150,000 Evidence of Provost Hay J.G.L. 9/6/1868 p. 491, 23/5/1871 p. 398
4. J.G.L. 23/5/1871 pp. 396, 398

* 'Battle of Stirling' vide infra p.949

Aberdeen gas company paid 10 per cent annual dividends from 1857-71 and the shares of £2.10s.0d had a market value of £5.4.9d, reducing the dividend to about 5 per cent on the market value. Aberdeen corporation[1] viewed the overall market value as £209.10.0d per £100 stock, and claimed that 9 per cent annuities would raise each £100 stock to a market value of £225, the equivalent of a "bonus" of £16,250 to shareholders. Ten per cent annuity would have further raised that "bonus" by £7.10.0d per £100 stock. Viewed from the shareholders' side, if they wished to subsequently sell the annuities, the 9 per cent annuity of £4500 per year was, the corporation argued, equal to a market value totalling £5830 per year with 20 years purchase prices. Parliament accepted this reasoning, but still awarded the company 10 per cent annuities to penalise the corporation which had used unjustified pressure[2] to make a compulsory purchase instead of reaching agreement by arbitration. Elsewhere, many less prosperous companies willingly accepted annuities slightly lower than former dividends.

The heavy expenditure necessary to renew a retort-bench and accessories, or provide additional gasholders, has already been mentioned[3]. Analysis of total fixed capital expenditure shows the heavy cost also incurred in pipes, which made changes in cast-iron prices of great importance to company finances. Periods of cheap iron, as shown in Figure 4.5 , stimulated support for new rival and Consumers' companies, sometimes abetted by ironmasters[4] seeking to raise sales. Total expenditure on Greenock[5] gasworks up to 1829 included £2841, or 33.9 per cent, on mains

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1. J.G.L. 23/5/1871 pp. 393, 398

2. To block a Bill by Aberdeen gas company to increase the capital stock from £65,000 to £80,000, the Corporation employed a London engineer, Mr. Barlow, to design a new gasworks costing £65,000 fixed and £10,000 working capital, and promoted a Bill to construct such a gasworks. J.G.L. 23/5/1871 pp. 391, 393

3. Vide supra p. 778

4. Vide infra 'Tolcross' p.1123

5. Other expenditure was £2627 on buildings, ground, gasometer-tank and walls; £1733 on gasholder, purifiers, condensers etc., £1170 on interest, management, plans and sundries. J.G.L. 10/5/1881

Table 4.61 Relative Values of Fixed Capital Equipment at Stornoway and Selkirk (1887)

Equipment	(1) Stornoway £	(1) Stornoway % Total	(2) Selkirk £	(2) Selkirk % Total
(1) Buildings				
Dwelling House (Manager)	250	11.1	350	2.8
Retort House	120	5.3	1943*	15.3
Coal Stores	131	5,8	442	3.5
Boundary Walls	75	3.3	729**	5.7
Lime Shed/Purifier House	50	2.2	***	-
Store and Coke Shed	35	1.5	75	0.6
Chimney and foundations	60	2.7	142	1.1
	721	31.9	3681	29.0
(2) Apparatus				
Retort Bench and fittings	60	2.7	*	-
Gas holder	495	21.9	3050	24.0
Condensers	20	0.9	316	0.2
Purifiers	30	1.3	1773	14.0
Tar and Water Cisterns/ Tools	12	0.5	94	0.7
	617	27.3	5233	41.2
(3) Distribution Plant				
Station Meter	-	-	209	1.6
250 Meters	300	13.3	-	-
Mains Pipes	547	24.2	2748	21.7
Governor and fittings	15	0.7	75	0.6
250 Service Pipes	60	2.7	744	5.9
	922	40.8	3776	29.8
Total	£2260		£12690	

Note - 52 retorts at Selkirk; * Retort bench included with Retort House;

** walls, causeway, garden

*** purifiers, purifier house, and lime shed in same category

Selkirk works evaluated by Robert Mitchell

Sources - S.R.O. Stornoway Minute Book op cit; Selkirk Minute Book op cit 15/10/1887 and service pipes. Dunfermline[1] had spent 42.6 per cent on pipes by 1830, and Dunse expected to spend at least 30 per cent that way in 1835. Evaluations of fixed capital equipment[2] at Stornoway and Selkirk gas companies in 1887, verify the heavy cost of mains pipes, at 24 per cent and 22 per cent respectively of total fixed capital, and also the large expenditure on meters[3], at 13 per cent of the total for Stornoway.

Table 4.62 Fixed Capital Expenditure at Dunfermline (to 1830) and Dunse (1835)

Items	(1) Dunfermline £	%	(2) Dunse £	%
Ground	358	-	-	-
Buildings	1079	30.5	350	32.3
Apparatus	950	26.9	375	34.6
Pipes (including laying)	1506	42.6	360	33.2
Total (excluding ground)	3535		1085	

Sources - (1) Dunfermline Ref. Lib. Dunfermline Minute Book op cit 26/5/1830
(2) Estimate of expenditure by Mark Taylor S.R.O. Dunse Minute Book op cit 26/6/1835

Only gradual extensions of mains pipes could be financed from surplus revenue. Major extensions required a heavy outlay in a short period of time and the risk of inadequate remuneration was more daunting. The effect of this upon markets is examined later[4], but the reluctance of companies to finance large extensions was most noticable. Only where future revenue was guaranteed were such steps taken, often with the aid of loans.

1. Per-centage of expenditure excluding ground purchased.
2. These were professional evaluations by a consultant engineers; few such accurate statements are extant, but the importance of pipes and meters is also apparent in partial capital accounts shown later. Vide infra Appendix VI.1
3. Statistics on meter and pipe expenditure by the Edinburgh and Leith companies, and municipal works, from 1870-99, and by Dundee municipal works from 1872-81, are given in Appendices. Vide infra pp1570,1571
4. Vide infra Markets p.1234 et. seq .
Service pipes were supplied gratis only in short lengths, 21 feet at Lesmahagow in the 1890s; and 20 feet at Dunse in the 1830s; consumers paid for any extensions.
S.R.O. Lesmahagow Minute Book op cit 20/4/1898
Dunse Minute Book op cit 26/9/1836

Table 4.63 Reduction in Iron Gas-Mains Prices (1815-64)

Diameter inches	1815 A	1815 B	1829 A	1829 B	1843 A	1845 A	1859 A	1864 A
1	-	-	1/2	-	1/1¼	1/1	-	-
2	5/-	-	2/2	9/6	1/8½	-	1/9	-
3	6/-	-	3/4	9/-	2/3½	-	2/3½	-
4	8/6	-	4/7	9/-	2/9½	-	3/2	-
5	10/-	-	6/2	9/-	-	-	-	3/-

Note - A cost per yard

B cost per cwt

Sources - 1815 F. Accum Practical Treatise, (1815) op cit p. 186

1829 Dunfermline Minute Book (16/4/1829) - Tender by Devon Iron Co.

1843 Boness Minute Book (4/12/1843) - Tender by Devon Iron Co.

1845 Cupar Minute Book (11/12/1845) - Tender by Shotts Iron Co.

1859 Muirkirk Minute Book (16/7/1859) - Tender by Messrs Laidlaw.

1864 Cupar Minute Book (3/6/1864) - Tender by Robertson and Wilson.

A history of Devon Iron Company, one of the major gas-pipe suppliers, is given by J.L.Carvel: One Hundred Years in Coal - The History of Alloa Coal Company (1944, Edinburgh) ; see also B.F. Duckham Scottish Coal Industry (1970) pp. 150, 188. Vide infra p. 1625 Appendix X.2

The Vale of Leven company in 1855 extended mains beneath the River Leven to Messrs. Orr Ewing's Levenbank works[1] only in return for a guarantee that the Works would use this gas for 10 years. Inhabitants of nearby Jameston[2] village agreed to consume at least £30 gas per year before the Company undertook to supply them also. By 1856 these extensions had cost £342, including £60 for the connection to Jameston, on which the Company forecast an increased revenue of £230 a year. A special general meeting in 1857 also considered supplying gas to Renton[3] township at a cost of £500 for the main pipe and £160 for meters, but refused to proceed unless Renton would guarantee to consume, annually for five years, gas equal to one third of the cost of the extension. This was not forthcoming, and Renton later developed an independent gas company. Also in 1857 Balloch villagers petitioned the Vale of Leven company, but only when three[4] of the residents guaranteed to consume £40 gas per year did the company agree to lay suitable main pipes costing £116 from Jameston village.

Lesmahagow company expanded with equal caution[5], and in 1894 for example, agreed to lay a two inch main to Bankhouse only when the builder, Mr. Clarkson, "promised to fit up twelve houses with three lights in each"[6]. Companies had to reach a balance between the cost of extending main pipes, and the increase of revenue which was possible. In 1901 the Cupar company[7],

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1. S.R.O. Vale of Leven Minute Book op cit 27/12/1855
2. ibid 20/5/1856
3. ibid 13/7/1857
4. viz. G. Wotherspoon; Mr. Mitchell of Balloch Hotel; P. McAlester and J. Nairn joiners. ibid 31/8/1857
5. Netherhouse district was supplied for Mr. Ferguson in 1853, and Auchtyfardle in 1866 for Captain Mossman, entirely at the expense of those individuals.
   S.R.O. Lesmahagow Minute Book op cit 17/6/1851, 21/6/1853, 2/7/1866
6. ibid 15/9/1894
7. S.R.O. Cupar Minute Book op cit 14/12/1901

for example, considered buying three miles of mains to supply Ceres village, which already had distributing pipes and consumed 175,000 cu ft of high candlepower but expensive oil gas from a local plant. The three inch mains would have cost £310, while Cupar expected to sell 500,000 cu ft of cheap coal gas to the village. This would have increased the company revenue by £22, or £38 if higher differential gas prices were charged. Conversely, 5 per cent interest on the equipment cost of £340, plus working costs of £7.10.0d per year, amounted to £25, so the venture was not pursued in view of inadequate profit margins.

Apart from dividends payments and reinvestment[1], surplus annual profits and unexpended share capital could be used to create 'Reserve Funds'. This generic term covers both 'contingency' and 'sinking' funds, since these terms were interchangeable in the eyes of many directors in the early nineteenth century. 'Contingency funds' accumulated at a specific rate, and maintained at a fixed minimum level, were compulsory under the contract of co-partnery[2] of many gas companies. Elsewhere, the level or even the existance of such a fund involved a later and deliberate policy decision by shareholders, rather than a simple improvement in book-keeping methods[3]. The origin and function of reserve funds is of particular importance since they constituted the principle 'shock absorber' between the Company and the economic climate in which it developed.

'Reserve Funds' are, however, poorly documented. Often they commenced as true 'Sinking Funds', accumulated at compound interest to repay debts; the cecession of debt resulted in their conversion into contingency funds

1. Large chartered gas companies were compelled by Parliament to operate some of the earliest Contingency Funds, as did Paisley from 1826. These companies also developed "Deterioration Funds", which were used to circumvent restrictions placed upon their use of capital as previously stated. Paisley "Deterioration Fund" by 1840 was recorded as cash in the Bank, and was in effect a Reserve Fund.
H. Lords 31/7/1844 pp. 212-45; Vide infra p. 977

2. Vide infra pp. 927, 976

3. One important factor influencing book-keeping may be noted in regard to the need for reserve funds. The amount of necessary working capital increased comparatively slowly. Except during coal crises, raw materials were paid from successive collections of gas rent made during the same year. Often, annual contracts for raw materials were signed before the

to meet unforseen circumstances, which also provided reserve liquidity to meet unusually high "working costs"[1]. But "working costs" included re-ploughing 'profits' as well as buying coal. Company decisions varied, however, and in some cases the Fund was not used as reserve liquidity, and remained intact even when external loans were acquired[2]; sometimes reploughing expenses were paid by a "loan" from the Fund which had to be repaid within a given period of time. The Fund was normally placed on deposit account at a local bank, but by the 1880s when gas companies had grown quite large, it was used to speculate in the stock of other commercial companies.

Some form of 'Fund'[3] was almost universal among gas companies by the 1840s. In 1837 Selkirk[4] company resolved to pay 10 per cent of annual profits into the British Linen Bank, until the Fund reached £100, compared to the Company's debts of £170. By 1843, when all debts had been repaid, the Company agreed to reduce the price of gas only upon the understanding that revenue would still allow normal dividends plus £71 into the "Sinking Fund" each year. The Fund had been transformed into a Surplus or Reserve Fund.

A.G.M., but annual 'profit' was declared after a deduction for raw material expenditure in the previous year; it was not a 'profit' in excess of adequate reserve working capital for anticipated expenditure during the forthcoming year. Only when coal prices were forcast to rise was restraint, if any, placed upon dividends to increase reserve liquidity for the impending difficulties. Directors could manipulate the amount of "profit" publically declared, by varying the amount of money paid out on supplies and materials before the time of auditing, unless specific provision was made to account for stocks on hand.

1. c.f. The Birmingham Canal Company in 1800-24 altered the function of the "Sinking Fund" in a similar way; Midland Railway in the 1840s used a "depreciation fund" for reinvestment. S. Pollard <u>Genesis of Modern Management</u> (1968) pp. 280, 283
2. <u>Vide</u> <u>infra</u> p.778
3. The alternative, sometimes used in the 1820s, was to record all unexpended revenue as "cash carried forward", an undifferentiated account which could be used for any purpose. Flintoff's complaints over 'secret funds', <u>vide</u> <u>infra</u> p.1160
4. S.R.O. Selkirk Minute Book <u>op</u> <u>cit</u> 4/2/1837, 2/5/1843

Stranraer[1] company operated two genuine Sinking Funds at invervals between 1840 and 1865, and in 1865 it was converted to a Reserve Fund. A general meeting in 1840 resolved to abstract $7\frac{1}{2}$ per cent on all debts from annual profits until debts were fully repaid, but the following year voted "that the company shall have no provision for a sinking fund" in the contract of co-partnery. This is incomprehensible unless the second decision really referred to a Reserve Fund accumulated annually, because a true Sinking Fund on debts was subsequently formed though related to the size of debt instead of the size of profits.

Table 4.64 Stranraer Sinking Fund (1852-4)

Date	Total Debt £	Money taken from Annual Profits (% on past year's debt)	
1852	321	$7\frac{1}{2}$%	£400
1853	302	$7\frac{1}{2}$%	£350
1854	26	$7\frac{1}{2}$%	£300

Source - S.R.O. Stranraer Minute Book op cit

Total repayment[2] of loans was completed in 1865, and the following year, "the current account being overdrawn [at the Union Bank] it was agreed to uplift as a loan the deposits made by the Company as a sinking fund, to be paid into the current account for a term". Later in 1866 a distinct Reserve Fund was created "on an Interest Receipt in name of the **Preses** and Treasurer".

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1. S.R.O. Stranraer Minute Book 6/10/1840, 9/1/1841, 29/6/1852, 28/6/1853, 30/6/1857
In 1861 Stranraer Company was forced to pay £500 to Stranraer Academy, because of a forgotten clause in the 1836 Contract which made over all surplus profits above $7\frac{1}{2}$ per cent to the Academy. A Sinking Fund was then used to repay the Bank Loan which that involved.

Stranraer Sinking Fund

Date	Cash Added	Total Fund
1863	£100	100
1864	233	
1865	100	103
1866		208

S.R.O. Stranraer Minute Book 1/7/1863, 1/6/1864, 3/7/1865, 4/7/1866

2. ibid 4/7/1866 £208 paid into the new Reserve Fund

Dalkeith[1] opened a "Sinking Fund" in 1839, only after completing the total repayment of debts contracted in 1829, by issuing new stock. The fund was accredited with £270 of equipment on hand, mainly unused retorts, and with £230 from the last call made on new shares. It was kept separate from total reserves, however, and in 1841 contained only £500 of the total £972 reserve funds in the National Bank. Bathgate[2] company opened a "Sinking Fund" in 1841, after repaying all debts, and in 1845 the Directors were empowered to invest those reserves as they saw fit.

There was no point having an authentic Sinking Fund in the same bank from which loans were obtained, but the pre-existence of a Reserve Fund apparently increased the willingness of banks to lend by overdrafts instead of the more expensive Bills[3]. In 1844 Galashiels[4] had £200 in a Sinking Fund, but no outstanding debts. This deposit account with the National Bank was overdrawn by £775 in 1847 during repairs to the gasholder tank, and not repaid until 1851 when a further £48 was also deposited as "Sinking Fund".

The new Ayr company[5] set up a true Sinking Fund with £106 in 1847 to repay debts involved in purchasing the gasworks. In 1848, despite continuing debts, it was renamed a Contingency Fund to which £200 was added, and shortly afterwards £200 "borrowed" for reinvestment in equipment. When total debts were repaid with new share capital in 1852, the Fund remained in existence and the Directors were empowered to raise it from £1000 to £2000 if necessary. £1000 from the new stock was then entered, and a further £2000 in 1875 from the sale of more stock.

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1. S.R.O. Dalkeith Minute Book op cit 21/6/1839, 30/6/1840, 18/6/1841
2. S.R.O. Bathgate Minute Book op cit 18/5/1841, 20/5/1845
   In companies which placed the Reserve Fund on deposit receipt at a bank, the Working Capital was kept in an entirely separate, cash receipt (current) account.
3. Vide infra p. 769
4. During 1858 the Galashiels Deposit Account was again overdrawn by £739 during equipment extensions, but in 1860 alternative loans were taken and £163 deposited as a Reserve Fund in the Bank; not as a Sinking Fund.
   S.R.O. Galashiels Minute Book op cit 2/7/1844, 6/7/1847, 24/6/1851
5. S.R.O. Ayr Minute Book op cit 28/6/1847, 3/7/1848, 4/7/1853

The Reserve Fund[1] was a buffer which enabled a company to replough for all but the largest items of equipment, whenever the need arose, thereby reducing interference by minor annual fluctuations in gross profits. In 1858 the Ayr directors decided £1000 was an ample reserve, thus releasing £695 for equipment investment to reduce the Fund to that level. Thereafter reploughing which exceeded deductions from annual revenue, was met by temporary "loans" from the fund.

Table 4.65 Reserve Funds of Ayr Gas Company (1850-68)

(£)

Date	Total Reserves	Annual Increments	Deposit in Bank	Fund 'Loaned' for Reploughing
1850	843	-	-	-
1851	859	-	-	-
1852	1000	-	-	-
1853	-	450	-	-
1854	-	100	-	-
1856	-	195	-	-
1858	1695	-	-	-
1860	522	-	-	-
1864	357	-	-	-
1866	566	-	316	250
1867	800	-	447	353
1868	836	600	150	686

Note - records incomplete. Source - S.R.O. Ayr Minute Book op cit

Because reinvestment was deducted before calculating annual 'profits', the reserve fund enabled the Company Directors to reduce the occurrence of anomolous "profits" caused by annual fluctuations in reploughing. It was a stabilizing factor in financial management.

As companies grew larger, like Ayr[2] after 1890, the 'Reserve Fund' was less frequently used because the current account was sufficiently large to absorb a considerable amount of reploughing. Ayr in fact opened a second deposit account at the bank which paid for capital equipment up to about £500. The 'Reserve Fund' could remain unused until major equipment was required, perhaps only once a decade.

1. *Vide infra* p.843

2. In 1889 Ayr "Contingency" or reserve fund was renamed the "Reserve Fund for Extraordinary Expenditure and equalization of Dividends" S.R.O. Ayr Minute Book *op cit* 13/3/1889

Cupar set up a "Sinking Fund" in 1843, with a deposit of £100, to go towards debt repayment[1]. Further details of the Fund in the 1840s are absent, but it charged into a general 'Reserve Fund', and in 1848 £154 was removed from it to maintain normal dividends during the purchase of a new gasholder which partly involved reploughing.

Table 4.66 Fluctuations in Annual Increment to Cupar Reserve Funds (1852-61)

Date	£	Date	£	Date	£
1852	150	1855	50	1858	50
1853	50	1856	50	1859	-
1854	50	1857	60	1860	100
				1861	0

Source - S.R.O. Cupar Minute Book op cit

The Cupar company had no loans outstanding when this "Sinking Fund" was placed in the British Linen Bank in 1852, and in 1861 the Fund contained £400. During the inverval, at least £560 had entered the Fund so that £160 had been abstracted, probably for equipment purchases. In 1866, £500 was transferred from the Fund to the current account, as "working capital" because of heavy expenditure on mains extensions the previous year which created a liquidity crisis. Similarly in 1869 £200 was transferred to the current account, during the construction of a gasholder and other equipment, which also required heavy loan capital. The "Sinking Fund" was not a substitute for loan capital, but merely a useful adjunct.

Reserve funds at Cupar in the 1870s are unrecorded but the total amount grew considerably and a distinction was made between the "Sinking Fund" and other reserves. Thus in 1880 total reserves were £1586, of which only £594 was Sinking Fund on Deposit receipt, and the remainder was surplus profits for use on reinvestment. In the early 1880s all Cupar reserve funds were depleted as a result of reinvestment, and recurrent liquidity crises in 1887-1900 were caused by the absence of a Reserve Fund[2] to fall back on.

1. Total debts £400 in 1843.
   S.R.O. Cupar Minute Book op cit 2/10/1843, 9/7/1861, 13/12/1866, 9/6/1869 6/7/1880

2. Capital extensions in 1887 cost £1079, of which £479 absorbed the total Reserve Funds, and £600 was used in loans.
   ibid 4/7/1887

The Reserve Fund even in the 1880s was not designed to meet large capital outlays. It served rather as an 'equalizing fund' for annual reinvestment, or dividend payment, or reserve liquidity after very heavy reploughing. Thus at Dalkeith[1] in 1876 £706 was spent on capital equipment of which £206 was charged against the year's profits and the company agreed "to carry forward £500 of this extra outlay in order that it may be spread over several years" as a loan from the Reserve Fund. £200 was "repaid" in 1877, but when further extensions were made the following year £150 was charged to annual profits and £150 carried forward. In 1892 when £327 was spent on new equipment, only £127 was charged against current revenue, and the rest repaid to the Fund in succeeding years.

At Bathgate[2], £40 was extracted from the £100 "Sinking Fund" in 1844 to pay dividends. The following year £25 was put in, but £50 removed to pay dividends, and again £50 in 1846 on the understanding that it would be recouped during the year. In 1893, after a slump in by-product revenue, £25 was again removed to pay dividends. Selkirk[3] "Sinking Fund" served many purposes. In 1845 it was used as working capital, in the current instead of deposit account, after the company had taken heavy loans besides reinvesting profits. Between 1865-6 a reserve fund of £922 changed into a bank debt of £1295 when all reserves were used for reploughing. Again in 1873 the total reserve fund of £2600, plus a loan of £3000, was used for capital equipment purchases. In 1874 the resumed Sinking Fund of £135 was mobilized as working capital because of the coal crisis. Similarly in 1893, when heavy reinvestment of revenue on a new gasholder produced an apparent trading deficit of £30, £606 was taken from the reserve "Surplus Account" to pay dividends. At various times the Selkirk fund had also been used as a genuine sinking fund, and was used to repay £400 debts in 1860 and £500 in 1864.

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1. S.R.O. Dalkeith Minute Book op cit 4/7/1876, 19/7/1892
2. S.R.O. Bathgate Minute Book op cit 19/5/1846
3. S.R.O. Selkirk Minute Book op cit 8/6/1859, 25/12/1854, 8/6/1864, 10/6/1874, 18/7/1893

Genuine Sinking Funds were opened by some companies in the late nineteenth century, but normally only by those which had no Reserve Fund remaining. Dalkeith in 1903 contracted heavy debts, but lacked any reserves and opened a new "Reconstruction Account"[1]. Annual increments were highly irregular, and although the debts were fully repaid by 1908, during a trade slump in 1906 Dalkeith directors resolved to spread repayment out over 12 years rather than raise extra capital stock.

Ambiguous "reserve funds" characterised chartered companies[2] as much as other companies, although Parliament enforced the retention of some authentic reserves. In 1861 Glasgow Gaslight Company[3] had £5000 invested in 3 per cent Government Consols, but the additional reserve fund of £29,105 which should have been invested "in a security, separate from that of the company", had in fact been spent on capital extensions of the gasworks; any demand placed upon that "fund" could only be met by taking a bank loan. Reinvestment through the "reserve fund" occurred on a large scale, £1161 in 1859, and £2562 in 1860, despite complaints from consumers.

Long-term external investment of reserve funds only became possible in large companies which had a considerable surplus above the amount required for normal working costs and annual reinvestment. From the late 1870s an increasing number of gas companies were in this position and able to supply capital to other sectors of the economy. Normally they favoured only "blue-chip" investment, or heavy collateral security, but still encountered great difficulty in recalling the money when it was required. Dalkeith[4] gas company in 1870 loaned £1000 to an Edinburgh builder, against the security of property in Balfour Street there. This was recalled in 1873, because of the coal crisis, but the builder was unable to pay so the property was seized. It

1. Dalkeith placed £315 in the fund in 1903, £380 in 1904, £25 in 1905, £121 in 1906, £300 in 1907 and £500 in 1908
S.R.O. Dalkeith Minute Book op cit

2. Vide infra pp. 977, 1121

3. Evidence of J. McClelland, C.A.
J.G.L. 12/2/1861

4. S.R.O. Dalkeith Minute Book op cit

had to be repaired before taking tenants, and although the company held it until 1878, the investment caused extra expenditure at a time when the Company really required liquid funds.

Stranraer[1] was placed in the same position with Glasgow Corporation Stock, purchased in 1895. Extensions were in progress on the works in 1900 when expensive coal reduced liquid funds, and loans had to be taken because the Glasgow Stock was "very low". It was sold at the first suitable opportunity, in 1903. The choice of investment was normally placed in the hands of professional sharebrokers. Banff company chairman, Provost Coutts, suggested in 1881 that part of their reserve fund could be invested in other commercial companies through L. Stephen, an Aberdeen advocate who handled the investment of several Trusts. The gas Directors agreed to make an investment, but to rely on their own judgement. This proved impossible and Messrs. Horn and Smith, sharebrokers of Aberdeen, later placed £500 at 5 per cent interest for them in the London and Canadian Loan and Agency Company[2].

The failure of the City of Glasgow Bank in 1878 due to fraud, apparently convinced some Gas Companies that bank deposits were not necessarily safer than commercial investment. Thus in 1880 Selkirk gas company[3] altered its contract of co-partnery, which had placed all funds in the British Linen Bank, and transferred £500 of the deposit to the Union Bank, and the current account to the National Bank of Scotland. During 1881 Selkirk withdrew £2000 of reserve funds from the Union and British Linen Banks, to seek greater remuneration elsewhere. £1000 was placed in both the Scottish and New Zealand Investment Co. Ltd and the Dundee Mortgage and Trust Investment Co. Ltd for three years at 4%, renewed in 1885 for five years at 4½ per cent. In 1887 both were converted from terminal to perpetual

1. S.R.O. Stranraer Minute Book op cit 6/9/1895
2. In 1886, however, the money was recalled and £450 distributed among shareholders as a cash bonus.
   S.R.O. Banff Minute Book op cit 5/7/1880, 15/8/1880, 9/11/1880, 25/6/1886
3. S.R.O. Selkirk Minute Book op cit 16/2/1885, 15/7/1887

debentures, indicating the satisfaction of the gas company[1].

Ayr gas company began its external investment programme in 1893 with a conservative purchase of £2000 in Government Consols, but in 1898 changed to Glasgow Corporation stock, and a loan to Ayr town council. Dalkeith[2] in 1887 paid £619 for £400 stock in the National Bank, but popular stock of this description proved worthwhile both in terms of appreciation and ease of disposal. In 1903 it was sold at a premium of 460 per cent and used in conjunction with a loan of £3000 to finance very extensive additions to capital equipment costing £5700. During 1888 Dalkeith gas company refused to give a loan at 3½ per cent on the Bond of a Perthshire estate, and after trying to invest £300 in the National Bank or British Linen Bank but finding the premium too high, disposed of £1200 or a 30s. bonus to all shareholders[3] in April 1889. In 1912 the Company also failed to get £500 invested in both Edinburgh Water Trust and Edinburgh Gas Commissioners.

The reserve fund was occasionally invested in the gas company's own stock. This incestuous practice raised the dividend of the remaining shareholders, but completely wasted the capital reinvestment potential of surplus profits. It was a distortion of company contracts, designed to prevent monopoly shareholders[4]. Bathgate company[5], for example, in 1847 spent £51 of reserve funds repurchasing its stock at market prices from J.A. Anderson. Boness[6] company in 1849 repurchased 11 shares for £66, the parity value, from A. Vannan of Boness Distillery. The Limited company at Buckie[7] in 1883 purchased 1000 new £1 shares of its stock at 10s.0d, and in 1891 paid the remaining 10s.0d. Companies regarded this reserve stock as if it was reserve capital, only to find that it could not be sold when money was urgently required for extensions or contingencies

1. In 1886 Selkirk had £800 invested in the local Burgh, but uplifted it that year and resolved to invest £1000 elsewhere; the Freehold and Savings Company was apparently chosen, for £1000 debenture stock was withdrawn from that company in 1896 in order to finance a new retort bench at Selkirk. Further investment occurred later, and in 1908 during a fall in sales, Selkirk sold the two investments held, £400 in the Australasia Mortgage and Agency Company, and £1000 on 4 per cent Bond with Selkirk Co-operative Society. S.R.O. Selkirk Minute Book op cit 19/7/1886, 9/3/1896; loose paper dated 25/5/1908
2. S.R.O. Dalkeith Minute Book op cit 25/5/1903, 3/7/1903
3. S.R.O. Dalkeith Gas Company op cit 13/4/1889
4. Such purchases could have been used to boost shares to an artificially high market value. Vide infra p.1505
5. S.R.O. Bathgate Minute Book op cit 18/5/1847

The rapid deterioration of capital equipment led to early recognition of the need for adequate depreciation accounting. Describing private gasworks in 1814, J. Sinclair[1] allowed 10 per cent per year for wear and tear, repairs and new retorts. The proposed Dundee Portable Gas Company[2] of 1825 allowed 20 per cent annual depreciation on wagons, harness and horses, and 10 per cent wear and tear on machinery. Creighton[3] in 1824 advised coal gasworks to allow 2½ per cent annual depreciation on gas-mains, and 10 per cent depreciation cum repairs on other equipment, plus the cost of renewing 81 per cent of all retorts per year. In 1844, Alcock[4] estimated the average overall wear and tear on gasworks to approximately 5 per cent per year. Nevertheless, in practise most companies used over-simplified methods of book-keeping which did not stipulate the rate of depreciation. Until the 1850s or 1860s, company accounts were usually prepared by the gas manager and directors[5], who frequently confused the fixed capital and working costs. Renewals and even fairly large extensions were therefore recorded as working costs, and financed out of profits.

When reinvestment on capital equipment was recognised as constituting a long-term rise in the overall value of the works, it appeared even more difficult to estimate the correct value of that increase by making, at the same time, an evaluation of decrease caused by deterioration of other equipment. Many failed to realise this, and even the published examples of company

6. S.R.O. Boness Minute Book op cit 18/6/1849

7. Buckie failed to notify the Registrar of Companies, and in 1900 had to apologise to the Lords of Council and Session.
S.R.O. (B.T.2/310)

1. J. Sinclair Appendix to the General Report of the Agricultural State and Political Circumstances of Scotland (1814, Edinburgh) Chapter XVI Appendix 2
Vide supra pp.77,79

2. Perthshire Courier 29/4/1825 Vide supra p.433

3. 'Gas Lights' Supplement to Encyclopaedia Britannica (1824) op cit

4. Evidence of G. Miller, Superintendent of Glasgow C.&S Gas Company H. Lords 1844 Vol. 8 p. 219

5. Vide supra pp.619,624,662.
c.f. The Imperial Continental Gas Association in 1824-50 charged renewals directly against current expenditure, and late eighteenth century companies also typically lacked depreciation allowances or even reserve funds. Alternatively, the Association found it highly desirable to conceal reinvestment this way.
S. Pollard Genesis of Modern Management (1968) pp. 280, 284

Table 4.67 Long Term Investment of Reserve Funds

Date	Gas Company	Loan (£)	Investment	Annual Interest %	Time Duration (years)	Date Sold	Revenue of Sale (£)
1873	Dalkeith	1000	J.Watt, builder (1)	-	-		
1875	"	220	" (property repairs)	(£137)	-	1878	1425
1879	"	1400	Trustees R. Ireland(2)	5	5	1880	200
1883	"	"	" "	4.5		1883	200
						1884	200
						1885	100
						1887	700
1881	"	1000	Lady Boswell (3)	3.75	5	1888	
1887	"	619	£400 stock National Bank	5	-	1903	1840
1912	"	1000	British Investment Trust (Terminable Debenture)	4	3		
1914	"	500	"	4	3		
1881	Banff	500	London & Canadian Loan Co.	5			
1881	Selkirk	1000	Scottish & New Zealand Investment Co. Ltd	4	3		
1885	"	"	" (renewed)	4.5	5		
1887	"	"	" (Perpetual Debenture)	4.5			
1881	"	1000	Dundee Mortgage & Trust Investment Co.	4	3		
1885	"	"	" (renewed)	4.5	5		
1887	"	"	" (perpetual Debenture)	4.5			
1885	Stranraer	350	Mrs. A.Nelson (4)	4		1897	350
1895	"	800	Glasgow Corporation Stock	2.5		1903	
1897	"	400	" "	2.5		1903	
1893	Ayr	2000	Government Consols			1897	2000
1898	"	3369	Glasgow Corporation Stock	3.5			
1912	"	1000	" (renewed)	3.5			
1898	"	1000	Ayr Corporation Loan	3			

Note - Security provided: (1) House property; (2) Bond over property; (3) Bond over Auchinleck estate; (4) Two Houses and Life Insurance Policy.

Source - S.R.O. Gas Company Minute Books op cit accounts, like Auchterarder[1] in 1854, simply ignored depreciation and re-investment. Ayr gas company at first showed all expenditure on renovations as an increase in the capital value of the works, as if none of the earlier equipment had been scrapped. From 1843, Stranraer[2] company differentiated "Real Net Profit", from the 'Net Profits' which remained after reinvestment on equipment or "extraordinary expenditure", but again without considering annual depreciation.

Gas meters, purchased out of profits, deteriorated rapidly and produced some of the earliest uses of depreciation accounts. Until 1844 when Glasgow[3] and Aberdeen supplied free meters, most towns made heavy hire charges. Crossley's original patent meters cost £2.6s.0d but were only expected to last 3 years and hence not widely used. When the patent expired and prices fell to £2.2s.0d they were rented out in Dundee at 4s.0d per year (9.5 per cent) or sold at prime cost. Dundee[4] old company in 1846 kept the meter account entirely separate from the general profit and loss accounts, and used meter rent as a sinking fund to replace meters which numbered 1000.

Smaller companies also adjusted the hire charge to approximate the cost of renewals, normally using 10 per cent per year[5] on prime cost, but in many cases the meter revenue was not placed into a separate account for renewals; it was added into the general profit and loss accounts, and both

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F. Crouzet Ed. Capital Formation in the Industrial Revolution (1972 p. 137

1. J.G.L. 10/12/1854 p. 350
2. The Definition of "extraordinary expenditure" was made by the Directors, and consequently the items which were entered varied, so that "Real Net Profit" could be boosted to raise confidence in times of economic difficulty when dividends and 'Net Profit' were low.
3. By 1869 Glasgow old gas company had meters worth £50,000 on free hire to consumers
J.G.L. 13/4/1869 p. 274
4. By 1846 only 100 consumers in Dundee retained time-contracts without meters.
Evidence J. Russell, Dundee Gas Manager H. Commons 1846 Vol.98
25/3/1846 p. 22-6
5. e.g., Annan in 1864 charged 10 per cent per year.
S.R.O. Annan Minute Book op cit 15/7/1864

the renewal of meters and the purchase of extra meters[1] for new consumers[2] was deducted from revenue received during the year in which such purchases were made. This distorted 'real' annual profit and expenditure.

In the absence of competition[3], stringent economic conditions caused by high coal prices or a contracting market for gas were the main stimulous for improved management and accountancy practices. Gasworks equipment differed from that used in many other industries in that it was unlikely to suffer obsolescence. Unlike, for example, textile machinery where a manufacturer[4] possibly had to recover his outlay in profits within five years, and replace the machinery by a more advanced design within a decade, most sub-sections of gas equipment remained in use for twenty or thirty years, or longer depending upon the rate of deterioration. Technical progress was slow, competition rare, and increased demand could usually be met simply by adding a suitable new sub-section or extention to the existing manufacturing equipment.

Consequently, J. Cox[5], a Glasgow accountant employed in 1861 by the

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1. Meters remained expensive. In 1829 Dunfermline company sold the smallest, Size No. 0 at £1.11.6d, No. 1 at £2.19.0, No. 2 at £4.1.0d and No. 3 at £7.7.0d. Dalry company in 1840 purchased No. 0 meters at 10s.0d each but these were discontinued in 1843 because of inaccuracies. Other meters purchased by that company from Messrs. Cochrane of Edinburgh in 1834 were £2.5.0d each, and both Messrs. Milne and Messrs. Cochrane in 1835 refused the company's proposal to pay 21s.0d to 30s.0 extra per meter in return for the manufacturers keeping them in repair. Dalry purchased more meters from Messrs. Milne in 1843 at £1.16.0d each, probably the most popular size.
S.R.O. Dalry Minute Book op cit 29/6/1840, 6/9/1840, 12/5/1843, 3/12/1834, 8/8/1835, 17/11/1843; Dunfermline Ref. Lib. Dunfermline Minute Book _op cit_ 24/7/1829 . _Vide infra_ pp. 1233, 1226 _et seq_

2. Most meters in use were hired out. The Vale of Leven Company which reduced meter rent from 2s.6d. to 1s.6d.per year in 1852, by 1858 had 787 meters rented out, compared to 155 meters owned privately by consumers. S.R.O. Vale of Leven Minute Book _op cit_ 1/6/1852, 1/7/1858

3. S. Pollard _Genesis of Modern Management_ (1968) p. 286

4. S.G. Checkland _The Rise of Industrial Society in England 1815-1885_ (1969) p. 78

5. Glasgow City Archives _Miscellaneous Papers_ Vol. 18 p. 233
"The Cheap Gas Movement - Report by the Commiteee, and Report by John Cox" 1861. The Cheap gas movement repeatedly opposed the reinvestment of profits by gas companies, and urged them to pay for depreciation by the issue of new shares without realizing the effect this would have had upon dividends and therefore prices. Even municipal gasworks had to cover depreciation costs out of profits.
Vide infra pp. 1075, 1160, 1157

Cheap Gas Movement, reported that "with respect to devidend and interest, gasworks are placed in a different position to any other manufacture". Whereas a millowner's "capital" was the real value of physical equipment which could be surveyed, and new machinery "annihilates the capital expended on the old", "in a gas work all the old capital is kept afloat, although the plant which it represented has long since disappeared and been replaced by new". Rapid deterioration of ironwork and retort-benches was an important factor. Provided that reinvestment of profits merely kept pace with deterioration, no special accounts were necessary. When large equipment became dangerously dilapidated, the Manager gave advance warning to the Directors, and a temporary contingency fund, or more probably a loan, was used to surmount the problem. Long term depreciation funds to finance predictable replacements, were largely unknown outside large city companies like Glasgow.

In the late 1850s, Glasgow Gaslight Company regularly charged £1500 annual depreciation against the revenue, but made no attempt to separate many capital equipment extensions from repairs and renewals. The latter occurrence was not simply a result of poor book-keeping, but was a method of concealing reinvestment from profits. When J. Clelland C.A., inspected the books[1] in 1861 he attempted to distinguish "Extraordinary Repairs" from "ordinary charges on revenue", using the "meagre information" contained in vouchers of expenditure, and the verbal explanations of employees. Clelland regarded the extraordinary repairs, and the cost of replacing meters, as constituting a further depreciation account, and thus concluded that £9380 was charged for depreciation, out of revenue, in three years, 1858-60.

By 1869 the Glasgow companies were accused of having "really challanged the attention of the Corporation by keeping up the price of gas to to enable them to write off, illegally large sums from the original cost of their works in the shape of depreciation"[2]. The old Glasgow company had

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1. <u>J.G.L.</u> 12/2/1861 p. 97

2. Editorial in the <u>Journal of Gas Lighting</u>, which normally defended companies against municipal action.
<u>J.G.L.</u> 25/5/1869

reduced the book value of works and meters by £129,743 below their original cost of £488,430, in addition to maintaining a reserve fund[1] of £29,104 on the total share capital of £215,000. At a later date, Glasgow corporation resorted to similar manipulation of the depreciation accounts[2]. When the Edinburgh and Leith gas company accounts were checked by A. Lass, F.C.A., on behalf of Edinburgh corporation in 1888, he criticised that company also for the scale on which reinvestment and 'depreciation' had been made when compared to the trading profits quoted publicly by the company.

Table 4.68 Depreciation and Reinvestment by Edinburgh and Leith Company (1878-88)

Date	'Trading Profit' £	Real Profit £	% Extra	Date	Trading Profit £	Real Profit £	% Extra
1878	12,461	14,926	19.8	1884	13,001	19,602	50.8
1879	12,489	14,570	14.3	1885	12,922	21,627	67.4
1880	12,972	19,084	47.1	1886	13,371	19,376	44.9
1881	10,903	14,630	34.2	1887	19,475	22,250	14.2
1882	12,834	16,181	26.0	1888	26,331	-	-
1883	13,850	18,713	35.1				

Note - 'Trading Profit' as stated annually in Company accounts. Real Profit as gross profit, before depreciation and capital reinvestment. % Extra of Real Profit above 'Trading Profit'

Source - A. Lass <u>Gas World</u> 8/9/1888

When external accountants were employed by medium-sized gas companies, 'depreciation' was usually made only upon the written book value of the works after allowing for reinvestment of profits during that year. It did not normally involve a monetory fund for future re-equipment. The enlarged companies of the 1850s were most anxious to discover the precise annual ratio between extensions through reploughing and equipment deterioration, and to redefine 'profits' which previously fluctuated wildly whenever new equipment was purchased.

1. This reserve fund was permitted under the Glasgow Company's Act of 1857, but was grossly in excess of reserve funds permitted by the 1847 <u>Gasworks Clauses Act</u>. Parliament refused to allow the old company to retain £34,299 and the City and Suburban Company £25,500, from their reserve funds, in addition to the annuities granted during municipal takeover in 1869. <u>J.G.L.</u> 13/4/1869, 11/5/1869, 8/6/1869

2. <u>Vide infra</u> p.1075

The Vale of Leven[1] company at Alexandria in 1856 experienced a great rise in consumption, but very low profits, because new purifiers and retorts had raised "maintenance costs" that year by £180. Consequently an accountant was employed in 1857, "in deference to the feelings of a number of shareholders", to improve the book-keeping methods used by the Treasurer. Galashields[2] employed an external auditor for the first time in 1865, and began at that date to make a regular, annual depreciation allowance.

Table 4.69 Depreciation on Capital Plant at Galashiels (1865-1908)

1865-9	2½%	1883-99	2½%
1870-3	5%	1900-8	2½% 5% on prepayment meters and railway wagons
1874-82	1½%		

Source - S.R.O. Galashiels Minute Book op cit 8/6/1870, 2/5/1882, 4/7/1882, & c

Many companies, however, found difficulty in making any regular depreciation allowance, and instead irregular allowances occurred at convenient times. Banff[3] Directors from 1863 considered a regular depreciation to be desirable, but only undertook to do so in 1865 when a professional Accountant was employed, and were soon obliged to revoke the decision. Irregular depreciation resulted in shareholders having little idea of the real value of their property until a professional survey could be made.

Table 4.70 Depreciation Allowances at Banff (1848-96)

Date	Amount (£)	%	Date	Amount (£)	%
1848	425		1875	544	7½
1865	344	7½	1881	500	10
1868	252		1882		5
1873	414	7½	1896	46	

Source - S.R.O. Banff Minute Book op cit

1. W. Greenlees, accountant, provided great detail on the improvements required in book-keeping (data extant).
S.R.O. Vale of Leven Minute Book op cit 5/9/1856, 6/6/1857

2. Auditor Mr. Stalker. Low depreciation in 1874 to boost "profits" in coal crisis.
S.R.O. Galshiels Minute Book op cit 4/7/1865, 27/7/1865

3. The depreciation table is accurate at least up to 1876 when a review was made; later figures may not all be extant. From 1865, A. Duncan, Accountant of Banff was paid 2 guineas a year for preparing audits.
S.R.O. Banff Minute Book op cit 5/7/1865, 6/7/1863, 22/6/1865

Table 4.71 Fluctuations in Depreciation Allowances at Selkirk (1856-96)

Date	Amount £	% Nominal Stock	Date	Amount £	% Nominal Stock	Date	Amount £	% Nominal Stock
1856	83	4.9	1866	40	2.4	1878	125	2.8
1857	93	5.5	1868	0	0	1879	-	2.5
1858	77	4.6	1869	105	4.1	1881	51	-
1859	102	6.0	1870	165	6.5	1894	250	-
1860	0	0	1871	108	4.3	1895	250	-
1861	79	4.7	1872	132	5.2	1896	250	-
1864	88	5.2	1877	-	2.5			

Source - S.R.O. Selkirk Minute Book op cit

When insufficient attention was paid to the capital equipment account, professional evaluation produced a drastic revision of 'book' values. Thus Stornoway[1] gasworks was reduced in 1877 from £2259 to £1777 by writing off 10 per cent on buildings, 40 per cent on most apparatus, 20 per cent on mains pipes and 10 per cent on service pipes. Penicuik[2] company did not use a regular depreciation account until 1881 when a policy decision was taken to allow 2 per cent per year on the cost of the works, and 5 per cent on pipes and meters. Cupar[3] began a regular depreciation fund in 1894 to renew 1 to 2 per cent of capital equipment each year by subtracting that amount from the revenue, and either spending it immediately or investing it upon "approved security" until large items of equipment required replacement.

Professional auditing of accounts by non-partners was found unnecessary by most companies[4] until at least the 1860s. From 1869 the Ayr company accounts were checked by R.C. Cowan[5], accountant of Edinburgh, as well as by one Director and the Company Treasurer. Bathgate[6] employed a local banker as accountant from 1874, Muirkirk used a solicitor and accountant[7]

1. Vide infra p. 830
2. 2 per cent was £237 per year. J.G.L. 30/8/1881
3. S.R.O. Cupar Minute Book op cit 8/6/1894
4. Auditing and other duties of company employees are described elsewhere. Vide infra p.672
5. S.R.O. Ayr Minute Book op cit 7/7/1869
6. D. Simpson, paid 1 guinea per year. S.R.O. Bathgate Minute Book op cit 23/6/1874
7. A. Brackenbridge, paid £5 per year. S.R.O. Muirkirk Minute Book op cit 18/6/1877

from Cumnock from 1877, Stornoway employed G. MacKay[1] of the Caledonian Bank from 1880, and Stranraer employed an external accountant[2] from 1897. The new Inverkip company in 1869 employed Mr. Welsh[3], accountant from nearby Greenock, from its commencement, and other small companies which encountered financial problems were able to obtain professional advice at a much earlier period.

An external accountant, G. Marquis of Aberdeen, was employed by Banchory in 1856 to disentangle a wide variety of problems which had developed in the company's two years existence. The paid-up capital was £468, but loans were £926, and other debts €105. Like other small and badly managed companies many people had signed the contract but not paid for shares, many had paid for shares but not signed, and confusion reigned. Marquis, after a detailed study, showed that "the chief cause of the loss is the price charged for gas". This had been decided upon from observations of large town prices, but a small gasworks produced less gas per ton of coal, and lost more by leakage. Banchory sold 7000 cu ft per ton, compared to 9000 elsewhere. He observed that

> "in all small towns in the North where Gas has been introduced, it is believed the price has been for the first few years 16s.0d and in some cases even 16s8d. per 1000 ft .... As the number of consumers and quantity of gas increased, the price could be gradually lowered; but at the outset it appears to be not only a prudent but a necessary step for the safety of the shareholders - if not the permanency of the company - that the price should be such as to yield at least a moderate return on the Capital invested and leave something over annually for a Sinking Fund to meet the deterioration of Buildings, renewal of Plant, and Contingencies" [4]

This succinct definition of "Sinking Fund" as used in the mid nineteenth century, was followed by detailed estimates by Marquis on the costs which the company needed to budget for[5]. With professional accountants able

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1. Paid 3 guineas per year. S.R.O. Stornoway Minute Book op cit 15/7/1880
2. S.R.O. Stranraer Minute Book op cit 2/7/1897
3. Ardgowan Estate Office, Greenock. Minute Book of Inverkip Gas Company 31/7/1869
4. "Report by G. Marquis" October 1856. Gas was first produced in October, 1854, and sold first at 13s.0d and later 10s.0d; Marquis suggested charging 13s.4d. S.R.O. Banchory Minute Book op cit
5. Vide infra p.1505

to give this quality of assistance to gas companies by the 1850s, managerial problems even in small companies like Banchory were considerably reduced. External assistance in this form was a most important aspect of financial management in the late nineteenth century.

Two new aspects of accountancy appeared at Ayr gas company in 1891-6, largely in consequence of the coal crisis:- detailed analyses of past trends in price and revenue as an aid to forecasting charge; and a comparison of capital investment with total output. Ayr was a moderately large company with advanced financial practices, and these aspects of accountancy were probably used by only the large gas companies until the twentieth century.

Ayr gas manager prepared quarterly financial accounts from 1848, but the Directors only received an abstract comparing revenue with the corresponding quarter the previous year. In March 1891 the quarterly profit had risen by £42 compared to the past year, but the gas manager[1] forcast a rise in coal prices of 3s.0d. a ton, or £800 a year. The Company Treasurer/Auditor[2] therefore inspected the quarterly account in greater detail before advising against the reduction in gas prices proposed the previous year. Thereafter, the quarterly accounts were analysed in the same depth as previously applied to annual accounts, making accountancy that much more important as a tool of management.

The assessment of capital investment in comparison to gas production was a neglected aspect of accountancy until a relatively late date, despite its importance in relation to any increase in the nominal value of shares[3]. In 1875, two years after voting in favour of a £500 Bill

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1. Note the responsibility held by the Manager for price predictions. Vide infra p.621

2. In 1889, on the basis of past records on the relationship of gas-price, total sales, and profits, the Treasurer had advised regular reductions in gas price.
S.R.O. Ayr Minute Book op cit 10/3/1891

3. Muirkirk first learned of the method, from a consulting engineer, in 1896.
Vide infra p.820

instead of an increase in capital stock of £300, Dalry[1] shareholders raised their nominal capital stock from £2527.10.0d to £3538.10.0d, and individual shares from £7.10.0d to £10.10.0d, to reflect "large expenditures upon the Works which have recently been made out of the Savings of the Company". No engineering assessment was sought before this alteration, although in the following year B.M.McCrae of Dundee was employed to evaluate the fixed capital stock prior to a renewal of the company contract of co-partnery.

The two standard tests applied by McCrae examined whether the fixed capital[2] exceeded £1 per head of population living in the market area; and whether capital exceeded £1000 per million cu ft gas output. Dalry served an area with 5000 inhabitants, and in 1875 produced 4 million cu ft, from fixed capital evaluated at £3758, and McCrae concluded the works were quite viable and the capital of "very modest extent". During the subsequent year, large extensions of the retort house were consequently undertaken, using a further £600 loan capital[3].

Ayr applied the "method of comparisons" with detailed accounts from 38 other companies and corporation gasworks in 1892, showing coal and gas prices, by-product revenue, illuminating power and other statistics. When these were analysed by a professional auditor R.C. Cowan of Edinburgh[4], the capital discrepancy was first noticed. Ayr had £737 of capital equipment per 1 million cuf ft gas produced per year, while six other companies had only £337 to £570. This was a smaller burden than that suffered by municipal gasworks, like Edinburgh and Leith which paid annuities of £46,992 per year, equal to 9.03d per 1000 cu ft gas sold. But whereas many gas companies could provide a 5 per cent dividend from profits of 3d to 7.4d per 1000cu ft, Ayr required 8.8d per 1000 cu ft[5].

1. S.R.O. Dalry Minute Book op cit 3/9/1873, 28/6/1875
2. McCrae valued the land at £563 at 20 years' purchase price; boundary walls £46; buildings £434; apparatus, tanks, gasholder and tools £1508; mains pipes £648; service pipes £129; and meters £430. S.R.O. Dalry Minute Book op cit 3/11/1876
3. ibid 10/4/1878, 1/5/1878, 23/10/1878
4. S.R.O. Ayr Minute Book op cit 29/2/1892
5. Ayr required 12d profit per 1000 cu ft for 6 per cent dividends, and 16d for 8 per cent.

A solution was only possible in the long-term, by increasing the rate of depreciation, and reinvesting profits without allowing the shareholders to take higher dividends from that investment. Previously, depreciation had been neglected and as the capital expenditure increased, capital stock was raised to correspond with the book value of the works. In 1889 for the first time, the value of the works was decreased, from £33,162 to £32,959; any previous allowance made by the Directors for depreciation had been more than offset by renovations and reploughing from profits. After Cowan's report, however, the depreciation rate was raised from 2 per cent to 3 per cent, and in 1896 to 3½ per cent[1]; from 2½ per cent after 1899, it rose to 4 per cent after 1909.

From 1904-6 the cost of all maintenance, repairs and renewals was deducted directly from the "value" of the gasworks[2], falsifying the true position, possibly for tax relief. After 1908 the procedure was reversed, and the cost of repairs was added to the capital value. In 1911-12 the Directors[3] became concerned with this practice, and after 1913 again reversed it and deducted from the book value. In May 1913 £2925 was actually transferred on paper to the "Reserve Fund" to reduce the amount shown as "cost of works"[4].

When Muirkirk gasworks were surveyed by a consultant engineer[5] in 1896, he advised that no gasworks was "heavily burdened" if the capital stock did not exceed £1000 per million cu ft gas sold per year. This was much larger than the Ayr company accountant advised, and evaluations of this type were still in the developmental stage in the early 1890s. When Selkirk

1. Cowan in 1896 advised 4 per cent annual depreciation on the grounds that no Property Tax or local assessment would be made against sums written off.
S.R.O. Ayr Minute Book op cit 21/9/1896
2. The book value of Ayr works fell from £37,432 in 1903 to £37,302 in 1904.
3. S.R.O. Ayr Minute Book op cit 3/7/1912
4. ibid 8/5/1913
5. W. Fairweather, gas engineer of Kilmarnock. Muirkirk in 1896 produced over 2 million cu ft per year with £1000 capital stock. Shareholders were not impressed with the analysis and when 1000 new shares were offered preferentially to them, only 130 were subscribed, and 670 went to outsiders
S.R.O. Muirkirk Minute Book op cit 15/1/1896

gasworks were examined in 1906, the nominal capital stock was only £124 per million cu ft year. The consultant engineer[1] there claimed that £700 per million cu ft would be a "reasonable capital", and many prosperous Scottish gasworks had a far larger amount.

In 1902 the Ayr Directors revised their previous estimate, and decided that £1000 per million cu ft per year was a reasonable capital stock on the basis of purchase prices paid for municipal gasworks, shown in Table 4.72.

Table 4.72 Ratio of Stock Capital to Annual Gas Output (1872-99)

Date Works Sold	Gasworks	Price Paid £	Annual Output (millions cu ft)	Capital per Million cu ft (£)
1872	Kilmarnock	36,000	28	1285.7
1874	Belfast	386,000	355	1087.3
1877	Alloa	23,000	18	1277.8
1896	Dunfermline	101,000	58	1741.4
1899	Helensburgh	31,116	33	942.9

Source: S.R.O. Ayr Minute Book op cit 15/9/1902

Debt collection by unincorporated gas companies was both more difficult and less serious a problem than for companies like Shotts Iron and the Edinburgh and Leith Glass Company[2] where transactions included large sums of money. The large number of small gas consumers vastly increased problems of delayed payments, yet most companies were successful in reducing bad debts to quite small amounts, although in the Cupar[3] gas company, Fife, arrears were important enough to be shown in a separate

1. J. Hepworth, C.E., who valued Selkirk gasworks at £25,850, but the nominal capital stock was £4535. Because an early general meeting had fixed 10 per cent as the maximum dividend, the Company knew that at least £16,000 surplus profits had been reinvested. In 1905 the annual profit was £1018, but only £453 could be spent in dividends.
S.R.O. Selkirk Minute Book op cit Loose typescript 2/11/1906

2. The refusal of Scottish courts to entertain some actions for debt recovery by Shotts led that company to make an unsuccessful petition for Letters Patent in 1835, to operate under the 1834 Trading Companies Act.
A.M.C. MacEwan "The Shotts Iron Company, 1800-50" (Unpublished M. Litt. Thesis, 1972, University of Strathclyde) pp. 35-42

3. S.R.O. Cupar Minute Book 10/7/1867, 13/10/1881

account which amounted to over £115 by 1839. A firm stand taken by the Manager was most important, and heavy gas arrears at Cupar in 1867 occurred under the new Manager because "coming an entire stranger to the place" he was unused to the foibles of consumers. Again in 1881 the problem received attention, with £68 outstanding, and "the Manager was authorized to employ John Hart, Sheriff Officer, to collect the sums standing against a number of those in arrears without delay".

Gas companies had six methods for ensuring the payment of gas rent, or for minimizing unpaid debts: Payment in advance was adopted at an early stage for time-contract consumers[1]; the threat to disconnect supplies from defaulting consumers; regular and frequent collections to prevent large debts accumulating; deposits as security against intromissions; and discounts for prompt payment. Prosecution for non-payment was rare.

Disconnection was frequently used, but had the disadvantage of reducing sales. Dalry company in 1837 ceased to supply R. Barr of Courthill[2] who refused to pay his bill; Cupar[3] company in 1843 resolved to disconnect any consumer over one Quarter in arrears at the time of collection, and Galashiels decided in 1856 to disconnect all "who refuse to pay"[4]. In 1848 Bathgate gas company[5] authorized their Manager "to prosecute in his own name as an Individual" all persons who refused to pay for Company gas which he had supplied, and in 1859 decided to disconnect any consumer who was more than one year in arrears. Dunse[6] gas company threatened summonses against defaulting consumers, in the Small Debt Courts, in 1837 and 1838.

The problem became most acute during trade depressions. Dalry

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1. Vide infra pp. 957, 1223
2. S.R.O. Dalry Minute Book op cit 11/2/1837
3. S.R.O. Cupar Minute Book op cit 4/7/1843
4. S.R.O. Galashiels Minute Book op cit 1/10/1856
5. S.R.O. Bathgate Minute Book op cit 13/8/1855, 5/6/1859
   No prosecutions appear, however, in local Sheriff court records.
6. S.R.O. Dunse Minute Book op cit 7/2/1837, 7/3/1837, 2/5/1837, 6/3/1838

reported "pretty considerable" arrears in 1838 due to "the dullness of trade"[1]. In 1840 a list of debtors up to the previous year was sent "to Robert Crawford, Sheriff Officer, with instructions to recover the same for .. a commission at the rate of one shilling per pound"[2] recovered. Again in 1842 the Directors[3] reported that "the depressed state of trade was the sole cause of the arrears being so large", and during the previous year they had not considered it worthwhile to "incur expenses in prosecuting in the meantime" until regional trade improved.

From 1840 Dalry[4] disconnected all time-consumers who used gas too long, until they paid a fine of 2s.6d. In 1842 legal proceedings were taken in Beith Small Debt Court[5] against Dalry Street Lamp Committee, as well as individuals in arrears, and were apparently successful since in the following year the President, Secretary and Collector were instructed "to summon a number of debtors if necessary", and to reduce or "compromise" other debts. In 1843 the Directors imposed a sliding scale of fines for time-contracts used over hours: 1s.0d for the first offence, 2s.0d the second, and 3s.0d the third and later offences[6].

An examination of several Sheriff Small Debt Courts, including that for Bathgate[7] from the early 1830s to late 1860s, shows that very few consumers were proceeded against. Most consumers capitulated out of court. Thus when A. Brande, the manager of Hamilton old unincorporated company, summonsed Mr. Chalmers for installing and using a gas-light without payment

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1. S.R.O. Dalry Minute Book <u>op</u> <u>cit</u> 12/5/1838
2. <u>ibid</u> 29/6/1840
3. <u>ibid</u> 2/7/1841, 19/5/1842
4. S.R.O. Dalry Minute Book <u>op</u> <u>cit</u> 8/12/1840, 7/7/1841
   The right to collect £49 owed to the Company up to 1840 was sold to a collector. <u>Vide</u> <u>infra</u> p.1223
5. <u>ibid</u> 12/8/1842, 17/11/1843
   Beith Small Debt Court records at S.R.O. are not yet available for research.
6. S.R.O. Dalry Minute Book <u>op</u> <u>cit</u> 14/6/1843, 13/10/1844
   The Town Crier was periodically employed to remind inhabitants of the fines.
7. S.R.O. Sheriff Courts - Bathgate Small Debt Court Book.

in the 1830s, the Sheriff[1] told Chalmers to pay the 2s.6d demanded or pay a fine of two guineas.

During 1841, payment-in-advance commenced at Dalry as a new approach to the problem of arrears, and that Company also abolished the former system of random gas-rent collection in favour of set times during the year for all consumers, to obtain "cash payments more readily".

Bathgate company[2] from 1835 collected in advance for time contracts, at Lammas (1 August) and Candlemas (2 February), and collected all rents by meter on three specific days each year. Dunfermline[3] in 1836 collected twice a year for kitchen light time-contracts, and quarterly for metered gas. The Vale of Leven Company in 1847 collected metered gas rents Quarterly[4]. Selkirk[5] from 1836 made Quarterly collections, and instructed the manager to disconnect supplies and sue for payment whenever debts remained unpaid for 15 days. Stornoway[6] gas manager was instructed in 1856 to permit no arrears above one month, and the number of annual collections there was only reduced from 5 to 4 in 1890. Several companies which expected particular difficulty in obtaining payment made monthly collections, like Boness[7] in 1844 which copied the collections used at Crieff. This caused considerable clerical work, and at Annan[8] difficulty in balancing the books led to Quarterly collections being replaced by three per year from 1858. Stranraer[9] made the same alteration in 1856, although in 1845 that company

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1. Evidence of A. Brande, Hamilton gas manager. H. Commons 1846 Vol. 102 11/5/1846, p. 245
2. S.R.O. Bathgate Minute Book op cit 13/8/1835
3. Kitchen Light 8s.6d per year; metered gas 8s.4d per 1000 cu ft Dunfermline Ref. Lib. Dunfermline Minute Book op cit 18/8/1829
4. S.R.O. Leven Minute Book op cit 29/6/1847
5. Meters compulsory; gas 15s.0d; manager could inspect meters at "all reasonable times" and estimate consumption in the event of meter malfunction. S.R.O. Selkirk Minute Book op cit 4/2/1836
6. S.R.O. Stornoway Minute Book op cit 23/11/1856, 13/1/1890
7. S.R.O. Boness Minute Book op cit 9/8/1844. Advantage of frequent collections Vide infra p.1311
8. S.R.O. Annan Minute Book op cit 9/7/1858
9. S.R.O. Stranraer Minute Book op cit 5/6/1856, 25/6/1845

had threatened to prosecute everyone above one Quarter in arrears.

Deposits provided a new solution. As a result of the many bad debts caused by poor tenants leaving without paying, Stranraer[1] from 1858 forced all tenants of under £4 to pay part of their rent in advance or provide a guarantee from their landlords. The company found no further serious problems until 1889 when arrears became so serious that the Company Chairman alone was empowered to judge which new potential consumers could be granted a supply. From 1852 the Vale of Leven[2] company required all new consumers to lodge a "satisfactory guarantee for payment" with the company treasurer.

"Flitting", by gas consumers moving from one rented house[3] to another, had been a frequent cause of non-payment in large Scottish cities[4], like Edinburgh, until they introduced a deposit system in the 1850s, which was widely copied by municipal gasworks in the 1870s. Edinburgh originally took 5s.0d from each consumer as a safeguard, raised to 7s.0d in 1868, in both cases without paying interest. Parliament[5] then imposed a rebate as interest on deposits above 10s.0d, and in 1877 Edinburgh took either 7s.0d or 10s.0d with 5 per cent interest repaid annually.

In 1873-4 Dumbarton municipal gasworks only took deposits from reprobate consumers, but was unable to recover 95 per cent of arrears. The following year James McGilchrist, the gas manager, persuaded the council to take deposits from all consumers: 5s.0d for a single apartment, 7s.6d for 2, 10s.0d for 3, 15s.0d for four, and so on for larger houses. Shops and business premises paid an amount equal to 4 months winter consumption. Interest was paid at 2½ per cent on all sums held above 2 years, but the system reduced total arrears to less than 0.5 per cent of sales.

1. ibid 28/6/1858, 3/7/1889
2. S.R.O. Vale of Leven Minute Book op cit 15/1/1852
3. In 1884, 45,000 Edinburgh gas consumers (about a sixth of the total) moved house annually, usually about Whitsunday, causing great confusion in accounts even where deception was not practised. J.G.L. 3/6/1884
4. J.G.L. 26/11/1878 James McGilchrist (Dumbarton) on the deposit system In 1878, 1200 people a year were "flitting" in Dundee.
5. Vide infra p.997
J. Romans "The Edinburgh System of Collecting Gas Rents" J.G.L. 26/10/1869 p. 825

Table 4.73 Dumbarton - Gas Arrears as % Total Sales

1875	1.25%	1876	0.95%	1877	0.5%	1878	0.14%

Source J.G.L. 26/11/1878

From 1882 Rothesay[1] took a deposit of 5s.0d where gas was used in one apartment, and another 2s.6d for each additional room. Kirkintillock[2] gas commissioners demanded a deposit from all new consumers after 1888, though in the same year Kilsyth[3] commissioners abolished deposits of 2s.6d and 5s.0d. Shopkeepers in Cambuslang[4] in 1889 complained that their deposits of £1 to £2 had been held by the gas company for 5 to 10 years yet no interest had been paid. Deposits were not a source of company liquidity, however, and at Hawick[5] with a capital stock of £15,750 deposits were only £267 in 1888.

Discounts for prompt payment proved more acceptable to consumers, and developed mainly from the 1870s. At Dundee[6] the use of prompt payment discounts reduced bad debts from £668 or 17s.0d % of revenue in 1871 before the system began, to £176 or 6s.0d % by 1879. In 1877 Newport[7] company charged 7s.1d., or 6s.9d if paid within 14 days, while Broughty Ferry[8] charged 5s.0d with 5 per cent discount for prompt payment. Peterhead[9] in 1880 allowed 5 per cent off 7s.6d, and Rothesay[10] in 1885 allowed 10 per cent off 4s.7d for prompt payment, while Forres[11] in 1888 allowed 10d. off 6s.8d. Cupar[12] first introduced such discounts in 1895 when the gas price was reduced from 4s.7d. to 4s.2d conditional upon prompt payment, and in 1897 when the price was reduced to 3s.11½d, consumers who left bills unpaid for a month were charged at 4s.4½d.

1. J.G.L. 3/1/1882
2. J.G.L. 21/2/1888
3. J.G.L. 4/12/1888
4. J.G.L. 20/8/1889
5. J.G.L. 1888
6. J.G.L. 24/6/1879
7. J.G.L. 16/10/1877
8. J.G.L. 3/7/1877
9. J.G.L. 20/7/1880
10. J.G.L. 22/12/1885
11. J.G.L. 3/7/1888
12. S.R.O. Cupar Minute Book op cit 20/6/1895, 24/6/1897

The financial assessment of improved technology was perhaps one of the most difficult tasks for Directors. Small or routine items of equipment could be evaluated or requested by the gasworks Manager alone, and the cheapest supplies of large equipment could be ascertained by requesting tenders from manufacturers, but the decision whether to install new types of equipment at all rested with the Directors. The most adventurous of such decisions involved moving the entire gasworks to an entirely new site, away from the restricted and congested initial location. Galashiels company planned such a move in 1866, to a site between the Selkirk railway line and Gala Foot, where railway sidings to the works could handle 2000 tons of material a year. Besides providing room for expansion[1] in the future, detailed estimates were made of all advantages, as shown in Table 4.74

Table 4.74 Estimated Advantage of New Gasworks for Galashiels (1866)

	£	s.	d.
Better access from coal house to retort house equal to one man's annual wage at 18s.0d	46	16	0
Direct rail access from coal house to railway, with easy unloading, equivalent to 4 months work at 18s	14	8	0
Saving on lime cartage in works to purifiers, equivalent to 1s a day, excluding Sundays	15	15	0
Saving on removing spent lime, equivalent to 3d. a day	3	15	5
Saving on carriage of lime, coal, tar and ashes	100	0	0
Annual saving	180	15	5

Source: S.R.O. Galashiels Minute Book op cit 15/11/1866

Technical advice[2] was obtained from Messrs. Robertson and Co. of Berwick, from the gas manager of Warrington, and from Messrs. Hanna, Donald and Wilson of Paisley. The original estimate of cost was £7500, whereas the old works were valued at £4511 in 1863, and the Directors approved the scheme. Despite the detailed estimates, by April 1868 the new works had cost £14,863 and demand did not rise sufficiently rapidly to justify the change.

1. Gas consumption at Galashiels rose 7.2 million cu ft in 1857-67, of which 7 million was in 1862-3.
S.R.O. Galshiels Minute Book op cit 10/5/1862

2. ibid 15/11/1866

Witholding adequate investment on renovations was a shortsighted means of recouping the loss which involved very heavy expenditure at a later date. A normal retort bench was expected to last for 30 years, but by 1904 the bench at Galashiels was 36 years old, and the Manager warned that he had "foreseen for years the urgent need of a complete reconstruction, but owing to the bad times experienced in the town resulting in a serious falling away in the sale of gas, we have run the Retort Ovens as long as we dared"[1]. The arches were badly cracked and a "very considerable risk" since they supported 20 ton chimneys. Only under dire necessity, therefore, did the Directors agree to renovation despite the large gains possible on operations by using regenerative firing, and raising the number of retorts per oven from 3 to 6.

The old retort system used 20 ovens, but 8 new ovens required half the floor space for the same output and saved ½d per ton of coal, in fuel and labour costs, which on 6000 ton of coal per year was £400 or 2d per 1000 cu ft. Plans were prepared by G. & R. Hislop of Paisley at £2588, and by R. Dempster and Sons Limited of Elland, Yorkshire, who were awarded the contract at £2200. The installation commenced in 1904, and gas sales rose by 10 million cu ft in 1904-7, compared to under 1 million cu ft in 1900-3. A second bench, also of 8 ovens, was constructed by Messrs. Dempster in 1908 for £2172, and signalled the restoration of company prosperity.

Several gas managers in the early 1900s reviewed the crucial importance of correct capital expenditure. In 1904 the amount of fixed capital in different Scottish gasworks, compared to sales, varied widely from 6d to 1s.6½d per 1000 cu ft. Consequently gas prices in many towns could not be reduced further by good management[2], because of earlier over-

1. S.R.O. Galashiels Minute Book op cit 5/1/1904, 2/2/1904, 6/9/1904
2. D. Robertson (Dunoon) Presidential address N.B.A.G.M. 1904 p. 23

spending on excessively large facilities, "undue capital expenditure" to make good excessive deterioration from a period when gas was sold too cheaply, or simply geographical factors which raised the relative expense of distribution plant.

Table 4.75 Variations of Fixed Capital Investment and Gas Prices in a Sample of Scottish Towns (1904)

Town	Cost of Interest and Sinking Fund per 1000 cu ft sold	Fixed Capital per 1000 cu ft sold		Nett (Prime) cost of gas into holder	Sale Price per 1000 cu ft	
	d.	s.	d.	d.	s.	d.
A	15.47	26	5	15.5	3	2
B	4.78	8	5	17.53	2	6
C	4.33	6	8	14.89	2	4
D	10.85	13	10	17.80	3	0
E	6.80	7	8	17.51	2	4
F	6.92	12	4	18.88	3	2
G	9.88	13	8	20.90	3	4
H	6.10	8	4	21.77	3	0

Source - N.B.A.G.M. 1904 p. 23

Capital investment was particularly heavy[1] during the decade 1895-1905 when gas consumption in Scotland rose by 49.81 per cent; and by 45.4 per cent in the twenty three towns with a population above 20,000. The average increase in daily output was 39.24 per cent, yet daily expenditure had risen 104.6 per cent, a burden which hampered any reduction in gas prices[2] in the early 1900s.

The relative price of gas at a specific location was chiefly influenced by the economies of scale relating output to equipment costs[3], and therefore the size of the market, as well as technological efficiency,

1. W. McLusky (Perth) Presiential address N.B.A.G.M. 1906 p.31
2. Two Scottish towns sold gas to industry at 1s.6d in 1906, but only to compete with section-gas equipment; most consumers paid far more.
3. This was a leading argument for opposition to Consumer Companies, and in support of monopoly supply. "In Gas Works, as in Railways, the profit depends on the extent of the use", so companies had a vested interest in reducing gas prices.
J. Kerr (Dundee Gas Co. Clerk) Statement Submitted to the Inhabitants of Dundee (1843, Dundee, Pamphlet) Dundee Ref. Lib.
Vide infra p. 1053

Table 4.76 Comparison of Capital Investment and Gas Prices (1895-1905) In Large Scottish Towns (over 20,000 inhabitants)

Town	% Increase in Annual Make 1895-1905	% Increase in Maximum Daily Make 1895-1905	% Increase in Capital 1895-1905	% Decrease in price	Reciprocal (i.e. $\frac{1}{x}$) of Proportion of Max. Daily Output to Annual Output 1895	1905
A	42.53	38.61	101.9	16.6	194	200
B	28.91	29.97	236.5	8.3	196	198
C	39.13	30.17	(Decrease 9.7)	20	175	187
D	54.75	37.99	118.6	15	181	202
E	50.48	22.66	19.4	3.13	163	186
F	46.31	34	100.6	13.16	190	208
G	82.81	69.18	99.8	24.4	182	197
H	85.90	80	117.6	13.3	176	182
I	126.58	103.25	122.2	24.4	174	193
J	82.85	59.74	63.6	35	173	198
K	80.90	43.83	207.8	nil	168	211
L	63.64	45.83	22.5	1.3	173	195
M	45.55	65.01	24.5	15.5	213	188
N	73.14	53.66	81.3	23.26	163	184
O	70.99	72.41	350.4	20	192	191
P	53.32	46.28	125.8	15	183	192
Q	231.41	100	70.4	19.54	181	273
R	117.86	108.86	53.7	28.54	188	195
S	63.85	55.23	3.4	25	184	194
T	132.36	87.63	52.9	23.53	162	201
U	41.03	50	14.4	36.3	187	176
V	48.25	-	246.3	12.5	202	-
W	169.56	134.61	135	16.6	179	183
Average	45.49	39.24	104.62	18.99	-	-

Source : N.B.A.G.M. 1906 p. 31

See also 'Gas Price Related to Scale of Output' (*infra* p.1053)

Fig. 4.78

Geographical Variations in Nominal Capital Investment in Gas Companies (£) (1853)

Source - *vide infra* p.1399

Fig. 4.78 ctd. Geographical Variations in Nominal Capital Investment in Gas Companies (£) (1853)

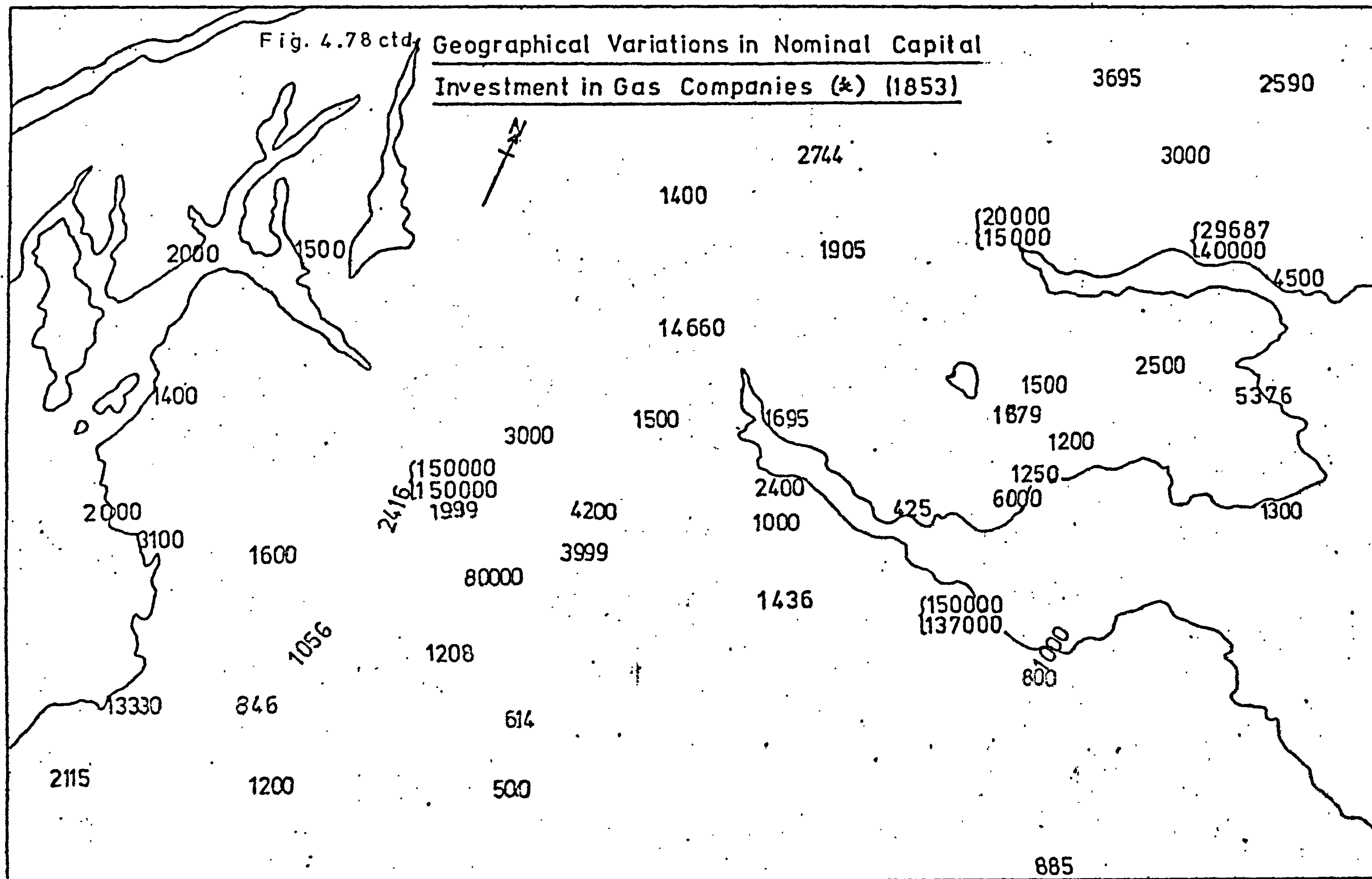

Table 4.79 Variations in Gas Price in Sample of mainly Eastern Towns (1848)

Dundee	5s. and 6s.8d.	Stirling	8s.4d.	Newburgh	10s.
Edinburgh	6s.6d.	St. Andrews	8s.4d.	Inverkeithing	10s.6d.
Dunfermline	7s.6d.	Auchtemuchty	9s.	Ferryport on Craig	11s.8d.
Kirkcaldy	7s.6d.	Dysart	9s.7d.	Crail	12s.6d.
Cupar	7s.6d and 8s.4d.	Leven	10s.	Ceres	12s.6d.
		Markinch	10s.		

Source S.R.O. Cupar Minute Book op cit 12/9/1848

Ayr[1] gas company in 1845 surveyed other Scottish towns to assess a suitable price to charge for gas, and made another comparison with 29 other Scottish towns in 1852. Galashiels[2] raised the price of gas in 1847 after a comparison with Selkirk and Hawick which both charged 12s.6d. In the 1880s, even in the case of towns charging very high rates, the "method of comparisons" remained important. Alyth[3] in Perthshire, for example, in 1884 reduced gas from 6s.8d. to 6s.3d to conform with the price in the adjoining towns of Kirriemuir, Blairgowrie, and Coupar-Angus.

Table 4.80 Variations in Gas Price in Sample of Towns (1886-7)

Galashiels	3s.2d.	New Cumnock	5s.	Invergordon	7s.6d.
Dumfries	3s.9d.	Helensburgh	5s.10d.	Tain.	9s.
Kilmarnock	3s.11½d.	Langbank	6s.3d.	Fort William	10s.
Lanark	4s.2d.	Thurso	6s.8d.	Granton (Strathspey)	10s.6d.
Motherwell	4s.7d.	Wick/Pultney-town	6s.8d.	Dingwall	10s.10d.
Dalry	4s.7d.	Lesmahagow	7s.		

Source J.G.L. 26/10/1886, 30/8/1887

The difference in gas price between Helensburgh, a residential centre for Glasgow commuters and holiday resort, at 5s.0d. in 1883, and the price of 3s.6d. at nearby Dumbarton, was ascribed entirely to the larger scale of output in Dumbarton where gas-light was used by industrial premises[4].

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1. S.R.O. Ayr Minute Book op cit 17/11/1845, 5/7/1852
2. S.R.O. Galashiels Minute Book op cit 8/7/1847, 16/11/1847
3. J.G.L. 8/7/1884
4. J.G.L. 4/12/1883
   Stranraer gas was expensive for the same reason, vide infra p. 1201

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Fig. 4.81

Regional Variations in Gas Prices in 1891

Old Pence per thousand cubic feet

Source - vide infra p.1755

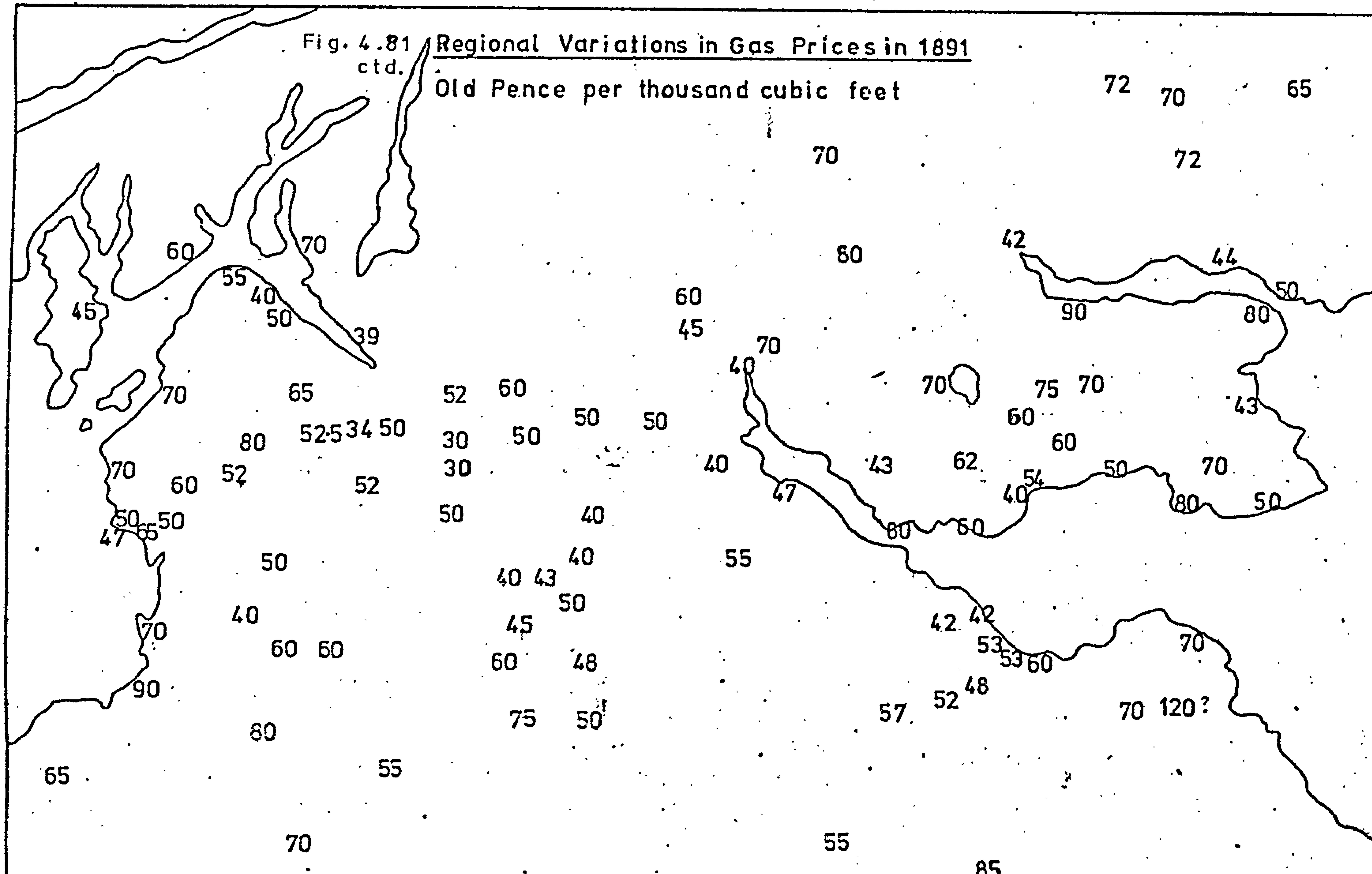

Fig. 4.81 ctd. Regional Variations in Gas Prices in 1891

Old Pence per thousand cubic feet

Dundee gasworks[1] from 1830 was the only Scottish town where prices were by statute related to the price in comparable towns elsewhere, but in several places a detailed "method of comparisons" was voluntarily adopted. Thus at Dunfermline[2] from 1879 the price was adjusted annually to be at or below the average price charged in Edinburgh, Glasgow, Greenock, Paisley and Kirkcaldy. Large consumers in many towns forced companies to grant discounts[3], and consequently to oppose municipal ownership of gasworks in order to maintain that privilaged position[4]. Alexander Anderson[5] of Aberdeen stated in 1871 that such consumers could still "screw out of the gas company whenever they choose, by threatening opposition .... an improperly large discount".

The earliest detailed examination of 'economies of scale'* was made by the Journal of Gas Lighting[6] in 1876. This concluded that companies with lengthy mains, supplying under one million cu ft per year as did many in Scotland, normally ran at a loss. Companies supplying 1½ to 2 million cu ft only paid a dividend periodically if at all. Towns using above 3 million cu ft, from 330 tons of coal at reasonable prices, did yield a

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1. Vide infra pp. 954, 1120, 993
2. J.G.L 17/6/1879
3. Vide infra pp. 1239, 1782, 477
4. e.g., Aberdeen municipal purchase in 1871 opposed by J. Keith of Messrs. Pratt and Keith (400,000 cu ft annual consumption), W. Sherries (250,000 cu ft annual consumption) and J. Webster. Vide J.G.L. 23/5/1871 p. 400
   Dundee municipal purchase in 1868 opposed by H.C. Briggs of Thomson, Shepherd and Briggs (1800 employees, £450 gas per year); N.O. Dalgleish of Messrs. Baxter Bros (4000 employees, £800 gas per year); G. Malcolm of Malcolm, Ogilvie & Co. (1000 employees, £300 gas per year); Thomas Smith of both Henry Smith & Co. and Smith, Mitchell & Co.; and R. Sturrock on behalf of Dundee Chamber of Commerce (157 members, founded 1864) representing firms like Messrs. Cox Bros (3500 employees) with a total annual gas expenditure of about £11,000.
   Vide J.G.L. 9/6/1868 p. 493
5. A. Anderson, Lord Provost of Aberdeen 1859-66. A leading supporter of Municipal purchase of Aberdeen gasworks in 1871; and of Aberdeen waterworks 1857-62.
   Vide infra p.1133 ; J.G.L. 23/5/1871 p. 395
6. "Considerations Affecting the Establishment of Gasworks"
   J.G.L. 28/3/1876 pp. 455-6, 4/4/1876 pp. 495-6

* Vide infra pp. 175, 323, 325, 482, 329, 874, 1150, 1183

profit provided the gas price was 50 per cent higher than in nearby large towns. Small companies which placed small orders for coal had greater difficulty obtaining high quality. Fixed capital expenditure was relatively higher than in large works because the fluctuations in demand were greater. At a small gasworks, daily consumption could vary from 12,000 cu ft to 5000 cu ft, and companies were often obliged therefore to purchase a gasholder equivalent to 36 hours maximum winter output, instead of 24 hours in other works, to enable the retorts to keep pace with demand. "There are few, if any, undertakings so much influenced by local circumstances as gasworks"; transport difficulties could be as important for profitability as coal costs, while small works also lacked a local market for by-products especially coke.

Table 4.82 The Influence of The Scale of Operations upon Gas Price (1876)

		(1) Capital £4500 Gas Price 6s.0d Dividend 5%			(2) Capital £12,000 Gas Price 5s.0d Dividend 6%		
Gas Annual Output		2.7 million cu ft			9 million cu ft		
		£	s.	d.	£	s.	d.
Coal (22s.0d per ton)		363	0	0	1188	0	0
Gas Manager's Wage		78	0	0	100	0	0
Stoker's Wage		52	0	0	104	0	0
Extra occasional labour		12	0	0	20	0	0
Wear and Tear (1½d. per 1000 cu ft)		18	15	0	62	10	0
Rent of Ground, Taxes		20	0	0	32	5	0
Purifying Material		9	7	0	20	16	8
Laying service pipes, repairs and new meters, repairs to tools }		17	0	0	18	0	0
Sundries, stationery etc }					15	0	0
Collector and Secretary		25	0	0	30	0	0
Bad Debts (1d. per 1000 cu ft)		12	10	0	41	15	0
Carried to reserve Fund		24	7	6	72	18	4
Dividend	(5%)	225	0	0	(6%) 720	0	0
Revenue - Gas (10% leakage)	(2.7 million cu ft)	810	0	0	(9 million) 2250	0	0
Coke (16s.0d chaldron)	(40 Chal.)	32	0	0	(160 Chal.) 128	0	0
Tar (1½d. gallon)	(2400 galls)	15	0	0	(7560 galls) 47	5	0
Total Annual Turnover		857	0	0	2425	5	0

Source - J.G.L. 28/3/1876 p. 455, 4/4/1876 p. 495

Two important external factors affected the growth of gas companies. Because they served only a local market[1], each company was profoundly affected by the prosperity of principal local trades[2], like textiles, rather than general national prosperity. But the price of gas was also closely related to the price of coal, which in turn reflected the national Trade Cycle. Because of market elasticity, cheap coal produced cheap gas which caused increased consumption, which in turn reduced manufacturing costs through the economies of scale. Expensive coal produced expensive gas, but if coal prices reflected an upswing in the economy, as in the coal famines of 1836-8 and 1872-3, gas consumption did not decline. A time-lag in the reduction of coal and gas prices during a downswing of the economy produced vigorous consumer agitation, but changes in the prosperity of local industries and trade were far more serious to a gas company than short term variations in coal prices.

Coal contracts were made annually, or even more frequently. During a coal crisis if prices were expected to fall, contracts were made for only a few months in advance of consumption. Gas managers were expected, though often failed, to predict such crises of rapid price increase, and efforts were then made to stock up in advance. Because coal was the largest single item of expenditure, most companies relied

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1. Expenditure on illumination was used as early as 1793 by W. Creech as an index of the "progress of manufacturers" and prosperity in a region. Creech believed that "few candles are either imported or exported", and therefore used the consumption to illustrate the growth of Edinburgh from 1763-91. Gas lighting is also a useful guide to local prosperity
<u>First Statistical Account</u> 1793 vol. 6

2. The effect of local prosperity appeared clearly in small companies serving aristocratic estates. At Stornoway in 1857 the consumption of gas fell from 710,000 cu ft (£429) to 664,800 cu ft (£401), "accounted for by the early closing [of shops] and Sir James (Matheson's) shorter stay on the island". Again in 1865 consumption fell by 29,200 (£17) largely through the absence of Sir James: the Castle had reduced gas consumption by £27, and coke purchases by £11. S.R.O. Stornoway Minute Book <u>op cit</u> 22/4/1857, 15/5/1865

Table 4.83

Expenditure Turnover

Total Annual Expenditure as a Percentage of Nominal Paid-Up Capital Stock

Reinvestment of surplus profits greatly altered the gross capital assets of companies; reduction of such funds increased the importance of loan capital during the crises of 1872-3, 1890-2 and 1900

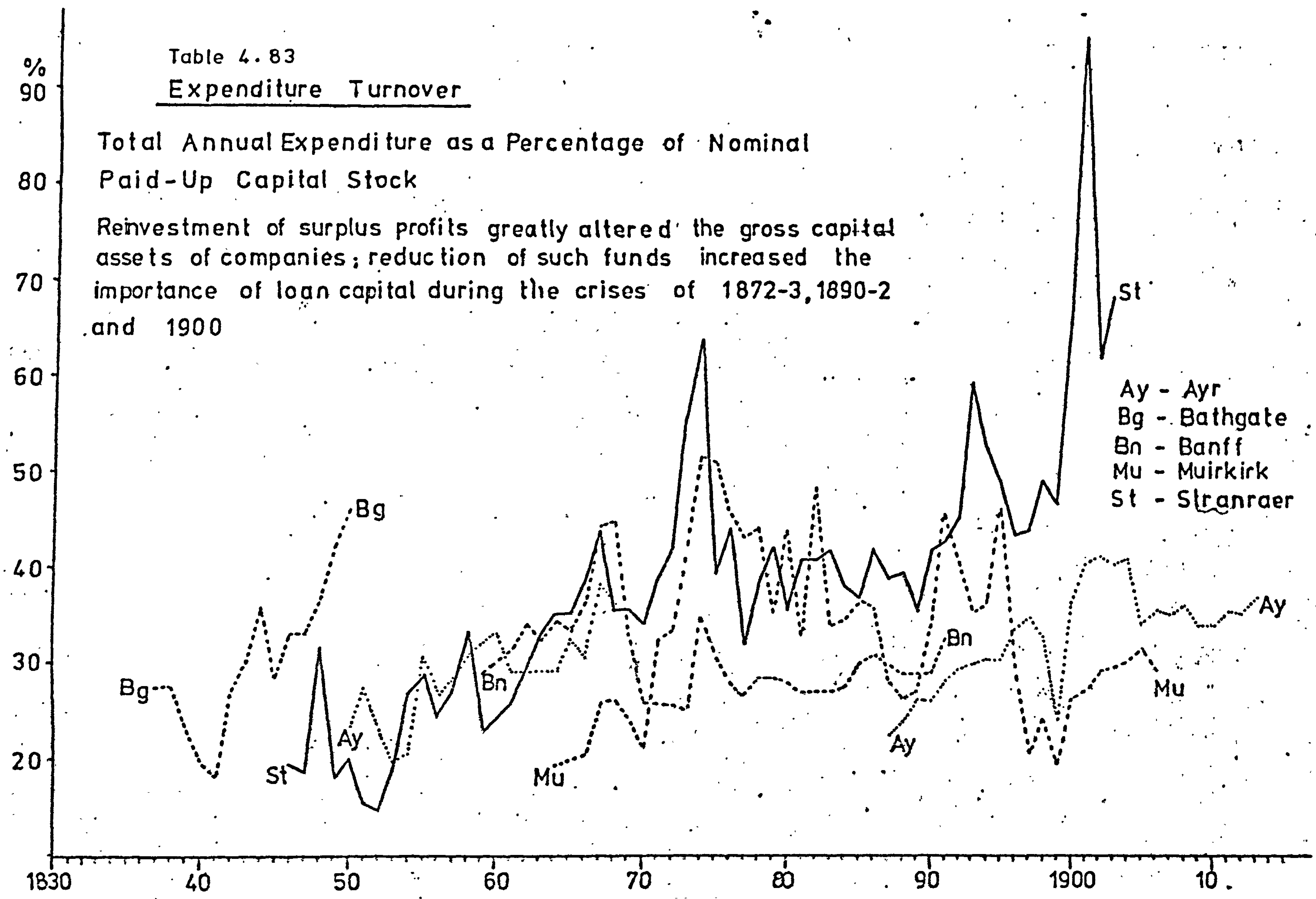
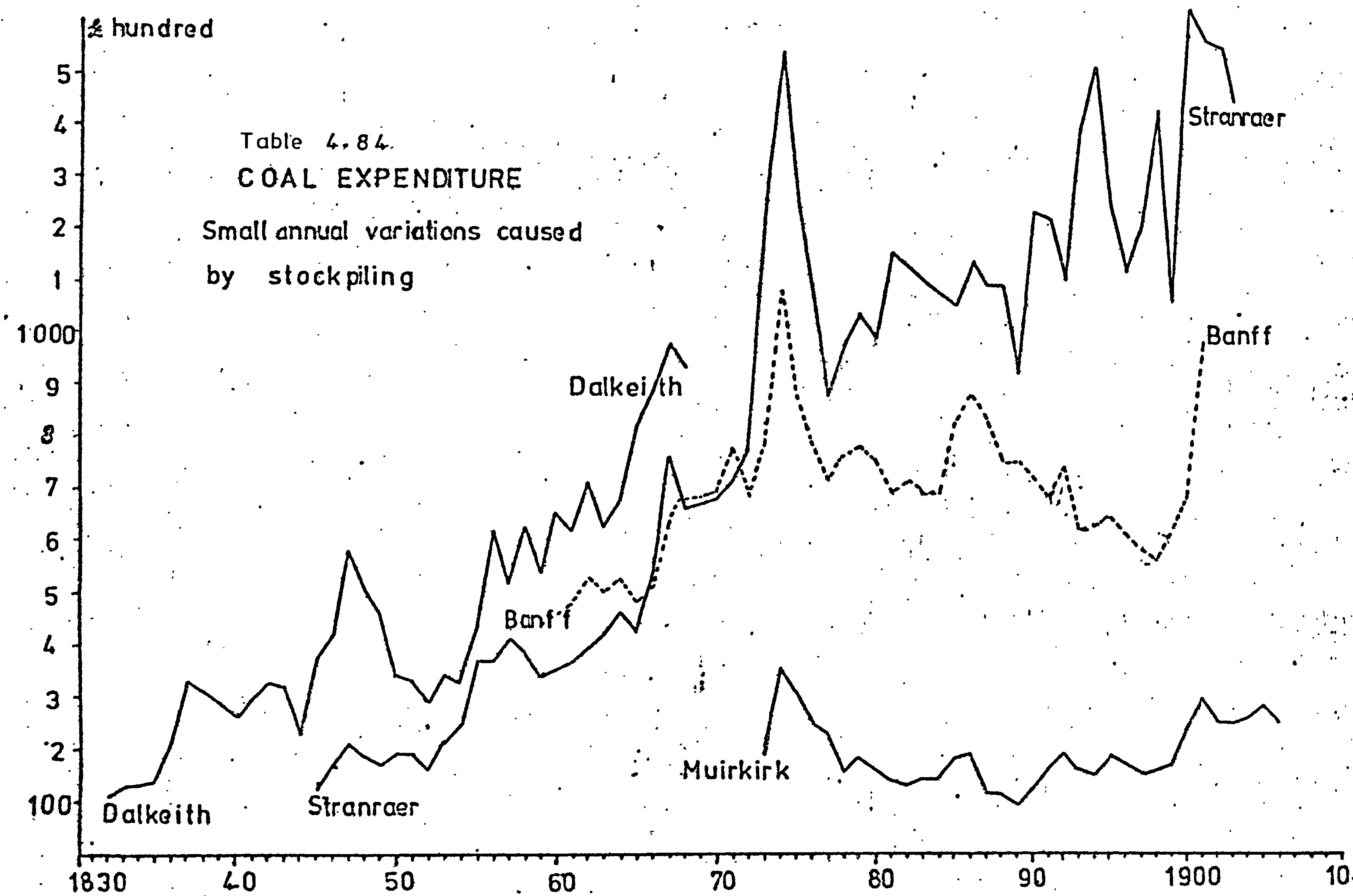


Table 4.84

COAL EXPENDITURE

Small annual variations caused by stockpiling



upon the collection of gas revenue to finance coal contracts[1]. Even where reasonable reserve funds were available, a rise in coal prices could produce a net trading deficit within a few months. A rise in coal prices was therefore followed almost immediately[2], in most cases, by an increase in gas prices.

Against this had to be weighed the disadvantages of provoking a reduction in gas consumption[3]. This reduced coal consumption but not wages, and because fewer consumers had to pay for higher working costs the total rise in gas prices was proportionally greater and could produce a progressive reaction. Through the Journal of Gas Lighting companies were aware of alterations made in retail prices by other companies, and some pride was taken in avoiding an unnecessary price rise. In 1866 Perth raised gas prices, but Cupar delayed and the crisis passed; Cupar again delayed in 1872, but for too long, and ran into debt.

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1. Thus in July 1875 Cupar annual general meeting authorized the Directors to borrow up to £1000, and raise gas from 5s.0d. to 6s.8d., because coal prices had doubled in two years and the Directors had "been obliged to lay in supplies much earlier than they have been in the habit of doing, and consequently they will require to pay for a considerable portion before the next collection of Gas Accounts in October".
S.R.O. Cupar Minute Book op cit 8/7/1873
2. i.e., In less than 12 months thereafter.
3. e.g., In 1890, Dalkeith raised the price of gas from 4s.0d to 4s.7d., which was expected to increase the annual revenue by £400, but instead resulted in decreased consumption and revenue only rose by £180.
S.R.O. Dalkeith Minute Book op cit 18/7/1890; 19/7/1892

Little documentation remains on conditions in the 1820s-30s, but there is no evidence of failure among the new gas companies. Technical problems and heavy working costs due, for example, to the repeated failure of cast-iron retorts at Dalkeith[1], were of greater significance than the rapid rise of coal prices[2] in 1836-8. Detailed statistics for the 1830s are only available from Paisley[3], on coal prices, and from Greenock[4] municipal gasworks on all aspects of revenue and expenditure. High coal prices and wages in 1837-8, are particularly evident in Figure 3.109. Total output rose rapidly in those years. Consequently, especially in 1837-8, the gasworks was forced to increase expenditure upon repairs, and on new gas lamps, despite the high market prices being charged for these. Thus the economic boom was at first self-sustaining, but the gas undertaking remained anxious to reduce total expenditure, and raise profits, as quickly as possible. Hence the outlay on repairing the retort benches at Greenock fell from a record level of £319 in 1837 to £87 in 1839. Total output rose from 13.56 million cu ft in 1837 to 17.53 million in 1839, but fell to 13.06 million by 1841. Manufacturing facilities which expanded to meet demand during the boom proved too large in the slump, which was intensified as all companies in a similar position attempted to reduce their outlay and recoup, through larger profits, the earlier outlay.

Coal prices again sharply rose in 1846-9 and wise companies allowed gas to follow suit. Selkirk had sold gas at 10s.10d since 1844, but charged 12s.6d. in 1846-8, before restoring the earlier price. Ayr company and Newtown Consumers company, despite earlier cut-throat competition, mutually agreed to a rise from 5s.10d. to 6s.8d. in 1849.

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1. S.R.O. Dalkeith Minute Book op cit 24/3/1828, 26/2/1830, 9/4/1839, 30/4/1847
2. Vide supra p.513
   Dalkeith annual coal expenditure rose from £127 in 1835 to £328 by 1837. The period 1835-7 was one of national speculative mania, especially in railway projects; Scottish iron output was rising rapidly, with new works at Dundyvan and Summerlee opened at that time.
   W.H. Marwick Economic Developments in Victorian Scotland (1936) p. 126
   B.C. Hunt The Business Corporation in England (1936) op cit p. 61
   A. Slaven The Development of the West of Scotland 1750-1960 (1975) p. 42
3. Vide supra p.503
4. J.G.L. 10/5/1851 Vide infra p.481

Rising consumption at the beginning of a coal crisis, resulting from the prosperity causing the crisis, was usually inadequate to overcome the higher cost of coal. It also produced false optimism since a recession could rapidly follow. Galashiels[1], for example, in 1846 determined to maintain the old gas price because higher consumption had offset the coal costs. The following year, despite a rise of £130 (31 per cent) in gas consumption, the price had to be raised to 10s.0d. to maintain liquidity. In 1847-8 gas sales declined by 619,000 cu ft, but wages and coal expenditure were still rising. Other towns experienced a trade depression[2] in the late 1840s, as at Stranraer[3] from 1842-7.

Improved technical management and lower charges for gas in Stranraer[4] increased consumption considerably by 1848. During 1850 cheap coal and iron, and increased consumption for public lighting, raised company profits there despite "the depression which has existed in this agricultural district during this past year - and which must have affected the town". Because coal and iron remained cheap, Stranraer reduced gas from 10s.6d to 8s.0d in 1852. A large increase in sales the following year "partly arises from a lower price inducing an increased demand on the part of old consumers, but chiefly from a large increase in the number of new ones". Consequently, despite high freight costs in 1853 which raised the price of coal, gas charges were not raised. High consumption was maintained, but resulted in unpostponable fixed capital expenditure during 1854 despite the new high level of iron and wage rates. Even the new gasholder could only be delayed one year, and was built in 1855 when construction charges were still high.

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1. S.R.O. Galashiels Minute Book <u>op</u> <u>cit</u> 7/7/1846, 6/7/1847, 30/6/1848
2. Handloom weavers were particularly depressed in the 1840s. A. Slaven <u>The Development of the West of Scotland 1750-1960</u> (1975) p.105
3. S.R.O. Stranraer Minute Book <u>op</u> <u>cit</u> 14/1/1842, 30/1/1845, 26/6/1849, 24/6/1850
4. S.R.O. Stranraer Minute Book <u>op</u> <u>cit</u> 24/6/1850, 7/5/1853, 28/6/1853, 27/6/1854, 14/5/1855

Another cyclical decline in profits occurred in many gas companies about 1855-8. Ayr[1] company suffered a sudden decline in profits in 1854-5, attributed to high coal prices and wages, and "the early shop shutting now generally adopted" which had reduced consumption. But "from the numerous buildings going on about Ayr", there was no lack of confidence in the future and rising consumption plus decreased expenditure gave high profits from 1857. At Alexandria[2] high coal prices in 1855 coincided with decreased consumption, but the extension of mains pipes continued. During the "severe commercial crisis" of 1858 consumption remained steady, and grew rapidly in 1859 when local trade improved and coal prices fell. Selkirk raised the price of gas in 1855 as coal rose, but the depression at local mills considerably reduced consumption and Selkirk profits fell from £320 in 1857 to £255 in 1858.

Galashiels[3] also faced high coal prices in 1855, but because of high demand, kept gas at 6s.0d and even took heavy loans to finance extensions of plant. Labour costs rose also, and in 1858 gas was raised to 6s.8d. while the town experienced "dulness of trade and loss of work". Several small consumers were unable to pay their accounts, and were given extended credit, a quite exceptional step for a gas company. Profits doubled in 1859, and large extensions were made including a gasholder. Recovery was, however, slower in Galashiels than elsewhere in Scotland. Consumption fell in 1862 during "the long depression of trade in the town", but rose very rapidly in 1864-5.

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1. S.R.O. Ayr Minute Book op cit 3/7/1854, 2/7/1855

2. Domestic consumption at Vale of Leven fell 282,000 cu ft, and factory consumption 51,000 cu ft. Gas price was not raised.
S.R.O. Vale of Leven Minute Book op cit 25/9/1855, 13/6/1859, 5/7/1859, 1/7/1858

3. S.R.O. Galashiels Minute Book op cit 8/6/1855, 3/3/1858, 9/6/1858, 1/7/1862

Table 4.85 Variations in Gas Price at Selkirk (1852-66)

1852	8s. 4d.	1857	8s. 6d.	1862	7s. 1d.
1853	7s. 6d.	1858	8s. 6d.	1863	6s. 8d.
1854	7s. 6d.	1859	8s. 6d.	1864	6s. 2d.
1855	8s. 6d.	1860	7s. 11d.	1865	5s. 10d.
1856	8s. 6d.	1861	7s. 6d.	1866	5s. 10d.

Source - S.R.O. Selkirk Minute Book op cit

High gas prices after 1855 provoked dissatisfaction[1] among consumers, and lower coal prices, and possibly labour costs, in about 1859 triggered Flintoff's Consumers Movement[2] in Scotland in 1859-63. The charges made in Glasgow during the 1850s were of paramount significance, and appear in Table 4.86.

Table 4.86 Coal Prices and Gas Charges at Glasgow City and Suburban Works 1845-58

Date	Coal per ton s.	d.	Gas s.	d.	Dividends %	Date	Coal s.	d.	Gas s.	d.	Dividend %
1845	13	3	6	8	3.125	1852	11	11.75	5	0	9
1846	14	9.5	6	8	7.5	1853	9	9	5	0	10
1847	15	6.25	5	0	6.66	1854	9	10	4	7	10
1848	18	9.5	5	0	5	1855	13	0.75	4	7	10
1849	14	10	5	0	6.39	1856	9	9	4	7	10
1850	12	5.5	5	0	7.77	1857	17	7	5	0	10
1851	11	9.75	5	0	8.88	1858	16	6	5	0	10

Source : J. McClelland, C.A. J.G.L. 12/2/1861 p. 97

Thereafter the 1860s saw no dramatic changes, and allowed a prolonged growth of company prosperity. In 1867 Banff[3] reported higher wage costs, but exagerated a rise of 5s.0d per ton as an "enormous rise in the price of Gas Coals". Even there, increased consumption, especially by a prosperous new woollen mill, prevented the Company from having to increase gas prices. Selkirk[4] also had expensive coal in 1867, but inexpensive coal in 1868-9.

1. High coal prices in 1856 were not offset by increased by-product revenue, but "high prices of oil and tallow" in England produced an "enormous increase" of 20 per cent in gas consumption during 1856, compared to the usual average increase of 8 to 10 per cent per year. J.G.L. 8/1/1856 p. 8
2. Vide infra p.1157
3. S.R.O. Banff Minute Book op cit 20/6/1867, 15/6/1868, 25/6/1868
4. S.R.O. Selkirk Minute Book op cit 19/6/1867

The coal crisis of 1872-3 was both sudden and severe. Banff[1] reported a rise of 5s.6d. per ton in 1872, but by 1873 prices had risen 125 per cent, only to collapse just as rapidly in the spring of 1874. Many companies were prepared to absorb the initial shock and protect consumers in the hope of a rapid return to normalcy[2]. Extensions of capital equipment, however, were frequently brought to a halt by the resulting lack of liquidity, a factor which may have contributed to the slump which followed the boom of 1872-3.

Company directors at Galashiels[3] in 1872 predicted a rise of £800 on coal expenditure, but left the retail price of gas at 5s.0d. In May 1873 it was belatedly raised to 6s.3d. because wages, and raw materials besides coal had increased in price. Dividends were reduced to 7½ per cent instead of 10 per cent in the interregnum, and depreciation reduced from 5 per cent to 1 per cent to boost 'profits'. Ayr also delayed the price rise until 1874, from 5s.5d. to 6s.3d. Cupar[4], Fife, in 1872 retailed gas at the normal rate of 5s.0d. in the hope that rising output would offset the coal prices. The following year coal had doubled in price, and besides a trading deficit Cupar had to raise the price to 6s.8d. and take a large temporary loan.

Large extensions at Selkirk gasworks were disrupted by 1874, when profits fell to £188 from £280 the previous year. Gas there was increased from 5s.5d. to 6s.8d. in 1873 and 7s.6d. in 1874 because heavy reploughing had increased the liquidity crisis and many consumers were unable to pay such high rates. By the slump of 1875 gas arrears were £146, which were written off. In March 1876 the manager was allowed to accept payments with a

1. At Banff, 5s.6d. per ton or £124 per year, was greater than the alarming rise of 1867; but in 1873 the increase was a further £223. In June 1874 prices fell on average 5s.6d. per ton. Closer attention to the types of coal used provided only a minor palliative.
S.R.O. Banff Minute Book op cit 18/3/1872

2. Stornoway already charged 12s.1d. in 1873 and did not raise the price. Later that year the small company was £93 in debt to Messrs. Ferguson of Lesmahagow, their main coal supplier. When the charge for Police street lamps was raised from 20s.0d to 30s.0d, the Company Secretary was "attacked and abused in the public street", and the rate had to be reduced. Experiments with peat gas were made, and £105 debt to Ferguson in 1874 was not repaid until November 1876.
S.R.O. Stornoway Minute Book op cit 8/7/1873, 30/9/1873, 8/11/1873, 9/12/1873, 7/9/1877
Vide infra p.525

10 per cent discount over previous prices "rather than create delay or recusancy". By prolonging the high gas prices a year or more longer than coal prices dictated provided a means for recouping on earlier mistakes, albeit to the great annoyance of consumers.

Table 4.87 Profits, Prices and Dividends at Selkirk During the 1872-4 Coal Crisis

Date	Gas Price	Dividend	Profits (£)
1869	5s.10d		407
1870	5s. 5d	10%	476
1871	5s. 5d	10%	429
1872	5s. 5d	10%	650
1873	6s. 8d	10%	280
1874	7s. 6d	5s.0d Old; 2s.6d. New stock	188
1875	6s. 8d	10%	884
1876	5s.10d	10% & Bonus (2½% Old, 1¼% New)	1032
1877	5s. 5d	10%	698

Source- S.R.O. Selkirk Minute Book op cit

Other companies were eager to lower gas prices as soon as possible. Banff[1] in 1876 reduced gas prices by an amount which, despite decreased coal prices, was forcast to depress total profits by £85 unless consumption rose rapidly. Confidence, social responsibility, and what the market would stand all influenced such decisions. Renton[2] gasworks, built in 1860 to serve a small village, was reconstructed in 1883 when output soared as the result of local, external economic factors: the village was a residential suburb for Messrs. Denny's shipyards at Dumbarton. External factors also produced a rapid growth of the Kirkmalcolm Gas Company[3], where two hundred new houses were built around 1880, and the West of Scotland Hydropathic Establishment opened with consumption by 700 lights. As many villages became absorbed into the large city economy by functioning as commuter suburbs, numerous gas companies of this type expanded rapidly through the transferance of money from city commerce into village trade as payment for services.

3. S.R.O. Galashiels Minute Book op cit 25/6/1872, 6/5/1873, 4/5/1875
4. S.R.O. Cupar Minute Book op cit 9/5/1872, 10/7/1873, 8/7/1873

1. S.R.O. Banff Minute Book op cit 22/6/1876
2. New 1883 designs by McGilchrist of Dumbarton gasworks. J.G.L. 17/7/1877, 21/8/1883
3. Supplied the Hydrapathic Establishment at 7s.6d., with 10 per cent discount on gas over £100. J.G.L. 3/2/1880, 10/2/1880

A 'Depression' in the 1880s was more than mythical for several gas companies in areas where local trades suffered. Selkirk gas company in 1877 languished from the "dulness of trade and the absence of several large consumers", and despite cheaper coal and lower gas prices, consumption declined in 1879-80. Stranraer experienced low consumption in 1881 and 1884, followed by a decline of 1.6 million cu ft in 1885 due to a trade depression in "some of the Factories", with Bowhill consumption alone falling by £338. In 1886 £200 of bad debts was written off, and several local companies became bankrupt, like Messrs. Brydone and Halliday who owed £76 for gas. Again in 1886-7 consumption fell by about 1 million cu ft worth £172, because the mills were idle.

Table 4.88 Profits, Prices and Dividends at Stranraer in the 1880s Trade Depression

Date	Gas Price	% Dividends	Profits (£)	Date	Gas Price	% Dividends	Profits (£)
1879	5s.0d	10	772	1886	3s.6½d	10	663
1880	4s.7d	10	500	1887	3s.6½d	10	278
1881	4s.7d	10	Def.51	1888	3s.6½d	10	387
1882	4s.2d	10	176	1889	3s. 4d	10	835
1883	4s.2d		306	1890	3s. 4d	10	691
1884	4s.2d	10	300	1891	4s.2d		594
1885	3s.9d	10	423				

Source - S.R.O. Stranraer Minute Book op cit Note - Def. is deficit

Local variations were quite marked. Ayr, with "the extension of new houses"[1], gave prosperity to the gas company through the 1880s.

Greenock[2] in 1885 experienced a large decrease in consumption, like many other Scottish towns[3], at a time when by-product revenue fell 50 per cent. The decrease covered all classes of consumers, and was the first in the history of that gasworks. £904 of the reduction was caused by large consumers,

1. S.R.O. Ayr Minute Book op cit 5/7/1882
2. Greenock Ref. Lib. Greenock Police Board Minutes (December, 1885)
3. Scottish iron-ore production fell sharply after 1883; shipbuilding slumpc.1883-6.
   A. Slaven The Development of the West of Scotland 1750-1960 (1975) p. 169
   S.G. Checkland The Rise of Industrial Society in England 1815-1885 (1969) p.66
   Depression of engineering and iron trades reduced consumption of gas in Motherwell in 1887, vide J.G.L. 12/7/1887

like sugar refineries, ship-builders, and other industries which used above £50 gas per year, but had reduced their hours of operation. This was only partially offset by an increase of consumers in the £10-20 bracket, using gas for cooking and for gas engines.

Table 4.89 The Effect of The General Trade Slump of 1884-5 on Gasworks Revenue

	1884		(nearest £)		1885	
Town	Gross Profit	Nett Profit	Deficit	Gross Profit	Nett Profit	Deficit
Aberdeen	8370	686	0	-	-	-
Dundee	17663	0	2823	17880	0	4102
Dumfries	1922	25	0	1808	5	0
Glasgow	73754	0	10751	81444	16863	0
Kilmarnock	3753	725	0	2521	4	0
Perth	3055	0	729	3565	8794	197
Greenock	12125	3908	0	9974	877	0
Paisley	8567	2720	0	14233	0	0

Note - In 1884 Glasgow corporation wrote off £17,166 additional depreciation
In 1885 Kilmarnock purchased £955 regenerative furnaces out of annual revenue

Source - Greenock Ref. Lib. Greenock Police Board Minutes (December, 1885)

In Dumbarton[1] gas consumption fell 10.5 per cent in 1886 because of the slump in shipbuilding and marine engineering. A severe trade depression in Dundee[2] that year closed several factories, which reduced gas revenue there by £4000 whilst by-product revenue fell by £4500.

Coal prices rose sharply in 1890-1 and renewed fears of an exhaustion of supplies. Galashiels raised gas from 2s. 11d in 1889 to 3s.9d by 1892 and purchased 'Peebles' oil gas[3] equipment to supersede high quality coals. The coal strike of 1894 convinced many more companies of the need for similar action. Selkirk[4] raised gas from 3s.4d to 4s.2d in 1891, but

1. J.G.L. 17/8/1886
2. J.G.L. 1/6/1886
3. S.R.O. Galashiels Minute Book op cit 7/1/1891
Many companies turned increasingly to oil-gas enrichment. Vide supra p.448
4. Coal purchased at Selkirk rose from 18s.6d to 28s.0d per ton on average in 1891 i.e., £855 on a consumption of 1800 tons.
S.R.O. Selkirk Minute Book op cit 30/6/1891

c.f. In March 1891 Ayr considered reducing gas to 3s.9d, but postponed a decision because coal was expected to rise by 3s.0d a ton.
S.R.O. Ayr Minute Book op cit 10/3/1891

experienced the first important trade revival for a decade. Heavy capital equipment expenditure, including a gasholder, was made in 1892, but a new depression affected local industry in 1896-7.

Table 4.90 Effect of 1891-3 Coal Crisis upon Galashiels Finances

	Expenditure				Revenue		
Price of Gas	Date	Coal	Wages	Total Expenditure	Gas Revenue	Coke Revenue	Tar Revenue
4s.2d	1889	3161	836	9445	8348	182	351
4s.2d	1890	3136	854	9405	7681	233	717
4s.2d	1891	3612	914	10194	7932	305	973
4s.2d	1892	4437	936	10681	8728	362	1059
4s.2d	1893	4886	972	10765	9229	295	686
3s.9d	1894	4243	1024	10893	9719	310	354
3s.9d	1895	4390	1054	11055	9576	426	564

Source - S.R.O. Galashiels Minute Book op cit

While several authors have suggested[1] that increased coke-revenue offset increases in the price of coal, this was demonstrably untrue of the times of coal scarcity.

Table 4.91 Impact of 1890-1 Coal Crisis upon Gas Prices in Various Towns

Company	1889	1890	1891	Company	1889	1890	1891
Selkirk		3s.4d	4s.2d	Barrhead		4s.4½d	4s.7d
Blantyre		3s.9d	4s.2d	Dalkeith		4s.0d	4s.7d
Kirkcaldy	3s.1½d	3s.4d	3s.6½	Crieff		4s.7d	5s.0d
Innellan		5s.6d	6s.8d	Bervie	8s.9d	9s.2d	
Castle Douglas		6s.3d	6s.8d	Alyty	5s.10d	6s.3d	
Kelso		4s.7d	5s.0d	Stirling	3s.7d	3s.9d	4s.2d
Largs		4s.7d	5s.0d	Huntly	7s.1d	7s.11d	
Kilbirnie	3s.4d	5s.10d		Dundee	3s.6d	3s.8d	

Sources - See below [2]

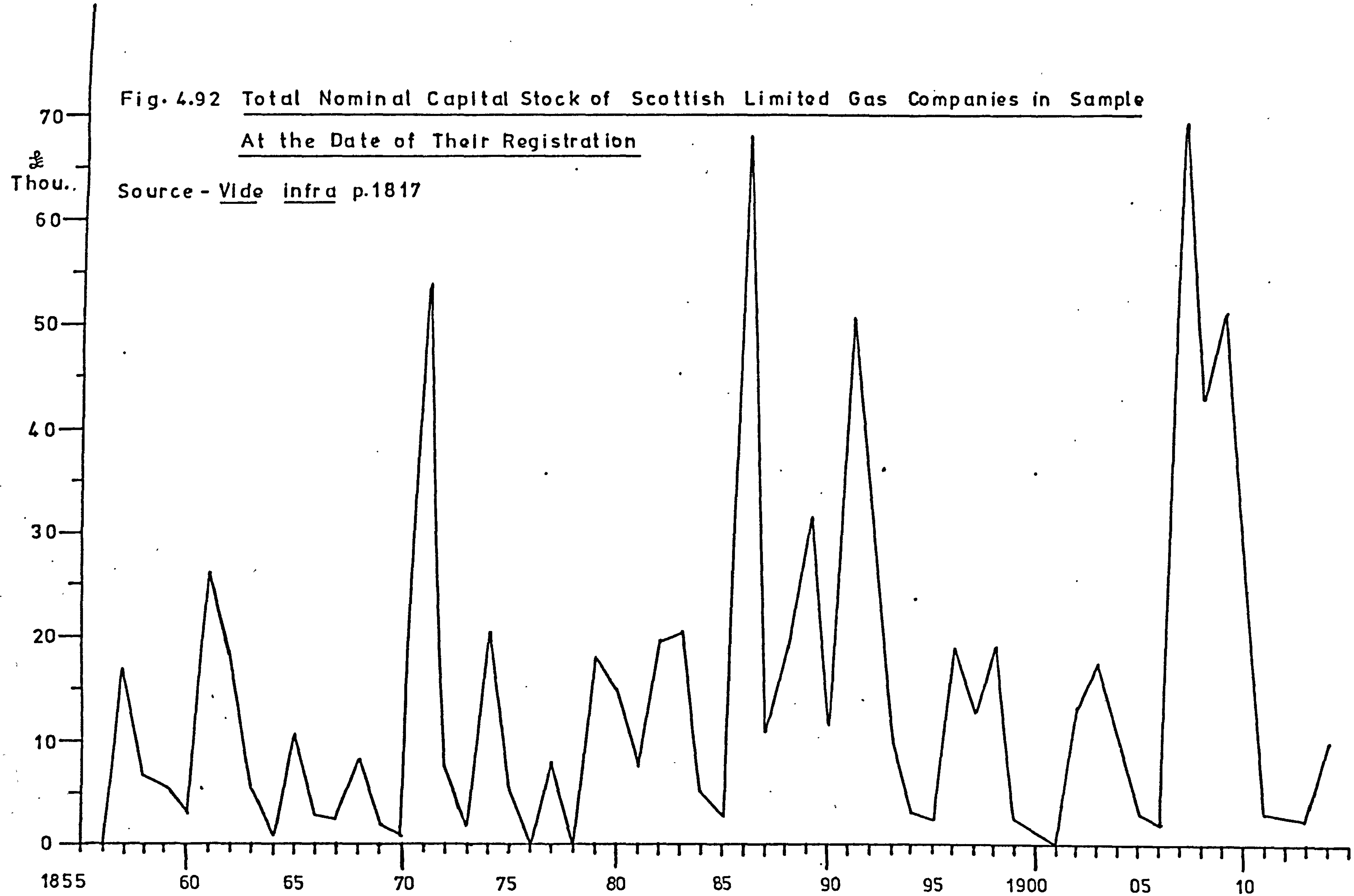
During 1889-91 the increase in gas prices varied from 2d to 30d, but affected companies at all price levels.

The sharp price rise in coal in 1899-1903 had similar

1. e.g., M.E. Falkus Economic History Review 1967 II Series Vol. XX op cit
2. J.G.L. 21/7/1891, 14/7/1891, 7/7/1891, 23/6/1891, 9/6/1891, 19/5/1891, 15/7/1890, 27/5/1890, 26/5/1891, 20/5/1890, 13/5/1890.
   Note - Kilbirnie works, with 700 consumers, run by W. & J. Knox of Eglinton Iron Coy. During the railway strike in January 1891, Fifeshire gasworks were supplied by coalmasters who sent their own locomotives onto the main lines to make delivery.
   J.G.L. 6/1/1891
   Some gas companies, like Ochiltree in Ayrshire with a capital of £800 in £1 shares, were dissolved because of the high coal prices and a threat by consumers to use paraffin oil lamps. J.G.L. 15/12/1891

Fig. 4.92 Total Nominal Capital Stock of Scottish Limited Gas Companies in Sample At the Date of Their Registration

Source - *Vide* *infra* p.1817



effects. Companies like Banff[1] raised gas prices, postponed any large capital extensions which had been planned, and turned to alternative methods of enrichment like Benzol. Local manufacturing prosperity remained important, also, and in 1905 total gas consumption in Banff declined entirely due to a slump in the boat-building trade[2].

Despite the financial problems caused by coal crises, Limited Liability was not a panacea for financial stability. Fractional shares were not permitted though several gas companies had allowed their shares to be sub-divided. Alteration of the nominal value of shares became more difficult, and Companies which used loan capital encountered difficulties in providing security for loans after accepting Limited Liability. Confusion over these issues and over the advantages of registration dissuaded many gas companies from registering. In 1879 the Cupar[3] directors considered and then rejected the possibility of registering, and another move to do so was defeated at the annual general meeting in 1882. In 1893, a year before the Company's deed of co-partnery was due to expire, the Directors formed a Committee[4] to investigate in depth the advantages of Limited Liability. At Kirkcaldy, where registration had cost £177, the main advantage "was the limitation of the responsibility of the Shareholders in the event of any explosion or other accident resulting in destruction of property, or loss of life". This appeared so unlikely that the Cupar directors advised against the £80 cost of registration, and the partnership was renewed without Limited Liability. Finally in 1895 the shareholders voted in favour[5] though the decision was not related to any immediate desire for large new capital expenditure. Indeed when extensions were contemplated in 1897 the Company's solicitors[6] advised

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1. In September 1900 Banff raised gas by 7½d, and postponed extensions for one year until Benzol equipment overcame the problem of expensive high quality cannel. Banff coal costs rose £297 in 1900
S.R.O. Banff Minute Book op cit 7/7/1899, 6/9/1899, 12/9/1900
2. S.R.O. Banff Minute Book op cit 2/8/1905
3. S.R.O. Cupar Minute Book op cit 15/2/1879, 29/8/1882
4. ibid 19/1/1893, 6/4/1893
5. Carried by 43 votes to 14; verified at a special general meeting by 153 to 17. S.R.O. Cupar Minute Book op cit 11/7/1895, 24/11/1895
6. Messrs. Pagan and Osborn.
ibid 8/4/1897

that with Limited Company status it no longer had the right to borrow money. The Directors could pledge the Company's credit, but did not "have power in their constitution to pledge any special asset, or secure any special creditor", nor "have power to borrow on debenture so as to give a special security or preferential right of any kind to a lender". They could not borrow on the security of heritable property since it was held by Trsutees, nor on the Company moveables according to Company rules. Since the Cupar company had always used much loan capital, the error of registration could have been serious, but in the event the British Linen Bank was willing to provide 4 per cent loans, and the Company also later successfully negotiated personal loans[1].

Dalkeith[2] registered as an Unlimited Company in 1883 to overcome legal ambiguities over the position of partners who were also municipal officials, and a similar cause may also have influenced other companies to act likewise. In April 1883 the company treasurer, James Gray, was forced by the Town Commissioners to resign his position as a Commissioner because he was a partner in the gas company. To prevent a recurrence, Gray felt obliged to sell his shares to his son, G.E. Gray. Meanwhile a committee of four Directors deliberated and approved registration as a Joint Stock Company

> "as it would allow the company to sue and be sued, and also to hold property and investments in the Company's name instead of in the name of individual Directors as Trustees for the Company as at present [and] would remove all doubt as to the shareholders acting as Commissioners under the Police Act on the ground of the Company having a contract with the Commissioners for lighting the street lamps"

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1. The security offered is not recorded.

2. S.R.O. Dalkeith Minute Book op cit 6/4/1883, 9/7/1883, 8/10/1883, 27/5/1884

Many companies registered for Limited Liability for extra security[1] when they were making large additions to capital equipment, possibly to attract new investors. Gourock[2] registered in 1879 with a large increase of nominal capital, from £1800 to £6000, by the sale of 3000 new £2 shares offered preferentially to existing shareholders to finance extensions which included a new gasholder, condensers, purifiers and buildings. Portobello[3] company in 1889 took limited liability to help raise extra capital for equipment. Elie and Earlsferry[4] registered in 1896 when it was raising capital to purchase extra land and a new gasholder, and Carluke[5] was also financing reconstruction and a gasholder when it registered in 1908.

The second principal aim, possibly related to planned extensions was to oppose proposed municipal takeovers and acknowledge the extent of earlier reinvestment of profits. This was true at Stornoway where the Council had shown interest in acquiring the Company[6] which replied[7] by forming a Limited Company with 4000 ordinary and 1000 5 per cent Preference shares of £1, in

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1. Many small gas companies formed after the 1850s, registered immediately in anticipation of financial problems related to their small size. Detailed arguments on the advantages and disadvantages of Limited Liability stated from 1720-1864 are quoted by H.A. Shannon in "The Coming of General Limited Liability".
   Economic History (Supplement to the Economic Journal) Vol. II 1930-33 p. 267 See also H.A. Shannon "The First Five Thousand Limited Companies and their Duration" ibid p. 396
   W.H. Marwick "The Limited Company in Scottish Economic Development" Economic History Review 1934-7
   These authors do not give specific consideration to gas companies.
2. S.R.O. (B.T.2/ 878)
3. J.G.L. 23/7/1889
4. S.R.O. (B.T.2/3696)
5. S.R.O. (B.T.2/3915)
6. S.R.O. Stornoway Minute Book op cit 24/2/1888, 19/9/1887
   J.G.L. 8/5/1888
7. Registration cost £84. In 1888 another Bill of £58 from a local solicitor was also used before accepting the bank loan.
   S.R.O. Stornoway Minute Book op cit 4/4/1888, 29/9/1888, 31/7/1889, 30/9/1889, 10/10/1889

1888. The old company was purchased for £1752, and a programme of renovations began. Buyers could only be found for 100 of the Preference shares, however, and there were inadequate funds to pay for purifiers and scrubbers being built by Messrs. Laidlaws for £185.

Loan capital was therefore an immediate problem. The National Bank was willing to provide £500 against a mortgage (Bond) over the Company's property, or individual obligations by the Directors. After a month of indecision, while Messrs. Laidlaws granted a Bill of £177, the Directors decided to give the Bank a mortgage agreement, and the loan was used for fixed capital equipment.

Small companies were the first to take advantage of Limited Liability and large companies only followed after 1880, as shown in Table 4.93.

Table 4.93 Number of Scottish Gas Companies Registered for Limited Liability each Decade

£ Nominal Capital	Pre 1860	1860-9	1870-9	1880-9	1890-9	Post 1900
Under 500	1	0	1	1	1	1
501-700	1	5	2	0	0	0
701-1000	4	7	3	0	1	2
1001-1500	3	4	3	0	1	0
1501-2000	1	0	0	3	0	2
2001-5000	1	2	3	4	9	5
5001-9999	0	2	2	5	1	4
10,000 and above	1	1	1	2	3	10
Total Number of Companies	12	21	15	15	16	24

Source - S.R.O. Board of Trade Records

Limited Liability did not prevent gas companies using large quantities of loan capital, but the necessity of preparing accurate annual capital accounts for the Registrar of Companies proved a burden, and errors of compilation or of foresight did result in legal difficulties. Airdrie[1] gas company, which registered in 1862, had a contract which forbad the

1. S.R.O. (B.T.2/237)

Directors to borrow over £1000, but in 1900 this was changed to permit the Directors to borrow up to £3000, or a General Meeting to sanction up to £6000. Langbank[1] company in Renfrenshire was formed in 1868 with a nominal capital of £1200, but the following year Directors were empowered to borrow up to £400. Lasswade and Bonnyrigg[2] company in 1875 had a nominal capital of £1600 with £1360 paid up, but voted to take a Bond of up to £7000 to purchase property at Goatbridge, and lay new pipes to Keock and Polton Mills. Although part was repaid from profits, the nominal capital was raised through extra shares to £3000 in 1876, and £3500 with £2205 paid-up in 1878, to help repay the debt. The Kilmalcolm[3] company began in 1871 with a capital of £1000, but in 1879 the Directors were authorized to raise £300 on Bond, and in 1880 that was raised to £1000.

Debenture stock was used by a few limited companies. Bellshill[4] made a large increase in capital from £3000 to £15,000 in 1908, and although all of the new shares were subscribed and paid-up the same year, a Debenture[5] of £2500 was also obtained to finance extensions. Debentures were also used at Cardenden[6] where an entirely new gasworks was built in 1909 to supply 20 million cu ft a year to the villages of Auchterderran, Bowhill and Cardenden. It cost £10,500 of which £8500 was raised by the sale of £1 shares, and £2000 by 4 per cent Debentures.

Great difficulty was experienced by Limited Companies which wished to reduce the nominal value of shares. At Penicuik[7] the nominal capital in

1. S.R.O. (B.T.2/301)
2. S.R.O. (B.T.2/25)
3. S.R.O. (B.T.2/363)
4. S.R.O. (B.T.2/5215)
5. The Debenture was reduced to £2000 in 1910; £1250 in 1911-13; and £750 in 1914.
6. Cardenden had a nominal capital stock of £20,000. In 1912 a further 2000 shares were sold preferentially to residents of Kinglassie, four miles away, to finance gas mains to that village. S.R.O. (B.T.2/7022)
7. S.R.O. (B.T.2/755)

1877 was set at £8000 in £10 shares, but only £6 was called up, and in 1881 the company had the expense of applying to the Lords of Council and Session to reduce shares to £7.10.0d, and the total nominal capital to £6000. Over ambition produced "reserve liability" which negated all benefits to individual shareholders[1]. Tranent[2] gas company was formed in 1884 with a nominal capital of £2000 in £1 shares, but by 1899 only 1811 shares had been issued and 13s.0d called up on each. The Company wished to reduce its nominal capital to £851.8s.0d, and the nominal value of shares to 13s.0d, but the Registrar objected. In 1900 the case was taken before the Court of Council and Session, which insisted upon the shares remaining worth £1, but reduced the nominal capital to £1275 and liquidated the 536 shares held by the Company in its own stock.

Most gas companies, however, developed an efficient fiscal system which enabled them to overcome considerable problems caused initially by under-capitalization, and later by the periodic crises when coal costs rose steeply and absorbed the entire gross profit margin at constant gas prices. Loan capital, viewed first as a necessary but unwelcomed liability, was developed as a most profitable source for fixed capital expenditure, repaid gradually by reinvestment of the profits which it created. Depreciation funds developed slowly amongst unincorporated companies, but were popular with chartered companies in order to conceal extensions made from surplus profits. The reaction of consumers to these financial measures, and their adoption and manipulation by municipal gas undertakings, are examined later after a consideration of the internal organization regulating company operations.

1. Shareholders were liable to the full nominal value of shares, even where only part was called up initially.

2. S.R.O. (B.T.2/1358)