THOMAS NEWCOMEN c 1664–1729

Ironmonger and Inventor

Very few individuals have the privilege of a learned society being created in their name but Thomas Newcomen is one of these. The Newcomen Society was founded in 1920 by a number of engineers and others in honour of the man whose name is a symbol of Britain's great industrial movement of the nineteenth century.

Thomas Newcomen was born about 1664 in Dartmouth, Devon, reportedly in one of the quayside houses there and his father was a merchant venturer trading with interests in the ships Mediterranean and Norwich which sailed to all parts of the world.

After an early education, Newcomen probably served an apprenticeship in Exeter before establishing himself in business in Dartmouth as an ironmonger and chemist. This combination seems strange now, but in the 1600's the town chemist simply stored quantities of different herbs and potions along with the recipes showing how these should be combined to cure various illnesses. The ironmonger trade has also changed over the years and in those early days encompassed the activities of someone who not only supplied latches, locks, nails and other items, but who actually manufactured agricultural tools and other hardware. Thomas Newcomen was an accomplished craftsman as well as a trader, as shown by his intricate work on the Dartmouth town clock. It was this practical background that both helped and hindered him later in life.

He was a deeply religious man. At the age of forty one he married Hannah Waymouth, a bride of twenty two who later gave birth to two sons and a daughter.

In the course of his work he frequently visited mines locally and in the Midlands and became familiar with the major problems associated with their drainage plus the heavy cost of using horses to operate the pumps drawing water from the underground areas. The difficulties of draining mines was one of the major problems of the day. Other pioneers, in particular Denis Papin and Thomas Savery, were considering the use of steam in engines to power the mine pumps and Newcomen, in his travels and in conversation with others, was probably aware of these trials. He decided to start work on his own design.

His idea was to manufacture a vertically mounted cylinder with a close fitting piston, then create a vacuum beneath the piston and let the weight of the atmosphere above the piston drive it down. Many believed it was the vacuum 'sucking' the piston down but Newcomen knew that the weight of the column of air stretching thousands of metres upwards, bearing down on the top of this piston, was the source of the power.

With his trading partner John Calley (Caley or Cawley), who was also an accomplished plumber, glazier and craftsman, Newcomen set out to make a working model of his idea. Being a practical man he was determined to design a machine whose construction was within the competence and skills of the craftsmen of the day.

The first consideration in the design was how to create a vacuum in the space beneath the piston. This was achieved by forcing air out of this space with steam, then closing inlet and outlet valves to create a sealed volume. As the steam cooled back to water occupying less space, a vacuum was created between this fluid surface and the underside of the piston. Newcomen simply used steam as a means to create a vacuum. Enormous power was provided by the weight of the column of air bearing down on the piston.

His next consideration was how to speed up the cycle of steam generation, steam injection, and steam cooling. Initially he and Calley constructed around the cylinder a metal jacket through which cold water passed. This was an attempt to cool the steam quickly and whilst it had some effect, it was not the dramatic improvement they were seeking. During one test however, the piston unexpectedly descended with tremendous speed and force. By accident, a minute leak had allowed a small jet of cooling water from the jacket to enter the cylinder and cause almost instant condensation. The leak was eventually traced to the solder that had been used to plug a hole in the cylinder casting. Direct water injection was the breakthrough Newcomen had been seeking and allowed the machine cycle time to eventually reduce to less than six seconds. Newcomen and Calley were both adept at working with iron, brass, tin, copper and lead but ten years elapsed before they completed the design, development and manufacture of a working engine.

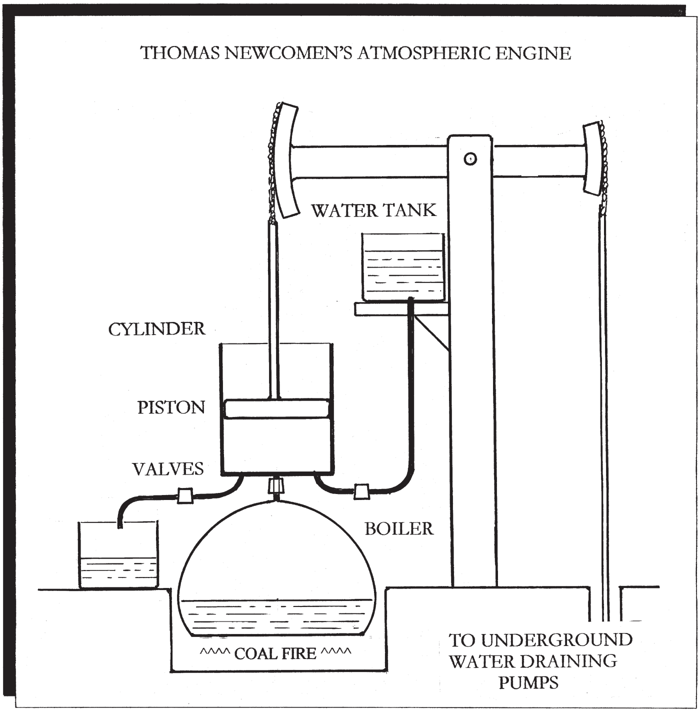
To those in the small scientific world centred on London and the Royal Society it seemed inconceivable that a non-academic man in Devon could have achieved the unique marriage of scientific principles and practical engineering to produce a revolutionary engine. At the time 'pure' or academic science received royal patronage and was generally confined to study and laboratory investigations with instruments and apparatus created by skilled horologists.

Newcomen wished to patent the engine's design but Thomas Savery owned wide rights covering his own invention for a steam engine and, on paper, the two designs could be construed to overlap. Patent laws were notoriously vague and as Savery had connections within the courts, Newcomen decided he would not wish to contest the situation so, when the opportunity presented itself, he became a partner with Savery.

There followed a period of development to connect the vertical motion of the piston to a water pump suitable for mining operations. This was accomplished with a large horizontal beam on a central pivot. One end of the beam was connected to the piston rod and the other to a vertically operating water pump which would be installed down into the mine. For the engine to operate continuously the valves controlling the steam, air and water had to be opened and shut in a precise sequence. Initially this was managed by boy minders but one, named Humphrey Potter, devised a system of latches and strings connected to the overhead beam that helped to make the cycle automatic.

It was the inspiration of harnessing atmospheric pressure to provide the main source of power to drive a practical, reliable, continuously operating and automatic engine that confirmed Newcomen as a genius.

In 1711 he offered to erect his first industrial engine. This first practical installation was at Coneygree coalworks, Tipton, Staffordshire, an area which was the home of many skilled craftsmen, the source of metals and plenty of coal for the engine's boiler. The cylinder was 53 centimetres diameter, 2.4 metres high with a boiler 1.7 metres diameter 1.9 metres high. Operating at a continuous 10 – 12 strokes per minute, the pump extracted 45 litres of water per stroke from a mine nearly 50 metres deep.



This was the first of many successful projects. Engines increasing in size up to 2 metres diameter being erected in Hungary, Sweden, Belgium, France, Spain, Austria, Czechoslovakia, and Germany as well as in Britain. Approximately 1,500 engines were built and the enormous capital investment that was needed for each one pays testimony to the success and reliability of the design. Newcomen and Calley were justifiably proud of their engines and, because of Newcomen's family history of world trading, they had the right combination of commercial ability and practical versatile craftsmanship that ensured success for their endeavours. For more than sixty years following his invention, the engine was still the most powerful and economic for draining mines.

There are not many records of Newcomen's activities during the later part of his life. Most of it was spent in London from where he maintained an interest in his engines and became involved in research and other inventions including one that considered the use of wind power. He died at the age of sixty seven in the house of his friend Edward Wallin in August 1729.

Newcomen received no formal official honour in his life time for his invention and sometimes the engines were referred to as Thomas Savery's or James Watt's. Even overseas laurels were awarded to the builders. He was not however embittered by this lack of recognition being too great and too modest to seek the world's acclaim. The work of creation was its own reward, a satisfaction which no one could take away.

Throughout his life Newcomen enjoyed the reputation of being a perfectly honest man. It has been said that he was the first great mechanical engineer. His engine was tailored to the needs, resources and skills of the time and was the most important single invention of the Industrial Revolution. Improvements were made later, but the first step in any endeavour is always the most difficult. Thomas Newcomen was the pioneer who took this step.

J A Knivett

GEORGE PARKER BIDDER 1806–1878

Civil Engineer

On 14th June, 1806 a son was born to William and Elizabeth Bidder and christened George Parker, the name Parker being his mother's maiden name. The Bidder's lived in Moretonhampstead, a small town on the edge of Dartmoor where William plied his trade as a stonemason. Little did the parents know that George, their sixth child, would become known as 'The Calculating Boy' and one of the most famous civil engineers of the nineteenth century who would bring prosperity to himself and his family.

As a child George gave little indication of his mental capabilities, tending to avoid school and preferring to amuse himself by playing games with marbles and conkers, working out in his head, the various combinations and sequences that arose from those games. His brother John had taught him to count and as a result, he acquired a fascination with numbers that led him to develop mental skills that would prove so beneficial in later life.

The school George attended was run by a local minister who reported that although George experienced difficulty with his writing, he had no problem understanding numbers and doing calculations. He frequently displayed his mental agility by encouraging local people to ask him complex arithmetical problems that he would then solve with remarkable rapidity.

George's father soon realised that he had a child prodigy on his hands and that his son's talent could be of financial benefit to the family. He started to exhibit the boy at local fairs and shows where he was advertised as 'The Calculating Boy' and in due course he travelled further afield, appearing in many towns across the country including London. Charges for admission were made and George's father quickly appreciated the rewards to be derived from these appearances. In the winter of 1816-17 George was invited to display has talents to Queen Charlotte who put to him several numerical questions, no doubt prepared for her in advance of the meeting, which he answered accurately and in record time.

In 1816, two gentlemen from Cambridge who had witnessed one of George's performances, persuaded his reluctant father to allow the boy to attend a school in Camberwell but after a year, his father, unwilling to accept the loss of income, withdrew George from the school. George does not appear to have resented the change and the tours he subsequently undertook no doubt helped to broaden his horizons. He remained cheerful and enjoyed joking with the questioners.

While exhibiting in Edinburgh in 1819, he caught the attention

EXAMPLES OF QUESTIONS PUT TO 'THE CALCULATING BOY'

Q. How many farthings are there in £367,548?
A. (in 15 seconds) 352,846,080

Q. Dividing £24 among 24 sailors so as to give the captains £4, the mates £2, the men 10 shillings and the boys 5 shillings, give the number in each class.
A. (in 2 minutes) 3 captains, 3 mates, 6 men and 12 boys.

Q. Suppose 4,535 grains of sand cover one inch square, how many grains will cover an acre?
A. 28,446,422,400

Q. If a coach wheel is 5 feet 10 inches in circumference, how many times will it revolve in running eight hundred million miles?
A. (in 50 seconds) 724,114,285,704 times with 20 inches remaining.

of Sir Henry Jardine, a prosperous Hong Kong businessman who, together with a group of friends, arranged for George to receive private tutoring and later, for his attendance at Edinburgh University. There he established a great friendship with Robert Stephenson, the son of George Stephenson the eminent railway engineer, which was to last throughout their lives and played an important part in influencing George to pursue a career in civil engineering. George was always grateful to his mentor and repaid his debt to him and Edinburgh by establishing the Jardine Bursary at the university for the benefit of students of limited means.

On leaving university and with the help of Sir Henry, George obtained an appointment as a trainee surveyor with the Ordnance Survey that involving extensive work in Scotland but after two years he moved to Cardiff and then to London. Here he took the next step in his professional career and moved into civil engineering, working as an engineering pupil with Henry Palmer, a well-known consulting engineer and former assistant to Thomas Telford. During this period he worked on surveys for the London Docks and various harbour, railway and canal projects but in order to help support his younger brothers, he also worked as a part-time clerk in the offices of Royal Exchange Life Assurance where his calculating skills were of great benefit to the company.

Following a short period with another firm of engineers where he worked on other schemes in the London area, he joined the practice of his friend Robert Stephenson. This was at the start of 'the railway era' and initially George worked on the London & Birmingham railway gaining valuable experience at a time of great activity when the rail network was being developed throughout the country.

In order that a proposed railway scheme could receive the approval of Parliament, it was necessary to prepare and submit accurate surveys of the intended route together with estimated construction costs for consideration by the appropriate Parliamentary Committee. Such schemes called for careful examination and involved cross-examining the promoters and expert witnesses and it was here that George's talents made their greatest impact. His practical knowledge of surveying, coupled with his prodigious memory and mental skills made him a most effective force when appearing before the Committees. His ability to spot weaknesses and errors in his opponents submission and to present counter-arguments made him such a formidable witness that on one occasion, opposing Counsel objected to his presence stating that 'nature had endowed him with particular qualities that placed his opponents on an unfair footing'.

This was the type of work in which he excelled and he loved the cut and thrust of argument and the analysis of technical problems. Consequently, his main contribution to the expansion of the railway network in this country was through the promotion of schemes rather than their construction and perhaps it is for this reason, that his name is not as well known as those of other famous railway men such as Brunel, Stephenson and Locke. It is a measure of his standing however, that he is portrayed with his contemporaries in the famous painting by John Lucas of 'Conference of Engineers at Britannia Bridge' that hangs in the Institution of Civil Engineers.

Bidder's entrepreneurial flair led him into other fields of development and as his wealth increased, he invested in land as well as a variety of businesses in which he took an active interest. One development with which he became associated was the electric telegraph, a new invention still in the early stages of its commercial development. By introducing it on the London & Blackwall Railway and later on the Norwich & Yarmouth line, he was able to effect economies by introducing single line operation with safe and reliable communication between stations. As the demand for this type of communication increased, he helped to promote and finance the Electric Telegraph Company and the subsequent development of transatlantic cables.

Bidder was responsible for many overseas projects including railway schemes in Norway, Denmark, Switzerland and India and as his reputation grew, he came into contact with many leading dignitaries and Heads of State. He reached the pinnacle of his professional career when he was elected President of the Institution of Civil Engineers in 1860-61.

Although Bidder's main home was in Surrey, he always had great affection for his native County of Devon and having bought a house in Dartmouth his wife Georgina and family of eight children gradually began to spend more time there. He became a member of the Town Council and took an active interest in local affairs, but felt unable to accept the office of Mayor due to his many commitments in London. In 1869 he became the President of the Devonshire Association for the Advancement of Science, Literature and the Arts, a position later held by one of his grandsons. In fact the immediate Bidder family tree contains many distinguished individuals.

The nature of his work meant that he spent long periods away from home but he kept in regular touch with his family. Hard work and dedication were always a feature of Bidder's life and they brought their just rewards so that he and his family were able to enjoy a standard of living his parents could never have envisaged. Together with Robert Stephenson, he made many business and social trips on Stephenson's yacht and at Dartmouth he acquired his own yacht, the equivalent to a personal jet aircraft these days. Always the engineer, his interest in boats and water led to him to assist William Froude, another famous engineer, on experimental work associated with the design of ships' hulls. He was a founder member of the Dart Yacht Club and played an important role in the Club obtaining a Royal Warrant.

Just prior to his death he purchased Stoke House, Stoke Fleming which he planned to enlarge but he died there on 28 September 1878 before the work could be completed. He was buried in the churchyard at Stoke Fleming.

Bidder's prodigious memory and mental agility remained with him until the end and even during the last few days of his life, he was still able to enjoy philosophical discussion and debate with his friends. Bidder's name frequently occurs in the nineteenth century annals of civil engineering and he is remembered in the town of his birth where a mosaic has been laid in the road approaching the parish church that illustrates some of the mathematical problems he resolved as a child. A lithograph of Bidder together with a marble bust can be found in the town's Bowring Library and on 29 May 2003 the Retired Chartered Engineers' Club, Exeter placed a commemorative plaque on the wall of the Parish Council Office in The Square that was unveiled in the presence of his grandson and great-grandson.

Blessed with a wonderful brain, Bidder developed his own method of mental calculation that he explained in a lecture to the Institution of Civil Engineers in 1856. This was complemented by a memory that retained basic information on which he relied when performing complicated calculations and which was probably the result of the games he had taught himself as a child. There is little doubt that his speed of mental computation would compare favourably with today's electronic devices that appear so indispensable for even the simplest of calculations.

A G Banks

WILLIAM BICKFORD 1774–1834

Inventor

The village of Bickington is between Ashburton and Exeter and the town of Simsbury is in Connecticut, USA. They are linked by the family name Bickford; William's early life was spent in the Devon village and Simsbury houses the headquarters of the large and successful Company Ensign-Bickford Industries Inc.

During William's youth agriculture was the main source of Bickington family's incomes with farms which had kept their relatively modest size for many generations. The holdings were generally owner-occupied and the Bickford name had been well established in the area for centuries. In addition to the usual activities of growing crops and rearing animals, the wool trade, initially as a cottage industry, became important in the region and timber also was a valuable commodity with the tree bark being used for leather tanning.

William turned to the leather tanning industry for his livelihood. He became a leather curer and manufacturer with work-shops in Devonport but family ties with Bickington remained strong and letters from his mother still survive advising on his way of life and work, as well as keeping him informed on family matters. Seeking to improve income from the business William moved from Devonport to Liskeard. He took charge also of the first Methodist school in Cornwall and stayed for six years before making moves first to Truro, then to Tuckingmill, near Camborne.

It was in Cornwall, at the heart of the mining industry, that he became aware of the harsh truth of a miner's life – one of misery, danger and sometimes, as the rent-paying tenant of a small damp cottage, squalor, often gaunt from existing on meals of only pilchards and potatoes. Working in the mines sometimes involved wading through chest-high waters having the phenomenal temperature of 100 degrees Farenheit breathing stale air at 90 degrees. There were other great dangers associated with the work and miners suffered the effects of terrible accidents. He met widows who were struggling to raise families, men with blackened faces who were maimed, deformed, blinded and lame.

William, a humane and sensitive man became distressed by the suffering and soon discovered that much of it was caused by the method of using explosive charges. The practice at the time was for the miner at the workface to make a fuse by filling a goose quill or straw with gunpowder before connecting it to the main explosive charge and igniting the fuse end. The method was dangerously unreliable, sometimes due to lack of care so the powder fuse had gaps in it, or the cover was pinched. Sometimes the quills were filled incorrectly, sometimes sand or grit was pushed into the frail tubes, sometimes damp was let in. Any of these things could cause premature explosions before the area had been evacuated, or cause delays, so that a miner approaching the charge to investigate, would receive the full impact of a late blast.

William became determined to design a safer and more consistent fuse and assisted by his son-in-law George Smith performed a series of trials and experiments. One of his first ideas was to place the main explosive material in a parchment tube and attach a smaller one containing powder as the fuse. The assembly was made above ground in conditions better than in the mine itself but despite all their efforts the trials were unsuccessful.

It was during a visit to his friend James Bray, a semi-retired rope maker, that William had the idea that eventually had a profound effect on miners' lives. Bray was spinning some yarn in the ropewalk, walking backwards, twisting it from bobbins to form a strong rope. William thought it might be possible to trickle gunpowder from a funnel into the core as it was being formed and then seal the outside of the rope with some form of coating.

He and George discussed the idea with Thomas Davey, a working miner who was ‘a great genius for mechanical contrivances’ and together after many experiments they produced a reliable and predictabe fuse. It consisted of twisted yarns round a core of powder, the whole encased by an overlay of more yarns wound in the opposite direction. The powder was trickled in by means of a drum and funnel strapped to the rope-winder’s waist. The finished product was passed through a vat of tar to create a waterproof coating that also held the whole together as a strong rope about 12 millimetres diameter and 19.8 metres long. When ignited at one end the fuse would burn at a steady, consistent rate so the miner could simply cut the required length according to the timing needs at the site.

This basic design of fuse remained virtually unaltered for more than a century despite tests on many alternatives and even after the introduction of electric fuses it remained in common use.

William initiated a patent for the ‘Safety Fuze’, entered into a partnership with Davey and travelled to many mining areas demonstrating the fuse.

Despite the many obvious advantages it was accepted only slowly, partly because miners often had to provide their own materials and the traditional methods cost less than the new. Also there were reported misfires which were eventually traced back to miners using the uncut long fuse to lower tools and equipment down mine shafts as if it were regular rope. This disturbed the powder in the core and caused misfires. William instigated a series of advertisements to explain the importance of proper use and soon the fuses were in great demand. It was some time however before the terrible toll of blinding, disfigurement and death was dramatically reduced.

Tragically William became seriously ill two years after the patent was granted and, completely incapacitated for work, died two years later in October 1834 at the age of 57. He did not live to see the major results of his work, which saved many thousand of lives and greatly improved the wellbeing of miners and their families. His Will included a wish that the business should continue with Davey and Smith plus two relatives in control.

To satisfy the increasing demand for the fuse, a factory was set up at Tuckingmill where it remained until closure in 1961 changing names in the interim period to Explosive Trades Ltd., subsequently the major UK partner in the formation of Imperial Chemical Industries. During its first year of operation, 72 kilometres of fuse were made; a century later the output at Tuckingmill was 170,000 kilometres per year and the total world-wide annual production was 450,000 kilometres. Given that the average length of cut fuse is about 0.5 metre, this production quantity represents an incredible number of individual, safe, controlled detonations.

Overseas manufacturing facilities were in France, Austria, Australia, Hungary and Spain. Another significant development occurred when Joseph Toy became involved with the Company and set up an enterprise in America as Toy, Bickford & Company, later to become Ensign-Bickford Industies, Inc. This organisation pays generous credit to William's achievements in its publicity material on the internet.

In Bickington Church, the scene of William Bickford's baptism more than two centuries ago, is a commemorative slate plaque:

William Bickford
1774–1834
Born in this parish
Inventor of
Mining Safety Fuse

A tribute to the man who, with a very simple invention, prevented terrible maiming and the sudden death of tens of thousands of miners.

J A Knivett

CHARLES BABBAGE 1791–1871

Computer Pioneer, Inventor and Mathematician

Charles Babbage, who is often referred to as 'the father of the computer', was born to a Devon family that was well established in the town of Totnes and part of his early education took place at the Secondary School there. Mathematics interested him and a lot of his leisure time was spent reading books on that subject so, by the time he entered Trinity College, Cambridge he was already a good student.

He enjoyed college life in the company of many friends frequently missing lectures to play games or go sailing on the river. As a new undergraduate Charles had looked forward to having many questions about mathematics answered by tutors but was somewhat disappointed and developed a programme of study for his own reading, mainly the works of foreign mathematicians.

He moved to Peterhouse College and was expected to excel in the final Senate House examinations but graduating without honours dashed any immediate hopes of a fellowship. He was awarded an MA later.

Marriage to Georgiana Whitmore at Teignmouth, Devon, resulted in a family of three boys and a girl and they all lived happily in London on a modest but comfortable annual income of £450, including an allowance from his father.

His home soon became a popular venue for some of the well known figures of the day, Wellington, Melborne, Brunel, Stephenson, Darwin, Dickens and Fox-Talbot the pioneer photographer, all enjoyed meeting there.

He was enthusiastic and inventive, gave series of lectures, became a fellow of the Royal Society and served on the Astronomical Society. He proposed the decimalization of currency, anticipated the role of tidal power as an energy source, and predicted the effects of the end of fossil fuel reserves, all this, nearly two hundred years ago! His many publications concerned subjects such as chess, barometric observations, calculating engines, geology, code ciphers, machine tools, solar eclipses, lighthouses, diving bells, submarines, statistics and the most successful work "On the Economy of Machinery and Manufactures" was later translated into six languages.

Always a prolific experimenter with a love of instruments and mechanical devices, his inventive spirit at school had led him to make a pair of hinged flaps which, attached to the feet, were supposed to allow a walk across the waters of the River Dart. They didn't work, and he got wet!

Later, more successfully, he designed and constructed the first known ophthalmoscope for examining the interior of the eye. Among his other many ideas were a fail-safe coupling for railway carriages, a form of camper-van and a pen for drawing dotted lines. Another idea was for an overhead rope-way system for postal deliveries throughout Central London; the country's first e-mail system!

Charles helped his friend Brunel by designing a machine to record automatically the motions of a carriage travelling on the wide gauge railway. The machine produced charts on many miles of paper and was really the ancestor of the 'black box' now carried on modern aircraft.

He was sometimes critical of the Government even suggesting on one occasion that it was 'incompetent to understand the merit either of the mechanical or mathematical'. He also criticised the Royal Society and the conduct of its officers and his comments affected relationships with some influential individuals.

However, Charles' lasting fame is based upon the idea of automatic calculation. In a period where a lot of thought was being given to relieving the manual effort of work, his calculating machine addressed the idea of relieving mental effort; it was the

Engines, their design and construction, that really dominated his life.

The dawning of the idea of calculating by machine came during a meeting with his old friend John Herschel when they were checking some new astronomical tables together. At that time published tables of numbers were used by scientists, engineers, architects, builders, merchants and bankers. Also for other commercial activities including navigation where errors resulted in many shipwrecks and tragic loss of life. Tables were produced by teams of 'computers', people who progressed manually through many operations to finally record the results; inevitably this process was prone to human error. The numerous mistakes he and John discovered whilst checking the tables prompted the wish that the figures had been produced 'by steam', in other words mechanically.

Inspired by this intellectual challenge he worked so hard on it that his health suffered as a result of the sustained mental effort and dedication to the task. Eventually he designed and later constructed a small experimental version of his Difference Engine, so called because it was based on the 'difference' principle of calculation. Then, following a favourable recommendation by the Royal Society and influential supporters, Government finances were secured for his proposal to construct a larger fully engineered machine, The Difference Engine No.1.

The design specified tens of thousands of parts including vertical shafts carrying meshing gears, all to be made with a degree of precision that was very unusual at the time. The whole structure was to be about 2.4 metres high, 2.1 metres long and 0.9 metre deep, powered by an operator turning a wheel. The demand for such high precision created real problems but, on the recommendation of his friend Brunel, Charles employed the very skilled engineer and draughtsman Joseph Clement and a period of concentrated work ensued. Tragically this was interrupted three years later by four family events that occurred more or less at the same time; Charles' wife and a new born baby, his second son and his father all died. He was inconsolable and embarked on a journey around Europe which lasted a year.

During these travels he met prominent scientists, visited workshops and talked to craftsmen as part of a study of engineering manufacture. The Engine Project was entrusted to John Herschel.

After Charles returned, the Treasury advanced further money and Clement assembled a small section of the Engine as a demonstration piece which worked perfectly; it ranks among the most celebrated icons in the prehistory of computing.

One year later Clement stopped work following an argument concerning financial compensation, patents and right of ownership. Sadly, although most of the parts for the calculating section of the Engine were complete, construction was never resumed. After the last payment to Clement the Government's outlay had totalled more than £17,000. Compare this sum with the £800 construction cost of a fully operational steam locomotive at the time.

The collapse of the project after a decade of design and development was the major disappointment in Charles Babbage's scientific life and he was never fully reconciled to the sad outcome. Occasional correspondence for support from successive Governments ensued and eventually an interview was granted with the prime minister, Sir Robert Peel.

By that time Charles had thoughts for a simpler Difference Engine and had ideas for a more sophisticated Analytical Engine. He had hoped to recieve new funding for the new designs but the meeting with Peel did not go well; they argued and the meeting ended acrimoniously.

Charles took two years to design his Difference Engine No. 2, an elegant and more efficient version of its predecessor. As before, it incorporated vertical shafts each carrying many gears but with an integral printing apparatus to press calculated results into paper maché or soft metal. Plans were offered to the Government but no finances were received.

The Analytical Engine, unlike the Difference Engine, was capable of calculating virtually any mathematical function and could be programmed for mathematical operations in any sequence. It was capable of choosing alternative actions depending on the value of a calculated result and also separated the section holding numbers, called the Store, from the section processing them, called the Mill. A Store was 6.1 metres long and the Mill 4.6 metres high, 1.8 metres diameter. The machine used punched cards, a technique borrowed from Jacquard looms controlling the patterns of woven threads by allowing certain rods of a bundle to poke through card holes and operate different parts of the mechanisms.

Charles became obsessed with increasing the speed of calculation and devised an ‘anticipating carriage’, a brilliant technical coup which acted as a psychological boost to his confidence. However only sporadic and inconclusive efforts were made to construct a full-scale Analytical Engine.

During the course of his life Charles’ outspoken views had not been well received by certain individuals and not everyone in a position of influence was convinced of the Engines’ merits. It may perhaps have been a consequence of this that Charles was excluded from the organization of The Great Exhibition of 1851 which was the largest industrial manufacturing spectacular yet staged. This exclusion was, for him, an affront to his self-perception as a statesman of the industrial movement and subsequently he became increasingly saddened by some of the events in his life. Lonely, he died on 18 October 1871 at his house in London.

He had once remarked that he would like to return in five hundred years time with a guide to explain all the scientific discoveries made in the meantime and certainly would have been enthralled to see that the calculating section of Difference Engine No. 2 had been completed at the Science Museum, London in 1991, the bicentennial anniversary of his birth. His status as a ‘computer pioneer’ may be based mainly on the concept of the Analytical Engine. His reputation as the ‘father of the computer’ perhaps rests less on the impressive mechanisms he designed, but more on the dedicated pursuit of the ambition to relieve human intellectual effort with machine operations.

By any measure, Charles Babbage’s enthusiasm, dedication and life achievements are remarkable and inspirational.

J A Knivett

FRANK WHITTLE 1907–1996

Engineer, Inventor and Pilot

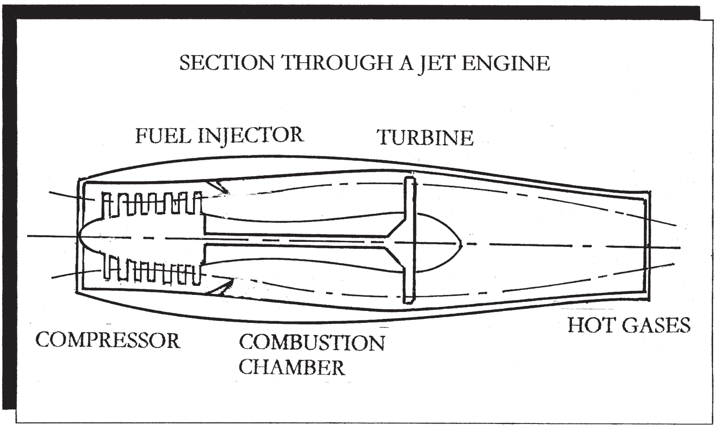
What do you want to be when you're grown up? An age-old question but a hundred years ago, and for many years since then, a boy would commonly answer 'an engine driver'. A girl might have said 'a nurse' and quite a number still would, thank goodness. Few however would now choose to drive railway trains. The appeal of controlling a heavy hurtling steam locomotive has now disappeared except on a handful of historically reserved private tracks as between Paignton and Kingswear.

Today's equivalent occupation for ambitious imaginative boys, and of course girls too, might be to captain and pilot a commercial airline 'Jumbo' or an A380 Airbus or a supersonic military plane. The existence of that possibility owes more to one English man than to any other single individual. He lived from 1907 to 1996. His name is Frank Whittle. He was a professional Engineer, a great inventor and an RAF pilot, and he lived in Chagford, Devon, from 1963 to 1976.

Until Whittle came along aircraft were propeller-driven with the power coming from internal combustion piston engines. Whittle revolutionised aircraft by inventing and developing gas turbine engines, both jet engines and turbo-props. We all now take for granted the hundreds of thousands of civil and military aircraft flying every day all over the world. Before Whittle's first experimental jet aircraft flew in May 1941 there were none. In less than one lifespan world travel has been changed from thousands voyaging by ship, often for weeks on end, to millions flying between countries and continents in hours. Of course, many people have helped to bring about this astonishing change but it was Whittle's imagination, inventive genius and engineering skill which launched the transformation.

Whittle's father owned a small engineering business in Leamington Spa, near Coventry, where the family lived. Frank won a scholarship to Leamington College but he was not a star pupil academically for he was too interested in aeroplanes and flight. When he was sixteen, he won an apprenticeship with the RAF at Cranwell. There he took great interest in aircraft design and his final coursework project in 1928 was an essay on 'Future Developments in Aircraft Design'. He concluded that a new type of power plant was required to increase fighter aircraft speed from about 150 mph to 500 mph. That was a fine target but he did not then appreciate how it could be achieved. The idea of direct jet propulsion did not occur to him until he had learned to fly and been posted with a Commission to a flying instructor's course as a trainee.

Whittle was a Chartered Engineer. He acquired that status after first qualifying as a pilot in the RAF and before being sent on a Service Engineering course and, in 1934, to Cambridge University to undertake an Engineering Degree. Even before he was transferred from flying to technical duties Whittle had made his first



masterly invention. It was to propel an aircraft by a hot gas jet produced as the exhaust from a gas turbine. The other function of that turbine was to drive through a common shaft an air compressor; the outlet from the compressor led to a combustion chamber and thence to the turbine.

Inorder for this concept to work, the compressor and turbine designs available at the time had to be improved greatly and significantly better heat-resistant materials had to be developed, particularly for the combustion chamber and for the turbine blades.

Whilst he was still an RAF Officer pre-war Whittle was allowed to form a Company, Power Jets, to work out solutions to all the practical problems and several young Engineers were directed to help him. One or two industrial firms were given sub-contracts by Power Jets not only to find solutions to the technical problems but also to build prototype engines. Over the next decade, British Thomson-Houston, Rover, Metropolitan-Vickers, de Havilland, Shell, Bristol Engines and Rolls-Royce were introduced into the effort to turn the original ideas into a practical proposition.

Because the project was being undertaken in wartime much secrecy was involved. The first jet aircraft, for example, was transported cross country on a truck under wraps. Since the general shape gave away the fact that there was an aeroplane under the covers, a false propeller was added to the front to conceal the form of the air intake. The secret was well kept until the flight of a prototype aircraft was achieved, thereafter it became inceasingly difficult to pretend all was normal as the uniquely fast aeroplane with no propeller flashed around the Midland skies. Success meant that experimental design and development gave way to factory production. Before the war ended in 1945 a new twin-jet-engined fighter, the Meteor, capable of more than 600 mph, was in squadron service with the RAF and since that time an increasing majority of aircraft built around the world have been jet-propelled. All primarily based on that first, and several other, inventions made by Whittle and the Power Jets team.

His great idea of direct jet propulsion then came to him and he shared his thoughts with the Instructor who taught him blind flying. This was an amazing contact at a crucial time for the Instructor, Flying Officer Patrick Johnson, was a young qualified Patent Attorney unable, in those days, to practise his profession until he became twenty five years of age. Johnson explained to Whittle that making an invention is only the first half of the story. Protecting one's right to it legally is at once essential and has to be properly done. Whittle was convinced. Johnson was willing to attend to all the formalities and for the next ten years and more the two worked together so that all the inventions of Whittle and of his Power Jets colleagues were protected by patents thoughout the industrial nations of the world.

Those inventions were concerned with all aspects of design and operation of the three main components of a jet engine, namely the air compressor(s), the combustion system and the turbine(s). Whittle personally made decisive improvements to compressor and combustion chamber design. He also made a most imaginative change to the basic layout of jet engines so that today they are almost all of a 'by-pass' type. In this concept, dating from 1936, the air entering the engine is divided so that some passes through the basic compressor, combustion and turbine stages but a greater part 'by-passes' most of the compressor and the core engine rejoining the engine stream in the propulsive jet. Such a design has a considerably better propulsive efficiency than is obtainable with a 'straight-through' jet, which is an important consideration particulary for commercial aircraft. Higher efficiency there means less fuel is needed, range is increased, operating costs and fares can be reduced.

When Whittle first put forward his ideas not many supported them. It was true that to carry them into effect there would need to be a considerable support in well directed research and development effort. Gradually, and then with more aceptance under wartime pressure, greater priority was given by those in authority to Whittle and to the Power Jets company. Once the practicability of jet propelled aircraft had been demonstrated, the importance and extent of the jet revolution became obvious.

Under wartime conditions great inventions of this kind were shared between the Allies. Whittle found himself sending engine drawings and performance calculations to the US Government Agencies so that US industry could go into jet engine production. Whittle himself was sent to the USA to explain his work and his plans. A contract was placed by the American Government on the General Electric Company to make a first batch of engines to the British drawings. The foyer of the GE factory office at Lynn Massachusets, near Boston, contained, and probably still does, a display of one of those engines. The enormous resources of the USA meant that the US Air Force as well as the RAF had jet fighters in service before World War II ended.

By 1946 the jet engine 'baby' had outgrown its Power Jets parent. Arrangements were made for that company to concentrate on research and development, on disseminating gas turbine technology and in world wide patent protection and licensing. Whittle himself had been promoted to Air Commordore RAF and knighted but it was difficult fo him to be incorporated into any Service or Industrial structure. He retired from the RAF as his wartime work and the enormous range of his innovations became widely known.

Honours of all kinds flowed his way. In his own words '. . . at home, I have a large collection of gold medals . . .' In this country he was made a Fellow of the Royal Society and the Royal Commission on Awards to wartime Inventors sponsored a grant to him of £100,000 tax free, an enormous sum in those days and the largest amount ever paid. In later years HM the Queen personally made him a Member of the 'Order of Merit', a very great honour indeed.

Whittle's later life was calmer and quieter than the pre-war and wartime years had allowed. For example, the twelve years he spent living at Chagford on the edge of Dartmoor were a period of his life when he managed to keep himself out of the limelight and certainly out of notice of the media. He was not, however, a recluse; he made and kept friends and never lost touch with his former Power Jets' colleagues. From time to time he suffered ill-health but apart from those periods he continued to take great interest in the aircraft industry and also in occasional parallel ventures in co-operation with the Shell Company and with Bristol Siddeley Engines Ltd.

Whittle's greatest contributions had all come, however, in the first half of his life. It was then that he was able to make fundamental technical proposals, primarily through a gift of imaginative perception. His proposals and inventions often came in the form of 'obvious' solutions to problems which had defied all efforts of others, sometimes for years. Such an ability is not always welcomed by those 'others' and he had suffered more than his fair share of their jealousy. It did not always help his reputation with his professional colleagues that often he simply could not comprehend their inability to see what he could see. Also he was almost always right in his technical diagnoses. To err is human, to be uncannily right most of the time is hard to forgive!

During the wartime years Whittle was working under great pressure in his unique capacity as a serving RAF Officer who was simultaneously bringing about a technological revolution within an established industry. Every day brought problems of all kinds. Some were technical, others were human and personal and much time was occupied coping with the Civil Service bureaucratic machine. A ridiculous example of the latter is found in the lengthy correspondence he exchanged with the RAF Personnel Branch about the appropriate daily subsistence allowance to which he was entitled when he was sent to the United States. The rates for Washington and Boston were different, so how did he divide his time? There were not many more important people sent to co-operate with the Americans at that time but he had to abide by all the rules and even as a Wing Commander had to await his turn in the queue for a place in a Liberator aircraft flying across the Atlantic!

From these comments it will be realised that although Whittle was a 'Great Man' of abnormal ability he was not absolved from everyday difficulties of life. Nevertheless his training as a professional engineer provided a solid foundation for his career. He chose to accept the discipline of study and the acquisition of relevant experience over several years to achieve the competence and status of a Chartered Engineer. Those acquiring that recognition in the community are all engaged in the application of science to the design, development and operation of machinery, of technical equipment and of construction works. There are various branches of Engineering in which one can choose to specialise. In Whittle's case it was Aeronautical. For others it might be Electrical, Mechanical, Structural, Transport, Manufacturing. Without fully qualified men and women working in all these fields of activity our lives would be much the poorer and less interesting. And every young Chartered Engineer has the prospect during his working life of making significant changes to an industry or even to transforming life for great numbers of people.

Air Commodore Sir Frank Whittle OM FRS FREng did! We are all his beneficiaries.

R C Orford

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Further information concerning the individuals featured in this non-profit-making book may be retrieved via Internet 'search engines'.

THE FUTURE

The achievements of just a few individuals have been described in this book and although they lived some time ago their successes have had an enduring effect on today's world.

Now, in the twenty-first century, just as in previous centuries, major pioneering projects demand the expertise of members of teams and these are invariably led by individuals with ambition, drive, imagination and enthusiasm.

Whether the project is an impressive structure or a delicate piece of medical equipment, each team member contributes to the final result. Individual members may have knowledge in the fields of geology, aerodynamics, metallurgy, electronics or another discipline and a successful venture also demands project control provided by expert planning and scheduling.

All these activities offer job satisfaction, challenges and opportunities, and all can contribute to make the world a better place and transform peoples lives.

Information concerning technical career options, qualifications and rewards is available from Libraries and Career Advisors as well as the Engineering Council's web site at www.engc.org.uk.

The writers of this book sincerely hope it has stimulated an interest in engineering and if it has inspired career aspirations in this profession then it has fulfilled its purpose.