In A State Of Great Forwardness
Manchester & The Coming Of The Gas Industry

Presented By Mr. T Mitchell & Mr. S Bennet

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INTRODUCTION

In any history of the gas industry the names of three pioneers, William Murdoch, Frederick Albert Winsor and Samuel Clegg are invariably mentioned.

Murdoch was the man who first demonstrated that coal gas could be economically produced as a fuel for gas lighting. Murdoch's work has been well researched from the records of his employer Boulton and Watt. His inventions and achievements were many and varied and Murdoch proved himself as a man of original thought and as an excellent engineer. He has rightly received the credit for his work.

Winsor was a German who came to this country to exploit the potential of the `new' gas light. He demonstrated the manufacture of gas and its use for lighting from an experimental plant on the stage of the Lyceum Theatre in London. He also lit a section of Pall Mall in 1807. Winsor had a vision of a central gasworks supplying many factories, street lamps and homes through gas mains in the public streets. Up to this time gas plants had been designed only for individual factories Winsor was responsible for the formation of the National Light and Heat Company and later the Gas Light and Coke Company. His work is well documented because his ideas were revolutionary and caused quite a stir at the time. However, he was not an engineer and got out of his depth when he tried to put his ideas into practice.

Clegg served an engineering apprenticeship at Boulton and Watt and later worked for Murdoch on some of his early gas experiments. He left Bolton and Watt to become an engineering contractor, developing and installing gas plants for lighting. He later joined Winsor at the Chartered Gas Light and Coke Company, where using his engineering expertise and knowledge of gas making turned the performance of the company around.

Unlike those of Murdoch and Winsor, Clegg's career in the gas industry goes well beyond the pioneering phase. Records of Clegg's work are between pioneering work and the development of the early gas industry. In general, Clegg's work is not reported as well or as fully as that of Murdoch and Winsor

This paper brings together records of Clegg's work throughout his career in the gas industry. It includes unpublished information from the work of the late E. G. Stewart, valuable details from the records of the (Chartered) Gas Light & Coke Company through the published work by Stirling Everard and the author's own researches at Dolphinholme and Stonyhurst College.

HIS EARLY LIFE AND CAREER 1781 to 1805

Samuel Clegg, one of the pioneers of the gas industry, was born in Manchester on the 2nd July 1781. He was the son of Wheatley Clegg, a wealthy Manchester business man.

Between 1794 and 1797 he was educated at New College, Manchester where he was undoubtedly inspired by John Dalton, Professor of Mathematics and Natural Philosophy. He took every advantage of the scientific education offered but never achieved similar standards in being able to express his thoughts and ideas in writing. Whilst at school his father died and his uncle, Ashworth Clegg took a close interest in Samuel's affairs.

On leaving school, Samuel began work in the counting house of Clegg and Rushouse, the business of his uncle. He did not settle in accountancy and longed for a scientific career. Efforts to dissuade him were unsuccessful and his uncle somewhat reluctantly allowed him to leave the company and follow a more mechanical and scientific career.

In 1798, he was engaged by the engine manufacture Boulton & Watt as an apprentice engineer at their Soho Foundry in Birmingham. Following the completion of what was a very creditable apprenticeship he became a highly skilled engineer and designer. He superintended the manufacture and erection of engine works of great ingenuity and difficulty. It was at Boulton & Watt where he met William Murdoch and was first introduced to gas. His first experience of gas came in 1802, when he assisted Murdoch with the illumination of the Soho Works to celebrate the Peace of Amiens. The illumination was mainly from oil lamps but there were two gas lights, one at each end of the works. The gas was produced by heating coal in retorts which were set in fireplaces. It was then conveyed in pipes which went up the chimneys and terminated in copper vases. When gas was produced in sufficient quantity it was ignited at the copper vases. These lights were known as Bengal lights.

It was probable that Clegg also assisted Murdoch with the early gas making experiments prior to the lighting of the Soho Foundry with gas in 1804. By this time Clegg had realised the potential of gas lighting and at the age of twenty-four left Boulton & Watt in 1805 to set up in direct competition with Murdoch as a manufacturer and installer of gas making apparatus.

ENGINEERING CONTRACTOR FOR PRIVATE GASWORKS 1805 to 1812

In 1805, Samuel Clegg established himself as an Engineering Contractor for Private Gasworks. His first installation was a prototype gas plant at his mother's house in Manchester and he used this to prepare working drawings. During 1805 he installed a gas making plant at the cotton mill of Henry Lodge at Sowerby Bridge, near Halifax. At the same time, his former colleague William Murdoch was installing a similar but much larger plant at the factory of Phillips and Lee in Salford. Clegg was aware of this and worked his men day and night to light `his' factory two weeks before the one in Salford was lit. In this he achieved, as he later claimed, the honour of lighting by gas the first mill in the kingdom.

Murdoch had suffered many problems through the late delivery of materials from Boulton & Watt and on the 23rd December 1805 wrote a letter to the Soho Foundry, which included:

> `If materials cannot be forwarded in a more expeditious manner than they hitherto have done it is of no use to think of taking orders here, for your old servant Clegg is manufacturing them in a more speedy manner than it appears can be done at Soho.'

This letter from Murdoch was the first recognition that Clegg was beginning to make an impact in the gas lighting business.

Lodge was so pleased with Clegg's work that in the following year he commissioned him to light his private mansion Willow Hall. Here Clegg first attempted to purify gas by adding lime to the water in which the gasometer floated.

In 1806, he erected a gas making plant at his own manufactory in Cupid's Alley, off Deansgate in Manchester. He installed a large Argand burner with a reflector behind it in order to experiment on gas lighting levels for use in factories. He also transferred gas from his gasometer (or more correctly, gas holder) to copper spheres for use at remote locations. This facility was no doubt used as a marketing aid to demonstrate the benefits of gas lighting.

In 1806, he provided and installed gas making plants for:

(i) Arthur Potter's cotton factory at Stormer Hill, Tottington, near Bury; (ii) Barton's dye house in Lower Ardwick, Manchester; (iii) Thornton's drawing academy at Bridge Street, Manchester and (iv) Gallymore's print works near Bury (believed to be Samuel Gallymore of Tottington).

Towards the end of 1806, Clegg was invited by the Borough Reeve of Manchester to convert to gas the oil lamp outside the Police Station on King Street. He used gas made on his own premises which was transported to King Street in a portable gasometer. He offered to light the whole of King Street for £ 140 but even though his gas light had been greatly admired, his offer was never accepted.

In 1807, he installed a gas making plant at the factory of T. & S. Knight at Longsight , near Manchester. This factory was visited by a Mr. Bage who wanted to see at first hand the effects of gas lighting. In a letter dated 5th March 1808 to Mr. Strutt of Millford Mills in Derbyshire, who himself was having gas installed by William Murdoch of Boulton & Watt, he wrote:

> `I am just returned from viewing some lights in a small factory near Manchester put up by Clegg. There are twenty-eight splendid lights equal each to ten or twelve of six in the pound; not nearly so offensive as candles or common oil; and what smell they have (in itself rather a pleasant one) might be diminished by ventilation, which seems very necessary where there is so much combustion. The expense according to the reports of Mr Knight the proprietor and Mr. Clegg the engineer is nearly as follows:-

Each retort holds 3 cwt. of coals, and 2.5 cwt. is burnt under it The gas supports the combustion of 28 lights for 4 hours. The expense of an apparatus for 100 lights including fixing, brickwork and tin reflectors amounts to £ 500, which at 10 per cent is ....**£ 50 per annum**

Repairs says Clegg would be estimated at £ 40 per annum as the chief source of expense is the burning of a saddle interposed between the fire and the retort, serving at once to preserve the retort and to equalise the heat, without which different gases would come over ....**£ 40 per annum**

Attendance, one man & assistant whilst charging and discharging, say................................. **£ 40 per annum**

Coals, 5 cwt. per hour for 100 lights. Suppose the season 400 hours, equal to 100 tons; of these one half are improved with coke and cost nothing, and half the remainder (they say the whole) is paid for by the tar Say 25 tons ....**£ 15 per annum**

Total Expense ....**£ 145 per annum**

In 1808, William Murdoch was awarded the Rumford Gold Medal by the Royal Society and Samuel Clegg was awarded the Isis Silver Medal by the Society of Arts. Ashworth Clegg conducted much of the correspondence and he described in detail the operation of Clegg's apparatus `for making carbonated hydrogen gas from pit coal and lighting factories therewith.' The equipment is shown in Figure 1 and the operation was described as follows:

`Reference to Mr. S. Clegg's improved Apparatus for extracting Carbonated Hydrogen Gas from Pit Coal. See Figure l, which is subdivided into Figs. 1, 2,3,4,5&6.

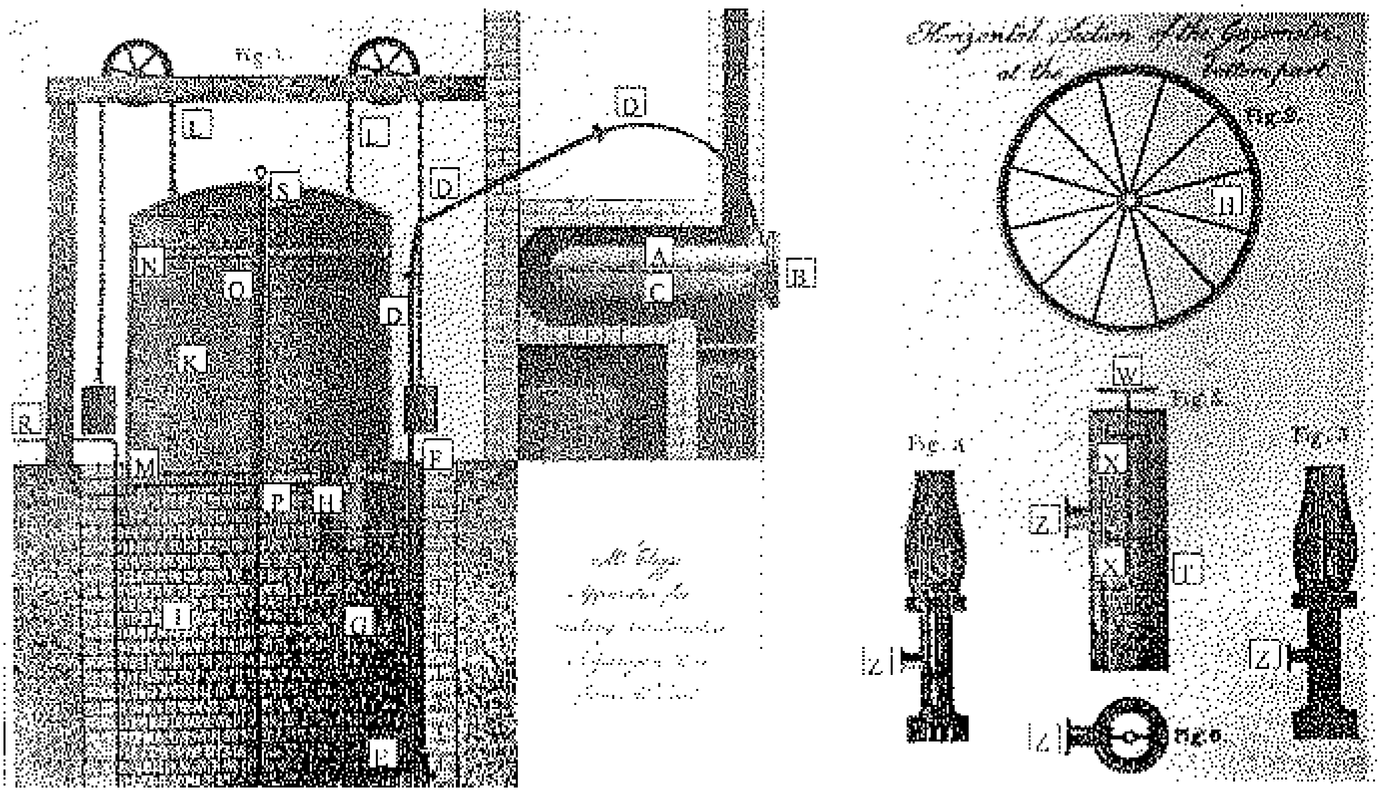


Figure 1 Mr Cleggs Apparatus for Making Carbonated Hydrogen Gas From Pit Coal

In Fig. l, A shows the cast iron retort, into which are put the coals intended to be decomposed by means of a fire underneath it, the heat of which surrounds every part of it, excepting the mouth or part by which the coals are introduced. The lid or iron plate B, which covers the mouth of the retort, is ground on airtight, and fastened by means of a screw in the centre. C is a shield or saddle of cast iron, to preserve the retort from being injured by the intensity of the fire underneath it, and to cause it to be heated more uniformly. DDD represents the cast-iron pipe which conveys all the volatile products of the coal to the refrigeratory of cast iron E, in which tar, &c., extracted from the coal is deposited, and from whence they can be pumped out by means of a copper pipe F. G is the pipe which conveys the gas to the cylindrical vessel or receiver H; this receiver is airtight at the top, and consequently the gas displaces the water in the vessel H, to a level with the small holes, where the gas is suffered to escape and rise through the water of the well I, into the large gazometer K. The use of the vessel H is pointed out as follows. viz: If the pipe G reached all through the water, without passing through the vessel H, the gas would not be rendered pure or washed; and if part of the pipe did not rise above the water, the water would have free communication with the tar, besides exposing the retort A to a very great pressure, so as to endanger its bursting when red hot. This vessel or receiver H, in a large apparatus, is about eighteen inches diameter and two feet long; the quantity of gas, therefore, which it contains, is sufficient to fill the pipes and retort when cold, and prevents the pipe G from acting as a syphon, and exposes the gas to water without endangering the retort.

When the operation begins, the upper part of the cylindrical gazometer K, Fig. l, made of wrought iron pipes, is sunk down nearly to a level with the top of the circular well I, and is consequently nearly filled with water, but it rises gradually as the gas enters it and displaces the water the two lengths LL suspended over pulleys by chains keep it steady and prevent its turning round, otherwise the lower stays M of the gazometer would come into contact with the vessel H. There are two sets of these stays, one shown at M, and the other at N.

There is also an iron pipe O made fast in the centre of the gazometer, by means of the stays, which slide over the upright pipe P, by which contrivance the gazometer is kept firm and steady, when out of the well: it likewise prevents the gas from getting into the cast-iron pipe P, and the copper pipe R, anywhere but through small holes made in the pipe O at S at the top of the gazometer, where the gas is perfectly transparent and fit for use.

The pure gas enters the tube O at the small holes made in its top at S, and passes on through the tubes P and R to the lamps, where it is consumed and burnt.

The seams of the gazometer are luted to make them airtight, and the whole is well painted inside and out, to preserve it from rust.

Fig. 2 shows a horizontal section of the lower hoop of the gazometer K at the part M, with its stays or arms, and the manner in which the iron pipe C, before described as Fig. l, sliding on the tube P, passes through the ring in the centre of the hoop; a horizontal section of the receiver H appears therein.

Fig. 5 shows a section of one of the gas lamps; the space between the outer tube T and the inner tube V is to be filled with gas supplied by the pipe R, shown in Fig. l, where a stopcock is inserted for adjusting the flame, which gas passes through a number of small holes made in the outer edge of the circular plate shown at Fig. 6, which unites the tubes T and V at their tops. V is the inner tube which conveys the atmospheric air into the centre of the flame; the upper part of this tube is made conical, or widening outwards, to join a circular plate with holes in it, a horizontal view of which is shown at Fig. 6. W is a button, which can be placed at a small distance above the mouth of the lamp, and its use is to convey, in an expanded manner, all the air which rises through this tube to the inner surface of the flame, which assists the combustion very much; this button may be set at any convenient distance above the tubes of the lamp, as it slides in the cross bars XX, by which it is suspended in the inner tube.

A current of air also passes between the glass tube or chimney and the outer tube T, through holes made in the bottom of the glass-holder, as in Argand's lamp; this surrounds the flame, and completes its combustion, as explained by the view Fig. 3 and section, Fig. 4, which have a glass upon each. ZZZZ, Figs. 3, 4, 5 and 6, show the tube through which the lamp is supplied with gas from the pipe R, Fig. l.

Some interesting information on the output and cost of this apparatus were contained in the following extract from a short letter written by Samuel Clegg himself and dated l8th May 1808.

> `A gasometer, containing seven hundred cubical feet of gas, weighs about twenty hundredweight, and costs about two pounds ten shillings the hundredweight.
>
> The whole of an apparatus complete, capable of supporting forty lamps for four hours, each lamp affording light equal to ten candles of eight in the pound, will cost about two hundred and fifty pounds. Each lamp consumes six cubical feet of gas per hour.'

In 1808, Clegg moved into larger premises at 8 Major Street, Manchester, comprising a house, foundry and gas plant works. From here he completely fabricated at least six gas plants, work which included the making of iron castings, pipes, valves and the preparation of wrought iron.

The first of these was erected later that year in a large manufactory belonging to Mr. Harris at Coventry. In previous installations the manufactured gas had retained almost all its impurities but it had become evident that unless it was purified then it could not be burned in closed rooms, the offensive smell caused headaches and in some cases affected the lungs. At Coventry, Clegg had introduced a separate condenser and attempted to purify the gas by adding slaked lime to the water of the gasometer tank. The lime was kept in suspension by an agitating paddle at the bottom of the tank. It is recorded that partial purification was achieved by this process but the difficulty of removing the spent lime from the gasometer tank proved to be a major obstacle to its further adoption.

The next two plants were constructed simultaneously in 1810 and commissioned in 1811. These were at the Dolphinholme Worsted Mill, near Lancaster and at Stonyhurst College, near Clitheroe. The gas plant at Dolphinholme was commissioned just ahead of that at Stonyhurst College, in February 1811. Although there is no detailed record of the equipment installed at Dolphinholme, a ground plan of the site is available and a copy of a part of this is shown in Figure 2. From this drawing and a knowledge of Clegg's technical achievements, a reasonable estimate of the gas equipment can be made.

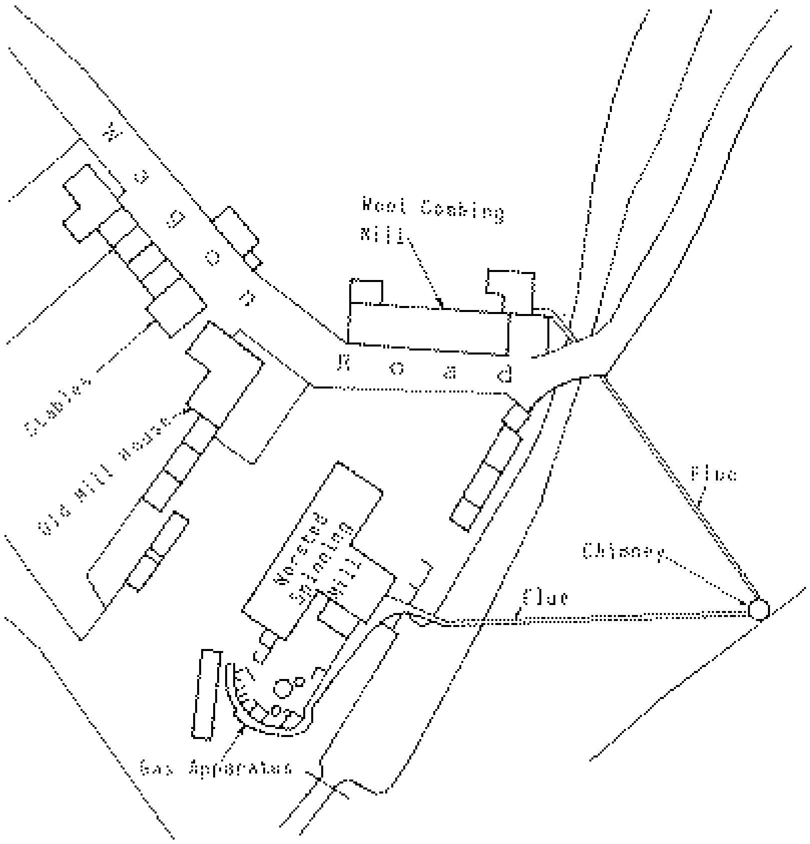


Figure 2 - Location of the Gas Plant at The Dolphinholme Worsted Mill

From the size of the mill it is estimated that at least two cast iron retorts were used. It is probable that the coal used in the retorts was cannel coal from Wigan. The superior gas making qualities of this coal were well known even in 181 l. It is not known whether the coke produced by carbonisation was used to heat the retort setting. In similar early installations it was usual to use common coal to fire the retorts and either sell the coke or use it elsewhere in the factory.

In Figure 3 it can be seen that there were four circular structures. The largest of these scaled 13ft 6ins and was either the gasometer or its tank. If the effective height of the gasometer was nine or ten feet then its capacity would be of the order of 1000 cubic feet. This would compare with the Stonyhurst plant where the gasometer's capacity is known to have been just that size. It can be readily assumed that the gasometer had one or two counterbalance weights as this was the standard practice at that time.

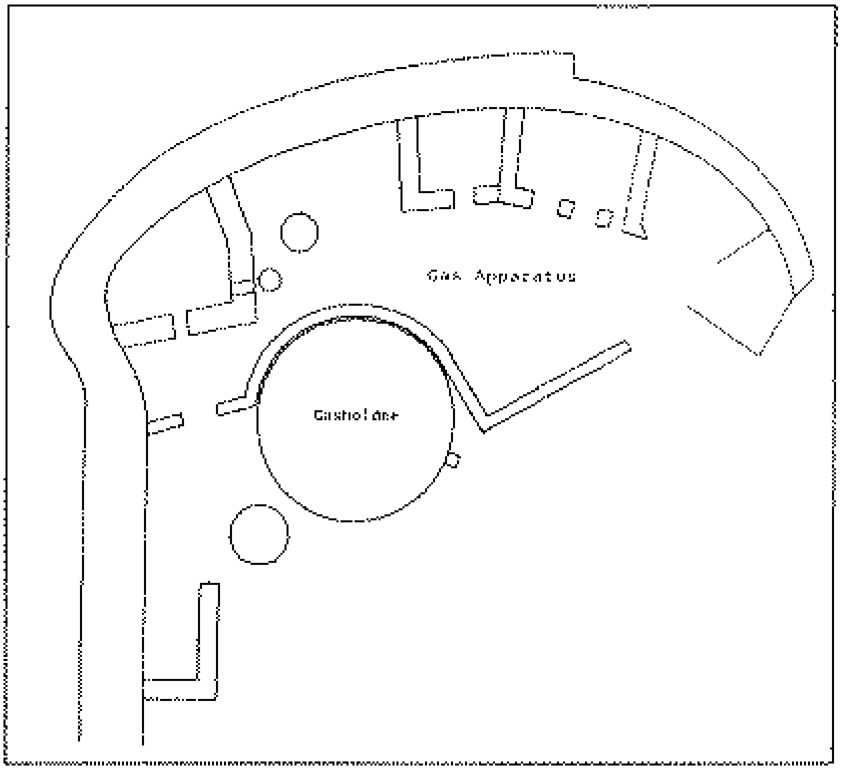


Figure 3 - Plan of the Gas Plant at the Dolphinholme Worsted Mill

The other three circular structures scaled 4ft., 2ft 6ins. and lft 6ins in diameter. The two smaller ones, by virtue of their position between the retorts and the gasometer, were probably condensers where a mixture of tar and ammoniacal liquor were removed and collected. It is believed that the 4ft. structure was a lime machine used for purification, as it is exactly the same size as the purifier installed at Stonyhurst. However, as Clegg credited Stonyhurst with having the first separate lime machine, the one at Dolphinholme was probably installed just afterwards. This could account for its location to the other gas making equipment.

The limestone chimney on the adjacent hillside was also a part of the gas plant. In 1841, Clegg's son, Samuel Clegg Jun. published his book `A Practical Treatise on the Manufacture and Distribution of Coal Gas'. In describing retort house chimneys, he records:

> `At Dolphinholme, in Lancashire, where a large worsted mill was lighted with gas, it was requisite to remove the chimney to some distance, the dwelling house of the owner being close by For this purpose the flue was carried along a field, rising about 1 in 20, for a quarter of a mile, and on the summit of this rise the chimney was erected, in the form of an obelisk.'

The chimney is in fact two chimneys, one built against the other. One flue was laid from the steam boiler at the wool combing mill, the other from Clegg's retort house. The remains of the main chimney are approximately twenty feet high. It has an internal diameter of 2ft 6ins at its base and tapers smaller towards the top. Its walls are some 2 ft. thick. The secondary chimney is some 4 ft. taller and has an average internal diameter of 3 feet at its base and tapers larger towards the top. The chimneys are generally in a poor state of repair.

The gas pipes and lights in the worsted spinning mill are shown in the part sectional drawing Figure 4. In the part of the mill which has been sectioned there appears to be 34 lighting points, each with 2 lamps. This would indicate 78 lights on a single cross section of the mill. Unfortunately, there is no indication to whether this configuration was repeated in the mill or whether there were any lights in other parts of the mill.

The Retort House Chimney at Dolphinholme

The drawing does, however, give a clear indication of the method adopted by Clegg to light the mill. The pipes were installed at ceiling level and each lighting point was supplied vertically downwards. This was then `teed' in the shape of an arc to support two lights. This arrangement was repeated throughout all four storeys of the worsted mill.

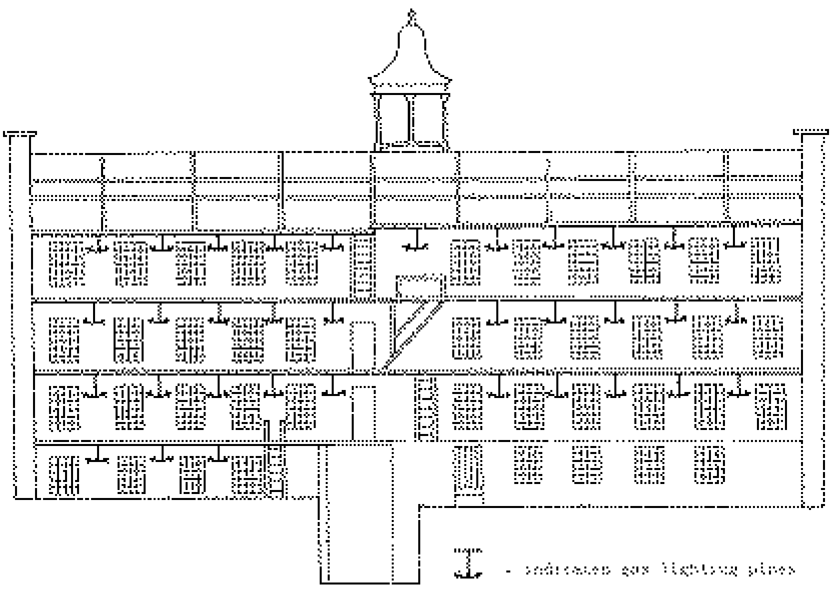


Figure 4 - Part Sectional Elevation of the Dolphinholme Worsted Mill

It is known that Clegg also lit the nearby wool combing mill for it is recorded on the ground plan that this mill was `heated by steam and lighted by gas'.

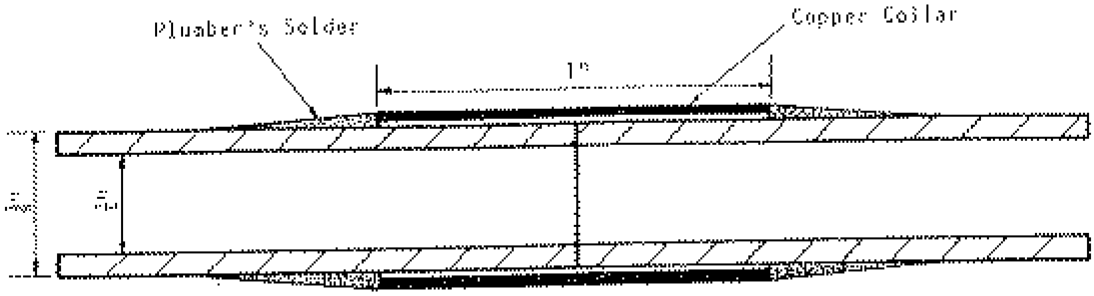
Old Mill House, the home of the proprietor Mr. Hinde, also had a gas supply installed by Clegg. It was the fashion of the day for the mill owner to extend the gas supply into his own home, especially where he lived nearby. In 1985, whilst property alterations were being carried out, a length of old copper pipe was discovered inside an old dividing wall of the house. The pipe had an external diameter of 3/8 in. and a bore of l/4in The pipes were two feet in length and had longitudinally brazed seams. They were joined by butting together and covering with a larger copper collar. Plumbers solder was then added and wiped around to form a seal between the pipe and the collar. It is possible that these pipes were very similar to those tinned copper pipes used by William Murdoch in lighting his house in Redruth in 1792.

Two brass fittings, an elbow and an equal tee were also found to have been used. The `thick-walled' copper pipes were threaded externally and screwed onto these fittings. Details of the copper pipe and brass fittings are shown in Figures 5, 6 and 7.

The man instrumental in bringing gas to Stonyhurst College was the head of the Roman Catholic Mission in Preston, the Reverend Joseph Dunn, affectionately known as Daddy Dunn. Dunn had a practical scientific interest and actively pursued undertakings of public utility to further the welfare of his parishioners.

The association between Stonyhurst and gas lighting goes back to 1808, when the College in the name of its procurator, the Reverend Charles Wright acquired five shares in Winsor's National Light and Heat Company in London. It is also interesting to note that Winsor's name appears on a list of potential subscribers to an appeal to extend the College in 1808. Samuel Clegg had advised Winsor on purification matters and it is believed that it was through these various connections that the Reverend Dunn first met Clegg and introduced him to Stonyhurst College.

A document still held by the College shows that Samuel Clegg was authorised to vote in respect of the shares held by the Reverend Charles Wright 'The document also bears the signature of Clegg, a copy of which has been included under his portrait at the beginning of this paper.



Scale: Twice Full Size

Figure 5 - Section of Copper Pipe Joint

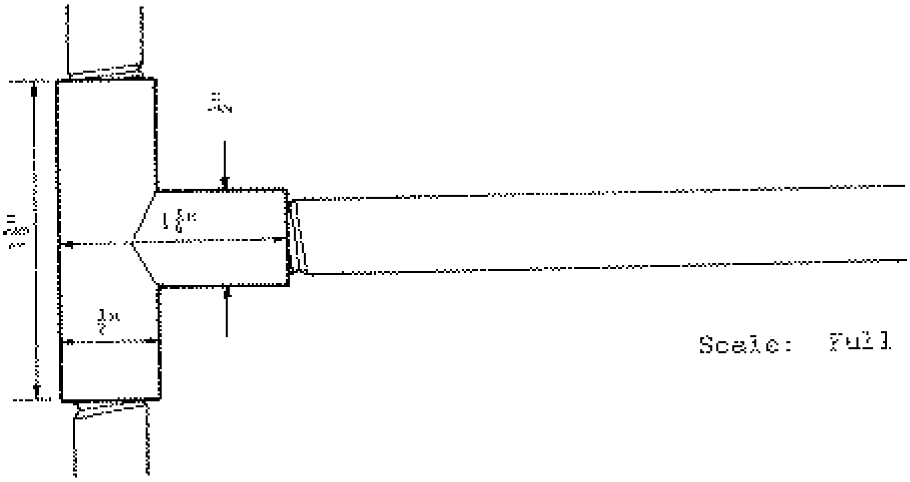


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Figure 6 - Detail of Brass Tee

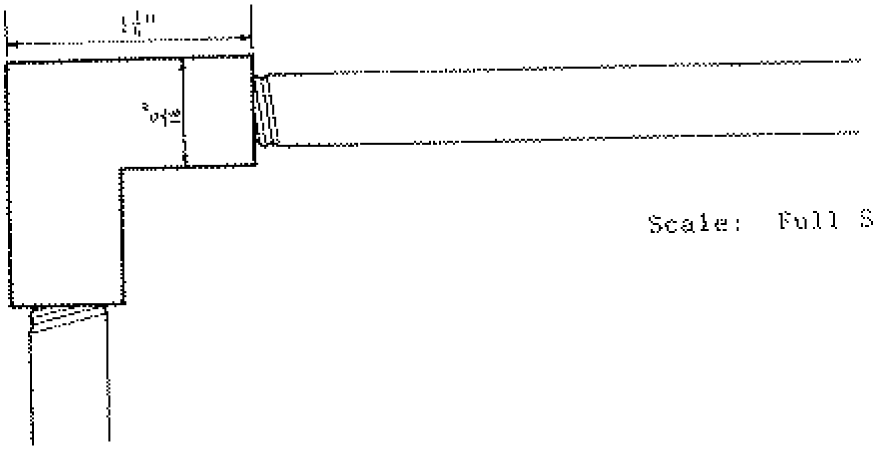

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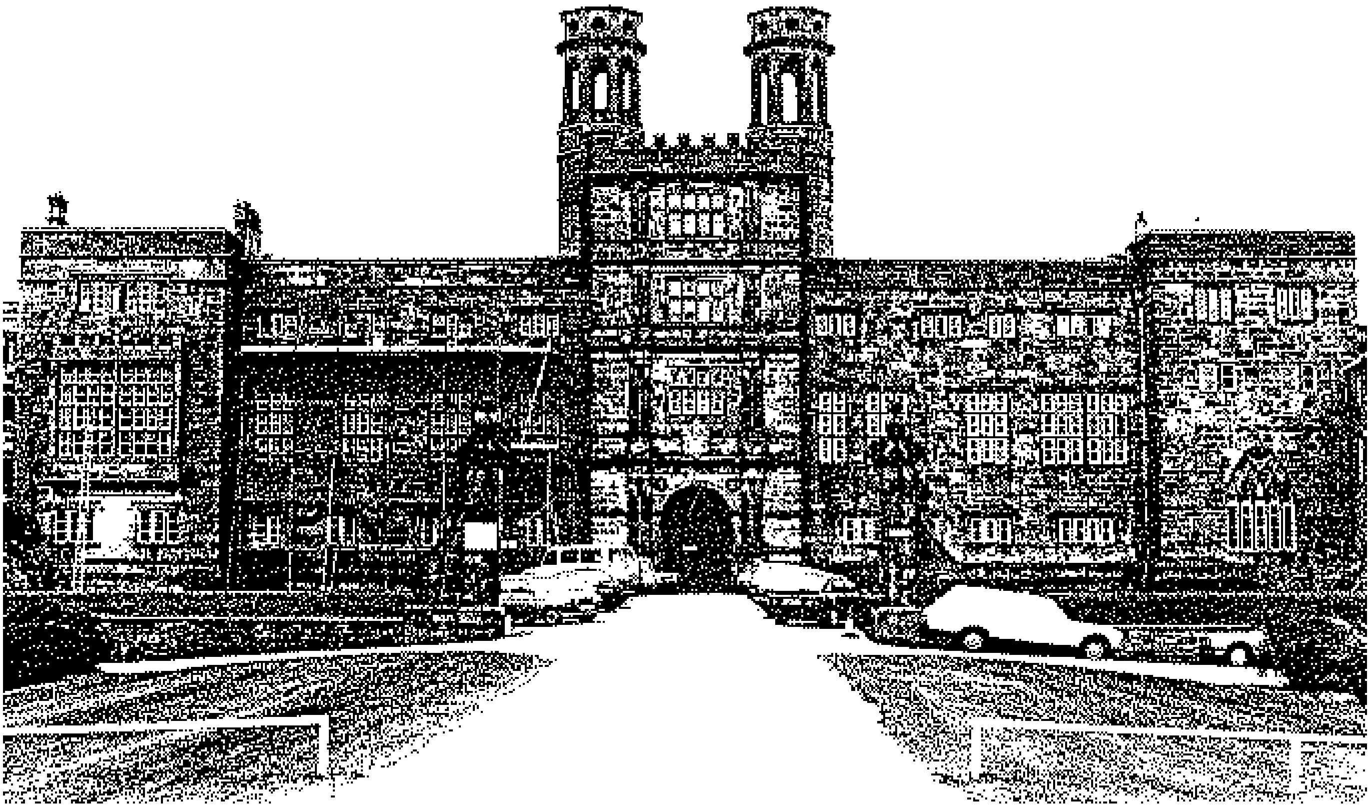
Figure 7 - Detail of Brass Elbow



Stonyhurst College - The West Front In 1986

Prior to the installation of gas at the College, the problems of purification were well known. This was borne out in a letter dated 2nd December 1809 from Father Nicholas Sewall to the Reverend Dunn. At this time Dunn was interested in installing a coal-fired central heating system and lighting the College by gas. Father Sewall writes (Figure 8):

> `Should we adopt the steam, how can you contrive the conductors so as not to be an eyesore; in the factories they pass through the middle of the rooms; that would not look well in our refectory, study place, etc. The gas tubes may be conducted about without being seen and if they are cleansed from all bad smell, as I suppose they may, we shall adopt them.'

Clegg was well aware that gas could not be safely used to light private rooms unless it was completely free from hydrogen sulphide and that the method he had adopted at Coventry did not completely solve his problems. He used the scientific facilities at the College and after some further experimentation he devised a separate lime machine which utilised lime water, where the spent lime water could easily be removed. The lime machine is shown in Figure 9. Clegg later claimed that this machine was the first ever employed for the purification of gas, a machine which was universally adopted and which rendered the introduction of gas practicable in any situation.

There was much conjecture as to who had first thought of using lime to purify coal gas. Murdoch, Clegg, Winsor (with his assistants) and Dr. William Henry (an eminent Manchester chemist) all seem to have some claim. However, it was Samuel Clegg who was the first to devise and construct a lime purifier that worked.

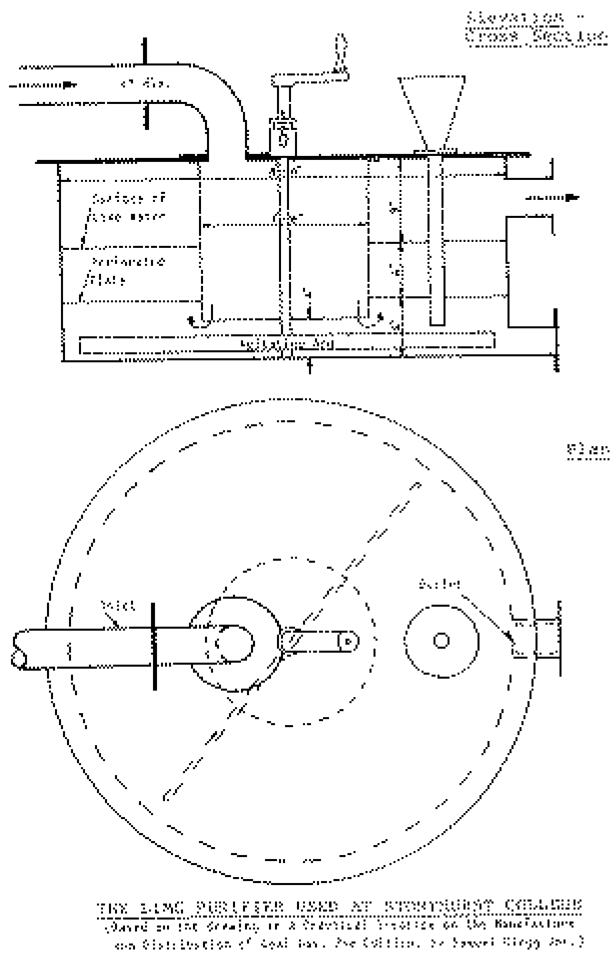


Figure 9 - The Lime Purifier used at Stonyhurst College

(Based on the drawing in A Practical Treatise on the Manufacture and Distribution of Coal Gas. 2nd Edition, by Samuel Clegg Jun.)

A contract for lighting the College was signed on the l7th March 1810. A part of this contract was transcribed by Father Charles Wright who at this time was the College Bursar.

Later that year on the 22nd November, Father Joseph Laurenson, Professor of Mathematics at Stonyhurst gives a progress report in a letter to the Reverend Dunn. Father Laurenson writes:

> `Clegg was here on Sunday last, and is gone to Lancaster to light up a great mill he has been engaged with for some time past; from thence he returns to Stonyhurst and proposes staying some time; indeed, he promises to have the lower Gallery and Refectory lighted up by Sunday week. I am surprised to find you a professed amateur of the Gas just going away, as it were on purpose not to see the first essay, your reputation will be ruined. I sent you back your letters. I have had Clegg to inspect my room where to fix my Gas-lamp. He brings his head man from Lancaster today or tomorrow. I think you will not find him at Manchester, and I would not come to see you there and miss the first lighting up of our House upon any consideration, especially as I know that no personal consideration could induce you to wish me to be absent when a business in which you and I are so much concerned is taking place.'

In fact the College was not lighted until l8th February 1811. A plan of the College dated `around 1810' showing the position of the gas plant is available at Stonyhurst, a copy of which is illustrated in Figure 12.

The gas holder had an approximate capacity of 1000 cubic feet, although this was somewhat smaller than the 1200 mentioned in the contract. Samuel Clegg, Jun. later records:

> `After Stonyhurst had been lighted (where the capacity of the gas holder was 1000 cubic feet), Mr. Wright the Superior of the College, complimented Mr. Clegg upon his success in lighting the establishment with gas, but suggested as an improvement the alteration of the size of the gas holder; he thought one of 1000 cubic feet was unwieldy, and advised that two should be erected to contain 500 feet each.'

It is not known why Clegg erected a circular gas holder at Dolphinholme and a rectangular one at Stonyhurst.

From detailed entries in the Stonyhurst ledger, it can be confirmed that Clegg was paid £480 for the gas installation. The payment was made in five instalments:

31 st October 1810 - £100
20th February 1811 - £150
23rd March 1811 - £50
5th June 1811 - £80
and l0th November 1811 - £100

A comparison of costs was made between the cost of gas lighting and the cost of lighting by candles, which also had been made at the College. The document is undated and estimates the final cost of the gas installation at £ 500 and is shown in Figure 13. The comparison shows that the cost of lighting the College with candles was six times that of lighting by gas.

On the evening of the l8th February 1811, Stonyhurst College became the first public institution to be lit by gas. Clegg also compressed gas into copper globes at Stonyhurst which were used to supply portable lights. It is possible that these may have been the ones used for demonstrations of gas lighting at the Preston Literary and Philosophical Society, out of which the Preston Gas Light Company was later formed.

Also in 1811, Clegg lighted a large cotton mill in Manchester belonging to Mr. Greenway, where four retorts were installed. The usual practice of isolating each retort with a valve was considered too expensive and as the retorts had to be repeatedly charged whilst hot, it was potentially dangerous. To obviate these problems he invented and installed the hydraulic main. The hydraulic main was used to convey gas from the retorts to the condenser and was so called because it was partly filled with running water.

The off take from each retort was individually connected to the hydraulic main and the gas was passed into it through a dip-pipe below the level of the running water. This automatically provided a seal to prevent gas from blowing back when the retort door was opened. The hydraulic main, although simple in design, proved to be one of Samuel Clegg's most important inventions. It was universally adopted on all subsequent horizontal and vertical retort designs.

In 1812, he lighted the extensive cotton mills belonging to Samuel Ashton and Brothers at Hyde. Here he first introduced his improved cylindrical retorts. These were twelve inches in diameter and six feet in length. The mouthpieces and door were ground to an airtight fit to obviate the need for clay luting. The hydraulic main was again used and an improved lime machine was introduced. Clegg also attached a mechanism to the gasometer to regulate the specific gravity of the gas.

Later that year he lit the house, shops and workrooms of the lithographer Mr. Ackerman of the Strand in London, see Figure 14. Here he had problems in discharging the spent lime water into the public drains. As an alternative, he used a separate machine in which lime in the form of curds was laid on a porous plate, by itself and sometimes mixed with potash. This was Clegg's first installation in London and the lighting was widely acknowledged and heralded as a great success.

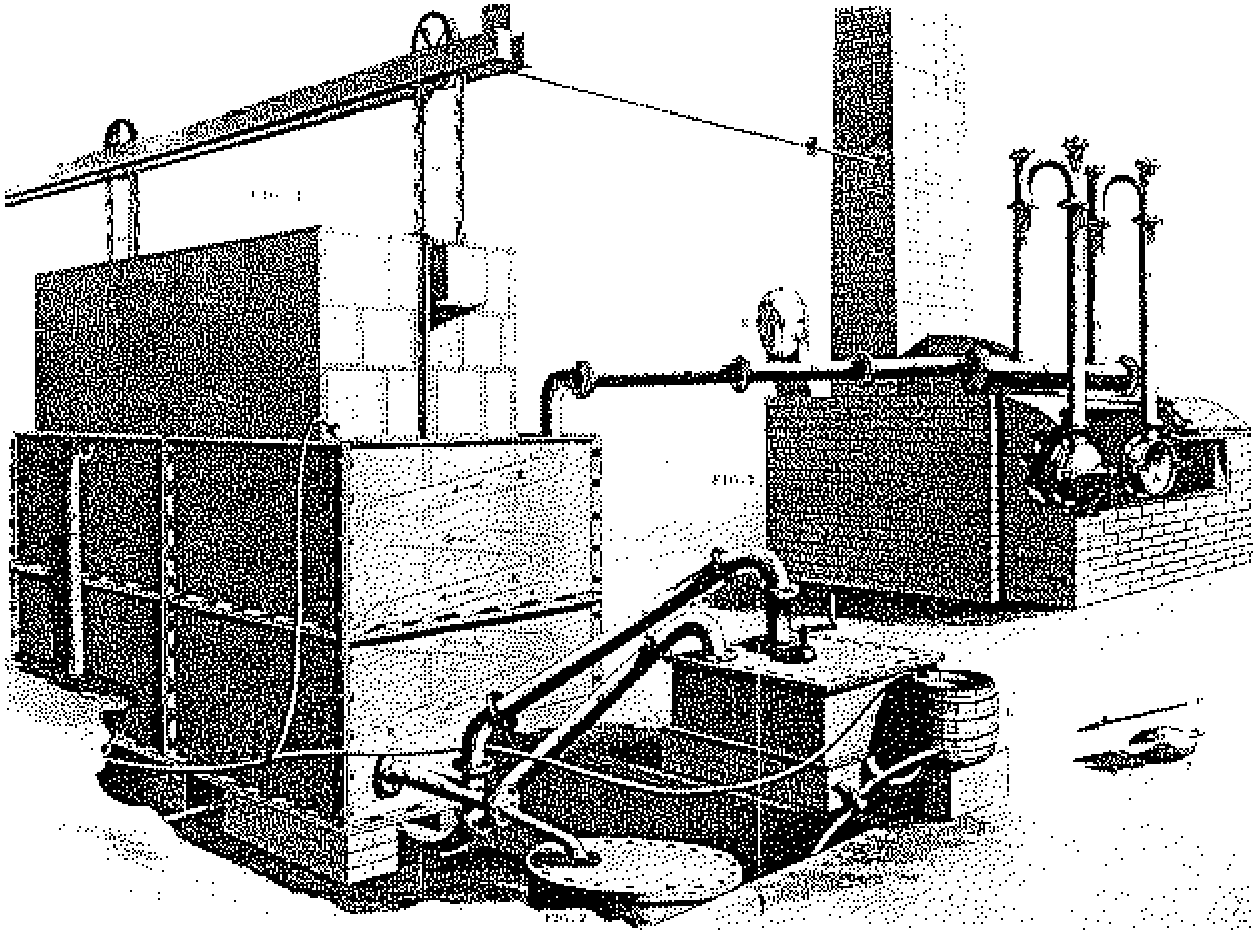


Fig 14- Gas making Plant similar to that erected by Clegg at
Ackerman's in the Strand 1812

After this installation in the capital, Clegg was invited to join the Chartered Gas Light and Coke Company as an Engineer. This company had to light the cities of London and Westminster from a central gas works. Accepting this invitation, Clegg closed his business at Manchester and took many of his skilled workers with him to the capital.

ENGINEER TO THE CHARTERED GAS LIGHT & COKE COMPANY 1813 to 1817

At the beginning of January 1813, Samuel Clegg took up the appointment of Engineer with the Chartered Gas Light & Coke Company at a salary of £ 500. He was to assist with the development and construction of a suitable gas making plant to serve the cities of London and Westminster.

The Chartered Company had been founded by Frederick Albert Winsor, a German who had lit a section of Pall Mall in 1807. He had the vision for a central gas works to serve many customers, with the gas being distributed through pipes in the street to individual factories, street lamps and homes.

In 1807, Winsor had succeeded in attracting a number of influential people to form a National Light and Heat Company. However, the wildly exaggerated claims made by Winsor resulted in political wrangling and much delay. The Bill as originally presented to Parliament was considerably altered and powers to supply gas were restricted to London, Westminster, Southwark and adjacent suburbs. Eventually, an Act of Parliament was passed and the Gas Light and Coke Company was awarded its charter on the 30th April, 1812.

When Clegg joined the Company, Winsor and two of the directors, James Hargreaves and Frederick Accum had been labouring unsuccessfully at Crown Wharf, Cannon Row to produce a working gas making plant. Winsor's experience was limited to small experimental plants and Accum, being a chemist had only theoretical knowledge. Hargreaves was a doctor of medicine with a mechanical bent but who had no engineering experience.

A new site was found for Clegg at Great Peter Street and here he designed and built the first public gas works. He also laid the street mains and provided street lamps to Westminster Bridge by December 1813.

At the Great Peter Street works the purifier was housed in a building next to the retort house. Gas escaping from the purifier came into contact with the retort flues, resulting in an explosion which injured Clegg and shattered several windows in the neighbourhood. A reoccurrence was prevented by drawing off the waste lime water through a water seal. However, the fear of another explosion made the public very apprehensive for some time.

The lamplighters were also wary of this new light and refused to light the new lamps, for they were frightened of being blown up. So for the first few nights, Clegg carried a ladder and did the job himself. By the 1 st April, 1814 the whole of the parish of St. Margaret's in Westminster had been lit, this being just 15 months from the date of Clegg' s appointment.
Also in 1813, Accum had taken on the design and construction of the Company's second works at Norton Fulgate where a contract to light the streets had been accepted. The contract was to run from November but by that date the works were far from complete. Clegg's duties were extended in order for the deficiencies here to be remedied and the works finished as speedily as possible. He went on to become the Company's Chief Engineer. He also built the Company's third works at Brick Lane.

It was during 1813 that Clegg met and married his wife Ursula. Ursula, who was from Newcastle and seven years older than Samuel, was the daughter of the Chartered Company's coal factor. There were two children by this union, a son Samuel junior born in 1814 and a daughter Margaret born in 1817. Both were born at the family's home in Lambeth.

In December 1815 he was granted patent No. 3968 for his improved gas apparatus. This included his rotary retort, a semi-fluid lime machine for purification (or cream of lime purifier), a rotative gas meter and a governor. These were described as follows:

> `This invention relates, firstly, (see Figure 15) to a flat horizontal retort, in which coal or other materials capable of producing inflammable gas are heated and the gas extracted by distillation. The fire by which this retort is to be heated is to be applied so as to heat certain parts of its capacity much more than others, so that some parts will thereby be heated to that degree which is proper for the complete extracting of the gas, whilst other parts of the capacity of the retort will be very slightly heated; and in some of those latter parts the door or opening through the materials are to be introduced into the retort is to be situated. Within the retort a surface is to be provided, upon which the coal or other substance to be distilled can be spread in a thin layer, in a horizontal position or nearly so; and the said surface must be capable of a motion within the retort for the purpose of removing the coals or other materials from the cooler part of the retort, at which they are introduced into the same, to the hottest part of the retort, where the gas will be extracted by the action of the fire. In this manner the coal will be heated slightly, and dried previously to being subjected to the red or greatest heat, and, from being spread thin, will require a less proportion of fuel to heat it, and the gas will be obtained in less time than by means of the retorts now commonly used in gas apparatus. Also, the coke which remains upon the moveable surface, after the gas shall have been extracted from the materials, may be removed from the hottest part of the retort to the cooler part near the entry door, at which it is to be withdrawn and replaced

with fresh materials. Retorts upon this principle may be constructed of various forms, either circular or otherwise, with the bottom horizontal or nearly so, and the motion of the surface upon which the materials are spread may be circular, upon a centre, or otherwise.

Secondly, (see Figure` 16) relates to a mode of `purifying gas' and consists of a large closed vessel formed 'like a hopper' closed on all sides to receive the gas after it has been partially purified; within this is a smaller vessel or lime trough open at the

top to contain lime and water; and there is also a third vessel or inverted trough into which the gas is received immediately from the retort. This inverted trough is open at the bottom, and the edge of the open part is immersed beneath the surface of the lime and water which is contained in the lime trough, so that the gas which is introduced into the last mentioned inverted trough cannot escape therefrom except for rising up through the lime and water; to facilitate this, holes or openings are made through the sides of the inverted trough near the bottom edge thereof, which holes or openings are beneath the surface of the lime and water contained in the lime trough, so that the bubbles of gas are obliged to rise up through the same and thereby become purified. This is the nature of the common purifying vessels in which the said holes or openings become frequently stopped by the lime unless water is mixed with it in sufficient quantity to render the lime completely fluid. This improved purifying apparatus also has a shaft or axis furnished with teeth or projecting claws, and so applied within the interior inverted gas vessel that it can be put in motion from outside the apparatus, and that its teeth, when in motion, would pass through and scrape out the said openings every time the axis is moved round. The lime trough is also movable on a centre or axis, in such manner as to be able to invert or incline it by a motion from the outside for the purpose of discharging the lime which it contains into the bottom of the external vessel from which it can be drawn out at pleasure. With this purifying machine it is able to employ lime water of semi-fluid consistence, Like thick cream, in which state it is contained in so much less bulk, after it has become impregnated with fetid impurities which it absorbs from the gas, it can be carried off from a manufactory without the difficulties which occur in getting rid of disagreeable lime water when it is quite fluid, as in the common apparatus.

Thirdly, (see Figure 17) relates to a gauge or rotative gas meter for measuring out and registering the quantity of gas which passes through a pipe or opening so as to ascertain the quantity consumed by any certain number of lights or burners. This gauge consists of a hollow wheel or drum capable of revolving vertically upon pivots in the manner of a water wheel. The hollow rim of the wheel is made close on all sides to form a circular channel, which is divided by partitions into certain compartments or chambers to contain the gas which is introduced into the wheel through one end of its axis, and carried off from the wheel through the other end. By certain contrivances it is so arranged that each of these boxes or chambers will be filled with gas from the entrance pipe and emptied of the same into the exit pipe ever time the wheel makes a revolution, by which means the number of turns the wheel makes when registered by suitable wheel work, become a record of the quantity or number of boxes full of gas which has passed through the gauge. The gas is conducted from the place whence it is supplied, and enters into the gauge through one end of its axis, and is conveyed into the chambers of the rim by certain hollow arms. The gas returns from the said chambers by certain other hollow arms, and is conveyed away through the opposite end of the axis of the wheel by the pipe which leads to the burners or place where the gas is consumed. No gas can pass from the pipe of entrance at one end of the axis and get to the pipe of exit at the other end of the axis without entering into and filling the said chambers. A sufficient quantity of water is put into the hollow rim of the wheel to fill a segment of the rim rather larger in its capacity than one of the compartments into which it is divided, and there are passages of communication between the chambers through which this water can pass from one chamber to the next, but the gas cannot pass. It is evident that the water, from its gravity, will always fill a segment in the lowest part of the wheel, and when the same turns round the water will occupy each of the chambers in succession as they arrive and during the time each one continues at the lowest part of the wheel. The pipes hollow arms which convey the gas to the chambers are so contrived, that when the entrance pipe to any one chamber is open to admit the gas, the exit pipe from the same chamber will be shut or sealed up, and vice versa, and this opening and shutting of the passages into and out of any one chamber takes place at that period of the revolution of the wheel when the water in the lower part thereof is on the point of entering into or going out from the said chambers, that is to say, when the water at the lower part of the wheel is on the point of quitting any chamber, the pipe of entry shall be open to admit gas into the said chambers, which gas expels the water from it through the passage of communication into the adjacent chamber until the first mentioned chamber becomes filled with gas, and the second mentioned chamber becomes filled with water; at the same time the pipe of exit from the second mentioned chamber is opened, and the water which enters from the first mentioned chamber displaces the gas, and it passes off through the exit pipe. The machinery for counting and registering the number of revolutions made by the wheel may be constructed in any of the ways usually employed for similar purposes. It is not essential to this gauge that the exit pipe from the chambers be conveyed through the axis, the same effects may be obtained by enclosing the whole wheel within a close vessel or case in which it can revolve freely, and allowing the gas to escape into the case from the chambers; when the same are to be discharged from this case, the gas can be carried off by the exit pipe. The means of opening or shutting the passages of communication may be varied; it may be done either by valves or by sealing the pipes with water or other fluid.

Fourthly, (see Figure 18) relates to a self acting governor for regulating the efflux or discharge of gas through any opening or openings or burners at which the gas is to be burned, so that the gas shall always issue from the said openings or burners with an uniform velocity, or nearly so, notwithstanding any variations which may take place in the pressure which urges the gas to pass through the pipes of supply. The pipe through which the gas passes to the burners must have in some part of it an aperture which is capable of being increased or diminished in its opening by a very slight force; and motion for diminishing or increasing the aperture is given by a small gasometer or inverted vessel, the mouth of which is immersed under water and its interior capacity communicates with the pipe of supply beyond where the aperture for regulation is placed. The gasometer must be sufficiently loaded to retain the gas within it at such a degree of compressure as will cause the gas to issue from the openings or burners with that degree of velocity which is necessary to support a required flame height. Now if the pressure of the gas in the pipe of supply is increased, it causes the gasometer to rise up more out of the water, and this motion is made to water, or it may be made to rise and fall with a circular motion upon a centre; in either case it should give motion to a lever, and this lever should effect the regulation of the opening by a communication from a part nearer to the centre of its motion, in order to render the motion for the regulation very small. To make the aperture through which the gas is to pass capable of delicate adjustment, the said aperture is made in a vertical plane, or approaching thereto, in order that the lower side margin or boundary of such aperture may be formed by the horizontal surface of mercury, tar, water, or other fluid, which is contained in a cup or basin suspended from the lever of the gasometer near the centre thereof, in this way when the assent of the gasometer causes the cup to rise up, the surface of the fluid rises with it and diminishes the height of the aperture through which the gas passes, so as to contract the area thereof; and on the contrary, by lowering down the cup, the aperture for the passage of the gas will be increased.

The rotary retort was used on several gas works that Clegg designed. Clegg's main reason for developing the rotary retort was to conserve fuel during the gas making process. This he undoubtedly achieved. It was the first time that a retort had been designed with fuel efficiency being the prime objective. Its use was discontinued probably because its design was too intricate for use in a hot environment. This would have resulted in high levels of maintenance.

The semi-fluid lime machine was a further development in the use of lime for the purification of gas. Clegg's gas meter set the standard for future station meters and his gas governor the standard for pressure control.

At the Chartered Company, Clegg trained and developed a number of gas engineers, who in turn influenced advances in the gas making process. John Malam (1791 - 1855), who like Clegg had been a pupil of Boulton & Watt, was appointed as foreman at the Great Peter Street works in 1814. Malam's achievements will best be remembered for his improvements to the gas meter but his other patents included an atmospheric condenser, clay moulded retorts, a purification machine, a method of dehydrating the gas and a purifier valve of `exceptional' tightness.

John Grafton (1796 -1872) was a pupil of Clegg at the Chartered Company from 1813 to 1817. From 1815 he was working as a `consultant' or was `on loan' to the Preston Gas Light Company, probably on Clegg's behalf. On completion of his articles he left the Chartered Company to take charge at Wolverhampton. He later moved to Cambridge in 1835. His inventions , patents and improvements included a hand lamp for lamplighters, retorts with clay linings, mixing lime with alkali in dry form for use in purifiers, fire clay retorts constructed in sections, a retort stoking machine and a triple bell exhauster.

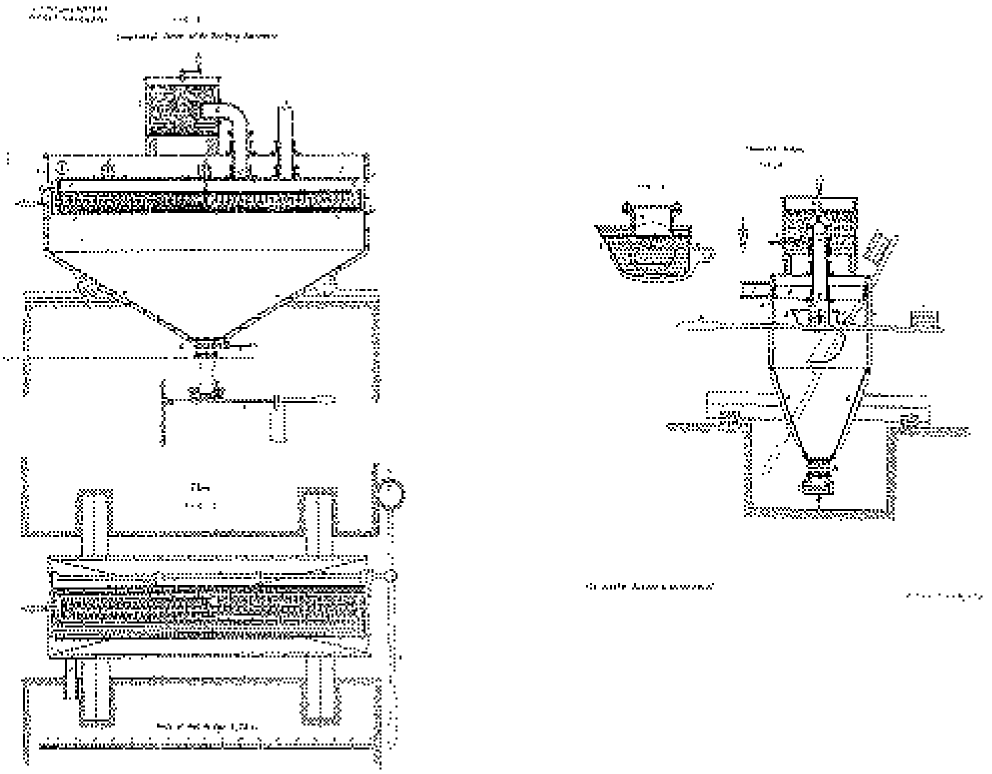
George Holworthy Palmer (1791 - 1868) was again a pupil of Clegg at the Chartered Company from 1813 to 1817. On completion of his articles he left to become Superintendent of the Royal Mint gas works, which was built by Clegg and Accum. His career after the Royal Mint was far from distinguished but some of his inventions were important to the development of the industry. He was engaged as Superintendent at the Shoredich works by the Imperial Gas Light & Coke Company, then as Engineer to the South Metropolitan Gas Light & Coke Company and later as Engineer to the Western (Cannel) Gas Light Company. He was dismissed by all three companies. His achievements in the industry included the purification of gas by heated oxide of iron, improvements to parts of gas meters, butterfly and balanced valves, a fan tar extractor and washing gas with ammoniacal liquor.

In addition to his previous patent, Clegg devised and patented a plant for the distillation of tar and, in association with John Malam, he continued with his experiments on the improved Argand burner.

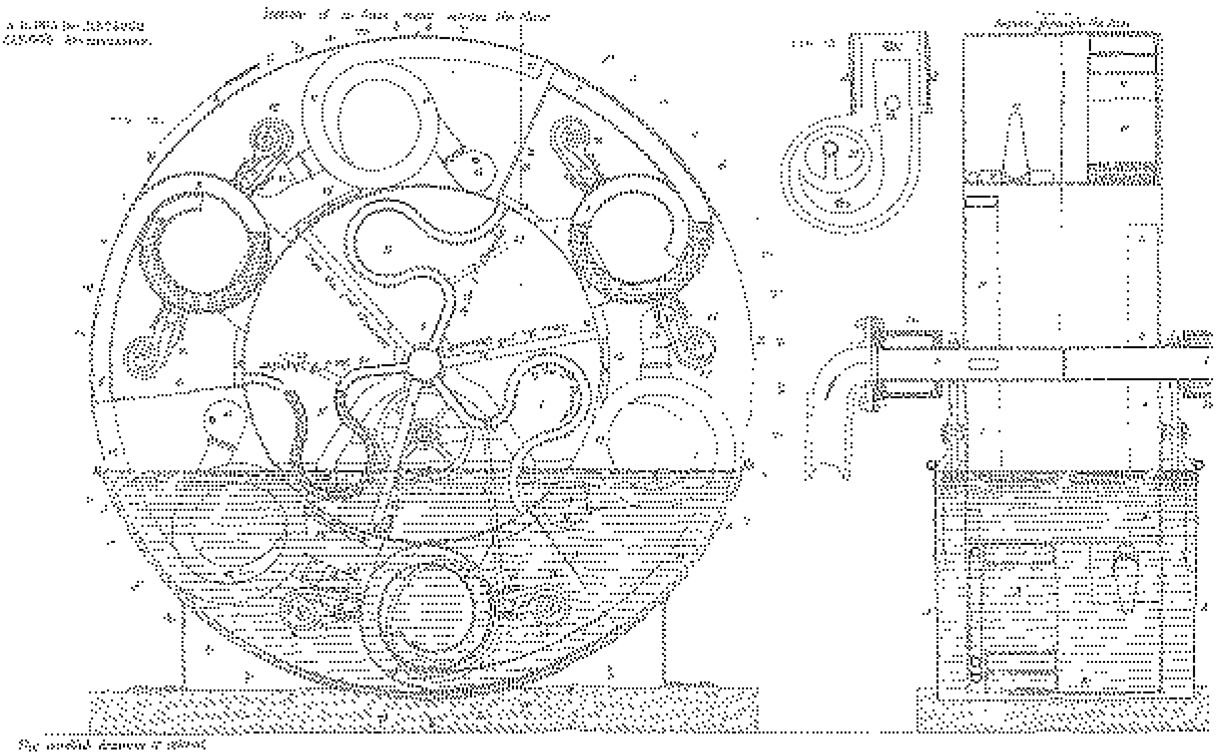
He also invented a collapsing gas holder, see Figure 19 and Appendix Page 57. This gas holder was fairly complex in its design and its capacity was small for the land it occupied. It did though avoid the need for extensive foundations. In practice it had a very limited success and was short lived. It was, however, an attempt by Clegg to eliminate expensive foundation work from the construction of the gas holder.

As Engineer for the Chartered Company, Clegg was responsible for supply of gas. He initiated the introduction of a detailed records system for the Company's mains. A map 'fixed on canvas on a spring roller in a case' was purchased from a map seller in the Strand. On this map, mains were plotted together with the distances of syphons, crosses, bends, etc. from the kerb stones.

In late 1815, when the distribution system was expanding and the demand for gas rising, the Company were experiencing difficulties in maintaining pressure at peak periods in the Strand. Clegg was given authority to construct a gasometer upon the new principle of a regulating cylinder of the dimensions of ten feet in diameter and twenty feet high, as early as possible'. A revolving gas holder to this design had previously been installed at the Great Peter Street works. The holder was completed and although its design proved not particularly successful, it remained in use for several years. This was yet another first for Clegg, a gas holder on the district to assist the supply system.



Semi Fluid Lime Machine for Purification



Rotative Gas Meter

These improvements in the supply activities, his patents of the gas meter and the gas governor, together with basic mains and service laying demonstrate that Samuel Clegg developed the basis of gas distribution as it would be recognised today.

Clegg concentrated his efforts in three main areas - coal supply, the state of the gas works and the supply system. It was quite apparent that with extensive knowledge in these key areas, his advice would be widely sought as the gas industry began to develop throughout the country. He was the pre-eminent gas engineer of the day and was soon to become the pre-eminent gas consultant. This was later to bring him into conflict with his employers.

In addition to Preston, where he used his articled pupil John Grafton, Clegg took on consultancy work for Bristol and the Royal Mint in London. This was accepted somewhat reluctantly by his employers. Bristol had sought Clegg's advice and presumably had some agreement with him prior to the Bristol Gas Light Company being formed. When their Engineer, John Breillat went to London to follow up plans for the gas works he found Clegg in a less than co-operative mood. However, a letter from Dr Kentish, the driving force behind the Bristol scheme, soon resolved the matter. Clegg designed their first works at Temple Banks. In 1817 it is recorded that he provided to John Breillat fitting-up instructions for the installation of gas lights.

The gas works at the Royal Mint was again designed by Clegg. This plant, which was installed in 1817 by Frederick Accum is illustrated in Figure 21. It also included Clegg's rotary retort, lime machine and gas meter.

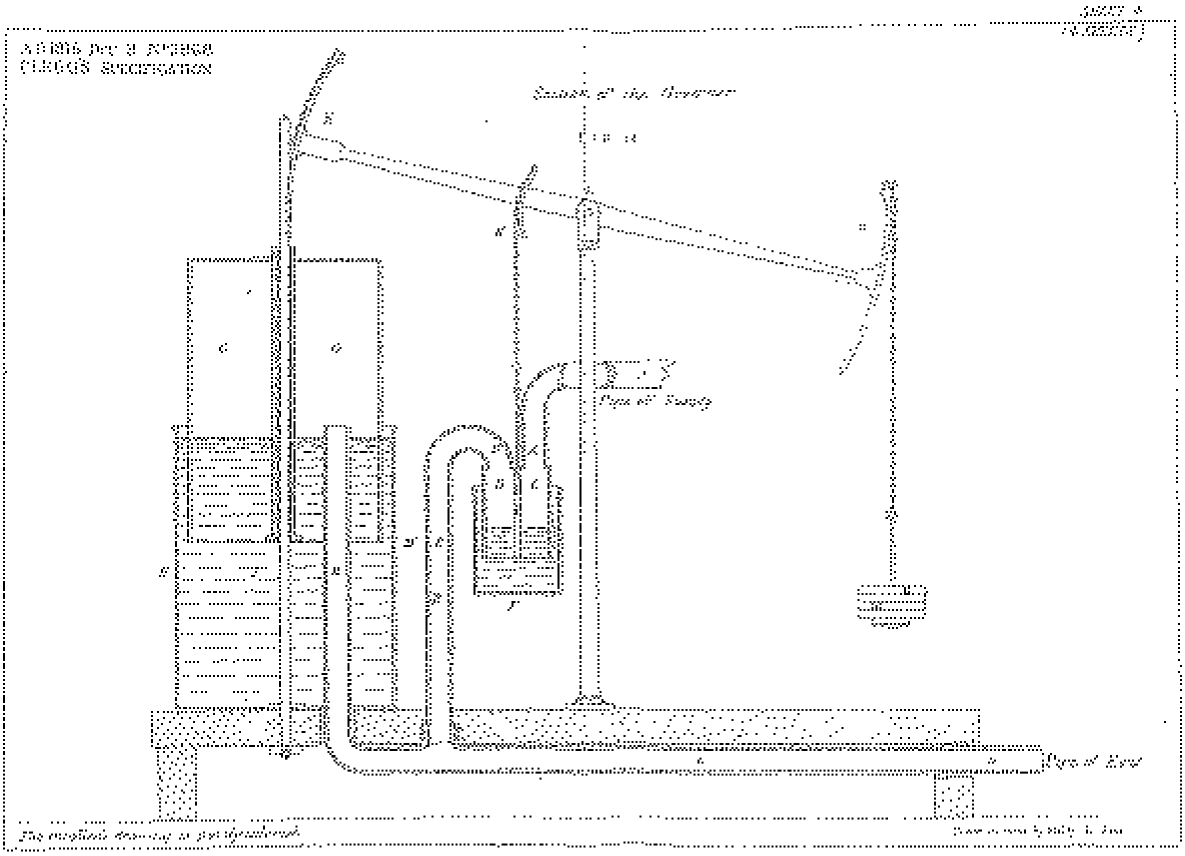
This was followed in 1817 by the design of the Whitechapel works for the London Gas Light and Coke Company. He also began to undertake consultancy work for other towns and cities. Amongst these was Birmingham, where the gas works was being developed by a London entrepreneur John Gostling. Here Clegg designed the works which included two rotary retorts alongside more conventional cast iron retorts. At Birmingham the gas holders were not housed, a practice which Clegg now adopted. By this time the directors of the Chartered Company were very critical of Clegg's consultancy work and on the 1 st April 1817 they parted company.
In the relatively short time he had been with the Chartered Company, just four years and three months, he had single-handedly transformed them from a struggling operation, not able to produce gas, to a thriving and expanding concern. The Company benefited from his numerous innovations many of which proved to be significant in the development of the gas industry.

HIS CAREER AFTER THE CHARTERED GAS LIGHT & COKE COMPANY 1817 to 1861

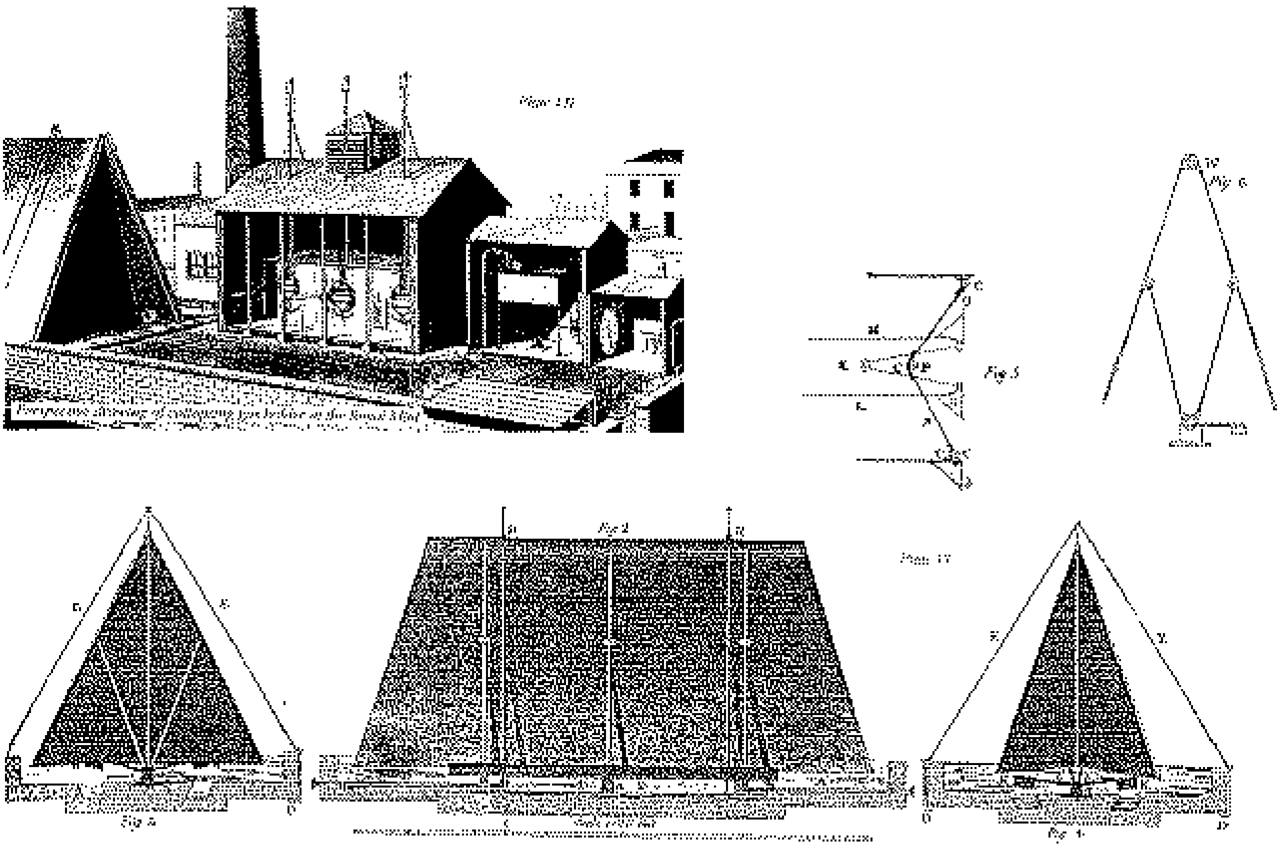
Between 1817 and 1821, Samuel Clegg was involved with the design and building of gas works in several towns including Birmingham, Dudley, Warwick, Kidderminster, Chester and Worcester. In 1820, he published a pamphlet detailing his inventions and achievements in the gas industry since 1805. This was probably done to promote his business activities.

Between 1821 and 1823 he was engaged as a consultant engineer to the London Imperial Gas Light and Coke Company, for whom he designed the large works at Shoredich and St. Pancras. In 1823 he became an advisor to the City of London Gas Light and Coke Company. He also was a member of the Congreve Commission which arbitrated on the boundaries of supply between the Imperial and Chartered Companies.

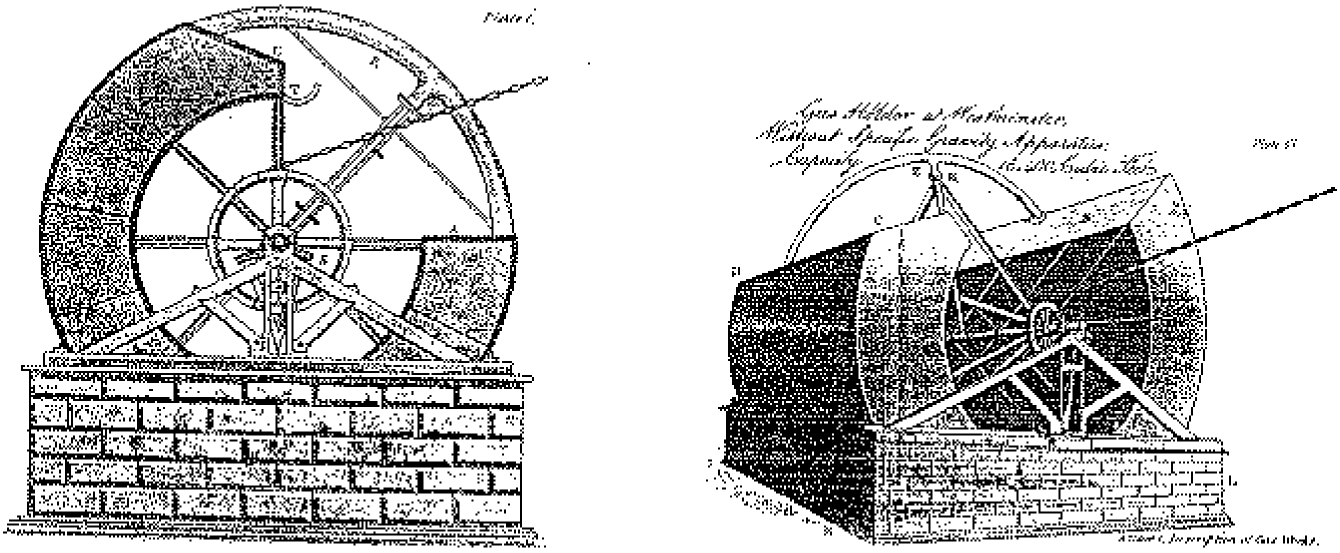
Clegg left the industry in 1824 and for four years successfully worked on the installation of steam engines in ships. He returned in 1828 as Chief Engineer to the Imperial Gas Light and Coke Company, where he designed their third works at Fulham. However, he was asked to resign in the following year after a dispute over his duties and responsibilities. He was awarded £ 350 compensation.



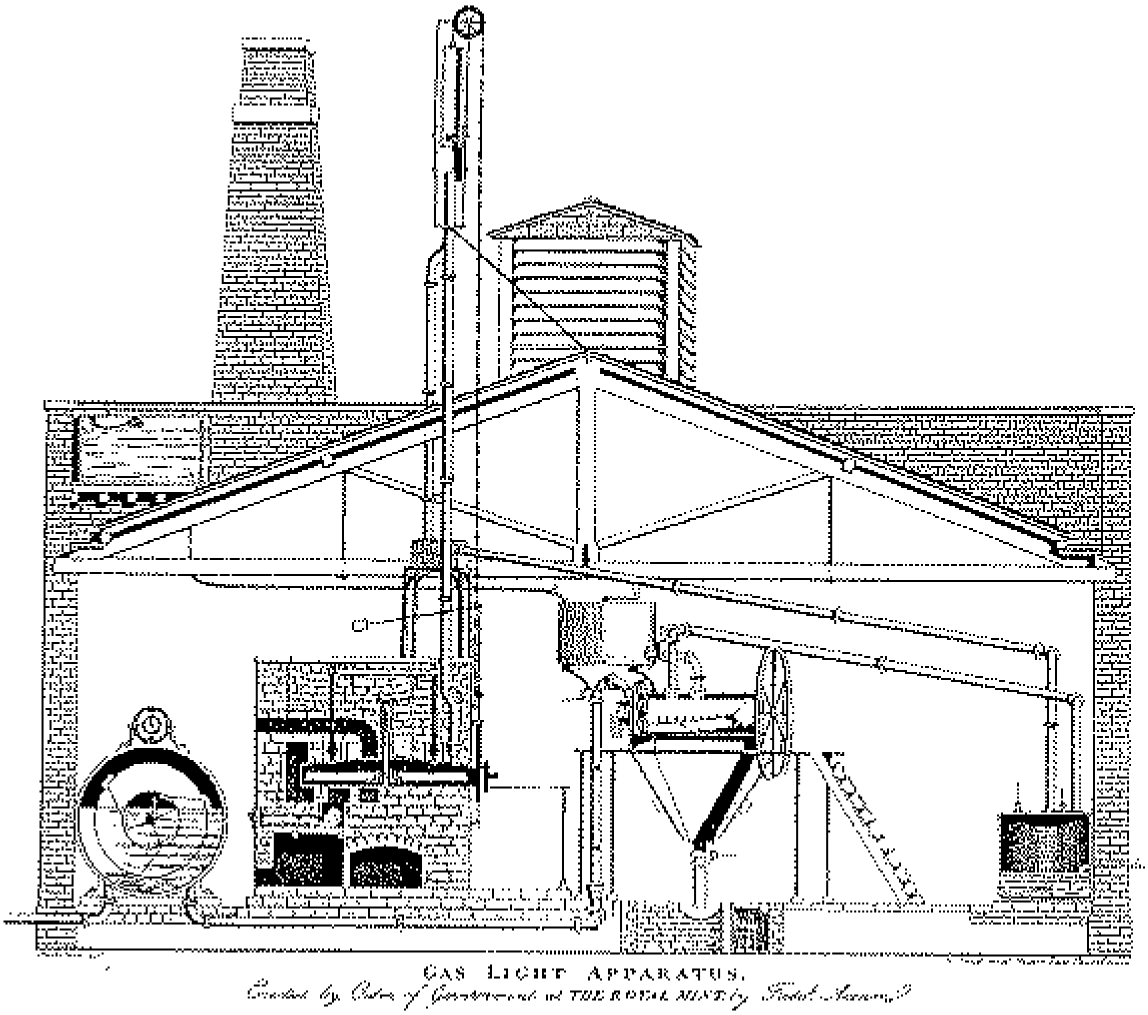
Gas Governor



Collapsing Gas Holder



Revolving Gas Holder



Sectional Drawing of The Gas making Plant Designde By Clegg
and erected by Accum at The Royal Mint

Leaving the gas industry again, Clegg invested his capital in an iron works in Liverpool but this business was unsuccessful and after four years it failed. Clegg lost all his money and his creditors were paid 17s 6d in the pound. It was some 20 years later, when his financial situation had improved, that he finally paid his creditors in full. Between 1834 and 1838 he worked as a Civil Engineer in Lisbon for the Portuguese Government on various public works.

Returning to England in 1838, although not working within the gas industry, Clegg patented an improvement to his 1830 pulse meter. This meter was a dry inferential meter, which worked with a minimum of pressure and had no wear or tear on its component parts. It was claimed to be vastly superior and considerably cheaper to the wet meter. The meter was not adopted in England but was widely used in France.

He became associated with two Portuguese brothers John and Jacob Samuda and together they developed the atmospheric railway. This was a railway system which transmitted power from pumping stations along the line and avoided the use of locomotives. Although several companies initially used this system, it was later abandoned.

Clegg did, however, benefit from the patent sale and from the publication of a book `The Adaptation of Atmospheric Power to Locomotion on Railways' of which he was the co-author with one of the Samuda brothers.

In 1847, after a gap of eighteen years Samuel Clegg returned to the gas industry as a Surveying Officer for the Board of Trade, a position which he held until 1856. His appointment followed the passing of the Gasworks Clauses Act and his duties were to examine the proposals of new gas bills presented to Parliament. At this time he also resumed his development work. In 1848, he invented and patented improvements for wet and dry gas meters. In the wet meter he incorporated a buoyant drum which ensured accuracy irrespective of the level of water within the meter. In 1850, he conducted a study to locate large gas works on the Newcastle coal field and distribute the gas long distances by a `national grid' to London and other cities. Although savings would have been made in the cost of transporting coal, the idea was not taken up because of the increased costs of distributing the gas and transporting the coke. In 1852, he patented a dry gas meter which was controlled by a pendulum.

In 1856, his son Samuel Clegg, Jun. died from kidney disease at the age of 42. He had enjoyed a career on the railways and became resident engineer in 1844 in charge of the construction of 60 miles of the Southampton and Dorchester Railway. Following the completion of this work he was appointed as Professor of Civil Engineering and Architecture at Putney College of Engineering and later Lecturer on Civil Engineering to the Royal School of Military Engineering at Chatham.
His death was a bitter blow for Samuel for his son had been a great ally and had assisted him with the promotion of his work. In 1841, Clegg Jun. had written his book

`A Practical Treatise on the Manufacture and Distribution of Coal Gas, Its Introduction and Progressive Improvement' . It was illustrated by engravings from working drawings and contained general estimates. In the writing of this book his son had free access to his father's manuscripts, journals and notes. Clegg Jun. updated and enlarged his book and this was republished in 1853. Both books were highly regarded and became the acknowledged text books on gas for many years.

Shortly after the death of their son, Samuel and his wife Ursula moved in with their married daughter at Putney Heath. In 1858, when he patented his new improved hydraulic gas meter with floating drum and pressure corrector, his son-in-law William Law witnessed the documents for him.

In 1860, they all moved to Havstock Hill in London and it was here that Samuel Clegg died from bronchitis on the 6th January 1861. He was 79 years of age. He was buried in Highgate Cemetery, as was his wife Ursula who died on the 3rd October 1865, aged 91.

CONCLUSIONS

In summary, Samuel Clegg had a very creditable engineering apprenticeship with Boulton & Watt, which was followed by a period of sound experience of installing engines. It was here that he first met William Murdoch and was introduced to gas. His break with Murdoch and Boulton & Watt was inevitable. He had seen the potential for gas lighting but the progress at Boulton & Watt was far to slow for his liking. He saw the need for a job to be done and set about it himself.
From 1805 to 1812 he manufactured and installed several gas making plants in which he consistently and successfully improved all aspects of the gas making process. It was widely reported that his appointment with the Chartered Gas Light & Coke Company was as a direct result of his gas installation for Mr. Ackerman in The Strand. On reflection, Clegg was probably the only man capable of taking on this job. His qualifications and experience were unparalleled at that time.

The period from 1813 to 1817 with the Chartered Company was undoubtedly the peak of his career. His inventions and engineering achievements set him apart from any other person in the gas industry. The fact that he was responsible for the successful completion of the first three public gas works is indeed a just testimony to his unique ability.

He was the pre-eminent gas engineer of the day and went on to become the pre-eminent gas consultant as the demand for gas spread. He was involved with the establishment of gas works in London, Birmingham and Bristol, three of the largest cities in the land, and many more.

After he left the Chartered Company his efforts were spread more widely throughout the country and his achievements here, although not well documented, should not be overlooked. Even though he left the gas industry for two spells he was always drawn back to where his heart belonged. He continued to make improvements to the gas meter and his last patent was taken out when he was seventy-six years of age, just three years before his death.

In considering his lifetime's achievements, Samuel Clegg was indeed a remarkable man. He has been rightly recognised as the first gas engineer and the gas industry can be justly proud of him.