The Spirit of Engineering

The Lives and Achievements of
Inventors and Designers
in the West Country

Compiled by Members of the
Retired Chartered Engineers' Club – Exeter
to commemorate the Club's
Twentieth Anniversary
June 2006

In memory of the late
Bob Flux
Founder of the
Retired Chartered Engineers' Club
Exeter

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INTRODUCTION

By John Conolly B Sc F R I N A
Chairman of the Retired Chartered Engineers' Club – Exeter

This book has been compiled by members of the Retired Chartered Engineers' Club, Exeter to commemorate its twentieth anniversary.

The Club was founded by Robert W Flux F I E E in June 1986. Membership quickly reached one hundred and has remained at that level for twenty years.

In addition to providing members the opportunity for social fellowship and to remain aware of new technical developments, an important Club objective is the encouragement of young people to enter the engineering professions.

Members hope that those about to embark on their chosen careers will find inspiration from the lives of individuals whose accomplishments have had an enduring effect on today's world. There are countless examples of 'the spirit of engineering' and this book records the achievements of just some of the characters who lived in and around the county of Devon.

Another of the Club's activities is an ongoing project to install commemorative plaques at places associated with those who have made significant contributions to the field of engineering. Currently plaques are installed to honour George Parker Bidder, James Green, James Meadows Rendel, Percy Carlyle Gilchrist and Sir Frank Whittle at Mortenhampstead, Exeter, Whiddon Down, Lyme Regis and Chagford respectively. With these tributes it is hoped to encourage even more interest in the engineering heritage of the West Country.

FOREWORD

By Andrew Ives F I Mech E F I E E

President of The Institution of Mechanical Engineers

The individuals whose lives are described in the following chapters have one characteristic in common – they achieved their ambitions!

Each one was driven by inspiration and dedication to reach a goal and it matters little that they were known as inventors, mathematicians or ironmongers – they all possessed the 'spirit of engineering' that leads to success. The triumphs, frequently accomplished against all the odds, produced outstanding improvements in the quality of life for their own and following generations.

The 19th and 20th centuries saw amazing developments in every field of technology and society continues to benefit from the application of technical expertise. Innovative communication systems, sophisticated medical equipment, new methods of power generation, and the latest products from some of the new sciences such as nano-technology are all around us.

At present, the central issues facing our world are concerned with the effects of pollution and the depletion of irreplaceable resources. Through research, scientists, physicists, chemists, geologists and many others will continue their vital contributions to resolve these problems, but engineering is the activity that makes the world habitable. It converts the results of this research in to solid, practical, useable products and processes.

This book has been compiled by Chartered Engineers who have spent a lifetime involved in worldwide projects. The achievements of our predecessors have been captured in the fervent hope that these will generate the enthusiasm of the 'spirit of engineering' in today's youth – the engineering pioneers of the future.

JOHN TAYLOR 1779–1863

Civil Engineer and Mining Entrepreneur

The quiet town of Tavistock stands on the edge of Dartmoor and it is difficult to believe that at one time its character could have been likened to that of the Klondyke Gold Rush in the Yukon, Canada. In 1796 the mineral ores, particularly copper, discovered in Devon attracted much attention and the population of the town doubled almost overnight. Surrounded by industrial mining activities Tavistock also was home to wool mills, foundries and tanneries pumping smoke, dust and dirt onto the houses and streets. Into this arena stepped a nineteen year old young man, John Taylor, who was to become acclaimed as the 'Patriarch of British mining'.

John was born in 1779 in Norwich, about as far away from any form of mining activity as it is possible to get in England, the first of seven children in a relatively prosperous family. His father was the owner of a yarn manufacturing business and instilled in his children a strict moral code including meticulous control of financial matters, unflinching honesty, propriety and trustworthiness in all their dealings. These qualities were to underpin John's subsequent successful career.

Early education was provided for the children by their mother Susannah and eventually all the sons became prominent members of many influential learned societies. She taught them the 'three R's' plus foreign languages and gave John mathematical instruments and a turning lathe to encourage his mechanical pursuits. He later attended a day school which provided a grounding in chemistry plus other scientific subjects and subsequently he became apprenticed as a land surveyor and civil engineer.

At the end of his apprenticeship Taylor's career suddenly changed course in a quite unexpected manner. He had been invited by friends, the Martineau family, to join them on a visit to one of the Devon copper mines east of Mary Tavy village in which they had a financial interest. His observations and comments about the mining operations so impressed them that they initiated an invitation for him to take on the management of this 12 hectare mine called Wheal Friendship. He accepted.

This was a most unusual situation since managers were invariably appointed from the ranks of those experienced in mining matters. The nineteen year old civil engineer from Norwich was faced with many challenges both managerial and technical and he must have seemed very young and inexperienced. Once in office however, he proved to be an immediate success, quickly identifying two of the major problems at the mine. One was associated with the efficient 'dressing' of the ore and the other was with its transportation to the nearest navigable port, Morwellham Quay on the River Tamar.

His ideas transformed the dressing floors into the most mechanised in the South West and the mine into one of the most profitable. 'Dressing' is the term applied to the various sorting, crushing, cleaning and grading processes to which the mined ore is subjected. His operating principle was to make good payment schemes for the workforce and initiate major capital investment for long-term profitability via mechanisation using latest technology. This approach was popular with the miners but was not always the philosophy of managers in rival mines who were often interested only in short term gains.

The problem of transporting ore efficiently to Morwellham Quay was twofold. The terrain and poor roads meant that teams of packhorses had to be used which was both time consuming and expensive. Taylor proposed a canal between the Rivers Tavy and Tamar. His planned route was not the most direct, but allowed mineral excavation at the same time as canal digging. Although the work started well, later tunnelling through hard slate deposits proved more difficult because of ventilation and flooding problems. He designed and installed special ventilating equipment and for this was awarded a medal by the prestigious Society of Arts. The canal project took thirteen years to complete and a part of it can be seen in the centre of Tavistock today. The basin at the other end of the canal was 73 metres higher than the River Tamar and an incline with double grooved rails was constructed. Barges were loaded onto trolleys connected to chain and windlass for transfer to the low level. Mineral ores and large quantities of arsenic went down to the quay and coal plus lime were returned up on these barges. A very large water wheel was installed to provide power for the many activities which included barrel-making for the arsenic. Soon Morewellham Quay became the hub of communications for the Tamar Valley industries with a world wide importance exceeding that of Liverpool. The canal fell into disuse only when the railway between Plymouth and Tavistock was constructed.

Under Taylor's direction the Wheal Friendship Mine continued to be developed with deep workings to 400 metres. The main source of power for the mines was water via leats and seventeen water wheels were installed, one an impressive 15.5 metres diameter. Within a year of office Taylor had developed enough confidence to take a direct financial interest in the re-opening of a neighbouring copper mine Wheal Crowndale (wheal is the Cornish word for mine – frequently used also in Devon). This too was a successful venture and enhanced his reputation.

By this time he had married Ann Pring of Awliscombe, near Honiton, and they lived at Whitchurch eventually producing a family of three daughters and the two sons John and Richard who were later to play key roles in the management of the business.

Unexpectedly, at the age of thirty two, Taylor left Tavistock receiving a heartfelt goodbye from many miners and their families whose respect and regard he had earned by managing so effectively the mines' affairs and the workers well-being. The move perhaps was prompted by the challenge of scientific and technical problems in the new but rapidly developing chemical industry.

He joined his brother Philip who was setting up a chemical manufacturing facility in Essex first concentrating on metallurgical problems associated with manufacturing sulphuric acid, then on a scheme to produce gas from oil instead of coal. The brothers applied for, and received, the patent for a process to refine and purify sugar. The following year the business was expanded again, this time into mechanical engineering manufacturing portable printing machines. John Taylor however was still very much interested and involved in mining affairs and as these were making more and more demands on his time he withdrew from all formal involvement in the chemical business.

His return to the mining industry was made via lead mines in Flintshire where he introduced the equipment and practices developed with such success in the South West. These mines soon became the most profitable in their region.

Taylor gradually became re-involved in projects at Tavistock with a reputation that allowed greater areas of control including the responsibility for the overhaul of port facilities at Morwellham Quay. He acquired land in Tavistock and built offices plus other premises for the mining business.

Soon his ambitions and skills resulted in involvement in mining activities in all regions of the British Isles including Ireland and Scotland. One enterprise alone in Gwennap, employed three thousand workers, dominated the district and endowed Taylor with an international reputation. He was associated with the Great Consols Copper Mine at New Bridge near Tavistock which ultimately produced over 600,000 tonnes of copper and was so successful that within six months after its opening each £1 Share was worth £800. Devon and Cornwall were soon satisfying more than half the world's needs for copper. By 1824 when he was forty five years old he controlled nearly forty large mining companies and several consultancies so it was not surprising that he set his sights on overseas opportunities.

The agent for the owners of the fabulously rich silver mine Real del Monte in Mexico contacted Taylor and after some negotiations a company was formed to operate the works. He hoped to introduce the methods for efficient mining operations which had been so successful in the UK but problems in Mexico proved to be of a much greater magnitude. Administration and communications were very difficult due to the distances involved. Time intervals could be measured in months for the answer to an operational enquiry being received back in Mexico from England, by which time site circumstances had usually changed. Delays occurred for the delivery of equipment spares and supplies from England since there were no local dealers and expensive haulage along two hundred miles of poor roads exacerbated the situation. Machines had to be shipped in parts for re-assembly on site. Good local workers were scarce and not amenable to the new forms of contract. Personnel transferred from England to supervise the workforce expected very high salaries. Sickness on a large scale was experienced and bandits frequently made raids for the payroll. In addition, there were severe technical difficulties in excavation and ore dressing plus a grave underestimate of the mine's flooding problems. The mine failed to produce a consistent dividend for the stockholders and in 1848 they voted to close the Company. This was of course a great blow to Taylor but was the only real major disaster in his long career which, in addition to projects in Britain, included overseas operations in America, Spain, France, Germany, Italy and Australia.

Notwithstanding extensive business commitments Taylor was involved in many other activities. He helped to establish an elementary school in Tavistock along with the library there, was elected to the Geological Society of London, contributed to the founding of the British Association for the Advancement of Science and assisted in the affairs of the University College of London. His sincere interest in the well-being of miners prompted him to crusade for a School of Mines so they could be educated in the latest technology for their industry. From these efforts evolved the Camborne School of Mines. His home saw many social gatherings with friends such as George Stephenson, Charles Babbage, Felix Mendelssohn, and members of the Brunel family.

In the 1850's he was in his seventies, suffered several health problems and gradually retired from business and technical activities. He died 1863 after a long and incapacitating illness but the business he established continued to expand and prosper for more than another century.

In sixty years of active working life, John Taylor had assembled a business empire matching in scale and geographic extent the largest in any branch of industry or commerce. His role in the creation of this empire was not so much as an inventor of brand new technology but more as a gifted intermediary. He identified the cause of a problem, suggested a solution and then motivated the inventor and user. A brilliant informed administrator and a clear thinking innovator joining technology with practicality, John Taylor fully justifies the title 'Patriarch of British Mining'.

J A Knivett

THOMAS FOWLER 1777–1843

Inventor

Thomas Fowler was born in Great Torrington, Devon in 1777 and after receiving a basic education in a small school in the town was apprenticed, at the age of about thirteen, to a local fellmonger, a seller of animal skins. However he had a yearning for mathematical study and the vision of a very different future.

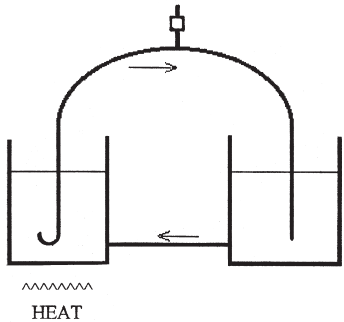
After long days treating animal skins he would spend much time at night studying mathematics and by the age of sixteen had thoroughly mastered the difficult subject of differential calculus. Few could have been more completely self-taught.

Mathematicians in those days were scarce in North Devon as well as in the great centres of education throughout the country but his dedication to study was eventually rewarded. By 1830 he had become established in the town as a bookseller and printer using the printing machine he constructed to drawings of his own invention. Later he became clerk then manager and partner of the only bank in Great Torrington, organist of the Parish Church and, by standing as a town councillor, a valued member of the local community.

At the age of thirty five, Fowler married Mary Copp, a twenty one year old local girl, who became his life long partner. Both Thomas and Mary came from large families, each having three brothers and three sisters. Over the period of twenty three years, Mary became the mother of their eleven children, a number of whom made their mark in life. One daughter, Caroline, was sufficiently literate to become an expert compositor, setting type for printing, working for her father in his printing business. Their son, Hugh, went on to publish several religious and educational books and in the later stage of his academic career became Headmaster of the Cathedral School in Gloucester. Another son, Charles, was appointed Professor at the Royal Academy of Music and became a noted concert pianist and composer.

In 1828, Fowler invented and patented the first convective heating system which was the precursor to the modern day central heating system. It was called a 'Thermosiphon' and the principle by which it works is very simple. It is based upon the idea that water may be heated and made to circulate through a siphon, as well as through horizontal pipes or, with force, through pipes in any direction provided that the height of the siphon is not greater than to be counter-balanced by the pressure of the surrounding atmosphere. Whenever heated fluid circulating through pipes is used for the delivery of heat, this principle is applied. It is the basic method used in today's central heating systems installed

FOWLER'S THERMOSIPHON



Curved pipe connecting the tanks is primed with water via top valve. Left tank is heated and the lighter warm water rises in the pipe then descends into the right tank starting a siphoning action. Cooler water transfers from right to left via lower straight pipe and circulation continues. Lower left hand bend prevents any rising air bubbles from entering the curved pipe, lodging at apex and breaking the siphoning action.

throughout the world to provide a comfortable temperature for modern living conditions.

Although this system was patented by Fowler the laws of the time were weak and flawed. By introducing any small modification or change to the original design features the resulting new version would not be covered by patent. This meant that others could reproduce Fowler's invention without penalty of any kind which, of course, soon happened. This loophole caused Fowler great distress as he was left helpless to prevent his invention being copied everywhere by others. The only remedy would have been to recourse to costly legal proceedings but, even if he had the means to do so, a successful outcome could not be assured.

During the 1830's Fowler was offered, and was pleased to accept, the appointment of Treasurer to the newly established Torrington Poor Law Union thus embarking upon a path that would lead to his next and most significant invention.

As treasurer of the Poor Law Union he was responsible for assessing and calculating the payments for each of the Parishes. Finding the necessary calculations cumbersome and tedious he determined to find a way of simplifying this procedure. Common logarithms were available at this time to help with the process but Fowler was not satisfied with these complex calculations and began to search for a simpler method. This led him to attempt to automate the calculations by using reference tables.

His solution was typically brilliant and led, in 1838, to the printing of Fowler's 'Tables for Facilitating Arithmetical Calculations'. These tables used a method based on his realisation that any number might be produced by a combination of the powers of 2 or 3. The first part of the Tables is in binary, a table of indices of the power of the number 2 from 1 to 130048. The second part is in ternary, or a table of indices of the power of the number 3 from 1 to 3985607. In binary, each figure increases twofold and in ternary, each figure increases threefold.

The thinking behind these tables was entirely new, and although the properties of the powers of the numbers 2 and 3 were known to mathematicians at the time, the want of some particular application for their use had not been established and had not therefore found an arithmetic use.

The binary system can best be described by imagining a horizontal bank of pigeon holes each capable of displaying just two characters, 0 and 1. The right hand window indicates the number of 'units' under consideration. The one to its left indicates the number of 'twos' under consideration, the next the number of 'fours', then 'eights' and so on. To indicate the quantity thirteen, the pigeon holes' display is; [1] [1] [0] [1].

Similarly, the ternary system uses three characters 0, 1 and 2 and windows' values progress from right to left in factors of three. ie. 'units', 'threes', 'nines', twentysevens' and so on. To indicate the quantity forty six, the display is; [1] [2] [0] [1].

Such was the success of these tables in reducing the time taken by accountants to produce their figures that Fowler was determined to continue his work in this field. Thus, between 1838 and 1840, he worked behind closed doors developing his thoughts on ternary arithmetic and extending his knowledge further with the creation of a mechanical calculating machine.

The first machine was constructed almost entirely of wood and made by Fowler himself on his premises at Great Torrington. Such was Fowler's anger and bitterness at the way his invention of the Thermosiphion was pirated and copied that he went to great lengths to protect the details of his machine from prying eyes. The 'uniqueness' of Fowler's ideas to mechanise calculation was based upon his realisation that he could simplify the whole process of calculating by using just the indices of the ternary scale rather than the values that the indices represent. His choice of sliding rods rather than rotating wheels in his machine was also significant in reducing mechanical complication, particularly in 'carry-over' operations. However, his excitement at completing this achievement was tempered by the dilemma he now faced of how to bring his unique invention to the attention of the wider scientific community without releasing any drawings or details that would enable others to replicate the machine for their own benefit and profit.

Fowler found a solution to this dilemma in the person of the

Rev. John Moore Stevens, Archdeacon of Exeter and someone in whom Fowler could trust, having a number of personal connections with great Torrington. Stevens was able to arrange a demonstration of Fowler's machine for Charles Babbage and others he felt might be interested. This contact with Babbage who was also at the forefront of the development of mechanical calculating machines at the time was to prove significant. There had been previous attempts to mechanise calculations in previous years but these devices had proved to be most unreliable and of limited application. Thus scientist, astronomers, navigators, engineers, surveyors, bankers and others all continued to rely on printed mathematical tables.

Fowler's machine which was 1.8 metres long by 0.3 metre deep by 0.9 metre wide, was exhibited and demonstrated before members of the Royal Society in May 1840. Later, the then Astronomer Royal, Professor George Airy, was to promote the machine to a gathering of the British Society for the Advancement of Science in August, 1840.

Charles Babbage, George Airy and many other leading mathematicians of the time witnessed Fowler's machine in operation. These names have become famous in the history of science, yet today it is difficult to locate many references to Thomas Fowler even though his machine was said to be superior in many respects to Babbage's calculating machine. Fowler's designs anticipated the modern computer by using a ternary calculating method. This is in contrast to Babbage's machine which performed a decimal calculation, an approach which made his machine very complex.

Fowler went on to demonstrate his machine at Devonport in 1842, and to construct a greatly improved version the following year. Tragically he then fell ill and died on 31 March 1843, without fulfilling the hopes of seeing his calculating machine receive the acceptance he believed due to it, as indeed did many others. If he had released some diagrams, drawings and details of its construction perhaps it would have been a different story, but his unhappy experiences with the Thermosiphon had such an impact on him that he felt he could not run the risk of a similar thing happening again.

Perhaps he was right to trust no-one in this developing market of knowledge; history is littered with examples of disputes over patent rights and litigation, but as a result of his actions Fowler ultimately was denied the scientific investigations of the whole principle of calculations and the acceptance of a machine that he so much desired.

It is hoped that one day the full significance of his invention will be realised and that he will receive the recognition he deserves. He was a man of remarkable intellect, perception and imagination who had a rare ability to move beyond accepted reasoning and produce simple, clear solutions to the most complex problems. The genius of Thomas Fowler, a true son of Devon, must never be forgotten.

N S Macaulay

JAMES GREEN 1781–1849

Civil Engineer

James Green was born in 1781 in Birmingham. His father was a civil engineer and contractor in Warwickshire and the adjoining counties and it was from him that James received his early experiences in the field of engineering.

Between 1800 and 1807 he was employed by John Rennie, one of the greatest civil engineers of the time, as an assistant working on extensive surveys, canal works, and drainage of bogs and fens and the design of engineering works generally, both in England and Ireland. At this time, the repair and replacement of Dymchurch, Sussex, seawall came particularly under Green's care and the reconstruction of the sea lock of the Chelmer and Blackwater Navigation was entirely entrusted to him by the landowner the Earl of St Vincent.

It was from here that Green came to Devon, and in July 1806 he became responsible to Rennie for the instruction of a local surveyor, Charles Tozer, at Totnes. Rennie was at that time reporting to the Duke of Somerset on ways of improving the navigation of the River Dart below Totnes bridge. Rennie also employed Green on a survey of the rock at Cattewater intended for use for the construction of the breakwater at Plymouth, which scheme commenced in 1812.

Meanwhile in a report to Lord Boringdon of Saltram in December 1805, Rennie had proposed an embankment from Pomphlett Point to Saltram Quay. This had a favourable reception and Lord Boringdon contracted with Green for the construction of the embankment 890 metres long to enclose 70 hectares. Two years later, following the collapse of the newly rebuilt Fennny bridges near Honiton, Green contracted for the design and construction of a replacement bridge across the River Otter; it had three spans of 12.8, 14.6 and 12.8 metres in brick-work and was 6.1 metres wide between the parapets. In 1808 the Plymouth Eastern Turnpike Trustees allocated funds for the construction of a bridge over the River Yealm, at Lee Mill, to be designed and supervised by Green.

Also in 1808 a committee of magistrates had been reminded of a letter of July 1800 from the Clerk of the Peace of Shropshire giving information on the conditions of appointment of Thomas Telford as their county Surveyor. The Devon magistrates decided to dispense with their six surveyors and appoint one civil engineer as their county bridge surveyor. Green was appointed at a salary of £300 per annum and therefore became Devon's first county bridge surveyor, a title which was quickly to become county surveyor when he took responsibility for the county buildings. As surveyor, he was contracted to inspect over two hundred and thirty bridges every year, to report deficiencies to Quarter Sessions and to obtain the magistrates' sanction to carry out repairs for a particular sum of money. Such was the on-going development in Devon that now, in the 21st century, there are 3,500 bridge structures in the county. Green was allowed to seek outside work and so put a series of advertisements in the Exeter Flying Post informing the noblemen and gentlemen of Devon and the adjoining counties that he had taken up residence in Exeter and was soliciting their patronage.

By 1820 some thirty-six bridges had been built or widened to take the rapidly expanded traffic of the day. Three span bridges were Fenny, New at Tawstock, Cadhay over the Otter, New at Kingsteignton, Emmets over the River Dart, Hele at Hatherleigh, Head over the Mole, Cowley near Exeter, Steps at Dunsford, Weston near Honiton and Brightly north of Okehampton. Standard widths were agreed with the justices for the most important turnpike roads 5.5 – 6.1 metres, for the lesser turnpike roads 4.6 – 5.5 metres, and for other roads 3.7 metres clear.

Green commenced work on a canal from Exeter to Crediton, but this project was halted almost immediately. For Lord Rolle and others he carried out land reclamation of Braunton marshes on the estuary of the River Taw where, with John Pascoe as his surveyor, an embankment 3,660 metres long enclosed 526 hectares and was completed in 1814. At Budleigh Salterton in the estuary of the River Otter, Lord Rolle commissioned Green to reclaim an area 1,830 metres long by 300 metres wide, enclosing over 567 hectares. In October 1813 he joined Joseph Whidbey, John Rennie and others in advising the Admiralty Solicitor that enclosing a creek at Alverstock, near Gosport, would interfere with the tidal flow near Portsmouth!

A most important architectural assignment had come to Green in 1810 when he transformed Buckland House, damaged by fire in 1798. His work there led the architectural historian Sir Nikolous Pevsner to say that his work showed him to be an accomplished innovative practitioner in the neo-classical style which was at this time becoming popular in Devon. His construction of St David's Church, only 100 yards from his home Elmfield, was commenced in 1816 and although it was replaced in 1897, the appearance of the church was well-known in Exeter from its distinctive octagonal tower with eight Doric pillars surmounted by a rounded dome.

In 1819 Green reported to the trustees of three turnpike roads, the Plymouth Eastern, the Ashburton and the Exeter, concerning the road from Exeter to Plymouth. As always in those days the problems were the need to reduce unnecessary ascents and descents, increase the road widths and improve the surfaces. In all, some 22.5 kilometres of road were realigned.

Early ideas for a canal from Bude to Launceston had surfaced in the 1770s and Robert Fulton had already suggested that inclined planes would be more suitable than locks for the 110 metres rise from the sea to the River Tamar. Inclined planes generally incorporated rails with trucks onto which the craft were loaded for them to be raised, or lowered from one level to another. In 1817 the fourth Earl Stanhope commissioned Green to prepare a plan of a possible line for a canal and Thomas

Shearm was appointed surveyor. Work began in 1819 and Green built 56 kilometres of canal with six inclined planes fed from a dam across the upper reaches of the River Tamar; a reservoir was included. Green invested £3,000 of his own money in the canal but the shares produced no return in his lifetime.

During the decade from 1821, one important scheme followed another. Some forty-six bridges were built or widened, including the magnificent five-arched Beam aqueduct north of Torrington and three-span bridges at Clyst Honiton, Gosford over the Otter, Long at Cullompton, Otterton, Tinhay over the Wolf, and Newnham over the Taw.

In 1823–24 Green combined with Underwood, the Somerset County Surrveyor, to produce plans for a new House of Correction to stand alongside the County Gaol at Exeter and Green became responsible for the construction of the £12,700 building. At this time his salary was £550 p.a. but he insisted that the County also paid him the fee of £87 16s. The magistrates eventually agreed but this matter caused resentment that was to surface in 1831 and cause a reduction in salary.

Green became heavily involved in canal work. The Bude canal was completed in 1824, a fine example of the use of 6 ton narrow boats and inclined planes. In 1824 he commenced the Torrington canal for Lord Rolle, extending from downstream of Weare Gifford to a point alongside the river south of the town and it was here Rolle also employed him to build new grist mills and erect the machinery.

Meanwhile in 1820 the City of Exeter had asked him to advise them on improvements to their canal and work proceeded on rebuilding the entrance sluice, providing a uniform depth of 3 metres lowering the cill of the Double Locks and constructing a culvert under the canal to drain land fed by the Alphin brook that had been cut off by the canal near Double Locks when the canal was first built in 1566. In 1824 he proposed that the canal should be extended 3.2 kilometres from opposite Retreat House to Turf, where vessels drawing 3.7 metres could navigate the estuary at all tides. The canal was further deepened but at Exeter there was solid sandstone below the river quays. Green therefore proposed the construction of a basin, independent of the river. Telford was consulted, and work proceeded on this project, the canal being opened to Turf in 1827 and the new basin completed three years later. Green was voted the Freedom of the City of Exeter in October 1830, his recognition was significant and unusual in view of the fact that he followed the beliefs of the Quaker church.

The idea of linking the Bristol and English channels had been alive since 1768 and in 1821 Green was asked to make a survey. He proposed a tub-boat canal to run from the existing canal near Taunton to Beer, and in 1824 Telford was also engaged to make a survey for a ship canal with Green signing the plans. Although an Act was obtained no more was heard of this scheme.

During 1823–24, in conjunction with Joseph Whidbey of the Admiralty, Green surveyed and reported on harbours of St Ives and Ilfracombe, and in 1827 he surveyed the bay for a harbour at Combe Martin. Also in 1823 he proposed improvements for Bridport harbour but instead a scheme prepared by Francis Giles was carried out in 1824.

In 1829 a scheme prepared by Green for a dock at Cardiff was adopted by Lord Bute and submitted to Parliament, but on the advice of Willliam Cubitt it was altered and West Bute Dock was subsequently opened in 1839.

Now having firm links with the Exeter Turnpike Trust, Green was invited to make a survey of the road between Exeter and Crockernwell, the Trust's limit on the way to Okehampton. He produced a new route from Pocombe bridge to Tedburn St Mary using the valley of the Alphin brook and it was opened in 1824. For the Countess Wear Committee of the Trust he rebuilt the swing bridge over the canal the following year.

In conjunction with a proposal to build Laira bridge, the Plymouth Eastern Turnpike turned to Green to improve the roads from the eastern bank towards Totnes. He produced a plan for a direct road to Yealmpton, some improvements to Ermington and then a new road up the Ludbrook valley, by-passing Ugbrook to Ladydown; this required new bridges over the River Yeo, the Ermer and the Lud. In 1825 a three-mile diversion was made just north of Sandwell to run directly to Totnes and again he was asked to supervise the building of a new bridge over the River Harbourne. In 1827 he was responsible for a new road to Yarcombe for the Chard Turnpike Trust.

In 1824 Green had built Eggesford bridge over the River Taw. This route saved over 300 metres of unnecessary ascents and descents and provided Green with the opportunity to build four more bridges with a view to them being taken over by the county.

As a result of a complaint that too much was being expended on the maintenance of the prisons, it was proposed in 1830 that Green's salary should revert to £300 per annum and a letter from Rendel was produced offering to perform all Green's duties for £300. Green accepted the reduction in salary but was forced to look outside the county for as much consulting work as he could command. Besides building another twenty-seven bridges in the next decade he turned his attention once more to canals and other proposals. For the Barnstaple Bridge Trust in 1834 he widened the existing 16-span bridge by cantilevering delicate and attractive footways 1.2 metres wide on each side using ironwork from the Neath Abbey Iron Company. In 1832 he proposed water supply, sewerage and railway schemes for Torquay.

Rennie had built over 17 kilometres of canal from Tiverton to the Devon-Somerset border to convey limestone from the Canonsleigh quarries, and this had been opened in August 1814. The Grand Western Canal proprietors wished to extend their canal to Taunton to join the Bridgwater and Taunton Canal. The distance was only 21 kilometres but the difference in level was 80 metres Green had presented a report to the company in 1829, advocating boats of 6.1 metres by 1.8 metres carrying 5 tonnes, six of these to be drawn by one horse. In a further report in 1830 he suggested one inclined plane and seven perpendicular lifts, with boats of 8 tonnes, at an estimated cost of £61,324. Work commenced in June 1831, but operating difficulties were experienced with both the lifts and the inclined plane and within five years Green had ceased to be engineer. Work was completed in 1838 at a cost of £80,000.

In 1831 a canal for Chard was proposed and Green was consulted. He proposed the use of two lifts, two inclined planes and two tunnels, all at a cost of £57,000. Work got under way in June 1835 but soon Green ceased to be engineer, no doubt because of troubles with the Grand Western Canal; the Chard Canal was completed by May 1842.

The silting of the Gwendreath estuary in South Wales in the early nineteenth century had caused Kidwelly to lose its facilities as a port for the coal of the valley. The Kidwelly and Llanelly Canal and Tramway Company had obtained powers by an Act of 1812 to extend the canal up the valley to beyond Cwm Mawr about 76 metres above sea level and in 1832 the company called in Green to report on extending the canal beyond the point reached in 1824. In 1833 he recommended two locks and then three inclined planes at an estimated cost of £35,845. By 1834 work was well advanced but the following year Green informed the directors that he was unable to finish his inclined planes. He was dismissed in 1836, in the same year being dismissed as engineer to Burry Port as the result of the collapse of a dock wall.

In 1830–31 Green's home was recorded at 38 Southernhay Place while in 1833, 1834 and 1836 it was in Magdalen Street. Following the above problems a notice of bankruptcy appeared in the Exeter Flying Post in March 1837 following an entry in the London Gazette. By 1838 Green had moved out of Exeter to Alphington, no doubt to economise. The sums involved in his failed contracts were probably so large that he had no opportunity to recover them from his income during the closing twelve years of his life. This would have affected his status in the Religious Society of Friends, who might have disowned him because of his bankruptcy.

A contract for a dock in Newport, Gwent, had been let in 1835, but within two years the contractors were in trouble and some time around 1840 Green was appointed to take over from the previous resident engineer to complete the works. He took up residence there but in the same year the Devon justices were told that Green could not continue his work in Devon satisfactorily without deputising the minor matters to his son. Some magistrates complained that they were having to do the work of the surveyor and Green was given twelve months notice from the Midsummer 1840 Sessions.

So Green left the county's employment and in 1841 was listed as living in Heavitree with his son as 'Green James and Son, Civil Engineers and Land Surveyors, Portview Cottage, Heavitree'. Green brought the work at Newport Dock to a successful conclusion in 1843. He then settled in London but because of the active competition of younger men, he was not so extensively employed as he might have been.

In 1844, because of his knowledge of the estuary of the River Exe, Green was consulted on the building of the South Devon Railway. Exeter City opposed the Bill to safeguard its navigation rights in the estuary and Green made a report in the same year. The essence of his evidence was that the embankment alongside the estuary would enclose 41 hectares which would make a significant difference to the movement, and hence the scour, of the water in the estuary as it crossed the bar.

The floating harbour of Bristol was made feasible by constructing locks on the river downstream of the docks and diverting the River Avon along a new channel to the tideway below the locks. No thought was given to intercepting and carrying off the sewage of the city away from the harbour. Further sewage was brought in by the tributary River Froome, which passed through a populous part of the city. In 1846 Green was instructed by the Council to advise on the measures for abating the nuisance. He recommended straightening the River Froome, making it of uniform width to give greater scour of the bed and intercept the sewers that discharged into it. The Council considered that it could not proceed because it did not have the legal powers but further instructed Green to advise on action to be taken between Stone Bridge and Castle Moat. The report was made in March 1846 and during the summer works were carried out at a cost of £4,537 to clear this area of accumulated sludge. Green presented a paper on these reports and works carried out to the Institution of Civil Engineers in February 1848. He had been proposed as a corresponding member by Telford in 1824.

In May 1805, Green had married Elizabeth Dand at St Martin's, Birmingham. A son, Thomas, died aged three in 1815, but another son, Joseph, was born in 1817. James Green died from a heart attack on 13 February 1849 at 67, Manchester Buildings, Westminster, and was buried on 28 February at Bunhill Fields as a non-member of the Religious Society of Friends, though his connection was enough for a Quaker burial. His death was noted in the Bristol Mirror which added that his son Joseph was resident engineer at Bristol Docks.

The scope of the projects with which he was concerned was incredible and few civil engineers matched his expertise in such a variety of fields.

A B George

JOHN STRINGFELLOW 1799–1883

Mechanical Engineer and Inventor

Entering the town of Chard, on the borders of Devon and Somerset, you are welcomed with the signs 'Chard, Birthplace of Powered Flight'. This surprises many who thought Kitty Hawk, North Carolina, where the Wright brothers flights in 1903 occurred, was the scene of the earliest powered flights. Chard's rightful claim rests on the inspired work of John Stringfellow.

Born near Sheffield in the middle of the industrial revolution, he was to see at first hand the many exciting developments that were changing the world at that time. Early in his life his family moved to Nottingham, a centre of machine lace making and where his father found work. As a teenager he was apprenticed to a lace maker during which time he found and developed the skills of a mechanic and engineer inherited from his father. He developed a particular interest in the design and manufacture of the bobbins and their holders that were used to carry the threads used in making the lace. Since just one loom needed hundreds of these bobbins, all subjected to wear and breakage, there would be a constant need for replacements and building a factory close to the mills purely to make bobbins would be a shrewd move.

At this time industry was going through a great upheaval. In the mid 1700's mechanical power was limited to three sources, man-power, horsepower and waterpower and it was the last of these that Stringfellow would have been most familiar with. However, steam was being harnessed and one of the first engines developed by John Watt in the 1760's featured a horizontal beam pivoted at its centre to create a vertical reciprocating motion at its ends. By the late 1700's the engine of James Watt had finally been made to rotate a shaft and then, by the turn of the century, as Watt's protective patents ran out engineers such as the Cornishman John Trevithick with his high pressure steam were making advances in the use of this form of power with its high efficiency.

Hand in hand with these developments came the mechanisation of many industrial processes but these improvements did not always receive universal acclaim. Millworkers smashed many machines that they thought threatened their jobs. These 'Luddite' activities prompted some of the lace mill owners to move from Nottingham to more rural surroundings such as Chard and this was where Stringfellow set up his factory in 1831 to make lace bobbins and their carriers.

Shortly after arriving in Somerset he married a local girl Hannah Keetch. For nearly all their lives together they lived in a house on the main street of Chard where they raised a family of twelve, nine of whom reached maturity.

A major use for the abundant power of steam was for transport. John Trevithick had a steam carriage running on the roads in 1800 and not many years later Brunel, among others, had steam driven ships travelling great distances. The two means of transport over land and over sea had been conquered by the power of machines. But man had also long dreamed of flying through the air as birds do. One of the first, in fiction at least, was the god Icarus whose avian exploits were limited only by the quality of adhesive he used; he flew too close to the sun and his wings fell off! Leonardo da Vinci had many ideas on the subject of flight mostly using flapping wings but also exploring the helicopter principle.

Two popular magazines published at this time were 'Mechanics Magazine' and 'Magazine of Science' and they, together with other magazines and National newspapers, were ever-ready to publish accounts however wildly phrased of any inventor's proposal for flying machines, details of progress in construction and the subsequent flight testing. Readers' comments and advice filled many columns and it is difficult at times to separate fact from fiction or truth from mere fancy in all this newsprint.

It is known that Stringfellow had had an interest in flying machines since his childhood and with the security of a successful business he was able to put his ideas for manned flight into practice. It is possible that Stringfellow was influenced by the work of George Cayley who at the time of Stringfellow's birth was making quite large gliders. Cayley had a very scientific approach and was the first person to specify the forces of thrust, drag, lift and weight acting upon a flying machine. He recognised the importance of streamlining and weight distribution in the structures. Being aware of the advantage of camber on the top surface of a bird's wing he correctly supposed that this added stiffness when needed on the down-beat or when soaring. Whether Cayley appreciated that the cambered upper surface added to the lift of a wing is not known. Stringfellow experimented briefly with ornithopters but quickly realised that designing a working structure with flapping wings held too many problems and that adding power to fixed wing gliders held better chances of success to achieve sustained flight.

In 1840 Stringfellow met and formed a partnership with William Samuel Henson, another lace mill owner recently moved from Nottingham to Chard, and a talented inventor who had already made successful gliding machines at the time of their meeting. The machines so far made by both men had no built-in means of sustaining flight. An engine of some sort was required to make them a serious means of transport but there were few possible power sources available in the mid 1800's.

The steel spring or clockwork mechanism was tried on models with limited success. The hot air engine was available but even if it could have been made light enough the size of machine needed to generate sufficient power would have been disproportionate to the airframe. This left the steam engine. Anything resembling Stevenson's Rocket as used on the railways would of course have been out of the question but Stringfellow had put his fine engineering skills to good use in making several small lightweight and powerful high pressure steam engines. Further, the use of propellers to convert engine power into thrust had been made by others; this principle was not challenged until jet propulsion was developed.

As Henson and Stringfellow proceeded with designing and building small versions of a proposed man-carrying aircraft it was realised that others were interested in their efforts so they patented their designs to prevent them from being stolen. The provisional patents that were published in 1842 created great interest and in order to take advantage of this and generate some much needed working capital Henson and Stringfellow formed the Aerial Transit Company. The design of the first full size flying machine was published but such was the extravagence of the claims made about the size, power, load-carrying capability and range that the whole scheme was ridiculed in the press. The hoped-for cash investments did not come and the company quickly folded. Henson had taken the major role in the technical aspects of this enterprise which had left Stringfellow relatively free to follow his own interests. The two men drifted apart and all that is known of Henson's subsequent history is that he married and moved to join his family in America.

The flying machines as initially tested were by no means complete. It was appreciated that the most important things to get right were the weight of the engine and airframe relative to the size and lifting power of the wings. To assess the forces created by air moving over a surface at high speed Stringfellow travelled on an express train and experimented out of the window with a device that could measure these forces with the surface tilted at various angles. Until it could be shown that a particular aircraft design could maintain level or preferably slightly climbing flight there was no point in proceeding with arrangements for steering and controlling rates of ascent and descent.

To give the best chance of success, the overall weight of the models including fuel and water for the engine were kept to a minimum and launching tracks were made to ensure the craft was released in the most favourable way. The aircraft would sit on a wheeled carriage mounted on a wire track sloping slightly downwards. On reaching a block at the end of the wire track the carriage released the aircraft which, it was hoped, would then assume free flight. The sizes of the various aircraft made over the years ranged from 3.0 metres to 6.1 metres wingspan and a major problem in testing them was to find spaces sufficiently large and yet private enough to avoid the distraction of spectators. Sites ranged from disused factories to abandoned churches.

On one occasion testing was planned to be on an open piece of land a couple of miles outside Chard. The machine was taken to a nearby shed ready for tests at dawn the next day. Everything went well until craft and carriage reached the end of the track when both crashed to the ground. The extra weight caused by the morning dew on the wing surfaces and their consequent loss of shape had been overlooked.

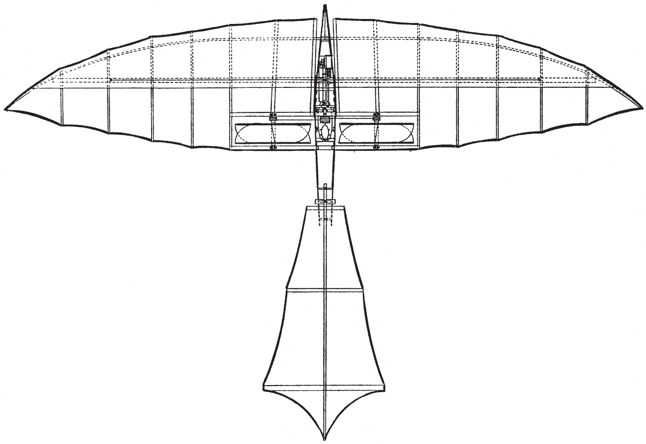
Stringfellow continued with his experimenting and between 1846 and 1848 completed the model that would truly fly. It was a monoplane weighing less than 4.1 kilogrammes with a wingspan of 3.0 metres having a total surface area 1.7 square metres . The silk covered wing was quite flat with the leading and trailing edges being smoothly curved. The tail member, also silk covered, was smoothly shaped but as no rudder was included the plane could not be steered, although the incidence of the tail could be adjusted to allow corrections to the flight path.

A steam engine was carried and two contra-rotating propellers 40.6 centimetres diameter each with 4 blades and mounted behind the wings were driven by pulley and cords from the engine. The engine incorporated a cylinder 1.9 centimetres in diameter with a 5.1 centimetre stroke driving the 6 groove pulley through a bevel gear. The water boiler was heated by a methylated spirit or naptha lamp.

To design and develop such a powerful steam engine light enough to be flown and also to construct an aeroplane capable of carrying it in flight was an incredible achievement by Stringfellow and a marvel of ingenuity.

The world’s first successful powered flight was at Chard in a room 20 metres long by 3.7 metres high. On release from its carriage the model climbed at an inclination of 1:7 and flew 12 metres before being stopped by a suspended canvas sheet. In

STRINGFELLOW'S POWERED FLYING CRAFT



August 1848 the second demonstration occurred in Cremone Gardens, a pleasure park in Chelsea, London, when an impressive, climbing, stable flight of 37 metres was achieved. These powered flights, the first in the world, did not, however, command a great deal of attention at the time and it was not until many years later that the full significance of them was appreciated. Stringfellow may have been disappointed in this but his aspirations were always fixed more upon the attainment of success than upon the aquisition of fame and wealth.

He continued his work during the next few years and, although rather hit-and-miss in achieving longer sustained flight, had his greatest successes in 1868 with a model steam powered triplane capable of giving a better more controlled flight with a stronger more compact shape. It was said this craft possessed 'one third the power of a horse whilst its weight was that of a goose'. The engine was found to have the greatest power for its weight in a competition held by the Royal Aeronautical Society in the aeronautical exhibition at Crystal Palace, London. It won a prize of

£100 which he used for the construction of a building 21 metres long to continue his experiments. In the same year he was elected to the Royal Aeronautical Society.

Soon after this his sight began to fail and although maintaining an interest in flight he did not achieve further practical success. Stringfellow, even during the time he had an active interest in aircraft, was so inventive and mechanically skilled that he often had to call a halt to his main passion of flight in order to satisfy other business customers. He became proficient in the new art of photography, invented a wheeled shield that afforded protection to soldiers from bullets and made a device called a scarifier for the 'blood-letting' regarded by doctors as a cure for most diseases of the time. This comprised a cutting blade mounted on a handle together with a depth stop and a cup to collect and measure the blood taken from the patient. One order for these gadgets was for 300 units to be used in China.

John Stringfellow died in 1883 at the age of eighty four. He always had a cheerful and vigourous personality and was energetic, level-headed, painstaking and enthusiastic. He had the instincts of a man of science but backed these with practical experiments and must be considered a truly all-round engineer.

It is ironic to consider that in 1867, the year before Stringfellow's greatest success, Nikolaus Otto had invented the four stroke cycle and the internal combustion engine. If those two men had met there is the possibility the Wright brothers' achievements of man-carrying flight would have been pre-dated by some thirty years.

G A Briggs

PERCY CARLYLE GILCHRIST

1851–1935

Chemist and Metallurgist

On the Marine Parade at Lyme Regis, Dorset stands a group of attractive thatched cottages that look out over Lyme Bay. It was here at Harville Cottage, the house of Thomas Clarke, a retired Master Mariner, that Percy Carlyle Gilchrist was born on 27 December, 1851. His mother Anne (nee Burrows) was from an upper class family and she and her barrister husband Alexander were of independent means sharing the same writing, scholarly and intellectual interests. Alex chose not to practice as a lawyer and instead he pursued his life-long ambition of becoming a writer. The early years of the marriage were nomadic ones, spent travelling the country in search of information for the book Alex was writing. Two years after Percy was born they made their first home in an old manor house in Guildford.

Three more children were born to the Gilchrists who by 1856 had settled in Cheyne Row, London, but in 1861 Percy contracted scarlet fever which, in those days, was a life-threatening disease. Through contact with his son, Alex also contracted the disease to which he succumbed. With four children to support, Anne continued with her writing while Percy attended Felsted School, Essex, where he displayed an interest in the sciences. From Felsted he studied at the Royal School of Mines, South Kensington where he became a Murchison Medallist and obtained his associateship of that school three years later. He also became a member of both the Institution of Civil Engineers and the Institution of Mechanical Engineers. In 1877 Percy married Norah Fitzmaurice, the daughter of Captain L N Fitzmaurice, RN, by whom he had a son Alexander, and a daughter Ellen.

Until the middle of the eighteenth century cast iron was the most common metal used in construction work but it contained a large number of impurities that made it brittle and liable to failure under stress. Removal of these impurities from the iron was a difficult process but when completed, it produced wrought iron that was softer and easier to work. However, both cast and wrought iron were prone to contain blowholes created during the casting process which made them unable to withstand strong tensile forces and it was this structural weakness that contributed to the disastrous failure of the Tay Bridge in 1879. By introducing carbon into the iron, steel could be created, a metal that was strong, flexible and durable, possessing all the qualities of cast and wrought iron but also capable of resisting high tensile forces. However, the process was difficult and expensive until Henry, later Sir Henry, Bessemer designed his converter.

Steel was produced in the Bessemer converter from impure pig iron smelted from the basic ores but sadly, it was not the perfect answer and frequently produced steel that was of poor quality and sometimes quite useless. The reason for this was eventually found to be the presence of the phosphorous that remained in the steel and which the converter had failed to remove. The most phosphorous-free ore in this country was the rich haematite discovered along the coast of Cumbria that led to the establishment of iron and steelworks in the region, the largest of which was at Barrow-in-Furness. But the deposits were limited and expensive to extract, consequently ore speculators moved to Spain where cheaper material was available.

After qualifying at the Royal School of Mines, Percy Gilchrist took up a post of analytical chemist at Cwm Avon Ironworks in South Wales and it was at this time that he was approached by his cousin Sydney Gilchrist Thomas, about a theory the latter had developed for eliminating phosphorous from Bessemer steel.

Sydney Gilchrist Thomas who was about nine months older than his cousin, was a remarkable man. Due to financial difficulties following the early death of his father, he was forced to abandon his dream of studying medicine and instead, become a clerk in the Metropolitan Police Courts. But his real interest lay in chemistry which he studied with dedication in his spare time. While attending a course of lectures at the Birkbeck Institution he became fascinated in a particular lecture that referred to the scarcity of low phosphoric ores in the steel manufacturing industry. Mr George Chaloner, a lecturer in inorganic chemistry and metallurgy, stated that 'the man who succeeds in eliminating phosphorous in the Bessemer converter would one day make his fortune' and it was this remark that fired the imagination of the young Sydney Thomas. Thereafter he dedicated himself to the study of the problem that eventually led to the discovery of a process that became known as the Thomas-Gilchrist Process and for which he and his cousin Percy became famous.

In due course, Sydney Thomas also qualified as a chemist, but whilst still a clerk to the police court, he pursued his investigations by converting a room in his house into a makeshift laboratory where he undertook experimental work. However, the conditions were far from satisfactory and quite dangerous.

He was encouraged in his research by Chaloner at the Birkbeck Institution but being unable to carry out full-scale tests in a converter, Sydney wrote to his cousin explaining his theory and setting out the lines on which it could be tested.

Initially Percy Gilchrist was sceptical about his cousin's work and having just obtained a new post at the Blaenavon Works, he was reluctant to get involved in unofficial experiments. Consequently the experimental work was slow to start. But Sydney's enthusiasm gradually infected Percy and following a further meeting between the two, it was agreed that experimental work would commence, financed by Sydney Thomas out of his meagre salary. Gilchrist started the work in a rough shed on a mountainside but little was done until 1877 when the experiments began in earnest. As Gilchrist began to anticipate the success of the experiments the work advanced quite quickly, necessitating

Sydney Thomas's more active co-operation; this required him to make frequent trips to Wales on the days he was off duty.

Similar work was proceeding without success on the continent and in America but the work that Percy Gilchrist was carrying out did not go unnoticed by E P Martin, the manager of the Blaenavon Works who became convinced that Gilchrist and Thomas were working on the right lines. He was so impressed with the results of their experiments that he arranged to relieve the cousins of their pressing financial worries by agreeing to buy shares in the patents for which they had applied, and to provide facilities for their research work to continue.

Details of Gilchrist and Thomas's work were presented for discussion at various meetings of learned institutions at home and overseas but their claims to have devised a process for successfully removing phosphorous from the Bessemer converter were met with scepticism and a certain amount of incredulity. However, a manager of a steelworks in Middlesbrough decided to pursue the matter and visited Blaenavon where he arranged for further tests that convinced him the dephosphorisation process was a commercial possibility. When the results of the successful tests became known Gilchrist and Thomas were besieged by steel manufacturers wishing to obtain the patent rights and their financial future was assured.

Sydney Thomas resigned his position at the police court and devoted himself to promoting the new process as well as negotiating patents and contracts with home and overseas manufacturers. New companies were formed of which the cousins were shareholders and Sydney travelled widely at home and abroad in connection with the work. Sadly he had never enjoyed good health and the strain of his early work, coupled with the extensive travelling soon took its toll. He spent the last few years of his life working on a project for converting the waste slag from the Bessemer converters with its high phosphate content into a basic fertilizer. He died, not yet thirty five years old, having made a fortune but not living to see basic slag become the highly valued fertilizer he had forecast.

Honours were bestowed on both men who were awarded the gold medal of the Society of Arts and the Bessemer Medal of the Iron and Steel Institute.

Percy Gilchrist moved with his family to Redcar where he continued his work in the steel industry as the managing director of the Dephosphorising and Basic Patents Company Ltd., a company originally established to protect the rights of the process he and his cousin had developed. He was also associated with other companies in the steel industry.

The Thomas-Gilchrist process was taken up actively on the continent and was duly extended to the Siemens open-hearth process but for some reason, it gradually ceased to be employed in this country until its revival by a British firm in the mid-1930's. Percy Gilchrist may not have been aware of this for after along illness, he died on 15 December, 1935 some fifty years after his cousin with whom he had revolutionized the steel manufacturing process.

Since his death improvements have taken place in the process and although historically Gilchrist has been overshadowed by the figure of Thomas, there is no doubt that Percy's contribution to the invention of the basic process was just as great. He was the practical chemist and metallurgist who proved by experiment what his cousin had developed in theory. He was a member of the Iron and Steel Institute, of which he became Vice President, for sixty years and was elected a Fellow of the Royal Society in 1891, an honour that surely would have been bestowed also on his cousin had he lived.

An obelisk erected on the site of the Blaenavon Ironworks in Monmouthshire commemorates the experiments carried out by Gilchrist and Thomas and the Retired Chartered Engineers' Club, Exeter has fixed a plaque on the esplanade at Lyme Regis to record Gilchrist's birth in the town.

This chapter embraces the combined work of both Thomas and Gilchrist and shows that success also can be achieved by independent dedication and hard work. Today we have cranes that could lift the Eiffel Tower, buildings that soar 800 metres skywards and vessels of 500,000 tonnes travelling the oceans, all as a result of their pioneering work in developing the steel manufacturing process. Sydney Thomas had the dream that Percy Gilchrist made come true with the result that both men are equally revered in the annals of steel manufacture.

A G Banks